PHYSICAL IMPACTS TO HABITATS IN TAMPA BAY

FINAL REPORT

MAY 1994
PHYSICAL IMPACTS TO HABITATS IN TAMPA BAY

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ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

The objective of this project was to identify, quantify, and map the physical impacts to the habitats of the Tampa Bay estuary. Many human activities have reduced or degraded a variety of bay habitats. The activities causing physical impacts include dredging of navigational channels, marinas and port facilities; dredge spoil disposal; filling of bay bottom for urban development; and the construction of seawalls and finger canals. As in other shallow estuaries that are heavily used by both commercial and recreational boaters, habitat damage due to prop scarring has occurred.

The Tampa Bay National Estuary Program (TBNEP) is defining management targets for the restoration, protection and enhancement of bottom habitat, and the physical impacts mapped in this project are a key component of the target setting process. The physically impacted areas were related to current and historical resource distributions using a geographic information system (GIS), and areas which were deemed nonrestorable or potentially restorable have been identified.

About 50% of the existing shoreline is modified. In some areas, such as Boca Ciega Bay, as much as 73% of the shoreline is modified. Besides the direct loss of habitat due to shoreline modification, indirect effects may also be important. Much of the original benefits of the non-hardened shoreline such as shoreline stabilization, reduction of suspended solids loads, and diverse estuarine habitats have been lost.

Much of the original mangrove shorelines and shallow seagrass beds of Tampa Bay have been filled for residential and commercial development. Over 13,000 acres have been filled since the early 1900’s, and nearly all (91%) of these filled areas are in the shallow shelf portion of the Bay. With the exception of the causeways and several fill islands, the majority of these filled areas (approximately 12,000 acres) have occurred in shallow waters which formerly supported seagrass beds. An estimate of approximately half of these filled areas exist adjacent to areas which continue to support seagrass today.

Navigational channels for commercial shipping activities were constructed primarily in the naturally deeper areas of the bay. Of the estimated 14,381 acres of channel and spoil areas, 87% have been constructed in the deep portions of the study area where it is likely that seagrasses never occurred. The principal channels extend along a naturally occurring trough extending from the bay mouth to both Old Tampa and Hillsborough bays.

An aerial survey was conducted to estimate the levels of prop scar damage in various areas of the bay. The results from this survey, conducted in early March 1992 indicate that the greatest degree of prop scar damage exists in Mullet Key and the Fort DeSoto Park area, Bishop Harbor, Weedon Island, and the northeastern portion of Old Tampa Bay near Double Branch and Rocky creeks. No estimate of the prop scar damage within Cockroach Bay was made. Approximately 35% of the total seagrass area in Tampa Bay falls within the heavy damage and moderately heavy damage categories. More than 40% of the seagrass areas were estimated to fall within the areas categorized as having sparse or no scar damage.
1. INTRODUCTION

1.1 BACKGROUND

This report quantifies and maps the physical impacts which have occurred within the Tampa Bay Estuary. Many anthropogenic activities have reduced or degraded a variety of habitats in estuarine ecosystems such as Tampa Bay. Land use alterations, discharge of domestic and industrial wastes, and agricultural runoff are some of the activities that have received a great deal of attention recently. Other activities have a more direct effect on habitat extent and quality. Notably, these activities include dredging and associated fill operations and shoreline modification. In Tampa Bay, as in other shallow estuaries that are heavily used by both commercial and recreational boaters, damage due to prop scarring can also significantly impact bottom habitats.

As urban development continues, the need for continued maintenance of existing channels and, in some cases the need for new channels, also continues. Maintenance dredging and dredge spoil disposal repeatedly impact bottom habitat in and around the channel. While the direct impacts of these activities are readily apparent, secondary impacts can also be significant. For example, altered circulation patterns, increased turbidity, and release of potentially toxic materials, can all be significant secondary impacts due to dredge and spoils operations.

Shoreline modification due to increased urbanization typically involves disruption of the shallow and intertidal habitats, including areas covered by submerged vegetation. There is also typically a loss of such intertidal habitats as marshes and mangroves associated with shoreline modification. Increased shoreline erosion can be one significant secondary impact due to shoreline modification.

The physical and biological impacts of dredging, spoil disposal, and shoreline modification have been the subject of earlier studies in Tampa Bay. Goodwin (1984) conducted an in-depth investigation of the impacts of dredge and fill operations on tidal flow, circulation, and flushing in Tampa Bay. He estimated that the surface area of Tampa Bay has been reduced by 3.6% due to dredge and fill activities. These losses were due to causeway construction, residential and commercial development, and port development. In addition to the direct loss of habitat, impacts caused by physical alterations to Tampa Bay include a decreased tidal prism and increased volume and depth in Hillsborough Bay, large changes in net circulation in both Hillsborough Bay and Old Tampa Bay, and increased landward and seaward exchange caused by tidal flushing. As pointed out by Lewis and Estevez (1988), changes in circulation and flushing can have severe impacts, especially in areas such as Hillsborough Bay where discharges of municipal and domestic wastes are concentrated.
Lewis (1977) examined the effects of dredging in Tampa Bay during the period of 1876 through 1976. He estimated that 44% of the marsh and mangrove habitat have been lost due to filling and excavation. He also hypothesized that much of the loss of seagrasses in Tampa Bay has resulted from direct excavation, burial, and decreased water clarity caused by physical alterations of Tampa Bay.

Fehring (1985) reported on the history of port development in Tampa Bay. He followed the changes due to dredging and spoil disposal since 1879 and provides a map showing the areas dredged or filled for port development over the past 100 years. Tiffany and Wilkinson (1989) also reported port development in Tampa Bay. They also discussed the potential environmental problems associated with port development and operation.

