

RELATIONSHIPS OF MOLLUSKS TO ENVIRONMENTAL CONDITIONS
IN HILLSBOROUGH BAY, FLORIDA

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United States Department of the Interior
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Southeast Water Laboratory

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This report relates mollusk diversity and abundance to environmental conditions in Hillsborough Bay, Florida. The report is based on biological, hydrological and sedimentological data collected by the U.S. Bureau of Commercial Fisheries (BCF) Biological Laboratory at St. Petersburg Beach, Florida and additional hydrological observations recorded by the Federal Water Pollution Control Administration (FWPCA) Hillsborough Bay Technical Assistance Project in Tampa, Florida. A check-list of the mollusks found in the Bay is appended.

Hillsborough Bay

Hillsborough Bay lies between latitudes $27^{\circ}49'27''\text{N}$ and $27^{\circ}47'12''\text{N}$ and longitudes $82^{\circ}28'24''\text{W}$ and $82^{\circ}24'38''\text{W}$. It is in the north-eastern part of Tampa Bay and covers about 40 square miles (Fig.1). Water deeper than 6 meters (m) is found only in the main ship channel that runs the length of the Bay with branches extending to ports on the eastern shore while water less than 2 m covers 42 percent of the Bay (Olson and Morrill, 1955). Sources of fresh water are precipitation (ca. 127 cm/yr), small streams, spring runs, and the Hillsborough, Palm and Alafia rivers (Dragovich and May, 1962; Dragovich and Goodell, in press; Hutton et al., 1956). Average annual air temperature over the Bay is 23°C and mean water temperature is about 25°C . Salinity and pH tend to be low near the entrances of tributaries, but averages for the Bay are 23⁰/oo and 7.6 (Hutton et al., 1956; Taylor and Saloman, unpublished MS¹).

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1. Taylor, J.L. and C.H. Saloman. 1968. Sediment, oceanographic observations and floristic data from Tampa Bay, Florida and adjacent waters. Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida.

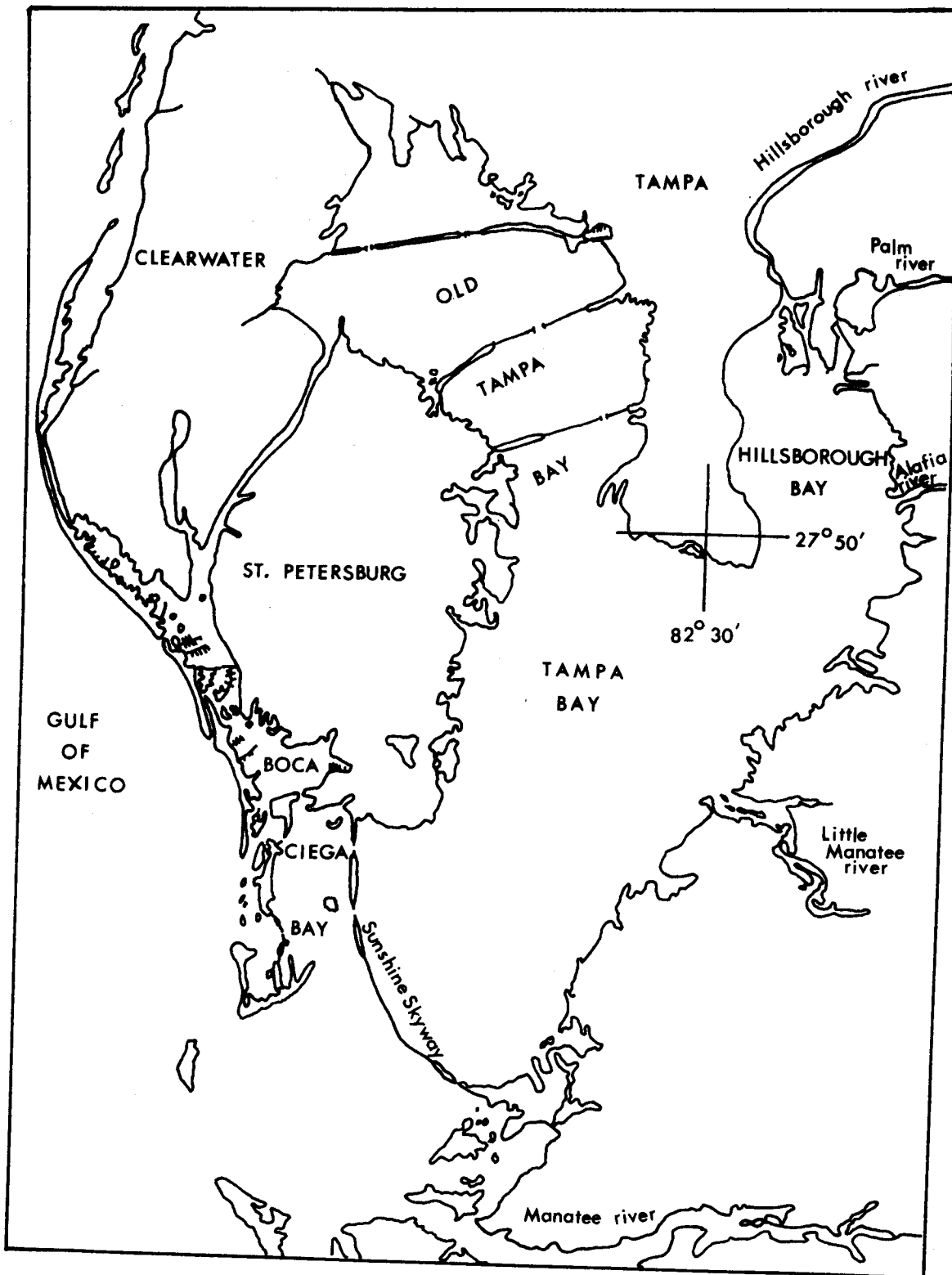


Figure 1. Tampa Bay, Florida, interbays, major rivers and cities.

