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IMPACT OF DREDGING IN THE TAMPA BAY ESTUARY, 1876-1976

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ABSTRACT

Tampa Bay is an estuary located on the west coast of Florida. One-sixth of the state's population lives in the three counties bordering its shores.

During the last 100 years four major types of dredging have impacted the bay: channel deepening, maintenance dredging, shell dredging, and dredging for landfill construction. These impacts range from the economic benefit provided by channel and port construction for what is now the eighth largest port in the nation to the environmental damage caused by dredging to create over 5,000 ha of landfill in the bay for residential, commercial, and dredged material disposal use. These landfills have resulted in the loss of 44% of the original marine wetlands bordering Tampa Bay.

Recent environmental concerns have halted landfill dredging and severely restricted maintenance dredging. Research on shell dredging in the bay indicate minimal impact if carefully controlled. New channel deepening and open water disposal of 55,000,000 m^3 of dredged material is planned as part of the Tampa Harbor Deepening Project, now in progress. This project has undergone intensive review and modification as a result of environmental concern by both citizens and scientists.

Introduction

During the 1960s, the population of Florida increased 37% from 4.9 million to 6.8 million, while the United States as a whole showed only a 13% increase. Three out of four of these new residents migrated from other states. The 1976 population is estimated to be 8.7 million with 74% of this number living on 28% of the land area, the coastal zone (Division of State Planning, 1976). Of the 40 estuarine study areas examined by McNulty et al. (1972) Tampa Bay is second only to the Florida Bay system in size (Fig. 1). One-sixth of the state's population lives in the three counties bordering the bay, Hillsborough, Pinellas, and Manatee.

Tampa Bay is divided into six sub-areas (Fig. 2): Old Tampa Bay, Hillsborough Bay, Upper Tampa Bay Proper, Lower Tampa Bay Proper, Boca Ciega Bay, and Terra Ceia Bay. Representative physical and chemical parameters for these sub-areas are also given in Figure 2. Olson and Morrill (1955), using as a basis a 1943 chart, determined the total area of the bay to be 90,500 ha with a shoreline of 320 km. As noted by Simon (1974) alterations to the bay since that time have made these figures obsolete. For example Olson and Morrill (1955) list the shoreline of Boca Ciega Bay as 42.3 km while Simon (1974) using a 1971 chart found it to be 199.6 km. The author is presently updating the work of Olson and Morrill (1955) using 1976 charts. These same authors noted

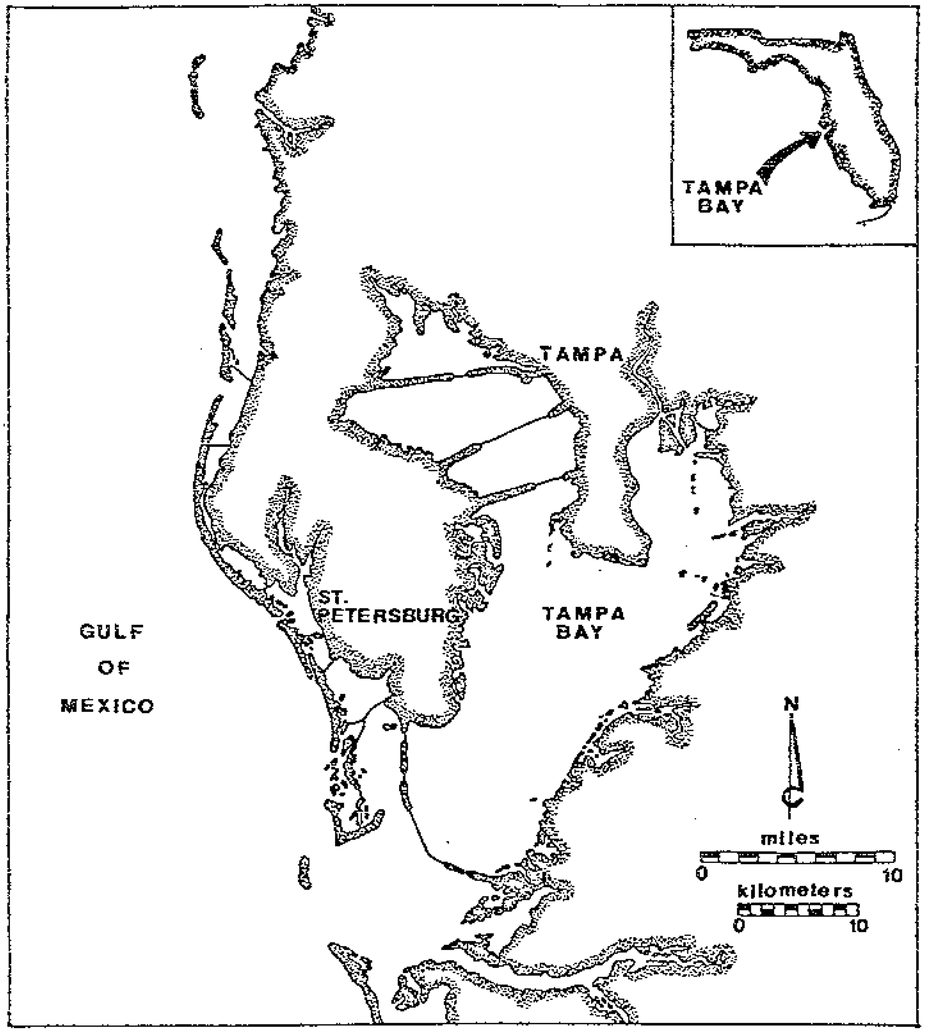

Figure 1. The Tampa Bay Estuary, Florida.