1.2 OBJECTIVES

The Tampa Bay National Estuary Program (TBNEP) will be developing a Comprehensive Conservation and Management Plan (CCMP) in which plans for the restoration, protection, and enhancement of critical living resources will be recommended. The Living Resources Subcommittee of the TBNEP Technical Advisory Committee held two workshops in the Fall of 1992 to identify a list of living resources to be targeted by this effort. In October of 1992, the TBNEP Management Committee agreed upon the following targeted living resources:

- Seagrass (bay) and submerged aquatic vegetation (tributaries);
- Salt marshes;
- Mangroves;
- Non-seagrass subtidal and intertidal benthic habitats;
- Pelagic.

Living resource restoration and protection targets will be established using data on the current and historical distributions of these resources, as well as the extent of permanently altered areas within Tampa Bay.

The objective of this project was to develop a GIS data base on these physically altered areas. Mapping the extent of physical impacts in the Bay will provide a key input to the development of living resource targets in a subsequent TBNEP project. These impacts will be related to the current and historical resource distributions using geographic information system (GIS) analyses. From these analyses, areas which are deemed nonrestorable or potentially restorable will be identified.
2. METHODS

The general approach to this project was to delineate the specific targeted living resources of Tampa Bay related to benthic habitats, and to compute baseline estimates of the anthropogenic physical impacts which have occurred within these areas. The specific data needs of the Tampa Bay National Estuary Program (TBNEP) guided the methods to be used for this study. In particular, this project provided GIS data layers of benthic characteristics, bathymetry, seagrass distribution, and physically altered habitats. The following text describes the methods used to classify these habitat characteristics and delineate the physical impacts to the bay.

2.1 STUDY AREA

The area of interest for this project is presented in Figure 1. For scientific and management purposes, Tampa Bay can be divided into seven geographic segments (Figure 2). These segments are based on those developed by Lewis and Whitman (1985), and vary in terms of surface water hydrology, salinity regime, habitat distribution, living resources, and patterns of anthropogenic impacts.

2.2 HABITAT

A classification scheme was developed to classify benthic habitats into several groups based on mapped characteristics of Tampa Bay. Since fine grain (muddy) sediments may be associated with accumulation of contaminants and are particularly susceptible to resuspension, sediment grain size was added to the classification scheme. Each individual habitat characteristic was mapped at a segment-wide scale using the same map projection, distance units, and horizontal datum. Classification was based on depth (deep vs. shallow), sediment texture (fine vs. coarse), and the presence or absence of seagrass. Bottom salinity regimes were observed to follow the seven bay segment delineations shown in Figure 2. Therefore, bay segment was included as a component of the benthic habitat classification scheme. The habitat classification layers were then combined using GIS techniques.
STUDY AREA LOCATION
Tampa Bay National Estuary Program, Physical Impacts Study

Figure 1. Map of study area location.
Figure 2. Tampa Bay segments.
An ongoing project is being conducted by the TBNEP to identify and map the distribution of submerged aquatic vegetation (SAV) within the estuarine portions of the tributaries to Tampa Bay. Hence, the results of the SAV study were not included in this physical impacts report. Preliminary results of a literature and common knowledge survey conducted for the SAV study indicate that the distribution of SAV within Tampa Bay tributaries is very limited.

Consideration was also given to inclusion of live bottom habitat within the benthic habitat classification scheme. These habitats support a diverse community of organisms such as sea fans, sea whips, hydroids, sponges, and corals, and they are usually associated with hard substrates. A general pattern of distribution of this habitat within the Bay is presented by Derrenbacker and Lewis (1982). Discussions with the TBNEP and its advisors in the Fall of 1991 resulted in the exclusion of this habitat from the present classification scheme. This was an attempt to avoid disclosure of more specific locations of this very sensitive habitat. The TBNEP, based on input from its Technical Advisory Committee in March of 1992 has since funded a separate task to map these areas under another project. The location of live bottom habitat will be included in the draft CCMP.

The methods used to delineate each component of the habitat classification scheme are discussed in the following text.

2.2.1 Salinity

Bottom salinity was delineated as the first component of the habitat classification scheme. The Environmental Protection Commission of Hillsborough County and the Pinellas County Department of Environmental Management record monthly salinity data at a network of fixed stations within the bay and its watershed (EPCHC 1991, PCDEM 1991). Hillsborough County bottom salinity data from 55 bay stations (1986 to 1990), and Pinellas County bottom salinity data from 11 bay stations (1990-1991) were used for this analysis.

The distribution of bottom salinity was computed for each station. These data indicate that the 7 bay segments (Figure 2) provide a suitable framework for classifying salinity regimes for this analysis. An interpolated pattern for the fifth percentile, median, and ninety-fifth percentile of bottom salinity for the Bay is presented in Figures 3a, 3b, and 3c. Tide and wind actions cause Tampa Bay to be a well mixed estuary, and differences in salinity between surface and bottom waters is minimal in most areas (Goodwin, 1987). However, since this study examines primarily benthic habitat, bottom salinities were used exclusively.
Figure 3a. Interpolated distribution of the 5th percentile of bottom salinity.
Figure 3b. Interpolated distribution of median bottom salinity.
Figure 3c. Interpolated distribution of the ninety-fifth percentile of bottom salinity.
2.2.2 Bathymetry

A bathymetric model was developed as the next component of the habitat classification scheme. Mean lower low water depth was interpolated from point soundings and an existing shoreline data set of the Bay.

A data set of digital hydrographic soundings was obtained from the National Oceanographic and Atmospheric Administration for 357,130 points within the Tampa Bay vicinity (NOAA, 1993). These mean low water data were recorded in a comprehensive survey during 1947 to 1958, and were corrected for tide or water level, vessel draft, and sound velocity. A subset of these data are represented as soundings and bathymetry contours on the current NOAA navigational charts (NOAA 1991). The vertical datum for these data was the Gulf Coast low water datum, and the horizontal datum was the NAD 1927 datum.

The digital shoreline GIS data for the bay was obtained from the 1990 seagrass survey conducted by the Southwest Florida Water Management District (SWFWMD, 1990). This shoreline is the official shoreline for the TBNP. These data were photo-interpreted from 1:24,000 scale color photographs made in December of 1990.

