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EXPLORATORY FISHING FOR THE SUNRAY VENUS CLAM, *MACROCALLISTA NIMBOSA*, IN NORTHWEST FLORIDA

John W. Jolley, Jr.

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Marine Research Laboratory
Florida Department of Natural Resources
Division of Marine Resources
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EXPLORATORY FISHING FOR THE SUNRAY VENUS CLAM, *MACROCALLISTA NIMBOSA*, IN NORTHWEST FLORIDA

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ABSTRACT

Exploratory fishing to locate commercially significant beds of the sunray venus clam, *Macrocallista nimbosa* (Solander), and to survey benthic fauna from 68 ft shoreward was conducted with a 48-in. hydraulic Nantucket clam dredge. Sampling was dependent on mild weather and was usually confined to sandy substrates.

One hundred seventy-three stations were established from the Alabama-Florida boundary line to Cedar Keys with five additional stations in southwest Florida.

Macrocallista nimbosa was the most abundant and frequently caught clam; 95% were taken in 10 to 40 ft and catch per unit effort was highest at 10 to 15 ft. It was caught predominantly in sandy substrates and most productive stations were in Area B, near Panama City, and in Area E, near Cedar Keys. Although these areas yielded smaller catches than those at the commercial grounds on Bell Shoal, they warrant further investigation. Offshore investigations in 41 to 68 ft showed no evidence of other potentially commercial clam stocks.

Paucity of small sunrays (<126 mm) tends to substantiate the hypothesis that subadults may move from inshore to offshore areas.

More than 140 species of fish and invertebrates were identified from catches; faunal associations varied with depth in some areas. Several benthic species were found commonly associated with sunrays, and a predatory relationship is suggested for two species.

Results at Cedar Keys indicated that the hydraulic Nantucket dredge should not be used in areas where grass beds are an important part of the environment.

*Contribution No. 187

INTRODUCTION

In 1967 a new fishery based on the sunray venus clam, *Macrocallista nimbosa* (Solander) developed in northwest Florida near Port St. Joe. At that time the Florida Board of Conservation (now Florida Department of Natural Resources [FDNR]) Marine Research Laboratory conducted initial observations on this new fishery and on the use of the hydraulic Nantucket clam dredge (Stokes, Joyce, and Ingle, 1968). From 1967 through 1969 the fishery produced almost 1.4 million pounds of sunrays with a combined value of over $140,000 (Florida Department of Natural Resources, 1967-68-69).

Stokes *et al.* (1968) reported that significant numbers of other species were harvested in association with sunrays. Some of these, especially quahogs and surf clams, are of commercial value if located in abundance. Large quantities of clams in other areas along Florida's west coast have been reported (Bullis, 1957a, b; Captiva, 1958; Akin and Humm, 1959; Bullis, 1962; Joyce and Williams, 1969).

Because of the economic value of the sunray fishery and the relatively small size of the productive area, the Marine Research Laboratory initiated an exploratory clam survey utilizing the R/V *Hernan Cortez* equipped with a hydraulic Nantucket clam dredge (*Hernan Cortez* Cruise No. 70). The first series of samplings were accomplished with a small dredge borrowed from the local fishery. The purposes of HC70 were to obtain preliminary information on the abundance and distribution of sunrays between Bell Shoal and Panama City, Florida, and to familiarize laboratory personnel with dredging operations. Although results during HC70 concerning clam abundance were inconclusive, valuable training and techniques were developed enabling the Marine Research Laboratory to expand the survey.

The R/V *Hernan Cortez* was completely re-equipped with a larger dredge and in November 1969, the main phase of exploratory clam fishing began (*Hernan Cortez* Cruise No. 82). The purposes of the expanded project were to locate new clam beds of possible commercial significance along Florida's northwest coast and to survey benthic fauna from inshore to a depth of 68 ft using a commercial hydraulic Nantucket clam dredge. In addition to sunrays, data were recorded on the following clams: quahogs, *Mercenaria campechiensis* (Gmelin); checkerboard clams, *Macrocallista maculata* (Linn.); disk clams, *Dosinia elegans* Conrad; surf clams, *Spisula raveneli* Conrad; giant heart cockles, *Dinocardium robustum* (Solander); bittersweets,

Figure 1. R/V *Hernan Cortez* and hydraulic Nantucket gear.

Glycymeris americana De France; lucines, *Lucina pennsylvanica* (Linn.); great tellins, *Tellina magna* Spengler, and others.

METHODS AND MATERIALS

Gear

1. A welded steel dredge cage was constructed with a 48 in. collecting blade, 8 in. diameter dredge manifold with 16 (3/4 in.) exhaust nozzles, steel sled runners, and a gate for dumping the catch (Figure 1).
2. An 8 in. intake-6 in. discharge Fairbanks-Morse centrifugal water pump was powered by a V-6 series GM diesel mounted on the after deck.
3. An eight-ply, 8 in. diameter intake hose 15 ft long with a foot-valve supplied water to the pump.
4. An eight-ply, 6 in. diameter clam hose was used to connect the deck pump to the dredge manifold. A 3 in. diameter polypropylene hauser was used for towing the dredge and absorbing shock. The ratio of hose length to depth was approximately 4 or 5 to 1, and hauser ratio was 3 to 1.
5. Six inch (outside diameter) steel hose sleeves, and King double-bolt hose clamps were used to connect clam hose sections.
6. An A-frame assembly was installed on the *Hernan Cortez* to raise and lower the dredge over the stern.

Operation

The hydraulic Nantucket dredge utilizes water pressure to force benthic organisms out of the substrate (Figure 2). As the dredge moves forward, the catch is forced over the collection blade into the back of the dredge. Thus, the sample is retained until lifted aboard and dumped for examination (Figure 3).

Sampling was confined to sandy substrate because 1) previous sampling indicated that sunrays were most often found in sand, and 2) the Nantucket dredge worked best in this substrate. Mud or rock substrates were occasionally encountered, reducing dredge efficiency and increasing damage to the dredge.

Dredging operations were confined to calm weather because of hazardous conditions and ineffectiveness of the dredge during rough seas. Each ten-minute drag was approximately 75 to 150 yards long and catch per unit effort calculations were based on the number of sunrays caught per minute. All data were recorded under the follow-

Figure 2. Water pressure used to force clams from substrate.

Figure 3. Dumping dredge contents.

ing categories: general data, physical data, dredge data, and benthic fauna.

General Data

Each drag was given a station number and the date, time, and location were recorded. Each location was plotted on a Coast and Geodetic Survey Chart and the chart number was recorded.

Physical Data

Depth was recorded before each drag. Surface and bottom temperatures (Centigrade immersion thermometer), bottom salinity (A.O. refractometer), water clarity (Secchi), towing speed, and water pump pressure were recorded during each drag. To maintain harvesting efficiency and reduce damage to the catch, pump water pressure was varied with depth: 30 to 35 psi, depth 10 to 30 ft; 40 psi, depth 35 to 45 ft; and 45 to 50+ psi, depth 50 to 68 ft. The substrate type was determined by examining the dredge contents. Meteorological data were recorded on a separate ship's log twice daily, mid-morning and afternoon.

Dredge Data

Total catch in bushels and percent live fauna were estimated for each drag. Most clams or aliquots were counted and measured (anterior to posterior length in millimeters). Weighted mean depths for the most abundant clam species (Table 2) were calculated by the following formula:

$$\frac{\Sigma\ (CD)}{T}$$

where C= number clams at a station; D =depth of that station; T = total catch of that species. Sunray density was recorded as clams taken per minute of towing time. Five to ten sunrays were preserved from each week's sampling in 10% Formalin for later gonadal analysis.

Benthic Fauna

All species were identified, counted, and most were released alive. Selected specimens were preserved for the Marine Laboratory vertebrate and invertebrate reference collections and several new species are being described.

AREAS SURVEYED

One hundred seventy-eight stations were established between Perdido Pass at the Alabama-Florida state boundary line and Cape Romano, Florida in depths of 10 to 68 ft. (Figures 4-18) but 90% of the sampling during HC82 was confined to northwest Florida. Areas surveyed were:

Area		Number of Stations	Range Sampled (ft)
A	South Shoal to Dog Island and vicinity	17	10-22
B	St. Joseph Spit to Panama City (excluding Bell Shoal)	26	14-65
C	Panama City to Destin	47	10-67
D	Destin to Perdido Pass	51	16-68
E	Cedar Keys vicinity	32	10-24
F	Cape Romano to Gasparilla Island	5	13-16

The discussions presented in this report do not include the Bell Shoal grounds. This small section, located in Area B, supports the present commercial fishery and has a very heavy concentration of sunrays. A single 15 to 20 minute dredge haul may yield from 1,000 to 2,000 clams.