Tidal currents are generally one knot or less (Taylor and Saloman)¹ and Olson and Morrill (1955) indicate Hillsborough Bay has the least amount of tidal current energy in the Tampa Bay system. Sediments of sand and shelly-sand are near shore and in isolated patches elsewhere, but silts compose bottom deposits throughout most of the Bay (Goodell and Gorsline, 1960; Taylor and Saloman¹). The port city of Tampa (population 305,667)² stands at the head of the Bay. Industrial installations border the eastern shore and residential areas and MacDill Air Force Base are along the western shore of the Interbay Peninsula. From this populous area, about 30 MGD of sewage enter the Bay from primary effluents at Hookers Point and MacDill Air Force Base. Another major source of pollution is the Alafia River which carries phosphatic wastes from extensive mining operations east of Tampa (Odum, 1953; Dragovich and May, 1962; FWPCA, project data).

Poor tidal circulation and waste discharges from sewage and mining wastes have created poor water quality conditions in Hillsborough Bay. Water turbidity is higher (19.2 JTU's) and light transmission is lower (30.3 percent of incident radiation at 40 cm) than any other part of Tampa Bay. Average concentrations of total nitrogen is about 56.4 $\mu\text{g-at/L}$, total phosphorous is about 26.2 $\mu\text{g-at/L}$ and mean annual production by phytoplankton is about 15.6 lbs Carbon/acre/day (Saloman and Taylor, in press; Kelly and Johnson, 1967). Biochemical oxygen demand (5-day BOD) indicates moderate to heavy organic pollution in most parts of the Bay and has an observed range of between 0.3 and 13.0 mg/L. Dissolved oxygen (DO) also shows broad fluctuations. The annual mean value is 4.4 mg/L, but in summer months anaerobic conditions may persist for protracted periods (Saloman and Taylor, in press; FWPCA project data).

Biological investigations in Hillsborough Bay have reported algal blooms (Dragovich, Kelly and Kelly, 1965), excessive growth of filamentous algae (Florida State Board of Health, 1965), large kills of crustaceans

2. Research Department, Greater Tampa Chamber of Commerce, 1965 estimate.

and fish (Hall, unpublished MS³). Obnoxious odors evolving from the western shore of Hillsborough Bay are a perennial problem. They cause much concern among residents along the shores and once were strong enough to cause the closure of the Bayshore Boulevard entrance to MacDill Air Force Base (Tampa Tribune, August 25, 1961). One objective of the Hillsborough Bay Technical Assistance Project was to determine the causes of these odors. Comparative studies of fishes, shrimp and crabs in all areas of Tampa Bay show that the least numbers of individuals and species occur in Hillsborough Bay (Sykes and Finucane, 1966). Mollusks of the Bay have not been previously studied in detail, but it is apparent from fishery statistic records that the oyster (Crassostrea virginica) declined drastically as coastal development progressed (Dawson, 1953). Conceivably, through increased nutrient concentrations in the Bay, the normal food organisms of the oysters can be replaced by populations less acceptable. This could cause elimination of oysters in much the way it occurred in Great South Bay, New York when high nutrient concentrations (primarily phosphates) from duck farm wastes encouraged vast blooms of Stichococcus and Nanochloris algae which caused starving and smothering of the oysters (Loosanoff and Eagle, 1947; Wallace, 1966). Parker (1959) described infaunal mollusks and extensive oyster reefs in enclosed bays near Rockport, Texas characterized by low and variable salinity. It is likely that a comparable mollusk fauna existed in Hillsborough Bay before heavy pollution.

Procedures

Mollusks, sediment samples, and hydrological data were collected by the Bureau of Commercial Fisheries at 45 stations in Hillsborough Bay between August 13 and September 5, 1963. Thirty-three stations were located at approximately one-half mile intervals along three transects and 12 were in unusual habitats and remote areas of the Bay. Supplementary hydrological data were obtained from four permanent hydrostations sampled

3. Hall, J.R. 1967. A blue crab kill in cut D channel on November 2, 1967. On file FWPCA, Hillsborough Bay Technical Assistance Project, Tampa, Florida.