Using Triangular Irregular Network (TIN) interpolation software (Arc Info, 1993), the point soundings and the shoreline delineation were used to interpolate a bathymetric model of the Bay at a horizontal resolution of 25 meters and a vertical resolution of 0.5 meters. This model was carefully visually compared to the bathymetric contours presented on the 1991 navigational charts (NOAA 1991). An area east of and adjacent to Cat’s Point in Boca Ciega Bay was updated with the 1991 information. A summary of the completed bathymetric model is presented in Figure 4.

Two depth classes were selected from the bathymetric model. These classes were shallow areas less than or equal to 2 meters, and deep areas greater than 2 meters. This depth break point was chosen because seagrasses typically occur at depths less than 2 meters in Tampa Bay (Lewis et al., 1985).

2.2.3 Sediment Texture

Bottom sediment texture classes were delineated as the next component of the habitat classification scheme. Bay bottom sediment texture data were digitized from values reported in a literature review conducted by Doyle and others
TAMPA BAY BATHYMETRY
Data Source: NOAA, Digital Hydrographic Data

Figure 4. Tampa Bay bathymetry. Data Sources: NOAA Soundings, SWFWMD 1990 Shoreline.
(Doyle et al., 1989). These data included relatively recent observations, and observations from an extensive survey conducted in the 1960's (Taylor et al., 1969). The station locations for these data are presented in Figure 5. A GIS data layer was developed by interpolating these data and by considering local depth conditions. Bottom texture data mapped by a recent survey conducted by the City of Tampa (Johansson and Squires, 1989) were used as the data source for Hillsborough Bay because of its greater spatial resolution and overall level of precision.

Two sediment texture classes were selected from the interpolated data. These classes were coarse grained areas with less than 50 percent of sediment smaller than 63μm grain size, and fine grained areas with more than 50 percent of sediment smaller than 63μm grain size. The grain size break was selected in order to classify fine grain (muddy) sediments in a manner consistent with the methods of the Johansson and Squires (1989) data set. Such fine grain sediments may be associated with accumulation of contaminants and are particularly susceptible to resuspension.

2.2.4 Seagrass

Existing seagrass meadow distribution data were compiled as the final component of the habitat classification scheme. The data were obtained in a GIS format from the 1990 Seagrass Survey conducted by the Southwest Florida Water Management District (SWFWMD, 1990). These data were photo-interpreted from 1:24,000 scale color photographs made in December 1990. Two categories of seagrass coverage (continuous and patchy) were combined into a single seagrass presence coverage.

2.3 PHYSICAL IMPACTS

Physical impact data sets for channels, spoil and borrow areas, filled areas, modified shorelines, and seagrass bed prop scar intensity were developed for this project. Each physical impact type was compiled into a GIS data set in order to quantify the extent of impacted habitat and to provide data sets of physically altered habitat for the future setting of living resource protection and restoration goals.
Figure 5. Distribution of sediment sampling sites.
Existing navigational channels, designated dredge spoil areas, and borrow areas were
delineated from 1991 NOAA 1:40,000 scale navigational charts. A set of historical
maps including USGS 1:24,000 quadrangles (1950 and present) and NOAA
navigational charts were obtained from the National Archives in Washington, D.C. and
examined. The navigational charts covered the following years and scales:

- 1877  1:40,000 scale (southern Tampa Bay only);
- 1926  1:40,000 scale (southern Tampa Bay only);
- 1928  1:40,000 scale;
- 1930  1:80,000 scale;
- 1950  1:40,000 scale;
- 1951  1:80,000 scale;
- 1961  1:80,000 scale;
- 1970  1:80,000 scale.

Information from these sources was used to interpret and delineate areas of Tampa
Bay which have been filled and shorelines which have been modified. The historical
materials were arranged in chronological order, and the patterns of development and
physical impacts to bay habitat classes through the decades were examined. The
impacted areas were then delineated on the shoreline from the SFWFMD 1990
seagrass survey. This shoreline, as stated previously, is the official shoreline specified
for use on all TBNEP projects.

The physical impacts GIS data layers were overlaid on the benthic habitat
classification scheme. The results of this procedure were mapped and tabulated on
a baywide and bay segment basis. The impacts due to the construction of major
shipping channels were developed using the methods described above. The more
local impacts of seawalls, smaller channels, and boat basins were assessed by
examining the relationship between percentage of seagrass coverage and distance
from modified and unmodified shorelines. To accomplish this analysis, the mapped
benthic data was used to compute percentages of seagrass coverage for areas
between 0 to 100, 100 to 200, 200 to 300, and 400 to 500 meters of modified and
unmodified shorelines.

2.4 SEAGRASS BED PROP SCAR INTENSITY

At the time of initiation of this study, data concerning the intensity of prop scar
damage to seagrass beds in Tampa Bay were primarily anecdotal and limited in their
geographic extent. To fill this data gap, aerial surveys were conducted by the TBNEP
to provide estimates of the relative degree of prop scar damage in areas throughout
the bay. A synoptic survey was conducted on March 6, 1992 from a fixed wing aircraft flying at a height of 500 feet over water and 1000 feet over land. These low altitudes and relatively clear water conditions on this day enabled an accurate qualitative assessment of the intensity of seagrass prop scars.

The areas with different amounts of prop scar damage were digitized and overlaid on the SWFWMD 1990 seagrass coverage. Values of prop scar intensity were then assigned to each seagrass area delineated by SWFWMD, and the extent of scar damage was quantified.

A lack of boat traffic data was a second data gap. Two aerial surveys were conducted by the TBNEP to estimate the relative intensity of boat traffic in different portions of the bay. The two surveys were conducted on Saturday, May 9 and Sunday, May 10 of 1992 from a fixed wing aircraft flying at an altitude of 500 feet over water and 1000 feet over land. The surveys were conducted between 1100 and 1300 hours at slack before ebb tide. These times were expected to have high levels of recreational boating activity in seagrass bed areas. During each flight around the periphery of the bay, two observers counted recreational boats in the seagrass bed areas, and a single observer counted recreational boats in the mid bay area. Boat positions were recorded to within approximately 0.25 miles of true position. Boats at port in marinas and boat basins were not counted.