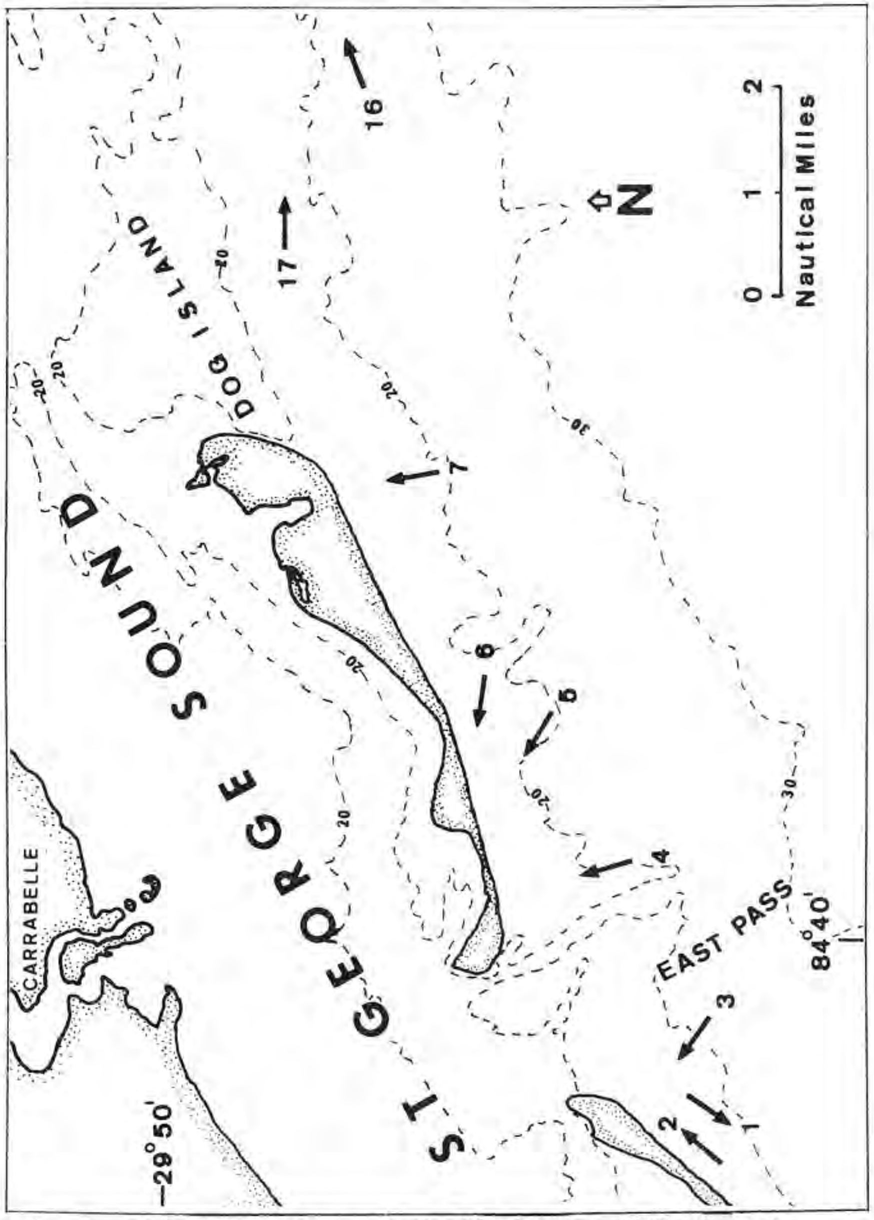

Figure 4. Station locations for Area A; Dog Island vicinity. C&GS Chart 1261

Figures 4-18: Depth of contours in feet; arrows indicate direction of tow — length not to scale.

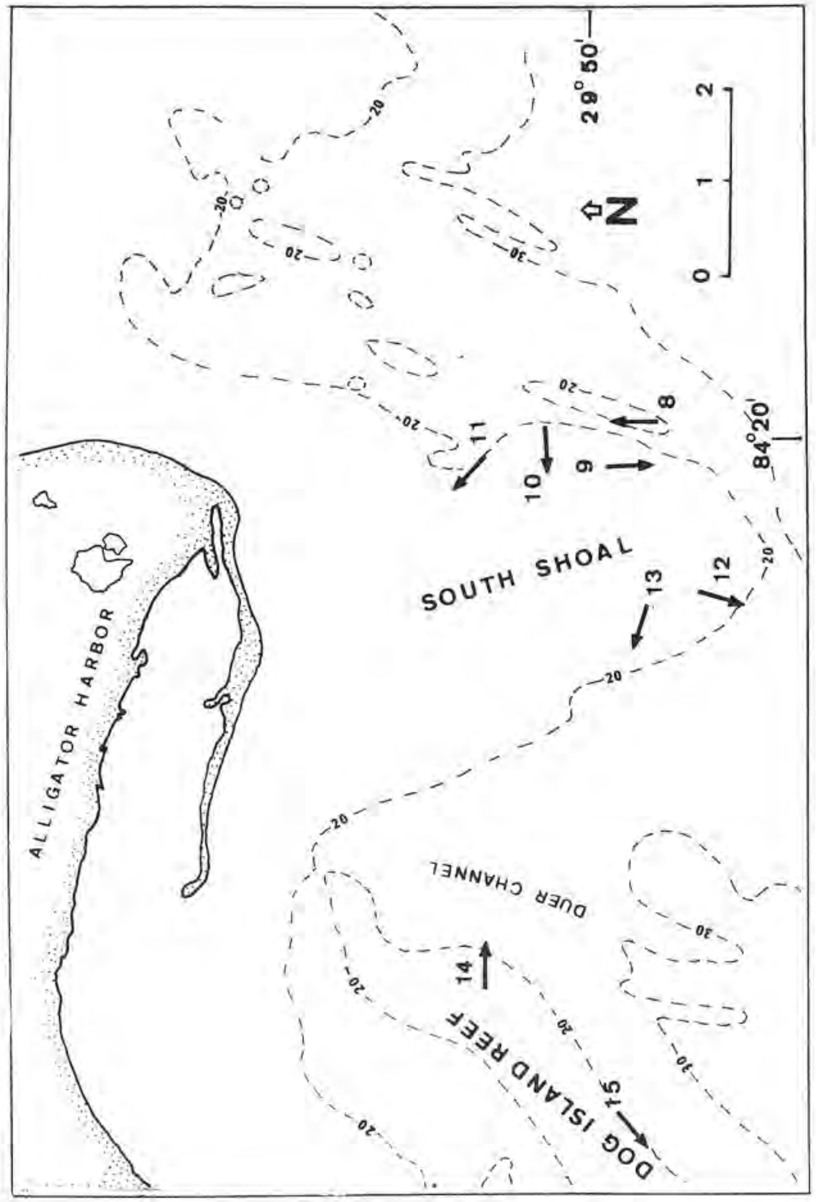

Figure 5. Station locations for Area A; Dog Island Reef to South Shoal. C&GS Chart 1261.

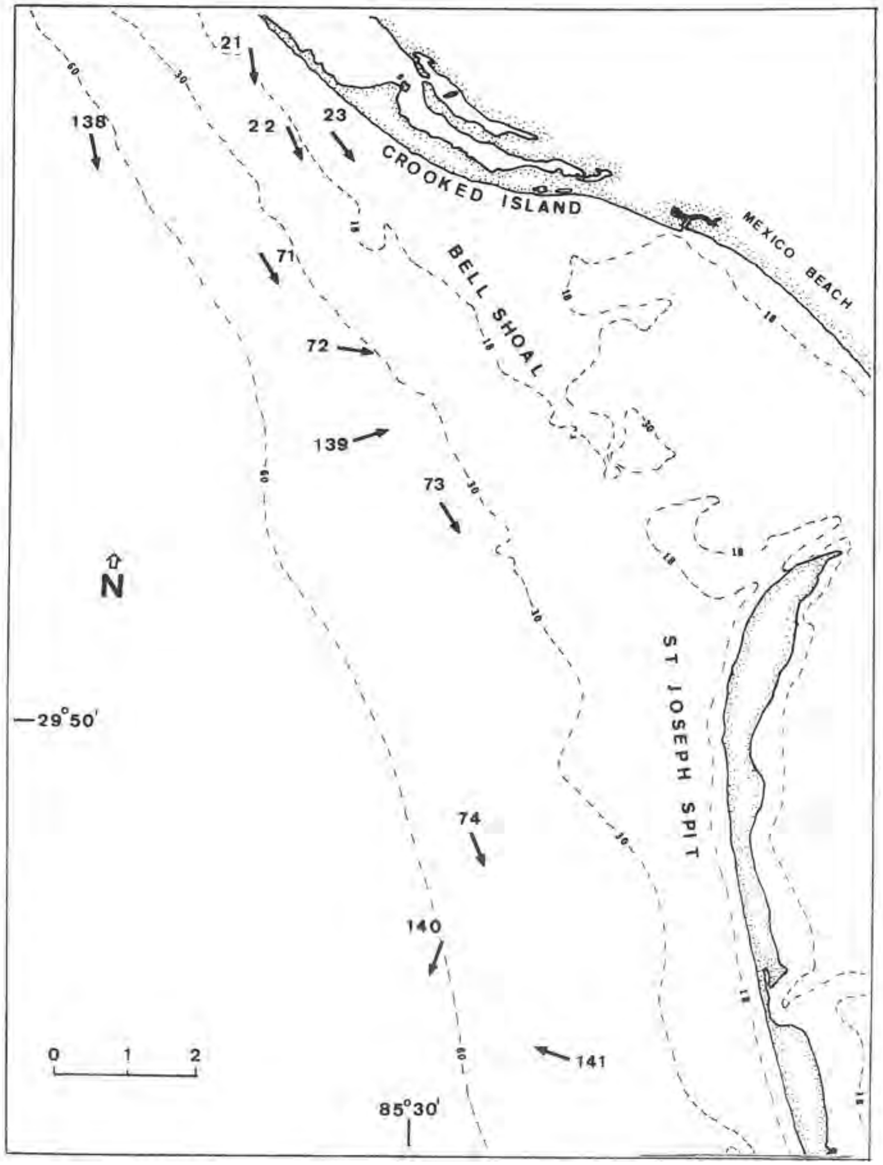

Figure 6. Station locations for Area B; Crooked Island to St. Joseph Spit. C&GS Chart 1263