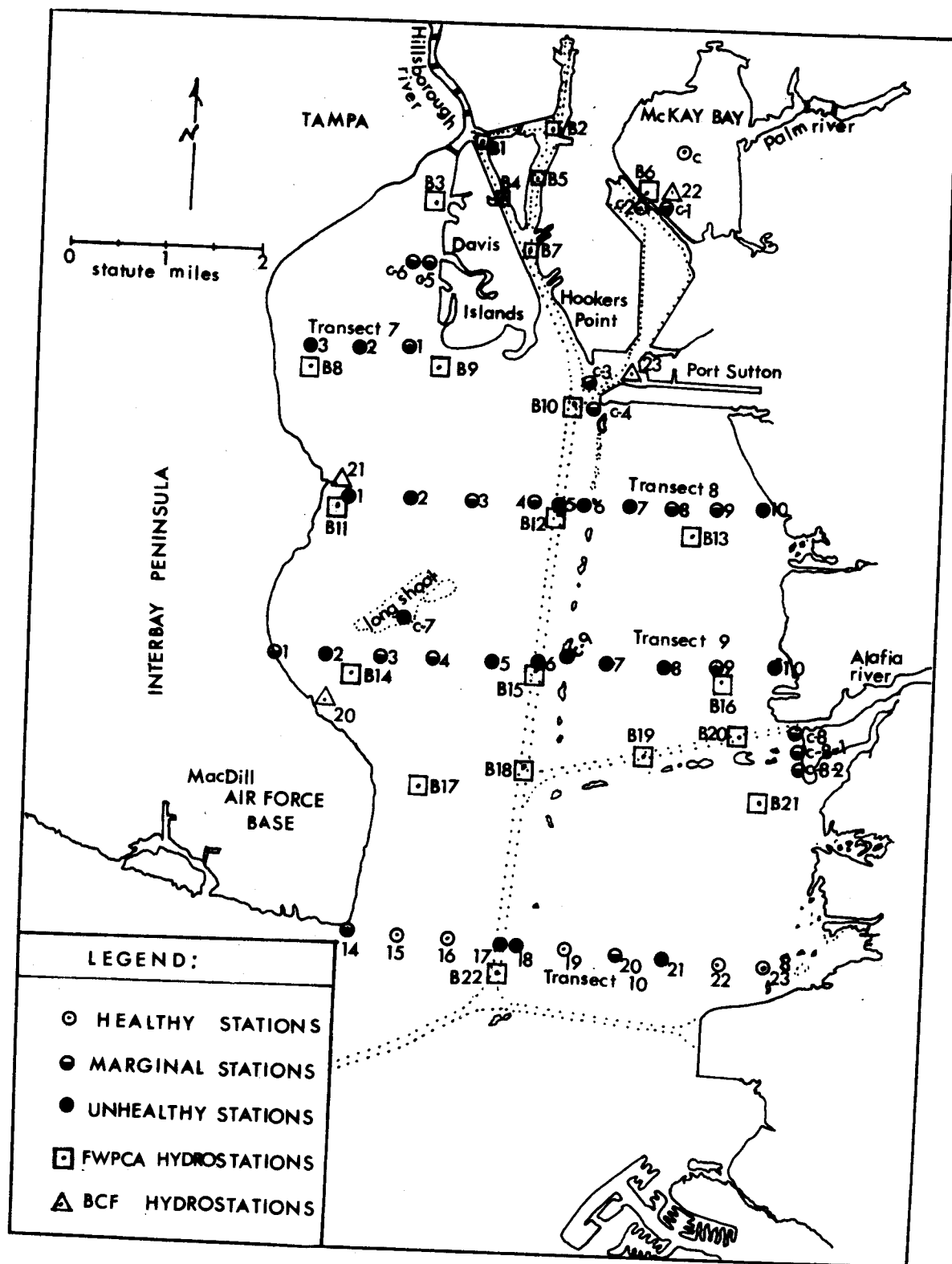


Figure 2. Sampling stations in Hillsborough Bay, Florida.

regularly by BCF and from 22 stations sampled by FWPCA in 1967 (Fig. 2).

Mollusks were collected by a 15 liter bucket dredge and bottom drag (Taylor, 1965) and at stations having water depth less than 1 m a shovel was substituted for the dredge (three scoopfuls approximating the area of the dredge). Shells were separated from sediments on a sieve of .701 mm mesh (Tyler #24 screen) and fixed in 10 percent seawater-formalin. A protein staining dye (Rose Bengal) was added to facilitate sorting organisms from debris. Specimens were later preserved in 70 percent isopropanol. Sediment samples were taken by the sedimentology laboratory of Florida State University (Taylor and Saloman)¹. Chloride dissolved oxygen and biochemical oxygen demand were determined by FWPCA.

Identification of mollusks were made by use of standard taxonomic works (Abbott, 1954; Keen, 1963; Perry and Schwengel, 1955) as well as by comparison with specimens in the U. S. National Museum.

Mollusk Diversity and Abundance

Sixty-four species of infaunal and epifaunal mollusks were identified from samples collected in August and September, 1963; and of these, 35 were collected live (Table I). Live mollusks were found at 26 of the 45 stations. At all stations where live mollusks were found, one or more of four species (Mulinia lateralis, Amygdalum papyria, Tagelus plebeius, and Nassarius vibex) was encountered. These four species are hereinafter referred to as the indicator assemblage. Where one or more species of the indicator assemblage represented less than 50 percent of the number of species collected alive, the station is classified as healthy; and where the percentage is equal to or greater than 50 percent, the station is called marginal. Stations where no live mollusks were collected are classified as unhealthy (Fig. 2 and Tables II through IV). From the standpoint of average abundance, healthy stations had a greater number of mollusks than marginal stations except in areas where one or more of the indicator species was especially abundant (Tables I through III).

Environmental conditions recorded at healthy, marginal and unhealthy stations indicate that depth, sediment type, bottom vegetation, salinity, DO, and BOD are factors influencing the benthic mollusks in Hillsborough

TABLE I. Mollusks Collected Live in Hillsborough Bay, August and September, 1963.