The boat traffic data were digitized and overlaid with the prop scar intensity data to examine the relationship of relative boating intensity to scar intensity. The results of these analyses are summarized in this report.
3.0 RESULTS

3.1 BENTHIC HABITAT CLASSIFICATION

A scheme was developed to classify and delineate selected benthic habitats of Tampa Bay. Classification was based on depth (deep vs. shallow), sediment texture (fine vs. coarse), the presence or absence of seagrass, and salinity regime (seven bay segments). Maps and tabulated results are presented for each habitat class. Approximately 240,000 acres of benthic habitats are distributed within Tampa Bay, and Figure 6 presents the results of the classification of this habitat. Table 1 presents a tabulation of the areal extent of each habitat class.

The general pattern of distribution of habitat classes is comprised of a relatively deep, high energy, central basin of coarse grained sediments with localized areas of fine grained sediments adjacent to the freshwater inputs of the Hillsborough Bay (Johansson and Squires, 1989) and Old Tampa Bay drainage basins. Several large areas of fine grain sediments in the deeper portions of Middle Tampa Bay are presented in Figure 6. These areas resulted from the interpolation of several groups of fine grained samples (Figure 5) reported by Doyle and colleagues (Doyle et al, 1989). It is likely that the actual extent of fine grain sediments within these areas is far less, and according to Brooks and Doyle (1991) may exist in localized bathymetric depressions. Figure 5 indicates that the sampling transect for which these fine grained samples were observed may have coincided with the East to West orientation of the deep areas containing the Cut G and Gadsden Point Cut channels (Figure 4).

The general pattern of distribution of benthic habitat classes for the shallow periphery of the Bay is comprised of a shelf of varying width surrounding the deeper basin. Seagrasses once covered most of this shelf. Table 1 indicates that approximately 400 acres of seagrass were located in areas classified as deeper than 2 meters. This estimate represents the sum of many smaller areas in the lower portion of Tampa and Boca Ciega Bays where seagrasses exist in the vicinity of the 2 meter depth contour. Given the resolution of these data and the shifting nature of the sediments in this area, the precision of the estimates in these extreme areas is likely to be relatively low.

The distribution of seagrasses has declined throughout the bay. Figures 7 and 8 present the change in seagrass coverage from the 1950's to present, and they were prepared as part of an ongoing TBNEP project to set goals for the restoration and protection of seagrass meadows in Tampa Bay. The overall decline in seagrass coverage is particularly evident in the northern areas of the bay (e.g. Old Tampa and Hillsborough bays). Recent reviews of the seagrass loss trend are presented in Lewis et al (1991) and Haddad (1989).
Figures 9 through 14 present more detailed views of the benthic habitat classes for each bay segment, and corresponding tabulated results are presented by acres and percent coverage in Tables 2 through 15. The least detailed of these data are the sediment data in areas other than Hillsborough Bay. Some of the mapped areas of fine sediments were the result of a relatively small number of fine grained point samples which influenced the interpolation of data in the adjacent areas. The depth data are relatively more detailed, but localized inaccuracies may result due to the shifting nature of the sediments and recent anthropogenic activities. The most detailed and most recent of the habitat class data are the seagrass data from the SWFWMD 1990 photo-interpretation.

A bay-wide qualitative survey of the benthic macroinvertebrates occurring in Tampa Bay was conducted in the 1960’s, and the results of this survey were compiled by Hall and Saloman (1975). The collection methods for this survey included two qualitative sampling devices (1 meter dredge and shovels) which were used in conjunction with a 0.701 mm mesh sieve to collect and separate the organisms from the sediment. Several of the more predominant species encountered during this effort are presented in Figures 15 through 30. The presence or absence of each species is labeled for the location of each sample.

Many surveys of benthos have been conducted in various locations throughout Tampa Bay, and some such as Taylor (1971) were synoptic in nature. The Hall and Saloman survey, however, represents a single source, intensive sampling effort, conducted on a baywide scale. The sampling effort of this survey was focused primarily on soft bottom habitats, and hence, organisms associated with oyster bars, mangroves, and live bottom areas are not emphasized. The geographic presence or absence of species presented by these results indicates the broad scale distribution of organisms which existed following the occurrence of major physical impacts to the bay in the years prior to the 1960’s. An ongoing synoptic survey will be completed by the TBNEP in 1994, and the results will provide more current bay-wide benthic information.

The typical patterns of estuarine macroinvertebrate distribution can be seen in these plots. The distributions range from that of the relatively persistent polychaete worm Paraprinospius pinnata which occurs in most of the habitats of the bay (Figure 22) to those of the opportunists such as the polychaete worms Streblogia benedicti and Capitella capitata (Leverone et al., 1991) which occur primarily in disturbed areas such as Boca Ciega and Hillsborough bays.

Other taxonomic groups, such as Ophiophragmus echinoderm species, and the cephalochordate Branchiostoma caribaeum appear to be distributed along gradients of environmental conditions such as salinity, depth, and water quality (Figures 29 and 30). In addition to being indicators of habitat conditions, many of these organisms can create localized benthic habitats such as the bar-forming oyster Crassostrea virginica or the tube-constructing worm Diopatra cuprea (Killam et al, 1992) (see Figures 15 and 24).
<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>116</td>
<td>24,295</td>
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<tr>
<td>Deep</td>
<td>17</td>
<td>394</td>
<td>14,848</td>
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</table>
Figure 6. Tampa Bay benthic habitat classification. Data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
1950 SEAGRASS DISTRIBUTION

Study Boundary:

- Seagrass Present
- Seagrass Absent, Deep
- Seagrass Absent, Shallow

Figure 7. Tampa Bay ca 1950 seagrass distribution. Data source: FDNR/USFWS.
Figure 8. Tampa Bay 1990 seagrass distribution. Data sources: SWFWMD, NOAA.
Table 2. Number of acres within each habitat class in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>36</td>
<td>5,469</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>51</td>
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Table 3. Percentage of acres within each habitat class in Old Tampa Bay.