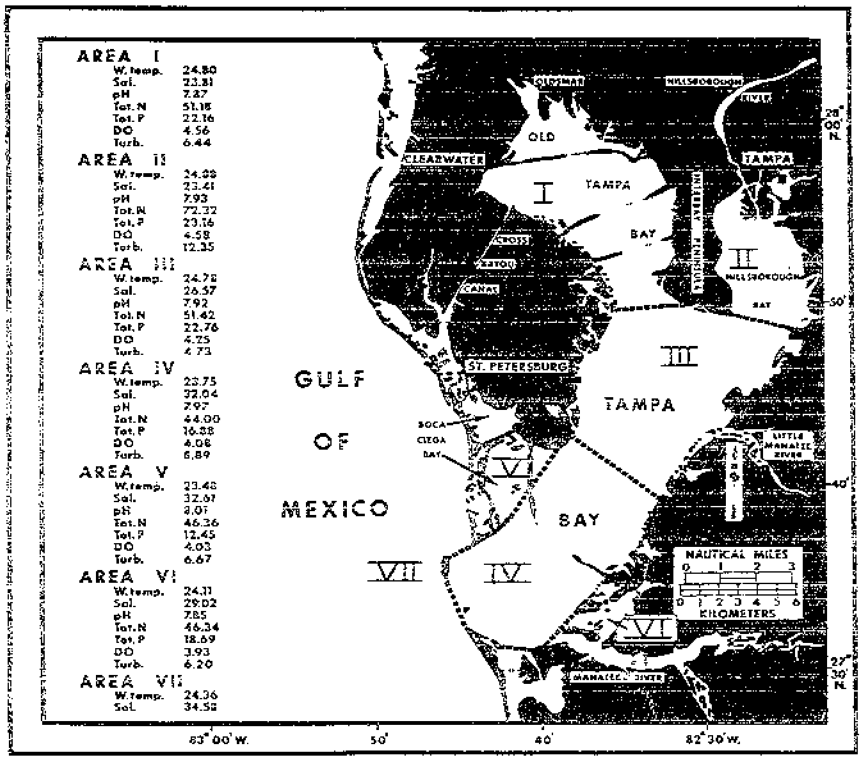

Figure 2. Hydrographic measurements for different areas of Tampa Bay and adjacent waters of the Gulf of Mexico, January 1965 through August 1967. Water temperature, °C; salinity, p.p.t.; pH; total nitrogen, μg at/l; total phosphorus, μg at/l; dissolved oxygen, ml/l; turbidity, J.T.U. (Original map slightly modified from Bureau of Commercial Fisheries Circular 313, 1969).

that "Tampa Bay may readily be classed as a shallow body of water since the modal depth is but 9.7 ft and 90% of its area has a depth less than 22 ft" (9.7 ft = 3.0 m, 22 ft = 6.7 m).

The subtropical climate of the Tampa Bay area supports both tropical mangrove forests and temperate tidal marshes along the shores of the estuary. Latest measurements, made with the assistance of the U.S. Geological Survey, Tampa office, show 5,630 ha of these intertidal marine communities remaining in the bay. This represents a 44% decline from those present in 1876 (Lewis, unpublished). The value of these communities in the production of detritus and their role in marine productivity in south Florida estuaries has been well documented by Heald (1971), Odum (1971), and Odum and Heald (1972). Submerged vegetation in the estuary consists of five species of seagrasses and 216 species of algae. Taylor (1971) estimated 8,500 ha of bay bottom was vegetated by seagrasses and conspicuous benthic algae.

Sykes and Finucane (1966) report twenty-three species of major importance in Gulf of Mexico commercial fisheries occur in Tampa Bay during immaturity. Old Tampa Bay harbored greater numbers of these species than any other area. Hillsborough Bay, similar in salinity regime, harbored fewer important species than any other area.

The reader is referred to Olson and Morrill (1955), Taylor (1973), and Simon (1974) for complete literature reviews and detailed discussions on the present status of the estuary.

During the last 100 years four major types of dredging have impacted the bay: channel deepening, maintenance dredging, shell dredging, and dredging for landfill.

Channel Deepening

Tampa Bay has provided protected anchorage for ships since the 16th century, including vessels carrying Ponce de Leon and Hernando de Soto (Lohse et al., 1969). The shallow depths were sufficient until the drafts of vessels had increased and deeper channels than naturally existed were necessary. Since dredging first began in Tampa Bay in 1880, 107 km of channels have been created (Taylor, 1973). The material dredged from these channels has been placed adjacent to the channels as submerged or emergent spoil areas (Fig. 3), or used as landfill for shoreline development (Fig. 4, 5, 6, 7). As can be seen in these photographs this type of dredging has produced large turbidity plumes from uncontrolled overflow in spoil areas and cutterhead disturbance of the sediments. Illegal filling of submerged land (under the jurisdiction of the State of Florida) occurred routinely in the 1960s and penalties were minimal. Often the illegally filled land was sold to the dredging company after filling and resold at a good profit far in excess of the fine or cost of dredging. The filling of Redfish Creek in Lower Tampa Bay in 1969 (Fig. 4) is an example where the land was filled

Figure 3. Dredging at Port Manatee, Lower Tampa Bay, September, 1968. The dredge and the channel it is cutting can be seen at the arrow. The diked port area and the undisturbed Redfish Creek mangrove forest (upper right corner) are at the top of the picture.

without permits and the fill left in place instead of being ordered removed. The area is still severely damaged in 1976 and it is unlikely it will ever recover. This blatant disregard for dredge and fill permit procedures has finally led to more recent illegal fills being ordered removed at the expense of the dredger. This kind of enforcement has significantly reduced the incidence of illegal filling in Tampa Bay.