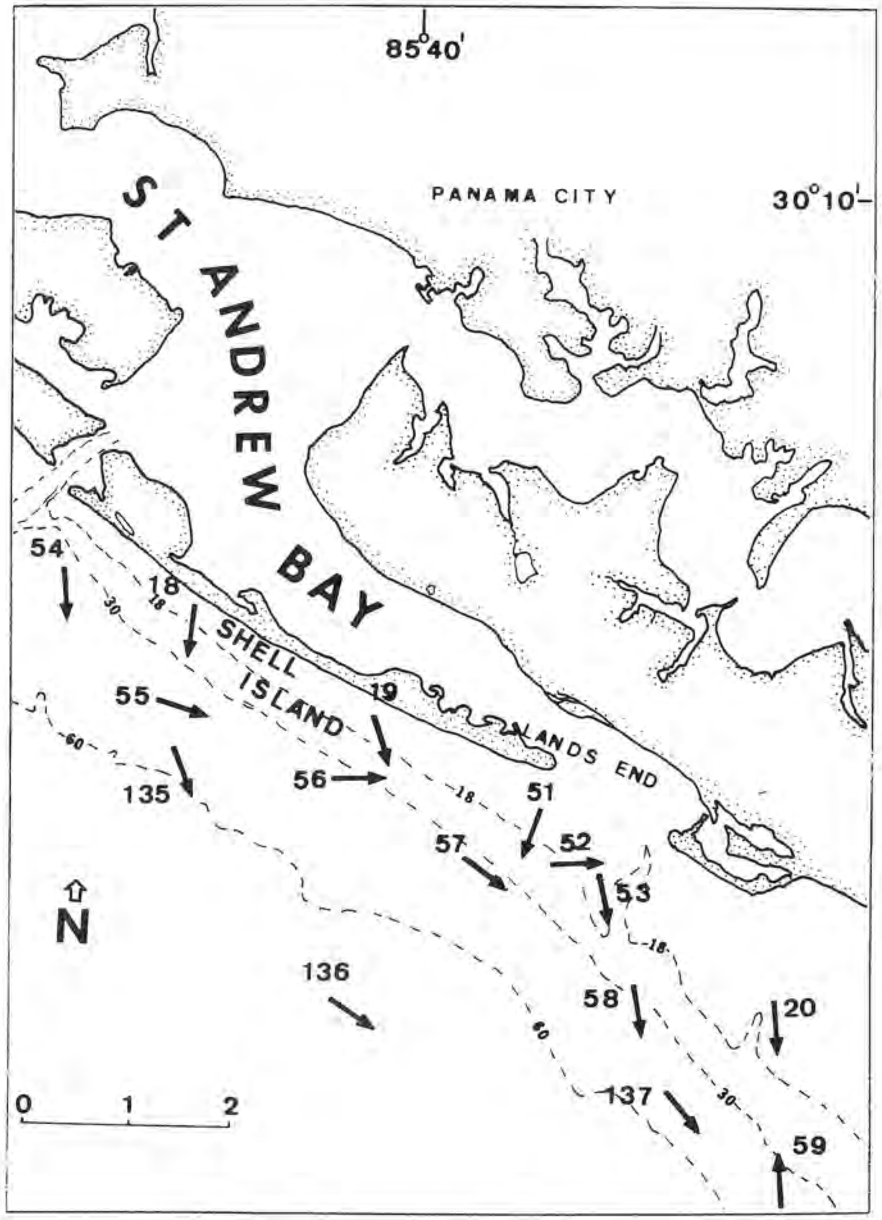

Figure 7. Station locations for Area B; Panama City-Shell Island vicinity. C&GS Chart 1263.

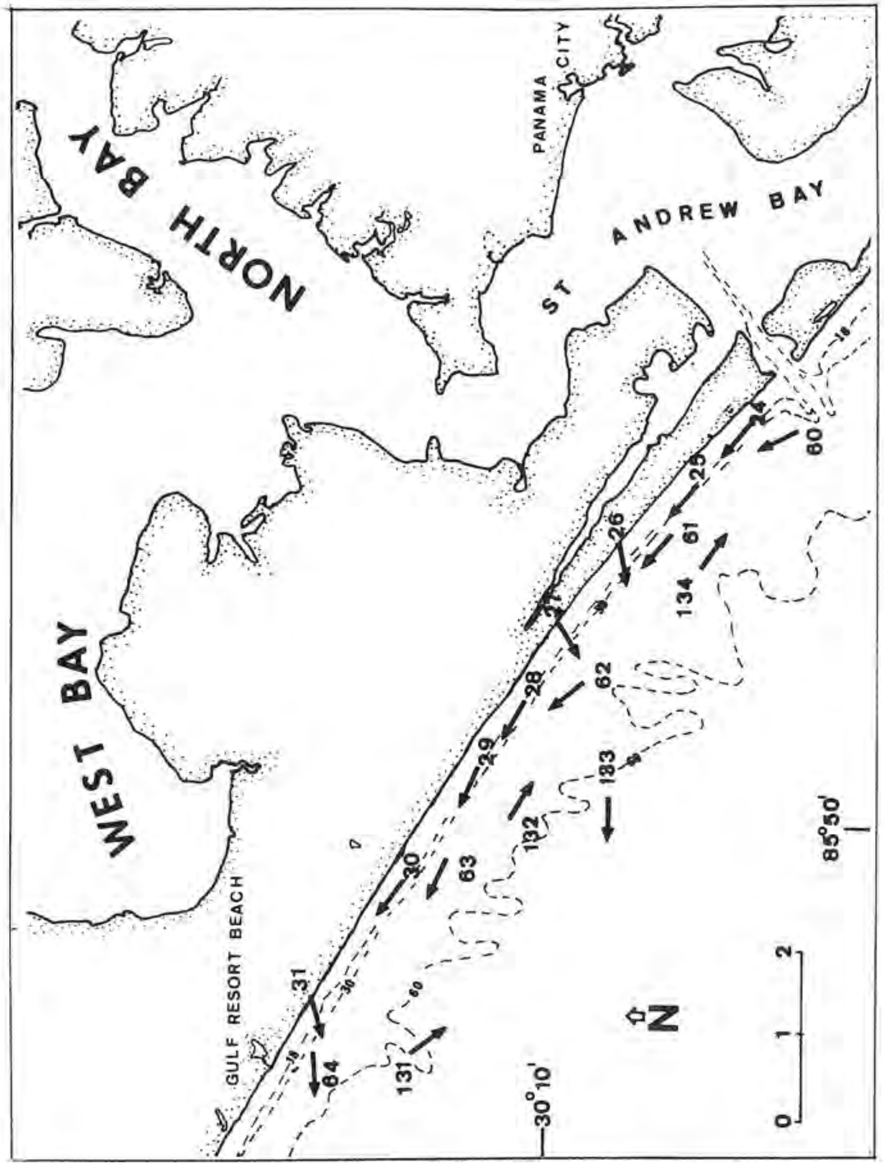

Figure 8. Station locations for Area C; Gulf Resort Beach to Panama City. C&GS Chart 1263.

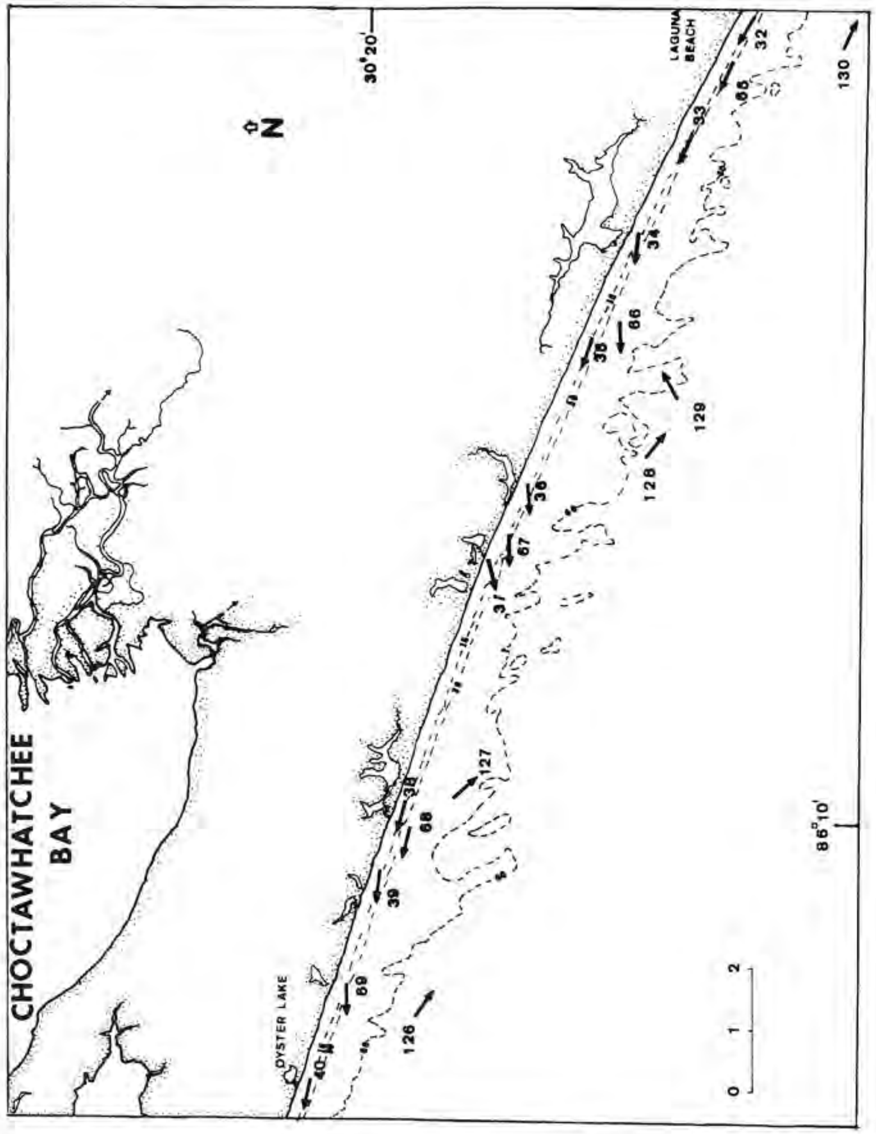

Figure 9. Station locations for Area C; Oyster Lake to Laguna Beach. C&GS Chart 1264.