Species	Station and Number of Samples																		
	7-1 2	7-2 2	7-3 2	8-1 2	8-2 2	8-3 2	8-4 2	8-5 2	8-6 1	8-7 2	8-8 2	8-9 2	8-10 2	9-1 1	9-2 2	9-3 2	9-4 2	9-5 2	
Mulinia lateralis						1	2				4	2				800	1		
Amygdalum papyria												40				1			
Nassarius vibex	4															122	4		
Tagelus plebeius												7		1					
Melongena corona						1													
Tellina versicolor																			
Mitrella lunata																1			
Ensis minor																			
Mercenaria campechiensis																	1		
Macoma tenta																			
Crepidula plana																			
Bittium varium																			
Anadara transversa																			
Thracia sp.																1			
Modiolus americanus												5							
Polinices duplicatus																			
Odostomia acutidens																			
Mysella planulata												5							
Epitonium humphreysi																			
Crassostrea virginica																			
Corbula caribaea																			
Anachis obesa																			
Tagelus divisus																			
Urosalpinx tampaensis																			
Nucula proxima																			
Natica pusilla																			
Laevicardium mortoni																			
Haminoea succinea																			
Epitonium angulatum																			
Crepidula fornicata																			
Corbula barrattiana																			
Brachidontes exustus																			
Acteon punctostriatus											4								
Ischnochiton papillosus						1													
Total number species (35)	1	0	0	0	0	3	1	0	0	0	2	5	0	1	0	5	3	0	
Total number individuals	4	0	0	0	0	3	2	0	0	0	8	59	0	1	0	925	6	0	

TABLE I. (Cont.) Mollusks Collected Live in Hillsborough Bay, August and September, 1963

Species	Station and Number of Samples														
	9-6	9-7	9-8	9-9	9-10	10-14	10-15	10-16	10-17	10-18	10-19	10-20	10-21	10-22	
	2	2	2	2	2	3	2	2	2	1	2	2	2	2	
Mulina lateralis				4		21	63				10	1		35	
Amygdalum papyria						21	30				3	4		41	
Nassarius vibex						9	10	3				1		4	
Tagelus plebeius						12									
Melongena corona							1								
Tellina versicolor							16	4			1			2	
Mitrella lunata						203	359	1							
Ensis minor						7								1	
Mercenaria campechiensis								4			2			1	
Macoma tenta							7	4			2			1	
Crepidula plana						3		1							
Bittium varium						10	1								
Anadara transversa							10				5				
Thracia sp.							2	1			1				
Modiolus americanus															
Retusa canaliculata							2								
Polinices duplicatus														1	
Odostomia acutidens							1								
Mysella planulata															
Epitonium humphreysi							6							1	
Crassostrea virginica							3								
Corbula caribaea								5			41				
Anachis obesa							22							1	
Tagelus divisus															
Urosalpinx tampaensis															
Nucula proxima											1				
Natica pusilla											2				
Laevicarium morntoni							3								
Haminoea succinea															
Epitonium angulatum							3								
Crepidula fornicata											1				
Corbula barrattiana											2				
Brachidontes exustus															
Acteon punctostriatus															
Ischnochiton papillosus															
Total number species (35)	0	0	0	1	0	8	17	8	0	0	12	3	0	10	
Total number individuals	0	0	0	4	0	286	512	23	0	0	71	6	0	88	

TABLE I. (Cont.) Mollusks Collected Live in Hillsborough Bay, August and September, 1963

Species	Station and Number of Samples													Station Frequency
	10-23 2	C 2	C-1 1	C-2 2	C-3 2	C-4 1	C-5 2	C-6 2	C-7 1	C-8 1	C-8-1 1	C-8-2 1	C-9 1	
<i>Mulinia lateralis</i>		129		268	63		8	150						17
<i>Amygdalum papyria</i>	300	26	1	16	80	2	3	22						14
<i>Nassarius vibex</i>	5			2	2		1	15						13
<i>Tagelus plebeius</i>		1	16	16	1					71	142	89		9
<i>Melongena corona</i>		10	1	4	5									5
<i>Tellina versicolor</i>				8										5
<i>Mitrella lunata</i>	30			8										5
<i>Ensis minor</i>	2				5		1							5
<i>Mercenaria campechiensis</i>														5
<i>Macoma tenta</i>														4
<i>Crepidula plana</i>	1	6												4
<i>Bittium varium</i>	10	17												4
<i>Anadara transversa</i>				3										4
<i>Thracia</i> sp.														4
<i>Modiolus americanus</i>		1						15						3
<i>Retusa canaliculata</i>	1													3
<i>Polinices duplicatus</i>	1													2
<i>Odostomia acutidens</i>	2													2
<i>Mysella planulata</i>		1												2
<i>Epitonium humphreysi</i>														2
<i>Crassostrea virginica</i>				2	2									2
<i>Corbula caribaea</i>														3
<i>Anachis obesa</i>					1									2
<i>Tagelus divisus</i>														2
<i>Urosalpinx tampaensis</i>				1										1
<i>Nucula proxima</i>														1
<i>Laevicardium mortoni</i>														1
<i>Haminoea succinea</i>		1												1
<i>Epitonium angulatum</i>														1
<i>Crepidula fornicata</i>														1
<i>Corbula barrattiana</i>														1
<i>Brachidontes exustus</i>	1													1
<i>Acteon punctostriatus</i>														1
<i>Ischnochiton papillosus</i>														1
Total number species (35)	10	9	3	10	8	1	4	4	0	1	1	1	0	
Total number individuals	353	192	18	328	159	2	13	202	0	71	142	89	0	

Bay.

Healthy Stations

Seven stations, or about 16 percent of those sampled, are classified as healthy. The average incidence of indicator species at these stations is 25 percent, and the average number of species and individuals per station is 10.8 and 223.8, respectively (Table II).

Most healthy stations are located at the mouth of the Bay along transect 10. The most diverse mollusk assemblage was observed at station 10-15 where 512 live individuals of 17 species were collected. At the opposite end of the Bay, healthy conditions were found at stations C and C-2, but throughout the rest of the Bay all other stations proved to be either marginal or unhealthy (Fig. 2).