Sherk (1971) has discussed in detail the effects of suspended and deposited sediments on estuarine organisms. These include loss of habitat, decrease in euphotic zone depth, (increased) oxygen demand, nutrient sorption and release, (decreased) primary productivity, benthic community disruption, direct mortality and other gross effects. The reader is referred to this source for more detailed information. Unfortunately, little research has been done on the effects of channel dredging and spoil disposal in Tampa Bay. Complete and permanent destruction of benthic communities and intertidal marshes and mangrove forests is an obvious result (Fig. 3, 4, and 5). Most of the effects discussed by Sherk (1971) are less obvious and little studied. Taylor (1973) describes five sediment groups for Tampa Bay: deep ship channel, soft spoil, firm spoil, soft undredged, and firm undredged. The firm bottoms supported the largest number of individuals and species while the ship channel supported the least. Results from shell dredging

Figure 4. Dredging at Port Manatee, Lower Tampa Bay, June 1970. The channel creation and filling for the port is complete. Excess fill has been placed in the Redfish Creek mangrove forest, totally destroying it, and additional fill can be seen smothering the offshore seagrass meadows. No permits were issued for this work.

research (discussed later) indicate rapid recovery of benthic communities disturbed by small, target specific dredging projects. Some recovery in some older submerged spoil disposal sites is evident from the data of Taylor (1973). How long this took is not known. Recovery of disturbed seagrass meadows is extremely slow after dredging (Godcharles, 1971) or even motor boat prop damage (Zieman, 1976). No complete survey of the area occupied by seagrass meadows in Tampa Bay has ever been made, thus it is impossible to determine at the present time what damage has been done to this valuable habitat. The work of Taylor and Saloman (1968) in Boca Ciega Bay assumed a standing crop of 798 kg/ha (dry weight) of seagrasses over the total fill area of 1, 400 ha, even though some of the filled areas were bare. This was felt to be a reasonable compromise since actual measurements of the area of seagrass meadows lost was probably not feasible.

An additional problem of open water spoil disposal from channel deepening is the possible impedance of normal circulation in Tampa Bay. In a report prepared by the Federal Water Pollution Control Administration on water quality problems in Hillsborough Bay (F.W.P.C.A., 1969) the following recommendation was made:

Figure 5. Port Manatee, Lower Tampa Bay, November 1972. Arrows indicate the extent of smothered seagrass meadows offshore of the filled area that was previously Redfish Creek.

> A master plan for dredging and filling in Hillsborough Bay should be developed by the pertinent federal, state, and local operating and regulatory agencies. Certain spoil islands, resulting from channel dredging, which impair circulation, flushing and exchange in the Bay, should be removed and maintenance spoil dredging material should not be deposited in the Bay.

This recommendation resulted from dye tracer studies in conjunction with studies on the impact of sewage pollution in Hillsborough Bay, where most of the impeded circulation problems were believed to exist. This recommendation was endorsed by the U.S. Army Corps of Engineers (1970) in planning for the Tampa Harbor Deepening Project and a study was undertaken by the U.S. Geological Survey jointly funded by the Tampa Port Authority and the Corps of Engineers. The study included water quality sampling, gathering and analysis of current and tidal data, and use of a hydrodynamic digital computer model of the bay. Goodwin (1976) reports the results of five model runs (historical, existing, and three proposed modifications as part of the Harbor Deepening Project) as follows:

> *Analysis of model results for simulation of channel improve*ment plans tested indicate that significant modification to the existing circulation pattern in Hillsborough Bay is

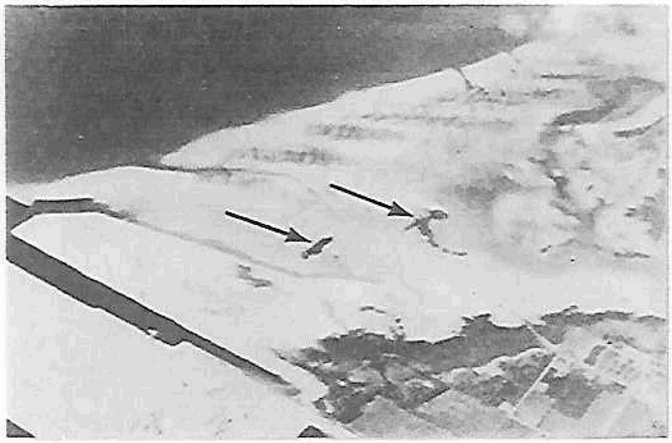

Figure 6. Channel dredging and filling to create Port Redwing in Hillsborough Bay, 1968. The fill site is incompletely diked and silt has spilled out and surrounded two Audubon Society Sanctuary Islands (arrows) and smothered submerged vegetation.

> possible. These analyses indicate that each improvement plan has desirable circulation features, but none provides a significantly improved flushing link between Hillsborough and Tampa Bays. Since little interchange existed between the two bays under natural conditions, the potential for significant circulation improvement is probably small for any spoil-island configuration.