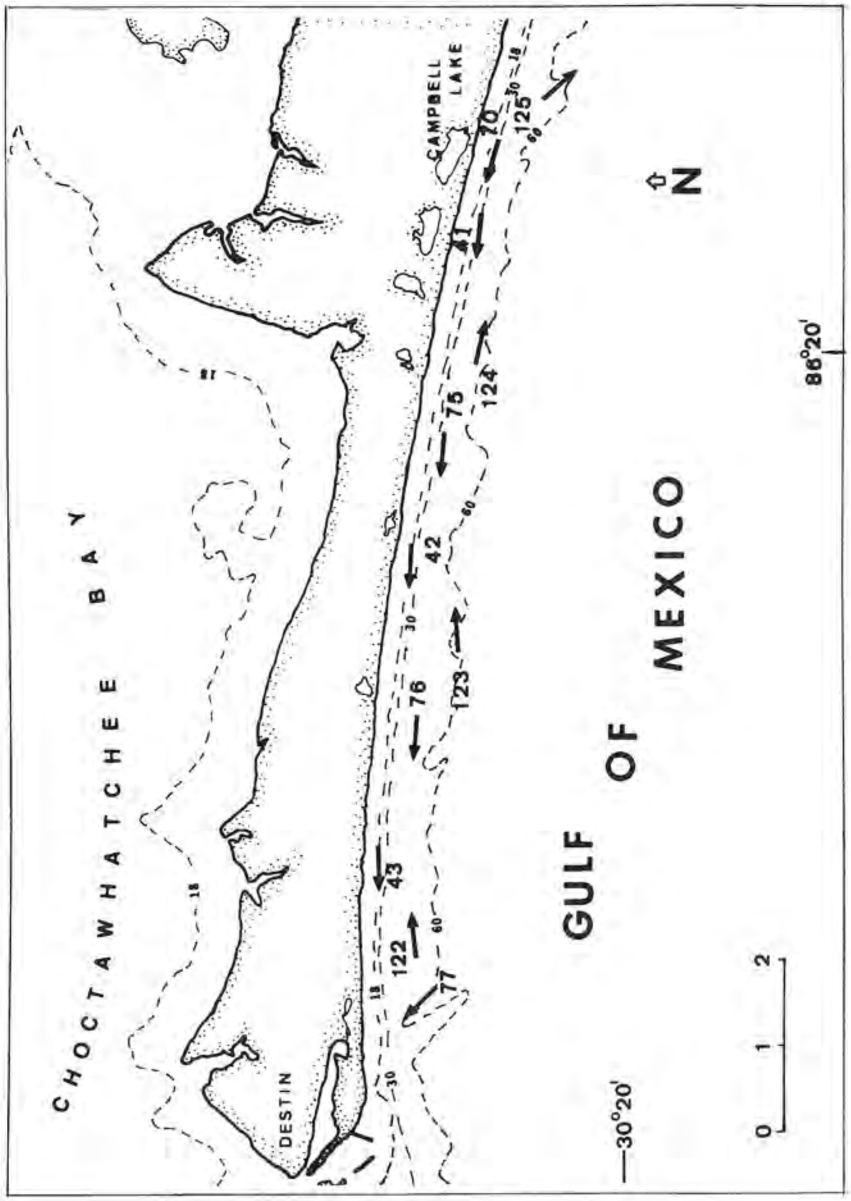

Figure 10. Station locations for Area C; Destin to Campbell Lake. C&GS Chart 1264.

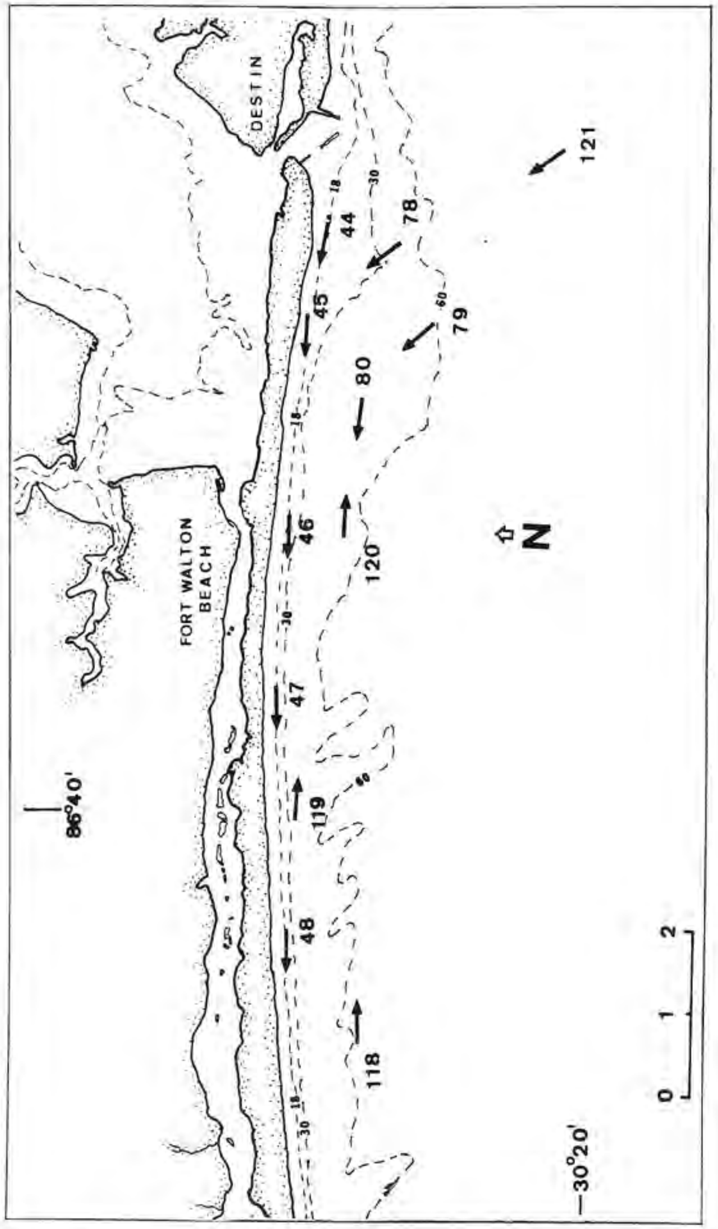

Figure 11. Station locations for Area D; Ft. Walton Beach vicinity. C&GS Chart 1264.

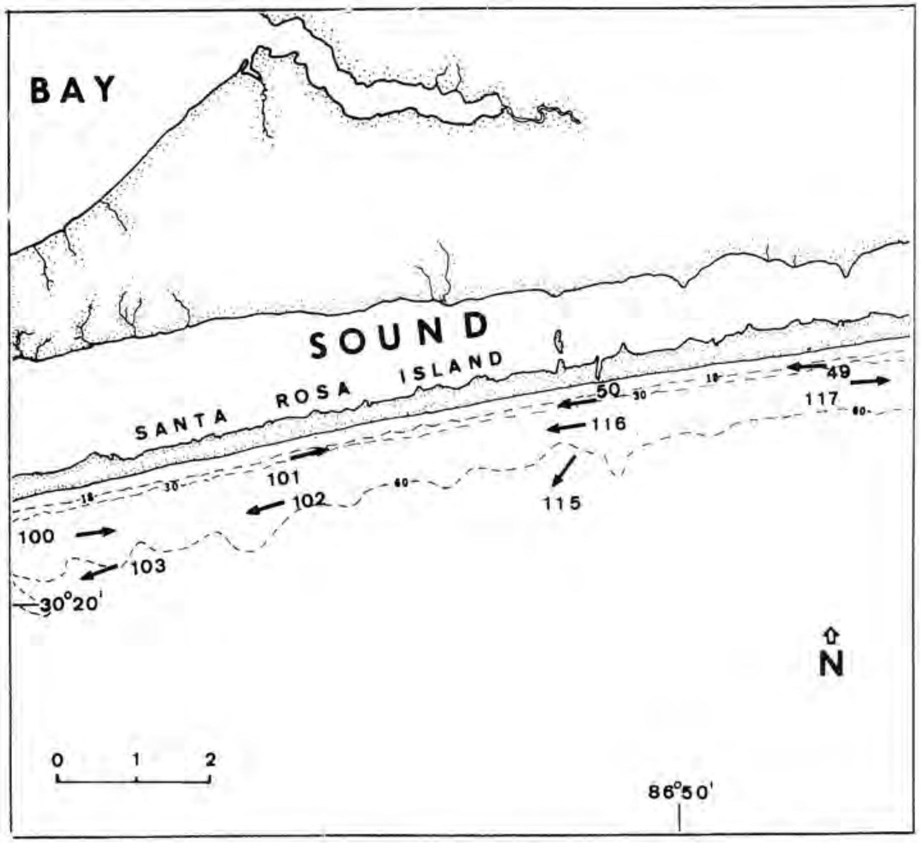

Figure 12. Station locations for Area D; Santa Rosa Island. C&GS Chart 1265.

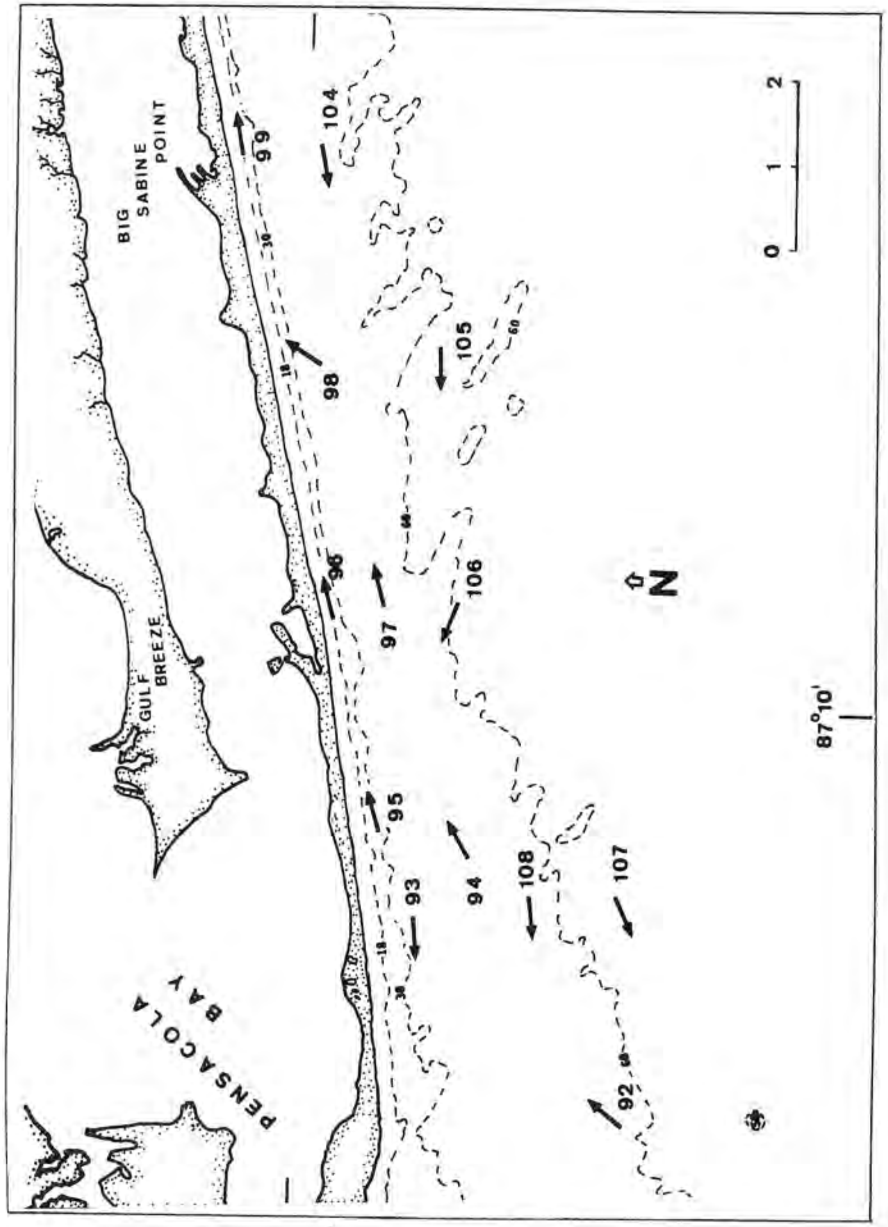

Figure 13. Station locations for Area D; Pensacola Bay to Big Sabine Point. C&GS Chart 1265.