At healthy stations the predominant sediment type was fine sand; and at all but two, red algae (Gracilaria foliifera) was found growing on the bottom. The algae provides a substratum for many epiphytic mollusks and fine sand is well suited for colonization by a variety of benthic species (Thorson, 1956; Jones, 1950; Pratt, 1953; Sanders, 1958; Brett, 1962; McNulty, 1961; Sykes and Hall, unpublished MS⁴).

Salinity at healthy stations was between 18% (stations C and C-2) and 23% (station 10-19). Lower values recorded in the northeastern arm of the Bay (McKay Bay) may be limiting to some mollusks found along transect 10, but salinity is not the controlling factor as diversity at C and C-2 is greater than that observed at many of the marginal stations where salinity is comparable or greater (Tables II and III).

Oxygen may be a limiting factor for many marine animals when the concentration falls below 2.5 mg/L (Emery and Stevenson, 1957). Biochemical oxygen demand is a measure of the rate at which organisms consume available oxygen. In unpolluted water, normal uptake for 5-day BOD is about 1-1.5 mg/L and figures for moderately and heavily polluted water are about 2-3.5 mg/L and 4 mg/L or higher.

No data are available for the healthy stations primarily because these locations were not pertinent to the odor problem.

4. Sykes, J. E., and J. R. Hall. 1968. Distribution of mollusks in dredged and undisturbed portions of an estuary. On file BCF Biological Laboratory, St. Petersburg Beach, Florida.

TABLE II. Healthy Stations in Hillsborough Bay, August and September, 1963.

Station	Number of Species and Individuals Collected Live	Percentage Indicator Species	Depth in Meters	Mean Grain Size Ø	Sediment Type	Bottom Vegetation	Bottom Salinity ‰
C	9 (192)	33	1.7	4.05	Coarse silt	<u>Gracilaria</u>	18.19
C-2	10 (328)	40	4.7	2.28	Fine sand	<u>Gracilaria</u>	18.56
10-15	17 (512)	18	3.0	2.74	Fine sand	<u>Gracilaria</u>	21.82
10-16	8 (23)	13	6.0	3.15	Very Fine sand	none	22.62
10-19	12 (71)	17	3.7	2.02	Fine sand	none	22.95
10-22	10 (88)	33	2.0	2.84	Fine sand	<u>Gracilaria</u>	22.43
10-23	10 (353)	20	1.0	2.59	Fine sand	<u>Gracilaria</u>	21.26
Mean	10.8 (223.8)	25	3.2	2.81	Fine sand	Range: 18.19 - 22.95	

TABLE III. Marginal Stations in Hillsborough Bay, August and September, 1963 (BCF) and 1967 (FWPCA).

Station (BCF)	Number of Species and Individuals Collected Live	Percentage Indicator Species	Depth in Meters	Mean Grain Size Ø	Sediment Type	Bottom Vegetation	Bottom Salinity o/oo	DO Max.,Min.,Ave. mg/L	BOD Max.,Min.,Ave. mg/L	Station (FWPCA)
C-1	3 (18)	67	1.0	2.32	Fine sand	none	18.33	4.46,0.99,3.39	4.30,1.30,2.60	B6
C-3	8 (159)	50	2.0	2.78	Fine sand	<u>Gracilaria</u>	16.35	0.78,0.00,0.28	0.90,1.20,1.10	B10
C-4	1 (2)	100	1.0	2.95	Fine sand	none	15.59	0.78,0.00,0.28	0.90,1.20,1.10	B10
C-5	4 (13)	78	4.2	2.58	Fine sand	none	19.78	10.16,0.00,2.30	7.51,3.00,4.40	B3
C-6	4 (202)	75	2.0	2.88	Fine sand	none	18.96	10.16,0.00,2.30	7.51,3.00,4.40	B3
C-8	1 (71)	100	0.7	2.51	Fine sand	none	0.74	6.50,2.58,4.64	3.70,1.80,3.51	B21
C-8-1	1 (142)	100	0.7	2.95	Fine sand	none	1.15	6.50,2.58,4.64	3.70,1.80,3.51	B21
C-8-2	1 (89)	100	0.3	5.28	Medium silt	none	3.69	6.50,2.58,4.64	3.70,1.80,3.51	B21
7-1	1 (4)	100	2.0	3.04	Very fine sand	none	17.79	7.78,1.22,4.41	7.75,0.90,2.40	B9
8-3	3 (13)	50	3.6	4.09	Coarse silt	none	19.78			
8-4	1 (2)	100	3.9	5.23	Medium silt	none	20.50			
8-8	2 (8)	50	2.8	3.14	Very fine sand	none	16.56	11.48,3.52,6.79	7.50,1.30,3.73	B13
8-9	5 (57)	60	1.0	2.51	Fine sand	none	18.78	11.48,3.52,6.79	7.50,1.30,3.73	B13
9-1	1 (1)	100	10.3	2.53	Fine sand	none	17.25			
9-3	5 (925)	60	2.0	2.38	Fine sand	none	18.37	10.88,3.23,6.12	7.39,2.30,3.37	B14
9-4	3 (6)	67	2.4	2.25	Fine sand	none	18.51			
9-9	1 (4)	100	2.8	3.37	Very fine sand	none	17.70	7.49,3.03,5.25	5.70,2.10,4.08	B16
10-14	8 (267)	50	1.0	2.68	Fine sand	<u>Gracilaria</u>	20.61			
10-20	3 (6)	100	3.9	2.88	Fine sand	none	22.92			
Mean	2.9 (103.6)	79.2	1.9	3.07	Very fine sand		Range: 0.74- 22.92			

TABLE IV. Unhealthy Stations in Hillsborough Bay, August and September, 1963 (BCF) and 1967 (FWPCA).