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<th>Seagrass Present</th>
<th>Seagrass Absent</th>
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<td>Fine</td>
<td>Coarse</td>
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<td>Shallow</td>
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<td>10.5</td>
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<tr>
<td>Deep</td>
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Figure 9. Old Tampa Bay benthic habitat classification. Data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 4. Number of acres within each habitat class in Hillsborough Bay.

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<th>Seagrass Absent</th>
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</thead>
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<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>Deep</td>
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<td>0</td>
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</table>

Table 5. Percentage of acres within each habitat class in Hillsborough Bay.

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<th>Seagrass Absent</th>
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</thead>
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<td>Coarse</td>
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<td>Shallow</td>
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<td>0.2</td>
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<tr>
<td>Deep</td>
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Figure 10. Hillsborough Bay benthic habitat classification. Data sources: NOAA; SWFWMD; Johansson and Squires, 1989. Note, Johansson and Squires assumed sediments in channels were fine grained and did not survey. Channels and spoil areas for 1990 presented in Figures 38 through 44.
Table 6. Number of acres within each habitat class in Middle Tampa Bay.

<table>
<thead>
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<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>5,013</td>
<td>0</td>
<td>10,840</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>24</td>
<td>8,012</td>
<td>46,768</td>
</tr>
</tbody>
</table>

Table 7. Percentage of acres within each habitat class in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>7.1</td>
<td>0</td>
<td>15.3</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>&lt;0.1</td>
<td>11.3</td>
<td>66.2</td>
</tr>
</tbody>
</table>
Figure 11. Middle Tampa Bay benthic habitat classification. Data sources: NOAA; SWFWMD; Doyle et al, 1989. Channels and spoil areas for 1990 presented in Figures 38 through 44.
Table 8. Number of acres within each habitat class in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>6,165</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>188</td>
</tr>
</tbody>
</table>

Table 9. Percentage of acres within each habitat class in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>10.3</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Figure 12. Lower Tampa Bay benthic habitat classification. Data sources: NOAA; SWFWMD; Doyle et al, 1989. Channels and spoil areas for 1990 presented in Figures 38 through 44.
Table 10. Number of acres within each habitat class in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>75</td>
<td>6,337</td>
</tr>
<tr>
<td>Deep</td>
<td>17</td>
<td>129</td>
</tr>
</tbody>
</table>

Table 11. Percentage of acres within each habitat class in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0.4</td>
<td>29.8</td>
</tr>
<tr>
<td>Deep</td>
<td>0.1</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Figure 13. Boca Ciega Bay benthic habitat classification. Data sources: NOAA; SWFWMD; Doyle et al, 1989. Channels and spoil areas for 1990 presented in Figures 38 through 44.
Table 12. Number of acres within each habitat class in Terra Ceia Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>998</td>
<td>0</td>
<td>1,633</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,259</td>
</tr>
</tbody>
</table>

Table 13. Percentage of acres within each habitat class in Terra Ceia Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>25.6</td>
<td>0</td>
<td>42.0</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>32.4</td>
</tr>
</tbody>
</table>
Table 14. Number of acres within each habitat class in Manatee River.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>6</td>
<td>266</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 15. Percentage of acres within each habitat class in Manatee River.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0.1</td>
<td>4</td>
</tr>
<tr>
<td>Deep</td>
<td>&lt;0.1</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 14. Terra Ceia Bay and Manatee River benthic habitat classification. Data sources: NOAA; SWFWMD; Doyle et al, 1989. Channels and spoil areas for 1990 presented in Figures 38 through 44.
3.2 PHYSICAL IMPACTS

Physical impact data sets were developed for this project for channels, spoil and borrow areas, filled areas, modified shorelines, and seagrass bed prop scar intensity. Each physical impact was compiled into a GIS data set following the methods outlined earlier. The physical impacts GIS data layers were then overlaid on the benthic habitat classification scheme. The results of this procedure are mapped and tabulated on a baywide and bay segment basis.

3.2.1 Filled Areas

Much of the original mangrove shorelines and shallow seagrass beds of Tampa Bay have been filled for the development of residential communities, roadways, ports, and other commercial facilities. Figure 31 presents the existing distribution of these filled areas. An estimated total of 13,161 acres has been filled since the early 1900’s (Table 16). An estimated 91% of this fill activity has occurred in the shallow shelf portions of the Bay, and an estimated 9% of the fill activity has occurred in the deeper areas of the Bay.

Except for communities such as Palmetto and Tampa, the bay shoreline remained relatively undisturbed as late as the 1870’s. In the 1930’s, the period of major filling had begun. At this time the Gandy Bridge causeways, Port Tampa and St. Petersburg waterfront areas had been developed and the major port facilities of Hillsborough Bay were begun with filling of the Davis Islands. In the 1950’s major circulation patterns of Boca Ciega Bay and Old Tampa Bay had been altered (Goodwin, 1987 and 1989) by the construction of causeways, the most notable of these being the Courtney Cambell and Gandy Bridge causeways of Old Tampa Bay. By the early 1960’s, the period of major residential development had begun with the filling of much of Boca Ciega Bay, the eastern shoreline of St. Petersburg, and Anna Maria Island. Transportation development had proceeded with the construction of the Pinellas Bayway, Skyway, and Howard Frankland causeways, and most of the major port facilities in Old Tampa Bay and Hillsborough Bay had been completed. Development in recent decades has resulted in the addition of major filled areas such those at Hooker’s Point, Apollo Beach, Hillsborough Bay spoil islands 2D and 3D, Big Bend, and the Pinellas Bayway.