Thus the conclusion that historical patterns of spoil deposition have impeded natural circulation is not supported by the U.S. Geological Survey, and while some improvement in circulation within Hillsborough Bay is possible, improved flushing from this highly industrialized portion of the bay is not felt possible. It should be noted that these conclusions are questioned by some scientists including those involved with a second computer model of the bay in operation at the University of South Florida. Further data gathering during the postdredging phase of the Harbor Deepening Project will hopefully resolve this question. Present plans for the project, which has been started, include dredging of "circulation cuts" through submerged spoil banks to improve internal circulation in Hillsborough Bay (Fig. 8). The entire project is scheduled to be completed in 1982 at a cost of $120 million. A total of 55,000,000 m^3 of material will be dredged to widen and deepen the main

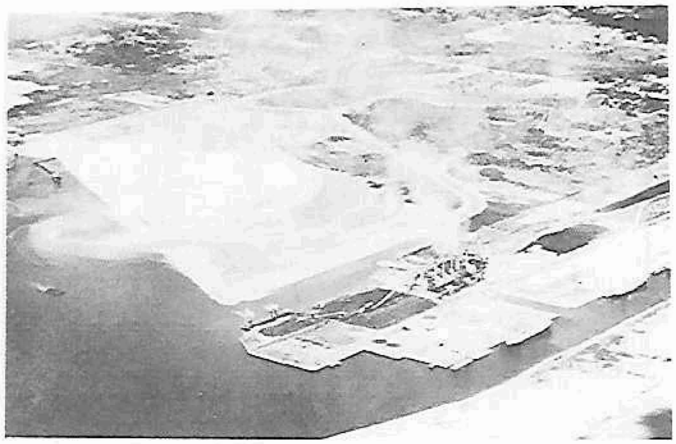

Figure 7. Deepening of East Bay (Upper Hillsborough Bay), September 1967. Material dredged was used to fill in submerged land and mangroves for a phosphate loading port facility.

ship channel from 10 to 13 m (existing depth 34 ft, finished depth 44 ft). There have been a number of revisions to the planned spoil disposal plan due to concern raised by scientists and lay citizens. All the spoil material is planned for open water disposal in the bay and an extensive monitoring program is planned in order to avoid the siltation problems previously seen in this kind of dredging (e.g., Fig. 3). In addition diked disposal areas will be created in Hillsborough Bay in order to contain much of the Harbor Deepening spoil and future maintenance spoil (see following section).

One of the unique features of the spoil disposal plan for Hillsbotough Bay (Fig. 8) is the creation of emergent recreation and wildlife islands. Their design is based on the work of Lewis and Dunstan (1975) on use of spoil islands by colonial seabirds in the Tampa area for nesting. Two islands located at the mouth of the Alafia River in Hillsborough Bay (Fig. 9) support large nesting colonies of seabirds including Brown Pelicans and White Ibis (Fig. 10a). In addition two species previously only occasionally observed in the Tampa Bay area have recently nested on these islands. Paul, Meyerriecks, and Dunstan (1975) report the Reddish Egret, rare in Florida since 1900, nesting on Bird Island in May 1974. The Roseate Spoonbill, last seen nesting in Tampa Bay in 1912, was reported nesting on Bird Island in April 1975 (Dunstan, 1976) (Fig. 10b). Part of the reason for the recent intensive use of these islands lies in the massive alteration to the submerged bottoms and feeding areas surrounding the traditional nesting sites by

TAMPA HARBOR, FLORIDA
MAIN CHANNEL
SECTIONS 4 and 5

PLAN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

TO ACCOMPANY GENERAL DESIGN MEMORANDUM- PHASE II

FEBRUARY 1975 File No: 45-31,940

EMERGENT MAINTENANCE DISPOSAL AREA

RECREATION AND WILDLIFE ISLANDS

CIRCULATION CUT(-15' MLW DEPTH x 1500' WIDE)

Legend for Figure 8.