Station (BCF)	Depth in Meters	Mean Grain Size ϕ	Sediment Type	Bottom Vegetation	Bottom Salinity o/oo	DO Max., Min., Ave. mg/L	BOD Max., Min., Ave. mg/L	Station (FWPCA)
C-7	0.7	-0.95	Very coarse sand	none	18.33			
C-9	0.7	-0.77	Very coarse sand	none	16.22			
7-2	4.2	5.76	Medium silt	<u>Gracilaria</u>	17.79	14.58, 2.75, 6.15	7.93, 2.00, 4.20	B8
7-3	2.7	----	----	none	17.61	14.58, 2.75, 6.15	7.93, 2.00, 4.20	B8
8-1	3.9	5.65	Medium silt	none	18.78	13.24, 2.20, 5.02	7.55, 1.70, 3.10	B11
8-2	3.3	2.93	Fine sand	none	19.04			
8-5	10.3	7.40	Very fine silt	none	22.92	1.47, 0.20, 0.52	7.33, 0.00, 1.90	B12
8-6	0.7	-1.90	Granule	none	18.60			
8-7	3.3	4.77	Coarse silt	none	19.42			
8-10	0.7	3.31	Very fine sand	none	17.94			
9-2	3.3	5.12	Medium silt	none	18.33	10.88, 3.33, 6.13	7.39, 2.30, 3.37	B14
9-5	4.2	7.55	Very fine silt	none	19.74			
9-6	12.1	6.91	Fine silt	none	22.38	1.44, 0.26, 0.65	1.10, 0.60, 0.90	B15
9-7	3.6	7.84	Very fine silt	none	20.05			
9-8	4.2	4.35	Coarse silt	none	19.42			
9-10	1.0	2.88	Fine sand	none	18.75			
10-17	10.9	4.46	Coarse silt	none	23.77	4.58, 1.60, 3.19	2.70, 0.60, 1.37	B22
10-18	0.7	-0.96	Very coarse sand	none	22.11			
10-21	3.6	3.62	Very fine sand	none	22.81			
Mean	3.8	5.37*	Medium silt	Range: 3.69-23.77				

*Negative grain sizes excluded.

Marginal Stations

At 19 stations classified as marginal, 50 percent or more of the species present were indicators; the average incidence being 79 percent. Average numbers of live species and individuals collected is 2.9 and 103.6 respectively - - less than half that of the healthy stations (Table III).

Sediments at marginal stations ranged from fine sand to medium silt. The average sediment type was very fine sand - - a slightly finer substratum than the mean bottom type of fine sand recorded at healthy stations. Two of the marginal stations had a fine sand bottom and Gracilaria present; and these contained greater mollusk diversity than other marginal stations. Absence of Gracilaria from most stations in shallow water is probably due to high turbidity (19.2 JTU's) and low light transmission caused by particulate material suspended in the water column. Wind-driven waves and currents are active forces that continuously resuspend fine grained sediments in shallow water.

The range of salinity at marginal stations is greater than at healthy stations. Brackish conditions (4 percent salinity) near the mouth of the Alafia River probably explains the absence of all mollusks except Tagelus plebeius at stations C-8, C-8-1, and C-8-2 (Fig. 2). At other marginal stations salinity values would not prove limiting to most mollusks found at healthy stations.

Dissolved oxygen and BOD were collected at 8 hydrostations between August 3 and September 28, 1967 (B6, B10, B3, B21, B9, B13, B14, B16). These stations are near 13 BCF benthic stations (C-1, C-3, C-4, C-5, C-6, C-8, C-8-1, C-8-2, 7-1, 8-8, 8-9, 9-3, 9-9). Comparison of these two sets of data shows that lack of oxygen may be an important limiting factor at marginal locations (Table III). Minimum DO's at the FWPCA stations are all below the mean value (4.1 mg/L) for the Bay (Saloman and Taylor, in press). Six of the benthic stations are apparently subject to severe oxygen depletions - below 2 mg/L - and the remaining seven stations where the minimum values do not reach this level, BOD averages indicate moderate to heavy pollution.

Unhealthy Stations

No live mollusks were collected at 19 stations classified as unhealthy (Fig. 2). Two of these were located along the eastern shore of the Bay (8-10 and 9-10) adjacent to an extensive area of gypsum (CaSO_4) spoil from processing phosphate ores. The gypsum forms a friable crust on the bottom that apparently prevents establishment of mollusks.

Sediments at other unhealthy stations had a mean grain size that ranged from -1.90 ϕ (granule) to 7.78 ϕ (very fine silt) (Table IV). Coarse sediments were found at stations near channel spoil islands or on a natural shoal of shell (C-7). Absence of mollusks in these areas can be attributed to wave action and abrasive forces that interfere with their settlement and survival (Pratt, 1953). Other unhealthy stations were in comparatively deep water in or near the channels where the average sediment type was medium silt. One factor that may prevent mollusks from colonizing these areas is the presence of concentrations of the toxic compound hydrogen sulfide which is released from underlying sledge beds (FSBH, 1965). Other reasons for the scarcity or absence of mollusks in areas where silty sediments accumulate are listed by Pratt (1953): (1) young may be smothered, (2) oxygen transfer is apt to be slow, (3) metabolic wastes are not rapidly removed.