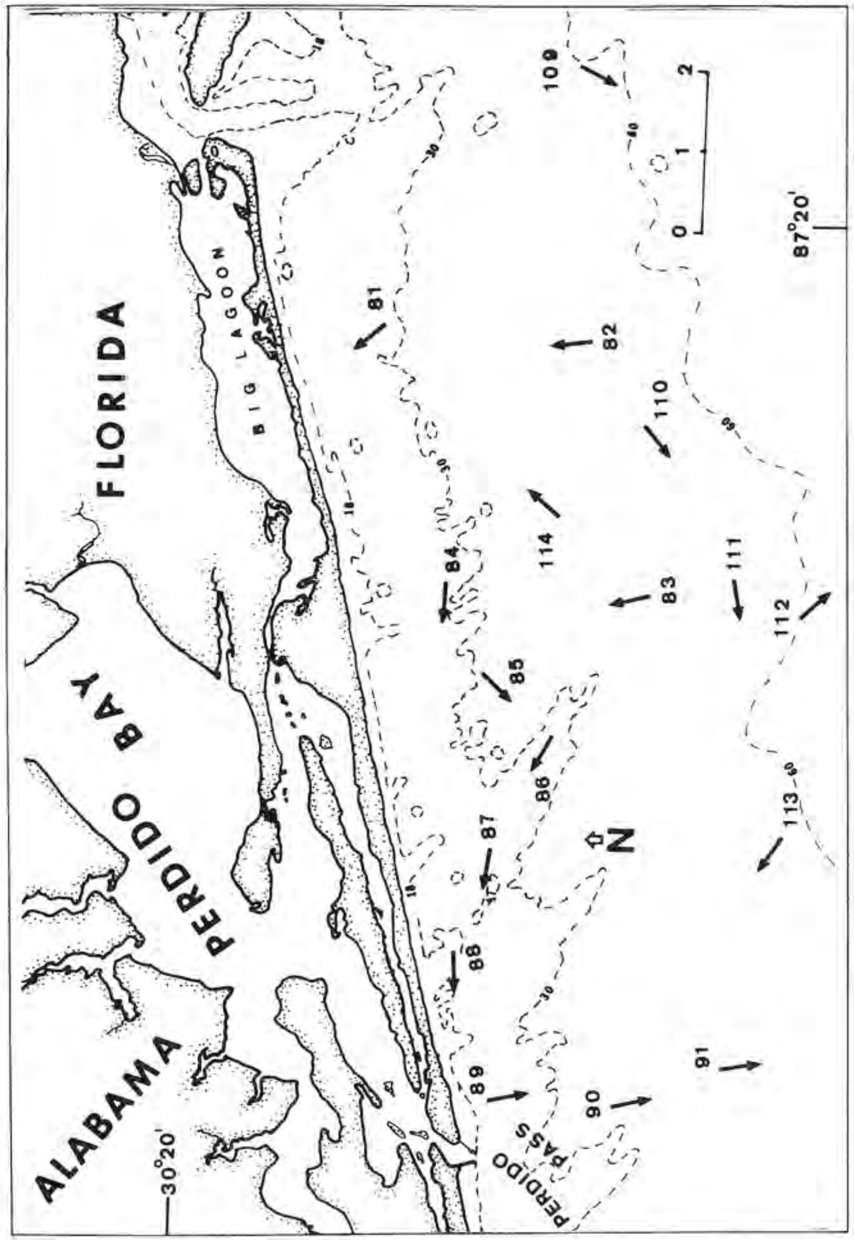

Figure 14. Station locations for Area D; Perdido Pass to entrance into Pensacola Bay. C&GS Chart 1265.

Figure 15. Station locations for Area E; Seahorse Reef vicinity. C&GS Chart 1259.

Figure 16. Station locations for Area F; Marco Island to Cape Romano Shoals. C&GS Chart 1254.

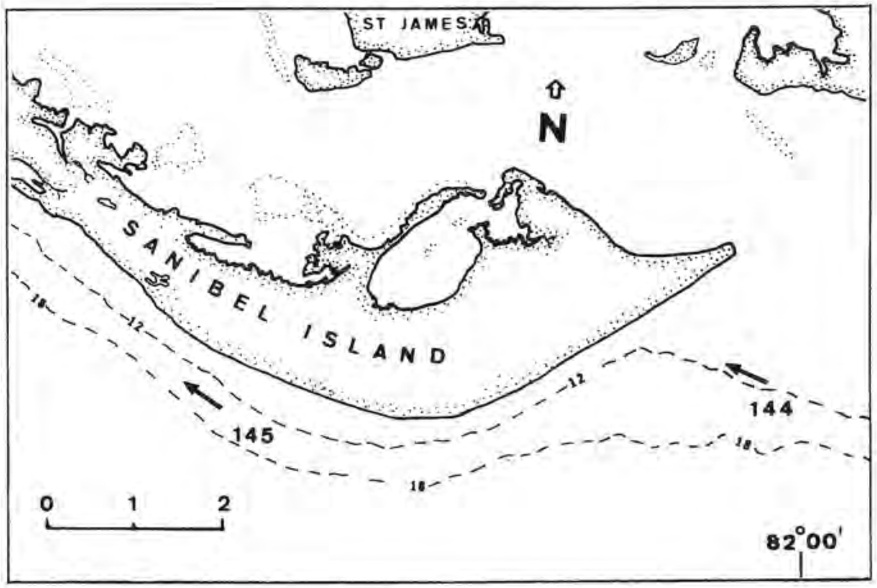

Figure 17. Station locations for Area F; Sanibel Island vicinity. C&GS Chart 1255.

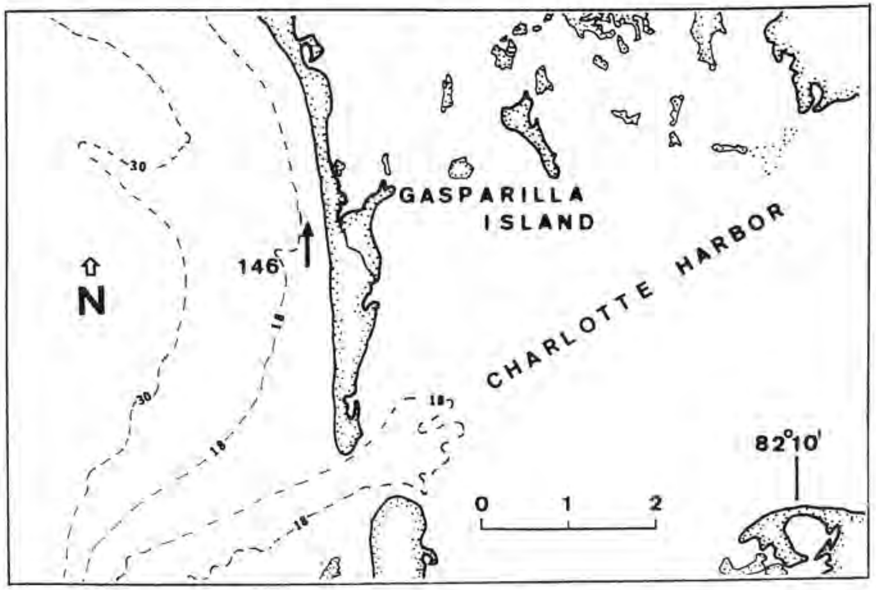

Figure 18. Station locations for Area F; Gasparilla Island. C&GS Chart 1255.

RESULTS

Total production and hydrologic data from each area are presented in Table 1.

Area A was suspected of supporting large concentrations of sunrays because of its apparent similarity in substrate and bottom contour to Bell Shoal and proximity to Alligator Harbor where concentrations of sunrays were previously reported by Akin and Humm (1959). Area A was least productive and the mean percent live fauna per station was the lowest recorded. Only 66 live clams representing four species, *Macrocallista nimbosa, Dinocardium robustum, Lucina pennsylvanica,* and *Noetia ponderosa* (Say) were caught.

Large quantities of whole, broken, and drilled clam shells were collected throughout the area and sunray shells (length 130 to 160 mm) were approximately 20% of the total catch. Apparently this area previously supported a large concentration of sunrays or the clam shells are coming from shallower water. Unfortunately, the draft (10 ft) of the R/V *Hernan Cortez* precluded investigations of the shallower portions of Dog Island Reef and South Shoals. The brown sand dollar, *Mellita quinquiesperforata* (Leske) was the most abundant live species taken in Area A.

Areas B, C, and D were similar in substrate, bottom contour, mean percent live fauna per station, total clams, and benthic fauna. Although Area B yielded more sunrays, slightly larger mean catches and more clam species were collected in Areas C and D; *Macrocallista nimbosa* and *Dinocardium robustum* were the most abundant clams. Live sunrays and sunray shells composed approximately 20 to 25% of the combined total catch from Areas B, C, and D. The purple sand dollar, *Encope michelini* (Agassiz) was the most abundant species and frequently comprised 20 to 90% of the mean catch per station in depths of 25 to 68 ft.

Offshore and inshore catches of total fauna varied considerably in size and species composition. Inshore, depth 10 to 29 ft, catches were generally small (1 to 4 bushels/station) and contained mostly live fauna while offshore catches, depth 30 to 68 ft, were usually larger (4 to 8 bushels/station) but contained less live fauna.