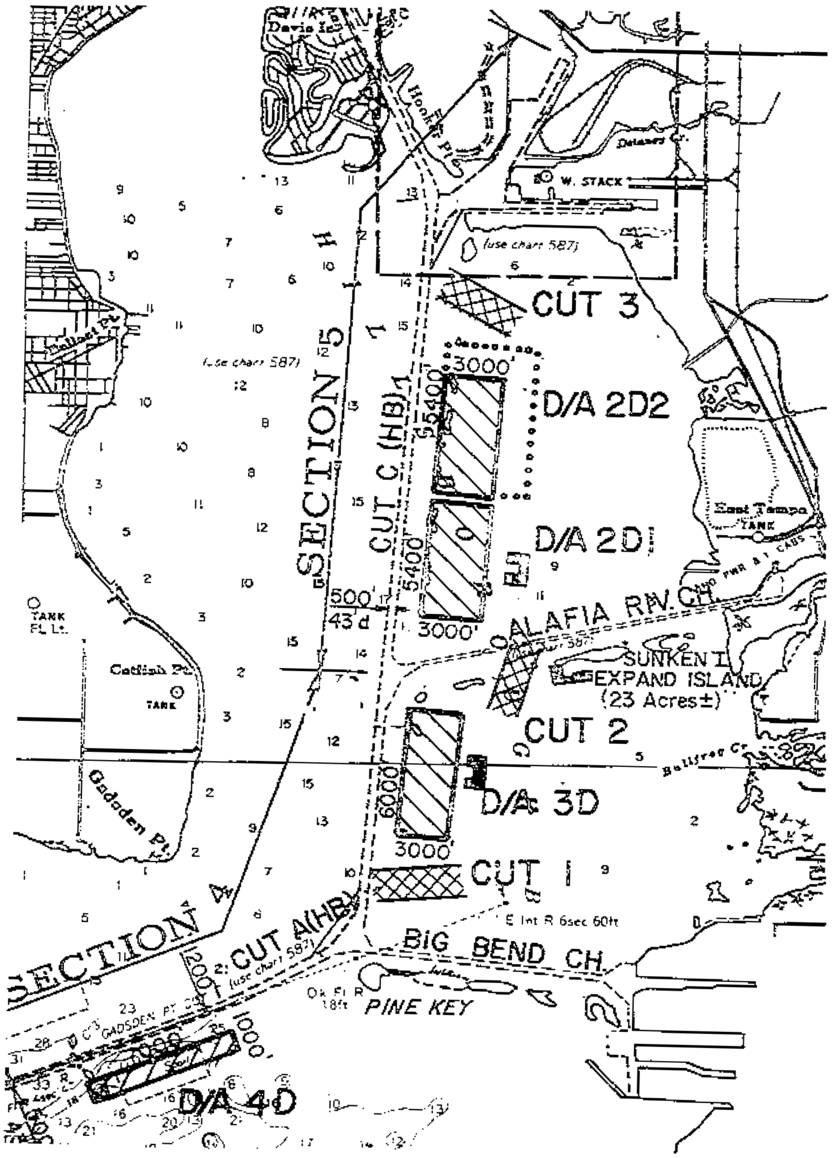

Figure 8. Proposed spoil disposal plan, Hillsborough Bay.

Figure 9. Two spoil islands at the mouth of the Alafia River, Hillsborough Bay. The upper island (Sunken Island) was created in 1961 and the lower island (Bird Island) was created in 1931. Sixteen thousand pairs of birds nest here annually.

dredging in 1966-67 (Fig. 7) and the loss of shoreline habitat to dredging and filling. It is hoped that the creation of islands from dredged material and properly planting them with native vegetation will provide additional habitat for colonial seabirds in Tampa Bay.

Finally it should be noted that the economic impact of channel deepening on the surrounding communities has been enormous. Cargo now being handled at the port is in excess of 42 million tons per year. This is an increase from 3,945,000 tons in 1940 and 25,898,000 tons in 1967. The port is the eighth largest in the nation with principal exports of phosphate and phosphatic products and imports of petroleum products, sulphur, and meats (Corps of Engineers, 1974). It has been estimated that the port provides jobs for some 36,000 wage earners with an annual salary of $210 million. The port is obviously an important part of the local economy and it is hoped that additional channel deepening to maintain the port can be accomplished with much more care and concern for the natural environment.

Maintenance Dredging

Once channels are deepened they must be maintained through dredging. Natural sediment inputs as well as man induced sediment input (e.g., sewage,

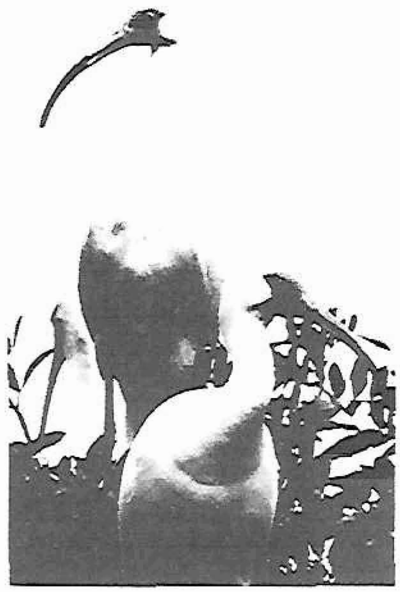

Figure 10a. White Ibis (Endocimus albus) photographed in their nesting colony on Sunken Island, April 1975.

Figure 10b. Roseate Spoonbill (Ajaia ajaja) nesting in a black mangrove tree (Avicennia germinans) on Bird Island, April 29, 1975. (From a slide taken by Helen Cruickshank for the National Audubon Society.)

runoff) gradually fill in these channels. Boyd et al. (1972) estimate the annual quantity of maintenance dredged material in the United States is 229 million m^3 as opposed to 61 million m^3 in new dredging. Historically large channel maintenance projects in Tampa Bay have been done with hydraulic dredges and open water disposal in spoil areas in the bay. Smaller berth maintenance projects were done with clamshell dredges mounted on a barge, again with open water disposal (Fig. 11). Recent concerns about water quality degradation from open water spoil disposal, particularly of contaminated spoil, led to the complete halt of open water spoiling in Tampa Bay at the end of 1973. Since then all maintenance dredging projects have been required to provide diked upland disposal areas (Fig. 12). The effectiveness of this requirement in reducing "pollution" from the maintenance material is widely argued (see U.S. Army Corps of Engineers, 1976, for update and list of available Dredged Material Research Program reports). The use of these upland disposal sites has increased the cost of maintenance dredging from \$1-2/m^3 to \$3-5/m^3 (Guy N. Verger, personal communication). In addition upland sites are scarce and valuable upland habitat or farmland may be permanently destroyed. Salt water intrusion into fresh water aquifers has also been a problem in the Tampa area. One problem solved by this procedure is the reduction in erosion of spoil back into the same channel from which it was dredged. The Corps of Engineers has decided that the long term solution to the problem is the creation of large (1.6 km x 0.8 km) emergent diked disposal areas within Hillsborough Bay as part of the Tampa Harbor Deepening Project (Fig. 8).