Gracilaria was absent from all but one station (7-2) and there it had no epiphytic mollusks attached. Many of the unhealthy stations had water too deep to permit growth of Gracilaria and at other stations, turbidity, wave action, or gypsum deposits are factors that would prevent its growth.

The salinity at unhealthy stations was similar to that at healthy stations and cannot be regarded as limiting factors in areas where no mollusks were found (Table IV).

Oxygen data from six FWPCA hydrostations (B8, B11, B12, B14, B15, B22) indicated moderate to heavy pollution near seven unhealthy stations (7-2, 7-3, 8-1, 8-5, 9-2, 9-5, 10-17) (Table IV). In the area around B12 and B15, low dissolved oxygen is apparently a persistent feature that eliminates mollusks in late summer and perhaps other seasons.

Broad fluctuations of dissolved oxygen at stations B8, B11, and B14 reflect planktonic cycles of photosynthesis and respiration, or organic pollution as seen in the high BOD's. Minimum values of dissolved oxygen at these stations were lower than average for the Bay and are probably suboptimal for many mollusks that inhabit other areas of Hillsborough Bay.

Benthic Zones

An approximation of healthy, marginal and unhealthy benthic zones can be outlined for Hillsborough Bay by extrapolating from water quality data and benthic sampling (Fig. 3).

Viewed in this manner, about 16 percent of the Bay can be considered healthy, 40 percent marginal, and 44 percent as unhealthy.

Most of the healthy area is confined to the mouth of the Bay near transect 10 where sediments and water quality appear to be optimum. Pollutants are also diluted as they disperse into the circulation of the Bay. The marginal zones contain the marginal stations defined within the section treating them and occur in parallel bands between the three unhealthy areas. The unhealthy zones lie in parallel bands along the eastern and western shores and the main ship channel of the Bay. As far as the eastern shore is concerned, the gypsum deposits alone probably serve to keep a normal benthic component from settling there. The unhealthy stations 7-2, 7-3, 8-1, 8-2, and 9-2 which lie near the western shore fall into the "odor-area" of the Bay. This entire region is subject to seasonal inundations of water hyacinths which come down the Hillsborough River, and rafts of Gracilaria. Both types of vegetation pile up on the beaches and in the shallow nearshore waters, die, and decompose. The decomposition depletes DO and leaves a large deposition of decaying plant matter on the bottom. Even with the medium silts at stations 7-2, 8-1, and 9-2, or fine sand at station 8-2, marginal or healthy bottom mollusks are excluded. Zero or near zero DO characterizes bottom water in the main ship channel. Diurnal studies of bottom DO at stations B1, B2, B4, B5, and B7 (Fig. 2) were undertaken from August 29 to September 1, 1967. Of 24 DO analyses at these locations the highest