With the exception of the causeways and several fill islands, the majority of these filled areas (approximately 12,000 acres) have occurred on shallow bay bottom which formerly supported seagrass beds. An estimate of approximately half of these filled areas exist adjacent to areas which continue to support seagrass today. The filled areas and the existing groups of habitats adjacent to the filled areas is presented on a bay segment basis in Figures 32 through 37 and Tables 17 through 30.
Figure 15. Distribution of the oyster, *Crassostrea virginica*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 17. Distribution of the bivalves, *Tagelus spp.* Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 18. Distribution of the gastropods, *Nassarius* spp. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 19. Distribution of the bivalve *Amygdalum papyria*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 20. Distribution of the bivalve *Mulina lateralis*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
**Paraprionospio pinnata**

Source: Hall and Saloman, 1975

Figure 22. Distribution of polychaete *Paraprionospio pinnata*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 23. Distribution of the polychaete *Streblospio benedicti*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 24. Distribution of the polychaete *Diopatra cuprea*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 25. Distribution of the polychaetes *Nereis* spp. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 26. Distribution of the polychaete *Capitella capitata*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 27. Distribution of the polychaete *Heteromastus filiformis*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 28. Distribution of *Glottidia pyramidata*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Figure 29. Distribution of the echinoderms *Ophiophragmus* spp. Base map data sources: NOAA; SWFWMD; Doyle et al., 1989; Johansson and Squires, 1989.
Figure 30. Distribution of the cephalochordate *Branchiostoma caribaeum*. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Table 16. Number of acres of filled areas within the proximity of each habitat class in Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>1,055</td>
<td>4,749</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
FILLED AREAS
Tampa Bay National Estuary Program, Physical Impacts Study

Figure 31. Distribution of filled areas in Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Table 17. Number of acres of filled areas within proximity to each habitat class in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>141</td>
<td>1,309</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 18. Percentage of acres of filled areas within proximity to each habitat class in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.4</td>
<td>59.8</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 32. Distribution of filled areas in Old Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 19. Number of acres of filled areas within proximity to each habitat class in Hillsborough Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>2,546</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>992</td>
</tr>
</tbody>
</table>

Table 20. Percentage of acres of filled areas within proximity to each habitat class in Hillsborough Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>0.4</td>
<td>0</td>
<td>71.7</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27.9</td>
</tr>
</tbody>
</table>
Figure 33. Distribution of filled areas in Hillsborough Bay. Base map data sources: NOAA; SWFWMD; Johansson and Squires, 1989.
Table 21. Number of acres of filled areas within proximity to each habitat class in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>772</td>
<td>0</td>
<td>2,246</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 22. Percentage of acres of filled areas within proximity to each habitat class in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>25.5</td>
<td>0</td>
<td>74.2</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Figure 34. Distribution of filled areas in Middle Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 23. Number of acres of filled areas within proximity to each habitat class in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>51</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 24. Percentage of acres of filled areas within proximity to each habitat class in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>81.4</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 35. Distribution of filled areas in Lower Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 25. Number of acres of filled areas within proximity to each habitat class in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>914</td>
<td>1,946</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 26. Percentage of acres of filled areas within proximity to each habitat class in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>27.1</td>
<td>57.8</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 36. Distribution of filled areas in Boca Ciega Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 27. Number of acres of filled areas within proximity to each habitat class in Terra Ceia Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>159</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 28. Percentage of acres of filled areas within proximity to each habitat class in Terra Ceia Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 29. Number of acres of filled areas within proximity to each habitat class in Manatee River.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 30. Percentage of acres of filled areas within proximity to each habitat class in Manatee River.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>88.4</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 37. Distribution of filled areas in Terra Ceia Bay and Manatee River. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Several areas on these maps for which modified shorelines are readily apparent were not identified as filled areas, and this is due to our visual interpretation of the historic charts of these areas as cuts into the existing shoreline rather than filled shoreline. Estimates of the total extent of filled areas within mangrove forests developed in this study are likely to be underestimated due to a lack of distinguishing features visible in the historical materials. A more precise estimate of the lost mangrove and saltmarsh habitat is being developed for an ongoing TBNEP project to set living resource targets for Tampa Bay. The draft results of this study indicate that an estimated 9,705 acres (43%) of the 22,516 acres of mangrove and salt marsh habitat which existed in the 1950's have been lost.

3.2.2 Channels and Dredge Spoil Areas

The major navigational channels and designated dredge spoil areas which exist in Tampa Bay are presented in Figure 38 and the extent of these features within the proximity of each habitat class is tabulated in Tables 31 and 32. The designated dredge spoil areas include submerged spoils only, and emergent portions of spoil islands were operationally defined as filled areas for this report.

The development of navigational channels in Tampa Bay has proceeded in a pattern similar to that of the filled areas. With the exception of Boca Ciega Bay, most of the navigational features were developed within deep, coarse grained areas lacking in seagrass (approximately 11,000 acres). Out of an estimated 14,381 acres of channel and spoil areas, an estimated 87% (12,455 acres) has occurred in the deep portions of the study area, and an estimated 13% (1,926 acres) has occurred in the shallow portions of the study area. The principle navigational routes extend along a naturally occurring deep channel extending from the bay mouth, splitting south of the inter-bay peninsula, and continuing into Old Tampa and Hillsborough Bays. Submerged dredge spoil areas are included in this analysis, and emergent dredge spoil islands such as the two large islands in Hillsborough Bay (2D and 3D) were classified and discussed in the previous section as filled areas.

The channels and spoil areas and adjacent benthic habitat classes are presented on a bay segment basis in Figures 39 through 44 and the areal coverages are tabulated in Tables 33 through 56. Clearly, there are many smaller channels, boat basins, and finger canals which have been dredged in the Bay and are too small to appear on the 1:40,000 scale navigational charts. The physical impacts of these smaller channels are included in a discussion of modified shoreline impacts in the next section. In addition, a mapping of impacts including these smaller features is being completed for an ongoing TBNEP project to estimate the loss of seagrass beds within the bay. Preliminary results from this work in progress indicate that an estimated total of 12,756 acres of physical impacts have occurred within the shallow areas of Tampa Bay.
The most extensive development of navigational features in shallow habitat classes has occurred within Boca Ciega Bay (Figure 43). Approximately 60% of the channels in Boca Ciega Bay were estimated to have been developed adjacent to, or in, shallow areas. However, a series of relatively naturally occurring channels have been cut through the barrier islands to Boca Ciega Bay by hurricanes and the effects of tidal actions. Navigational channels have often been located within these natural features. The most notable of these features occur at John’s Pass and Bunce’s Pass.