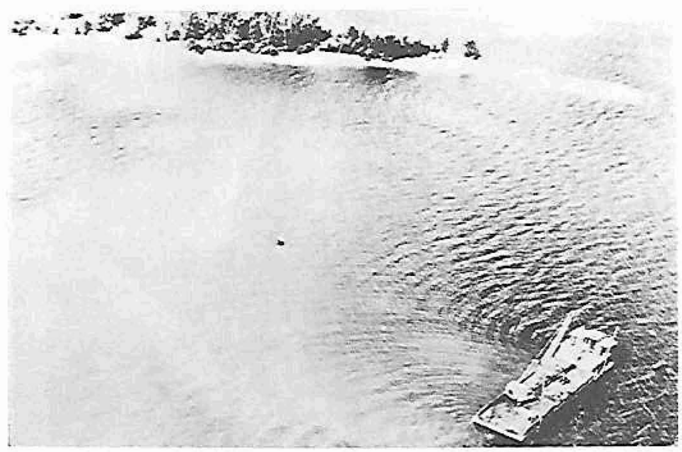

Figure 11. Open water disposal of maintenance spoil from berths in Hillsborough Bay into submerged spoil area behind an existing spoil island, December 1973.

Figure 12. Diked upland disposal site for maintenance dredged material at Port Manatee, October 1976.

Maintenance dredged material will be hydraulically pumped into these diked areas and they are planned to hold the amounts of material to be generated over the next 30 years. The long term containment of much of the contaminated spoil in the upper harbor (due to sewage discharged from the City of Tampa sewer plant - 40 MGD - presently only primary treatment) is expected to improve the long term water quality picture for Hillsborough Bay. Whether this will offset the loss of benthic habitat due to the creation of the disposal sites is impossible to determine at this time.

Shell Dredging

The dredge mining of dead oyster shell from Tampa Bay has taken place since 1946. Nearly 18 million tons of shell has been removed since operations first began (Taylor, 1972). The process involves removal of the shell and associated sediment by hydraulic cutterhead dredge, sorting over screens, and return of water and fines to the bay (Fig. 13). The silt plume associated with this unused material has been of major concern to regulatory agencies and the boating public. In addition concern has been raised about the destruction of benthic organisms and the long term modification of the biological communities in the dredged areas.

A recently completed long term effects study (Simon, Doyle, and Connors, 1976) has reached the following conclusions:

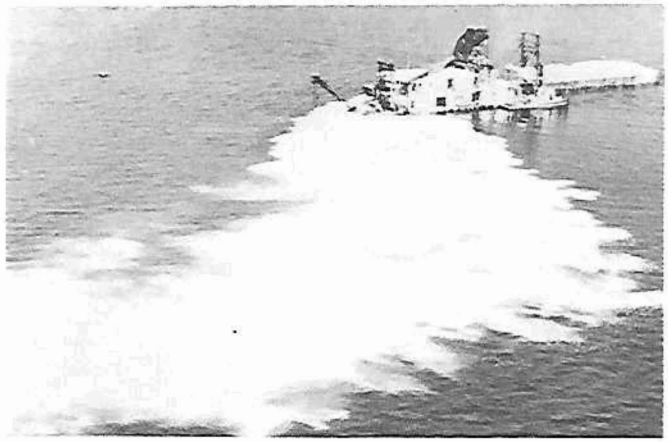

Figure 13. Shell dredging in Hillsborough Bay, October 1972.

1. Total suspended load within the plume raised by shell dredging ranged from about 20 mg/l to over 50 mg/l, close to background to about one and one half times ambient.

2. Light penetration within the dredge plume varied from 100% transmission to a low of about 10% transmission over a 1 meter light path. Most measurements within the plume were over 80% transmission. Both suspended load and percent transmission indicated that the highest suspended loads usually occurred near the bottom.

3. Biologically, the area disturbed by shell dredging returned to the same species assemblage, had the same number of species, the same density patterns, and the same or slightly lower biomass than undisturbed bay bottom within less than 12 months.

As noted by the authors their results are very similar to those of previous workers in Tampa Bay on shorter term studies and to those of researchers in San Antonio Bay and Mobile Bay. In relation to other dredging in the bay, however, the report cautions:

> ...it must not be assumed that the massive Corps of Engineers project to deepen the Tampa Harbor shipping channels can in any way be compared to the effects of a small, tightly controlled, target specific shell dredging operation. Large amounts of fine material which may be thrown up by several large dredges operating simultaneously could have a serious sedimentation impact on portions of Tampa Bay.

The remaining estimated 15 million tons of shell is presently being mined under strict supervision by state and federal agencies.

Dredging for Landfill

McNulty, Lindall and Sykes (1972) calculated that in 1967 filled areas (including spoil islands, causeways, housing and industrial fill) in the Tampa Bay Estuary totaled 4,266 ha. Nearly all of this was created through dredging submerged or intertidal bay bottom and pumping the spoil into emergent land sites, creating land where there were once mangroves, tidal marshes, or seagrasses. Taylor and Saloman (1968) report the expected impact of the filling of 1,400 ha of bay bottom in Boca Ciega Bay that has occured since 1950 and reduced the total area of the bay by 20%. Their minimum estimates of annual loss of biological resources are 25,841 metric tons of infauna. This represents an annual loss of about $1.4 million. Passavant and Jefferson (1976) have recently rechecked the estimates of filled areas in Boca Ciega Bay and revised the total figure upward to 2,200 ha including some fill on emergent land that was covered and enlarged by dredge materials.

The characteristic "finger fill" type development of Boca Ciega Bay (Fig. 14) and elsewhere in Tampa Bay (Fig. 15) permanently destroys the benthic community and associated vegetation in the fill site and creates a dead end canal system that supports much fewer marine organisms (Sykes and Hall, 1970).