Large quantities of quahog shells were caught at Stations 81, 84, and 86 southeast of Perdido Pass (depth 26 to 27 ft), but no live quahogs were recorded. Similarly, moderate quantities of calico scallop shells, *Argopecten gibbus* (Linn.) were taken in deep water

TABLE 1. TOTAL PRODUCTION AND HYDROLOGIC DATA

Area	No. Sampling Days	Sampling Dates	Total Stations	Total Catch (Bu.)	Mean Catch/Sta. (Bu.)	Mean % Live/Sta.*	Total Clams	Total Clam Species	Bottom Temp. Range (°C)	Mean Bottom Temp. (°C)	Bottom Salinity Range (o/oo)	Mean Bottom Salinity (o/oo)	Water Clarity (Secchi, ft)	Mean Clarity (ft)
A	3	11/23-11/25/69	17	65	3.8	11	66	4	14.5-15.8	14.9	33.93-35.54	34.97	11-18	12
B	7	12/9,12/19/69 1/13-1/14/70 1/19/70, 2/28/70 3/1/70	26	123	4.7	45	648	14	10.1-14.5	11.3	32.85-35.54	33.62	5.5-17	11
C	9	12/10/69 12/15-12/17/69 1/15-1/16/70 1/22/70 2/23-2/24/70	47	307	6.5	60	682	19	11.0-15.5	12.9	33.39-35.54	34.91	10-35	18
D	11	12/17-12/18/69 1/13, 1/31/70 2/4/70 2/13-2/14/70 2/16, 2/18/70 2/22-2/23/70	51	397	7.8	50	670	17	10.5-15.2	12.8	33.10-36.08	34.71	6-30	16
E	7	4/15-4/17/70 4/24-4/25/70 4/29-4/30/70	32	276	8.6	58	1391	13	20.2-26.5	23.5	28.00-33.39	31.09	7-18	13
F	3	3/31-4/1/70 4/4/70	5	84	16.8	12	296	7	22.0-24.0	23.0	30.69-32.31	31.88	2.5-8	6
Total	40	11/23/69-4/30/70	178	1252			3753	26						

*Volumetric estimate of live fauna in the total catch.

(50 to 68 ft) between Perdido Pass and St. Josephs Spit, but no live scallops were found.

Area E was most productive, especially the sand and grass portion near Seahorse Reef, and the mean catch of total fauna per station was 8.6 bushels. These catches averaged 58% live fauna, and approximately 1,391 clams, representing 13 species, were collected. *Macrocallista nimbosa* and *Dinocardium robustum* were most abundant and several stations produced more than 75 sunrays. *Mellita quinquiesperforata* was the most abundant species and was a large portion of most catches.

Stations deeper than 25 ft were not established in Area E, but several species frequently caught offshore (depth 30 to 68 ft) in Areas B, C, and D were taken near Seahorse Reef (Table 4).

Moderate numbers of live fighting conchs, *Strombus alatus* (Gmelin), were caught for the first time near Seahorse Reef although large quantities of dead conch shells were collected elsewhere.

Spot sampling was conducted in Area F, primarily to check the once productive quahog beds inshore near Cape Romano. Area F differed from other areas in terms of substrate (mud), mean catch per station (16.8 bushels), and benthic fauna. A large quantity of mud remained in the dredge after each tow and reduced the mean catch to approximately 12% live fauna. The clams recorded were considered a minimum estimate of abundance because: 1) the dredge rapidly filled with mud and greatly reduced the area effectively sampled, and 2) mud remaining in the dredge after each tow hindered the clam count. *Noetia ponderosa* and *Mercenaria campechiensis* were the most abundant animals; *Macrocallista nimbosa* was not found.

Analysis of Clams Caught

Macrocallista nimbosa, Dinocardium robustum, and *Lucina pennsylvanica* were the most abundant, frequently caught, and widest ranging clams (Table 2). Although D. *robustum* and *L. pennsylvanica* were not as abundant as *M. nimbosa*, they were taken in greater depths and on a greater variety of substrates. *Noetia ponderosa* was abundant only in Area F.

Table 2 presents data on the depth ranges, weighted mean depths, and substrates associated with each species. *Macrocallista nimbosa, Spisula raveneli*, and *Mercenaria campechiensis* were most abundant in depths 10 to 29 ft and were less frequently caught in deeper waters. *Dinocardium robustum, Lucina pennsylvanica, Tellina magna, Chione intapurpurea* (Conrad), and *Lucina multilineata* Tuomey and

TABLE 2. MOST ABUNDANT CLAM SPECIES

Species	Area	Total Caught	Catch Frequency	Depth Range (ft)	Weighted Mean Depth (ft)	Substrate
Macrocallista nimbosa	A B C D E	2,120	110	10-58	20	White sand, sand and shell or sand and grass
Dinocardium robustum	A B C D E F	600	104	10-65	23	Gray or white sand, sand and shell or sand and grass
Lucina pennsylvanica	A B C D E	302	60	10-68	28	Gray or white sand and shell, sand and grass or sand and mud
Noetia ponderosa	A C E F	336	11	13-67	14	Usually sand and shell or mud
Chione intapurpurea	B C D	85	35	18-67	42	Gray or white sand, sand and shell or sand and mud
Lucina multilineata	B C D	50	27	14-65	42	Gray sand or sand and shell
Laevicardium laevigatum	B C D	56	22	38-65	55	Sand, gray sand and shell, or mud
Macrocallista maculata	B C D E	39	20	20-67	56	Gray or white sand or sand and shell

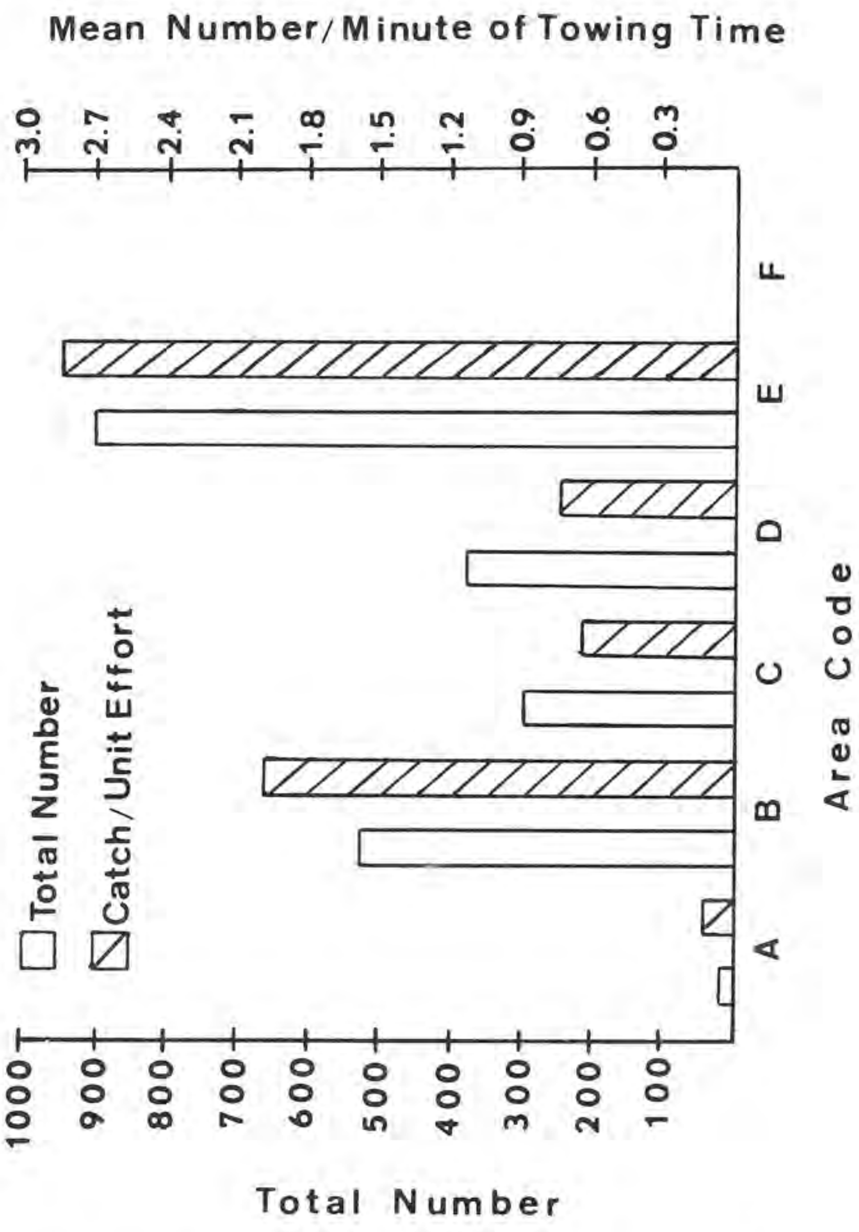

Figure 20. Total *Macrocallista nimbosa* and catch per unit effort by area.

Holmes occurred in most depths sampled. *Dosinia elegans*, *Macrocallista maculata*, *Glycymeris americana*, *Eucrassetella speciosa* (Adams), and *Laevicardium laevigatum* (Linn.) were most frequently caught in depths of 41 to 68 ft.

During HC82, 2,120 sunrays were caught and 95% of all sunrays were taken in depths of 10 to 40 ft (Figure 19). Catch per unit effort was highest at 10 to 15 ft (2.27 sunrays/minute), but remained relatively high to depths of 40 ft.

The commercial sunray grounds at Bell Shoal are composed of pure quartz sand (Stokes *et al.*, 1968). Similarly, almost 95% of the sunrays in this survey were taken in white sand or in some combination of sand and shell or sand and grass. The best catches of sunrays came from Seahorse Reef in sandy depressions surrounded by turtle grass, *Thalassia testudinum* (Konig). Sunrays are not generally considered to be abundant in heavily or totally grassed areas (Akin and Humm, 1959), and this was borne out by the survey. However, large catches were common on sparsely grassy bottoms where clam density was probably greatest in intermittent sandy areas. Few sunrays were taken in mud.

Catch per unit effort calculations suggest that Areas B and E are three to five times more productive for sunrays than Areas C and D (Figure 20). Areas B and E contained several stations which produced 50 or more sunrays. The most productive stations in Area B were 19, 20, 22, 51, and 53 located between Land's End, Shell Island, and Crooked Island (depth 10 to 18 ft). In Area E the best stations were 150, 151, 152, 155, 165, 175, 176, 177, and 178 located near Seahorse Reef, Cedar Keys (depth 10 to 18 ft).