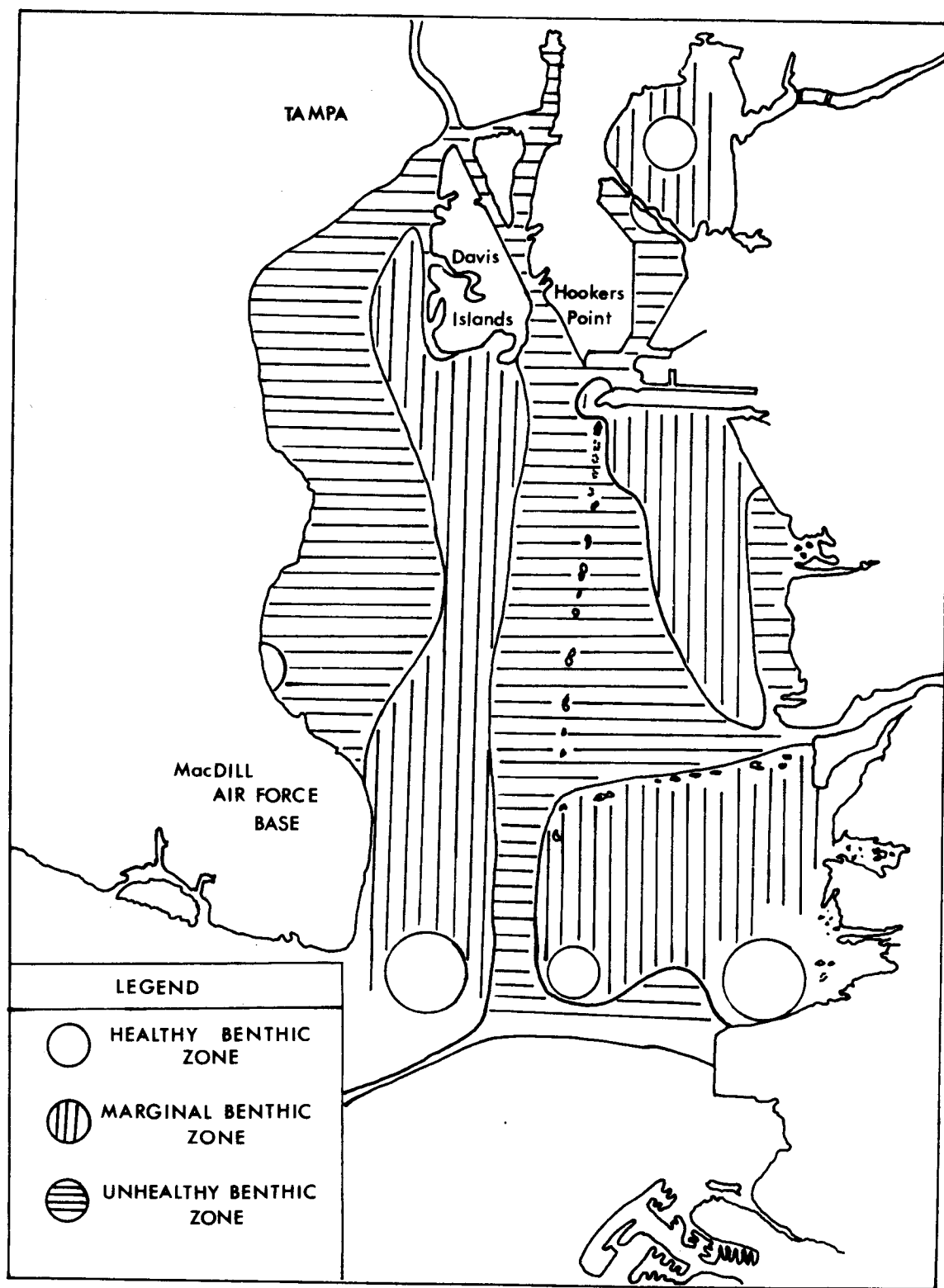


Figure 3. Benthic zones in Hillsborough Bay. Designations based on water quality data, benthic mollusks, and sediments.

average reading was 0.20 mg/L -- well below a minimum for benthic mollusks. Other channel stations (B10, B12, B15) recorded average DO's below the 1 mg/L level (Tables III and IV). Farther down the Bay, channel stations B18, B19, B20, and B22 (Fig. 2) have average DO's somewhat higher -- 3.18, 2.52, 1.88, and 3.19 -- but each in the August-September, 1967 period had several readings that went below 2 mg/L.

Pollution abatement would benefit Hillsborough Bay by eventually allowing normal estuarine assemblages to invade marginal and unhealthy areas. In zones where there are deep deposits of silt, however, biological recovery would proceed much more slowly or perhaps not at all (McNulty, 1966).

Hillsborough Bay is a rapidly dying part of the Tampa Bay estuarine ecosystem. The most obvious illustration of this fact is the perennial hydrogen sulfide odor problem that causes considerable discomfort to the residents along the western shores. As long as the processes that have brought about this unsavory situation for both the land and marine environment continue unabated, the death of Hillsborough Bay will be assured.

APPENDIX I

A Check-list of Mollusks Found in Hillsborough Bay

August and September, 1963

CLASS BIVALVIA

Family Nuculidae

Nucula proxima Say

Family Nuculanidae

Nuculana acuta Conrad

Family Arcidae

Anadara transversa Say

Family Pinnidae

Atrina rigida Solander

Family Mytilidae

Amygdalum papyria Conrad

Brachidontes exustus Linné

Modiolus americanus Leach

Modiolus demissus granosissimus Sowerby

Family Ostreidae

Crassostrea virginica Gmelin

Family Carditidae

Cardita floridana Conrad

Family Leptonidae

Mysella planulata Stimpson

Family Cardiidae

Laevicardium mortoni Conrad

CLASS GASTROPODA

Family Epitonidae

Epitonium angulatum Say

Epitonium humphreysi Kiener

Epitonium rupicola Kurtz

Family Rissoidae

Rissoina chesneli Michaud

Family Neritidae

Neritina reclivata Say

Family Tornidae

Skenea sp.

Family Cerithiidae

Bittium varium Pfeiffer

Seila adamsi H. C. Lea

Triphora nigrocincta C. B. Adams

Family Calyptraeidae

Crepidula fornicata Linne'

Crepidula plana Say

Family Naticidae

Natica pusilla Say

Polinices duplicatus Say

Family Muricidae

Urosalpinx tampaensis Conrad

Family Columbelloidae

Anachis obesa C. B. Adams

Anachis semiplicata Stearns

Mitrella lunata Say

Family Melongenidae

Melongena corona Gmelin

Family Nassariidae

Nassarius vibex Say

Family Marginellidae

Prunum apicinum Menke

Family Olividae

Olivella perplexa Olsson

Family Atyidae

Haminoea succinea Conrad

Family Retusidae

Retusa canaliculata Say

Family Pyramidellidae

Odostomia acutidens Dall

Odostomia impressa Say

Odostomia producta ?

Turbonilla viridaria Dall

Family Scaphandridae

Cyclichna bidentata Orbigny

Family Acteonidae

Acteon punctostriatus C. B. Adams

Family Ellobiidae

Melampus coffeus Linne'

CLASS AMPHINEURA

Family Ischnochitonidae

Ischnochiton papillosus C. B. Adams

Family Veneridae

Chione cancellata Linne'

Mercenaria campechiensis Gmelin

Parastarte triquetra Conrad

Family Petricolidae

Petricola pholadiformis Lamarck

Family Mactridae

Mactra fragilis Gmelin

Mulinia lateralis Say

Family Tellinidae

Macoma constricta Bruguière

Macoma tenta Say

Tellina alternata Say

Tellina lineata Turton

Tellina versicolor DeKay

Family Donacidae

Donax variabilis Say

Family Semelidae

Semele bellastriata Conrad

Semele proficua Pulteney

Family Solecurtidae

Tagelus divisus Spengler

Tagelus plebeius Solander

Family Solenidae

Ensis minor Dall

Family Corbulidae

Corbula barrattiana C. B. Adams

Corbula caribaea Orbigny

Family Pholadidae

Cyrtopleura costata Linne'

Family Lyonsiidae

Lyonsia hyalina floridana Conrad

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