Hillsborough Bay has been greatly modified by dredging, primarily for industrial sites and port facilities, as can be seen in comparing Figures 16 and 17. Figure 16 is redrawn from Coast Chart 177 dated 1879, and shows the existing marine wetlands at that time, 2,378 ha. Figure 17 is redrawn from National Ocean Survey Chart 11412 (1975) and shows 400 ha of wetlands remaining. This represents a total loss of 83.2%. For Tampa Bay as a whole our research indicates a total loss of 44%, from 10,050 ha in 1876 to 5,630 ha in 1976.

What effect has this massive alteration to Hillsborough Bay had? Taylor, Hall, and Saloman (1970) report on the results of sampling for mollusks in Hillsborough Bay in 1963. Their analysis of benthic mollusks and sediments at 45 stations revealed no mollusks at 19 stations, one or more of the four predominant species at 18 stations, and numerous

Figure 14. Boca Ciega Bay, September 1976.

Figure 15. The Apollo Beach dredge and fill project in Upper Tampa Bay, August 1969.

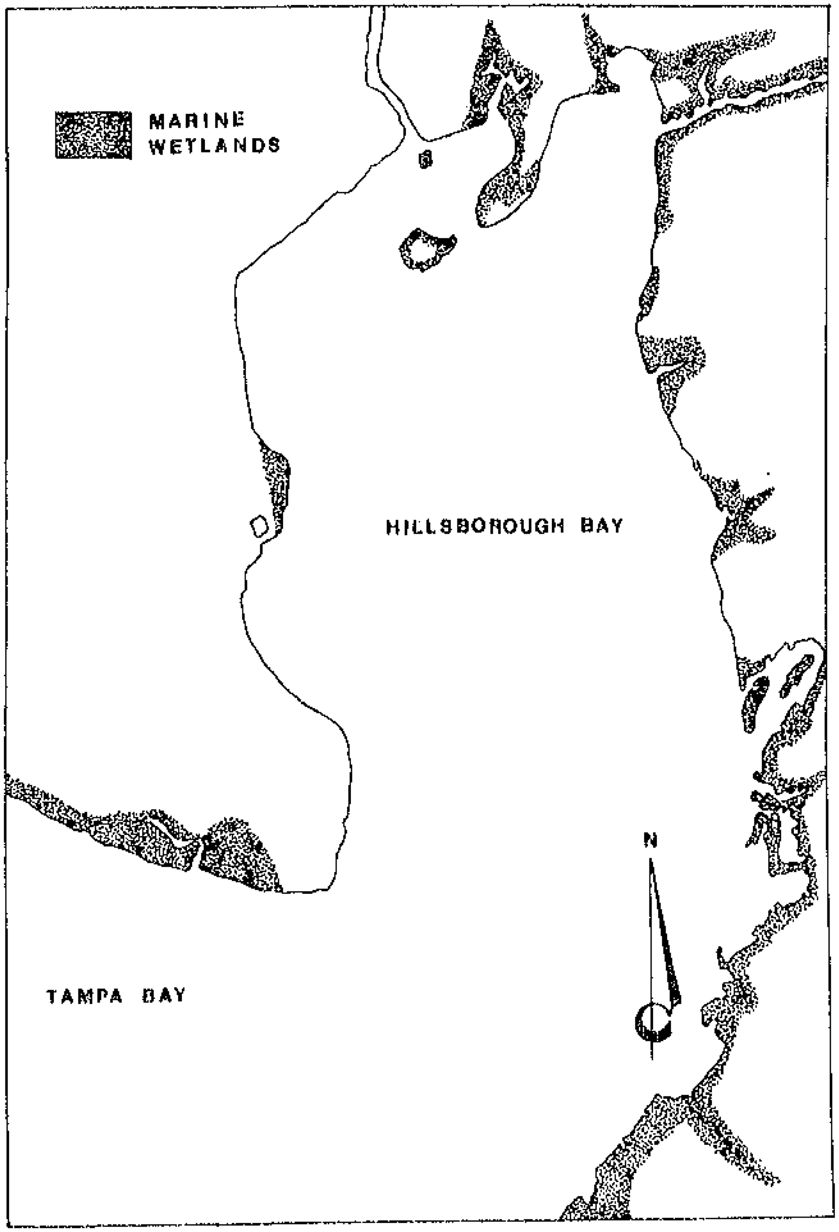

Figure 16. Hillsborough Bay and associated wetlands (2,378 ha) 1876.