Sediment resuspension represents another form of potential physical impact related to channels and dredge spoil areas. Increased turbidity at specific times and locations within the bay is likely related to vessel traffic and maintenance dredging activities. Schoellhamer (1991) reported that both storm water runoff and resuspension of bottom sediments by large vessel traffic contributed significantly to increased turbidity at specific locations and times within the bay. For example, the turbidity plumes observed during major channel excavation activities in 1977 and 1978 were reviewed by Goodwin and Michaelis (1984). The Environmental Protection Commission of Hillsborough County has reported a generally increasing trend for turbidity from 1989 through the 1991 period of this study (EPCHC, 1991). The EPCHC also indicates that no specific reason for the apparent trend was identified, and that possibilities included vessel traffic, maintenance dredging, algal blooms, suspended solids in runoff, and wind driven resuspension from shallow areas of the bay.
Table 31. Number of acres of channel areas within the proximity of each habitat class in Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>38</td>
<td>540</td>
<td>31</td>
<td>751</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>36</td>
<td>312</td>
<td>3,412</td>
</tr>
</tbody>
</table>

Table 32. Number of acres of spoil/borrow areas within the proximity of each habitat class in Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>6</td>
<td>260</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>25</td>
<td>1,129</td>
<td>7,541</td>
</tr>
</tbody>
</table>
Figure 38. Distribution of channels and designated spoil areas in Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Table 33. Number of acres of channel areas within proximity to each habitat class in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>38</td>
<td>204</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 34. Percentage of acres of channel areas within proximity to each habitat class in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>7.2</td>
<td>38.8</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 35. Number of acres of spoil/borrow areas within proximity to each habitat class in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 36. Percentage of acres of spoil/borrow areas within proximity to each habitat class in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>21.9</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 39. Distribution of channels and designated spoil areas in Old Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 37. Number of acres of channel areas within proximity to each habitat class in Hillsborough Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>5</td>
<td>53</td>
<td>319</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>1,165</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 38. Percentage of acres of channel areas within proximity to each habitat class in Hillsborough Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>0.3</td>
<td>1.7</td>
<td>20.4</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>3.4</td>
<td>74.3</td>
</tr>
</tbody>
</table>

Table 39. Number of acres of spoil/borrow areas within proximity to each habitat class in Hillsborough Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>128</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>528</td>
<td>996</td>
</tr>
</tbody>
</table>

Table 40. Percentage of acres of spoil/borrow areas within proximity to each habitat class in Hillsborough Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7.8</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
<td>32.0</td>
<td>60.3</td>
</tr>
</tbody>
</table>
Figure 40. Distribution of channels and designated spoil areas in Hillsborough Bay. Base map data sources: NOAA; SWFWMD; Johansson and Squires, 1989.
Table 41. Number of acres of channel areas within proximity to each habitat class in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 42. Percentage of acres of channel areas within proximity to each habitat class in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>3.4</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>

Table 43. Number of acres of spoil/borrow areas within proximity to each habitat class in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 44. Percentage of acres of spoil/borrow areas within proximity to each habitat class in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 41. Distribution of channels and designated spoil areas in Middle Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 45. Number of acres of channel areas within proximity to each habitat class in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>194</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>32</td>
</tr>
</tbody>
</table>

Table 46. Percentage of acres of channel areas within proximity to each habitat class in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>19.6</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Table 47. Number of acres of spoil/borrow areas within proximity to each habitat class in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 48. Percentage of acres of spoil/borrow areas within proximity to each habitat class in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Figure 42. Distribution of channels and designated spoil areas in Lower Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 49. Number of acres of channel areas within proximity to each habitat class in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>78</td>
<td>0</td>
<td>161</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>3</td>
<td>40</td>
<td>127</td>
</tr>
</tbody>
</table>

Table 50. Percentage of acres of channel within proximity to each habitat class in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>19.1</td>
<td>0</td>
<td>39.4</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0.7</td>
<td>9.8</td>
<td>31.0</td>
</tr>
</tbody>
</table>

Table 51. Number of acres of spoil/borrow areas within proximity to each habitat class in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
</tr>
<tr>
<td>Shallow</td>
<td>6</td>
<td>146</td>
<td>0</td>
<td>104</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>20</td>
<td>14</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 52. Percentage of acres of spoil/borrow areas within proximity to each habitat class in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
</tr>
<tr>
<td>Shallow</td>
<td>1.5</td>
<td>38.2</td>
<td>0</td>
<td>27.4</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>5.3</td>
<td>3.5</td>
<td>24.1</td>
</tr>
</tbody>
</table>
Figure 43. Distribution of channels and designated spoil areas in Boca Ciega Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 53. Number of acres of channel areas within proximity to each habitat class in Terra Ceia Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 54. Percentage of acres of channel areas within proximity to each habitat class in Terra Ceia Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 55. Number of acres of channel areas within proximity to each habitat class in Manatee River.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 56. Percentage of acres of channel areas within proximity to each habitat class in Manatee River.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>3.3</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 44. Distribution of channels and designated spoil in Terra Ceia Bay and Manatee River. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
3.2.3 Modified Shoreline

Much of the original mangrove and salt marsh shoreline of Tampa Bay has been hardened by the construction of seawalls, piers, and jetties, and by the backfilling of saltwater wetlands. These modified shorelines include both what has been delineated as original shorelines and new shorelines created by the construction of filled areas. The National Estuarine Inventory conducted by NOAA (Orlando et al, 1988) estimated that approximately one third of the shoreline in Tampa Bay is of the modified type. However, based on the results of this TBNEP study, approximately 50% of the shoreline in Tampa Bay is estimated to be of the modified type. The major areas of modified shoreline which exist in Tampa Bay are presented in Figure 45 and are tabulated in Table 57.