Mean length of sunrays on Bell Shoal was 130 mm (Stokes *et al.*, 1968). During this survey size range decreased slightly with depth (Table 3), but mean length of sunrays was consistently high (143 to 149 mm), indicating that small sunrays (<126 mm) were not common (Figure 21). Since other small clams, such as *Lucina multilineata*

TABLE 3. SIZE RANGE AND MEAN LENGTH OF *MACROCALLISTA NIMBOSA* BY DEPTH

Depth (ft)	No. Measured	Size Range (mm)	Mean Length (mm)
10-15	393	34-171	143
16-25	458	43-174	148
26-40	380	48-171	146
41-58	74	79-160	149

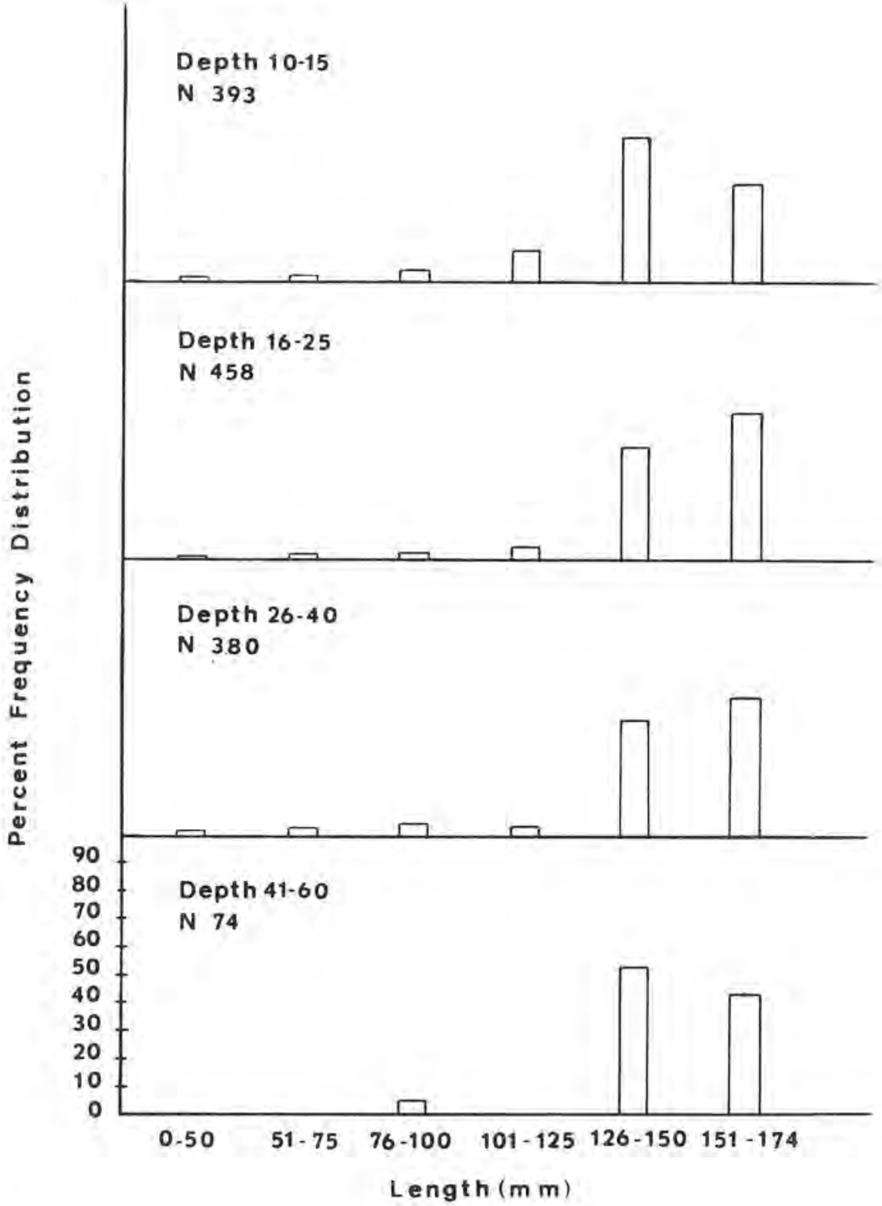

Figure 21. Percent frequency and size composition for *Macrocallista nimbosa* by depth.

and *Chione intapurpurea* were taken with regularity, the paucity of small sunrays in offshore areas is considered valid. This paucity and the abundance of small sunrays inshore (Akin and Humm, 1959; Stokes *et al.*, 1968) appear to further substantiate the suggestion by Stokes *et al.* and Joyce (1971) that there may be movement of subadults from inshore to offshore areas.

Stokes *et al.* (1968) reported that light intensity affected harvesting of sunrays and hypothesized that during periods of highest light intensity (noon hours) a portion of the population burrowed deeper, reducing the number of clams harvested per drag. Catch per unit effort data (Figure 22) appear to support Stokes' hypothesis. The mid-morning, afternoon, and late afternoon mean numbers of clams harvested per minute were larger than the numbers during the noon hours. However, since the first three morning hours were based on results of few stations and all stations were not in equally productive areas, the results may be biased.

Nevertheless, personal observations while diving in St. Josephs Bay (200 yards west of Black's Island) gave further evidence that sunrays are light sensitive. A thorough search of the area around noon yielded no clams. The same area beginning at 1:30 p.m. showed some clams to be present 3 to 6 in. deep. As we continued working, sunray siphons appeared throughout the entire area and we collected 530 sunrays in one and a half hours.

The absence and then appearance of sunray siphons probably indicates vertical migration or the possible relationship between siphon activity and light intensity. Earlier laboratory experiments (D. Eggiman, unpublished data) also indicated that siphon activity can be controlled by varying light intensity.

Analysis of Benthic Fauna

Over 140 species were identified from catches of the hydraulic Nantucket clam dredge and are listed in phylogenetic order by area and depth (Table 4).

Except in Areas E and F, the most abundant materials were mollusk shells and two species of sand dollars, *Encope michelini* and *Mellita quinquiesperforata*. Polychaetes, crustaceans, gastropods, bivalves, and echinoderms were abundant in all areas. Vertebrates were rarely collected because of their ability to avoid the dredge.

Faunal variation was recognized by depth in Areas B, C, and D. Offshore hauls yielded a mean of 14.5 live species per station and many of these — *Macrocallista maculata, Glycymeris americana, Dosinia*

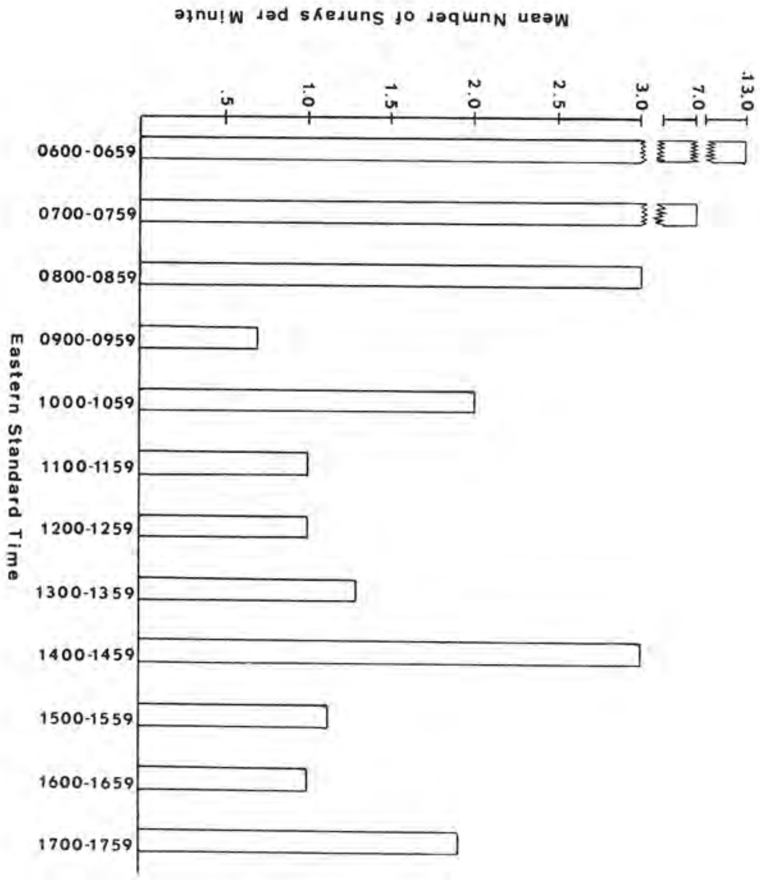

Figure 22. Catch of *Macrocallista nimbosa* per unit effort by time of day.

TABLE 4. SPECIES CAUGHT DURING R/V *HERNAN CORTEZ* CRUISE 82
(Parentheses indicate catch frequencies for 20 most frequently caught species)

	Area A	Area B			Area C			Area D			Area E	Area F
	Shallow	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Shallow
Cnidaria												
Class Scyphozoa												
Stomolophus meleagris		x		x								
Nemerteans				x							x	
Annelida												
Class Polychaeta												
Arenicola cristata	x		x		x	x	x		x		x	
Chaetopterus sp.			x	x		x	x		x		x	x
Onuphidae (89)	x	x	x	x	x	x	x	x	x	x	x	
Other polychaetes	x	x	x	x		x	x		x	x	x	x
Sipunculida (37)	x	x	x	x	x	x	x	x	x	x	x	x
Arthropoda												
Class Merostomata												
Xiphosorous polyphemus	x		x	x	x	x	x				x	
Class Crustacea												
Albunea gibbesii (86)	x	x	x	x	x	x	x	x	x	x	x	
Arenaeus cribrarius			x		x			x	x			
Calappa flammea (67)		x	x	x	x	x	x	x	x	x	x	
Calappa sulcata		x										
Callinectes sapidus			x			x					x	
Epioltus dilatatus											x	
Euceramus praelongus						x						
Fabia sp.			x			x			x	x	x	
Hepatus epheliticus	x				x			x	x	x		x
Lepidopa websterii							x				x	
Libinia spp. (49)	x	x	x	x	x	x	x	x	x	x	x	
Macrocoelma trispinosum											x	
Mithrax pleuracanthus											x	
Ovalipes guadulpensis (49)		x	x		x	x	x	x	x	x	x	
Pagurus impressus											x	