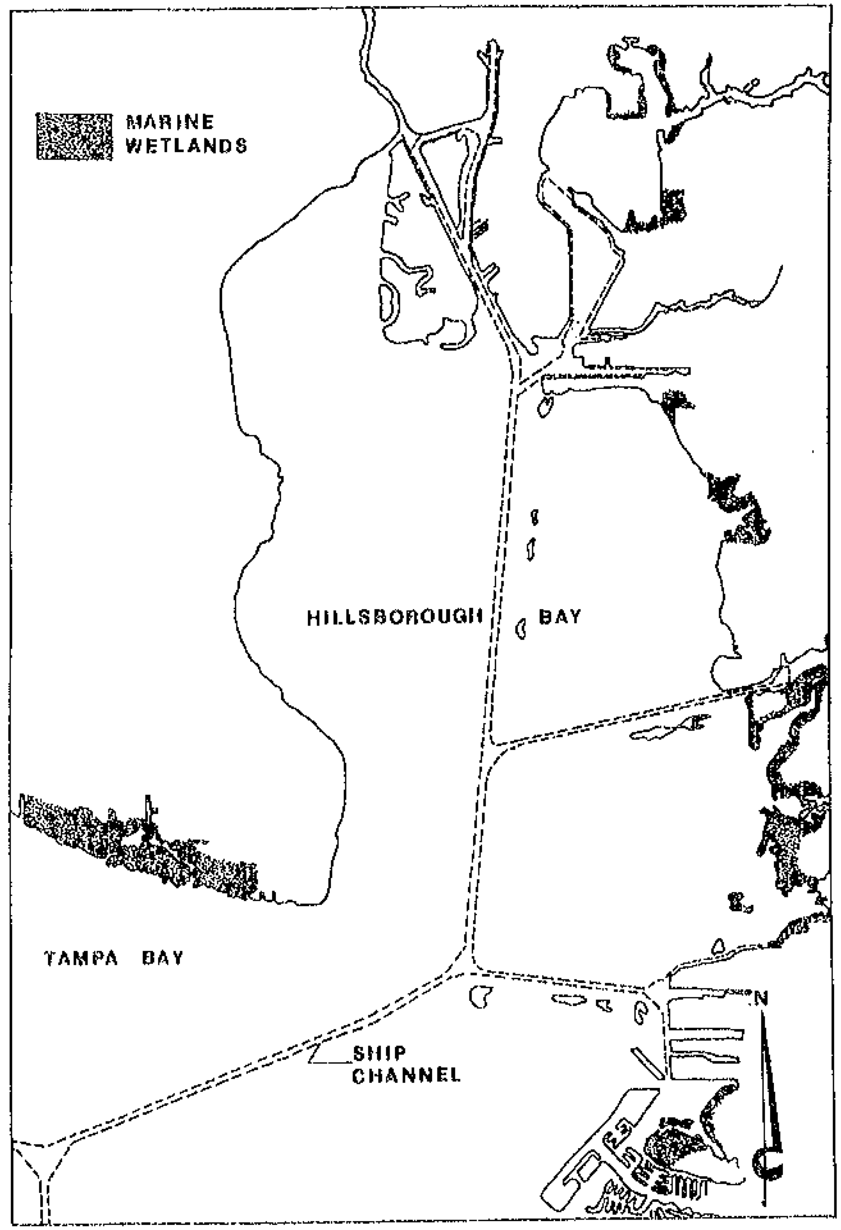

Figure 17. Hillsborough Bay and associated wetlands (400 ha) 1976.

species and large numbers of individuals at only 8 stations. From this information they concluded that 42% of the bay bottom was unhealthy, 36% marginal, and 22% healthy. Since 1963 six of the eight healthy stations have experienced large scale dredging impacts including channel deepening, spoil deposition, and filling of adjacent wetlands. As noted before the work of Sykes and Finucane (1966) has shown that Hillsborough Bay supports much fewer of the commercially important species than any other area of Tampa Bay. It should be pointed out that in addition to dredging sewage pollution has had a significant impact on Hillsborough Bay. Of the estimated 101 MGD of sewage entering Tampa Bay, 47% flows into Hillsborough Bay, most of it poorly treated. A new advanced waste treatment facility is scheduled for completion at Hookers Point (in Hillsborough Bay) in 1977 and will hopefully assist the recovery of this portion of the bay. It is during this same year that the major impact of the Hillsborough Bay portion of the Tampa Harbor Deepening Project (Fig. 8) will begin, and many scientists justifiably wonder how much more Hillsborough Bay can take.

As a result of the loss of wetland habitat and continued pollution in Tampa Bay commercial harvests of marine finfish and shellfish have declined. The figures in Table 1 show the commercial landings and value of Florida Gulf Coast fisheries (Taylor, Feigenbaum, and Stursa, 1973; Florida Department of Natural Resources, 1971; 1972). Although definite conclusions cannot be drawn from these figures there are certain trends that are disturbing. With increasing population and demand for seafood products the available fisheries appear to be declining. Their value at dockside to the fisherman will continue to increase, and so the price to the consumer. The general increase in environmental awareness and the obvious increase in the cost of marine products and their declining numbers convinced commercial fishermen, sports fishermen, and consumer that something had to be done. The result has been increased opposition to the issuance of dredge and fill permits, particularly for projects where water access was not absolutely essential. The recent denial of the Marco Island dredge and fill permit for most of the remainder of the controversial project saved over 80 km of mangrove shoreline from destruction, and represented a turning point for this kind of project. It is unlikely that any further massive dredge and fill such as has occurred in Boca Ciega Bay and Hillsborough Bay will ever be permitted again. With increased attempts to clean up other sources of pollution in estuaries like Tampa Bay it is certainly possible that the decline in catches shown in Table 1 will reverse, although the losses may be so great that catches of 135 million pounds (1960, 1965) may never occur again.

Table 1. Florida Gulf Coast Commercial Marine Landings and Value

YEAR	CATCH (1,000's of lbs)	VALUE ($1,000's)
1950	62,013	9,995
1951	88,271	15,414
1952	101,135	19,254
1953	108,027	25,372
1954	97,521	19,815
1955	105,756	21,190
1956	107,594	24,582
1957	109,275	24,205
1958	126,585	24,258
1959	131,887	18,191
1960	135,535	21,048
1961	125,379	20,303
1962	119,607	24,921
1963	124,683	22,477
1964	129,659	24,165
1965	135,866	26,866
1966	125,975	24,984
1967	114,408	23,118
1968	119,293	27,809
1969	116,500	29,500
1970	116,470	31,222
1971	107,485	31,187
1972	108,201	38,622

lb x 0.453 = kg

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