Table 4 (Continued)

	Area A	Area B			Area C			Area D			Area E	Area F
	Shallow	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Shallow
Paguridae spp.		x	x				x	x	x	x	x	
Pathenope serrata							x					
Penaeidae sp.					x					x		
Persephone mediterranea			x					x	x	x		
Petrolisthes galathinus											x	
Pilumnus sayi											x	
Polyonyx gibbesii											x	
Pontonia marginata							x					
Porcellana sayana											x	
Portunis gibbesii											x	
Portunidae sp.	x	x	x		x	x			x	x	x	
Ranilia muricata				x			x				x	
Sacculinidae		x					x					
Sicyonia brevirostris										x		
Squilla sp.									x			
Mollusca												
Class Amphineura						x						
Class Gastropoda												
Busycon contrarium		x	x	x				x	x	x	x	x
Busycon spiratum		x						x	x	x	x	
Cancellaria reticulata								x	x	x	x	
Cassis madagascariensis							x			x		
Chama macerophylla											x	
Conus spurius atlanticus										x		
Crepidula fornicata		x					x			x		
Crepidula sp.							x			x		
Distorsio sp.				x								
Fasciolaria spp.	x						x			x	x	
Ficus communis	x		x				x			x	x	

Table 4 (Continued)

	Area A	Area B			Area C			Area D			Area E	Area F
	Shallow	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Shallow
Murex dilectus											x	
Murex fulvescens										x		
Murex pomum				x								
Nudibranchia											x	
Oliva sayana (74)	x	x	x	x	x	x	x	x	x	x	x	
Phalium granulatum (67)		x	x	x	x	x	x	x	x	x		
Pleuroploca gigantea										x		
Polinices duplicatus		x	x				x	x	x	x	x	x
Scaphella junonia							x				x	
Sinum maculatum								x				
Sinum perspectivum			x				x	x	x			
Strombus alatus			x								x	
Terebra dislocata					x							
Terebra sp.					x	x			x	x	x	
Xenophora conchyliophora							x					
Class Bivalvia												
Anadara lienosa floridana				x			x			x	x	
Anadontia alba							x			x		
Anadora transversa						x	x					
Arcinella cornuta												x
Atrina rigida												x
Atrina serrata			x				x			x	x	x
Chione intapurpurea (35)		x	x	x		x	x	x	x	x		
Dinocardium robustum (104)	x	x	x	x	x	x	x	x	x	x	x	x
Dosinia elegans			x	x		x	x		x	x	x	
Eucrassetella speciosa						x	x			x	x	
Glycymeris americana							x			x		
Laevicardium laevigatum				x		x	x		x	x		
Lucina chrysostoma							x					

Table 4 (Continued)

	Area A	Area B			Area C			Area D			Area E	Area F
	Shallow	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Shallow
Lucina multilineata (27)		x	x	x	x	x	x	x	x	x		
Lucina pennsylvanica (60)	x		x				x		x	x	x	x
Lucinidae		x				x		x				
Macrocallista maculata			x	x		x	x	x	x	x	x	
Macrocallista nimbosa (110)	x	x	x		x	x	x	x	x	x	x	
Mactra fragilis				x								
Mercenaria campechiensis			x				x					x
Mytilidae			x									
Noetia ponderosa	x											
Pteria colymbus											x	x
Semele bellastriata											x	
Semele purpurascens											x	
Solecurtus cumingianus							x				x	
Spisula raveneli					x			x			x	
Tellina alternata							x		x			
Tellina magna (27)			x			x	x	x	x	x	x	
Trachycardium egmontianum							x				x	
Class Cephalopoda												
Octopus vulgaris							x			x		
Echinodermata												
Class Asteroidea												
Astropecten articulatus (98)	x	x	x	x	x	x	x	x	x	x		
Astropecten duplicatus	x										x	
Echinaster sp.						x	x		x	x	x	x
Luidia alternata		x	x		x	x	x	x	x		x	
Luidia clathrata (68)	x	x	x	x	x	x	x	x	x	x	x	
Luidia senegalensis												x
Class Echinoidea												
Arbacia punctulata							x				x	

Table 4 (Continued)

	Area A	Area B			Area C			Area D			Area E	Area F
	Shallow	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Shallow
Clypeaster subdepressus							x				x	
Encope michelini (108)		x	x	x	x	x	x	x	x	x	x	
Lytechinus variegatus						x					x	
Mellita quinquiesperforata (46)	x	x			x			x	x		x	x
Moira atropus (27)	x		x	x	x	x	x				x	
Plagiobrissus grandis (33)			x	x	x	x	x		x		x	
Class Holothuroidea												
Theelothuria princeps (52)		x	x		x	x	x	x	x	x	x	
Thyone sp.			x	x			x					
Other Holothurians				x	x	x	x	x	x	x	x	
Class Ophiuroidea												
Astrophyton sp.											x	
Ophiolepis elegans						x	x					
Ophiothrix sp.						x						
Other Ophiuroidea				x	x	x	x	x	x	x	x	
Chordata												
Class Acidiacea			x	x		x	x					x
Branchiostoma sp.	x					x		x			x	
Class Chondrichthyes												
Dasyatis sayi								x		x		
Myliobatidae												x
Raja eleganteria			x		x		x					
Torpedo nobiliana					x							
Class Osteichthyes												
Chilomycterus schoepfi								x				
Clupeidae										x		
Cynoglossidae											x	
Ogcocephalidae							x			x		
Ophichthyidae		x	x						x	x	x	

Table 4 (Continued)

	Area A	Area B			Area C			Area D			Area E	Area F
	Shallow	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Moderate	Deep	Shallow	Shallow
Tetraodontidae							x	x			x	
Triglidae											x	
Uranoscopidae											x	

Shallow = 10-29 ft; moderate = 30-49 ft; deep = 50-68 ft.

elegans, *Eucrassetella speciosa*, *Laevicardium laevigatum*, *Ficus communis* Röding, *Cassis madagascariensis spinella* Clench, *Murex* spp., *Fasciolaria* spp., various polychaetes, and ophiuroids — were usually absent nearshore. *Encope michelini* (the most abundant species in Areas B, C, and D) was consistently more numerous offshore; hauls generally contained 120 to 360 individuals and no single clam species predominated in these catches.

In contrast, nearshore hauls yielded 8.6 live species per station with *Macrocallista nimbosa* usually being the predominant clam. *Mellita quinquiesperforata* was occasionally taken in great quantities but it was conspicuously absent offshore.

Stokes *et al.* (1968) listed the most common species associated with sunrays but did not comment on their relationships. Commonly associated species during this survey were similar to those of Stokes *et al.* with the exception of Onuphids which were not listed by Stokes. The following were frequently caught with sunrays: *Dinocardium robustum*, *Astropecten* spp.*, Onuphids*, *Encope michelini**, *Albunea gibbesii**, *Calappa flammea*, *Theelothuria princeps*, *Oliva sayana**, and *Ovalipes guadulpensis*. Five of these (with asterisk) were also frequently caught in deeper water outside the optimal depth range (10 to 40 ft) for sunrays. No direct interrelationship with *Macrocallista nimbosa* is suggested for these five species; however, seastars (*Astropecten articulatus*) have been reported feeding on small bivalves of the genus *Macrocallista* (Wells, Wells, and Gray, 1961). The other four species (no asterisk) apparently have depth ranges similar to sunrays, but no positive relationship has been discerned. Experiments at the Florida State University Marine Laboratory (E.A. Cake, pers. comm.) showed that *Calappa flammea* are able to break open and eat live sunrays. This suggests a possible predator-prey relationship for some of the associated species.

Although *Dinocardium robustum* was the species most frequently captured with sunrays, it was never abundant in this survey (highest catch 28 at Station 164). The most productive area for *D. robustum* was near Seahorse Reef, but best catches came from stations yielding light to moderate numbers of sunrays.

CONCLUSIONS AND RECOMMENDATIONS

1. The hydraulic Nantucket clam dredge harvested a variety of benthic organisms in large quantities. Since this unit was primarily designed for sandy substrates, its use in mud or rock decreased har-

vesting efficiency and occasionally damaged the collecting blade. The dredge was easily operated in shallow to moderate depths, but sampling was more time consuming in deeper water. Raising and lowering the dredge was dangerous during moderate or rough seas and operations were limited to mild weather.

2. Pump pressure was a critical factor affecting harvesting efficiency. Insufficient pressure (20 psi or less) did not effectively force clams from the substrate, and excessive pressure forced many organisms under the collecting blade and often damaged a portion of those caught. Consequently, optimal pressure at the exhaust side of the pump was varied from 30 to 50+ psi with increasing depth.

3. Sunrays, the most abundant and frequently caught clams, were common at depths of 10 to 40 ft with greatest abundance occurring from 10 to 25 ft in white sandy substrates or sandy depressions surrounded by grass. Areas of greatest abundance (excluding Bell Shoal and St. Josephs Bay) were between Panama City and Crooked Island and at Seahorse Reef near Cedar Keys. Although these areas yielded smaller catches than those at Bell Shoal, the populations bear further investigation. Bell Shoal is unique, with its small area and heavy concentration of clams. Other such areas could easily be missed in a broad general survey such as this.

Significant numbers of quahogs *(Mercenaria campechiensis)* were caught in a few preliminary samples at Area F, but the condition of these once productive beds is still unknown.

4. Large quantities of dead sunrays (shells) in Area A at Dog Island Reef and South Shoals suggested either the presence of a population in shallow depths where the R/V *Hernan Cortez* was unable to work, or that this area once supported a population. Shallow water surveys are planned for this area.

5. Moderate to deep offshore stations did not yield evidence of heavy clam concentrations, and no single clam species predominated. Several offshore species *(Glycymeris americana, Dosinia elegans, Macrocallista maculata,* and *Tellina magna)* may have commercial potential, because of their large size, if located in abundance. Each of these is relatively palatable.

7. Stokes *et al.* (1968) found no detrimental dredging effects on sand substrates and this survey further verified these observations. Godcharles (1971) stated that use of a hydraulic mechanical harvester caused damage in grassy areas and should be restricted to nongrassy substrates. Similarly, results at Cedar Keys indicated that the hydraulic Nantucket clam dredge should not be recommended in areas where extensive beds of turtle grass are an important part of the environment.

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