The modified shorelines and adjacent habitats are presented on a bay segment basis in Figures 46 through 51 and are tabulated in Tables 58 through 69. The least percentage of modified shoreline exists in the southern portions of Tampa Bay, and the highest percentage of modified shoreline (73%) exists in Boca Ciega Bay.

As noted previously, there are many smaller channels, boat basins, and high energy shoreline areas associated with hardened shorelines that are too small to appear on the 1:40,000 scale navigational charts. A tabulation of these areas is included in the results of the modified shoreline impacts analyses in this section. The areas of the various benthic habitat classes within 0 to 100, 100 to 200, 200 to 300, 300 to 400, and 400 to 500 meters of both modified and unmodified shorelines (Figures 52 through 56) were calculated. The benthic habitats adjacent to shorelines was summarized by relating the percent coverage of seagrass in shallow areas to the distance from modified and unmodified shorelines. The causeways in Old Tampa Bay (Figure 46) are approximately 100 to 200 meters wide, and they provide a convenient reference point for interpreting these analyses.

In Old Tampa Bay slightly lower values of percent coverage of seagrasses were observed in areas adjacent to modified shorelines. However, approximately one quarter of the area within 100 meters of modified shoreline is covered by seagrass in Old Tampa Bay. These seagrass areas include the areas adjacent to the north and south sides of the causeways. Part of the shallow habitats adjacent to the causeways was created in formerly deep waters, and these shallow areas now support seagrass meadows. The results for Hillsborough Bay were difficult to interpret due to the fact that they were based on an extremely limited area of existing seagrass near Big Bend.

The Results for Middle and Lower Tampa Bay, Boca Ciega Bay and Terra Ceia Bay demonstrate a striking pattern of reduced seagrass coverage adjacent to modified shoreline. These results are likely due to direct physical impacts such as channels, and marinas that have been dredged adjacent to modified shorelines, and also to
Table 57. Estimated number of miles and percentage of total miles composed of modified shorelines in each bay segment.

<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>Modified Shoreline Length (miles)</th>
<th>Total Shoreline Length (miles)</th>
<th>Modified Shoreline (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old Tampa Bay</td>
<td>128</td>
<td>290</td>
<td>44</td>
</tr>
<tr>
<td>Hillsborough Bay</td>
<td>74</td>
<td>128</td>
<td>58</td>
</tr>
<tr>
<td>Middle Tampa Bay</td>
<td>170</td>
<td>329</td>
<td>52</td>
</tr>
<tr>
<td>Lower Tampa Bay</td>
<td>40</td>
<td>118</td>
<td>34</td>
</tr>
<tr>
<td>Boca Ciega Bay</td>
<td>172</td>
<td>237</td>
<td>73</td>
</tr>
<tr>
<td>Terra Ceia Bay</td>
<td>15</td>
<td>47</td>
<td>32</td>
</tr>
<tr>
<td>Manatee River</td>
<td>31</td>
<td>91</td>
<td>35</td>
</tr>
</tbody>
</table>
Figure 45. Distribution of modified shorelines in Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989; Johansson and Squires, 1989.
Table 58. Estimated area (acres) of various habitat classes within 100 m of unmodified shoreline in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0.1</td>
<td>551</td>
<td>11</td>
<td>2,103</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0.5</td>
<td>0.3</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 59. Estimated area (acres) of various habitat classes within 100 m of modified shoreline in Old Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th></th>
<th>Seagrass Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>1</td>
<td>567</td>
<td>8</td>
<td>1,788</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>34</td>
<td>19</td>
<td>405</td>
</tr>
</tbody>
</table>
Figure 46. Distribution of modified shorelines in Old Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 60. Estimated area (acres) of various habitat classes within 100 m of unmodified shoreline in Hillsborough Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 61. Estimated area (acres) of various habitat classes within 100 m of modified shoreline in Hillsborough Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 47. Distribution of modified shorelines in Hillsborough Bay. Base map data sources: NOAA; SWFWMD; Johansson and Squires, 1989.
Table 62. Estimated area (acres) of various habitat classes within 100 m of unmodified shoreline in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass</th>
<th>Present</th>
<th>Seagrass</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>766</td>
<td>0</td>
<td>2,240</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>101</td>
</tr>
</tbody>
</table>

Table 63. Estimated area (acres) of various habitat classes within 100 m of modified shoreline in Middle Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass</th>
<th>Present</th>
<th>Seagrass</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>175</td>
<td>370</td>
<td>1,779</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 48. Distribution of modified shorelines in Middle Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 64. Estimated area (acres) of various habitat classes within 100 m of unmodified shoreline in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>1,532</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 65. Estimated area (acres) of various habitat classes within 100 m of modified shoreline in Lower Tampa Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>229</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>
MODIFIED SHORELINE
Lower Tampa Bay

Map Legend:
- Coarse Gained
- Fine Gained
- Seagrass Meadow
- Modified Shoreline
- 2m Depth Contour

Scale 1:145,000
0 2
Projection UTM
Datum NAD 27

Map Prepared by Coastal Environmental, Inc.

Figure 49. Distribution of modified shorelines in Lower Tampa Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 66. Estimated area (acres) of various habitat classes within 100 m of unmodified shoreline in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>25</td>
<td>967</td>
</tr>
<tr>
<td>Deep</td>
<td>0.6</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 67. Estimated area (acres) of various habitat classes within 100 m of modified shoreline in Boca Ciega Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>25</td>
<td>392</td>
</tr>
<tr>
<td>Deep</td>
<td>2</td>
<td>23</td>
</tr>
</tbody>
</table>
Figure 50. Distribution of modified shorelines in Boca Ciega Bay. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Table 68. Estimated area (acres) of various habitat classes within 100 m of unmodified shoreline in Terra Ceia Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>518</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 69. Estimated area (acres) of various habitat classes within 100 m of modified shoreline in Terra Ceia Bay.

<table>
<thead>
<tr>
<th></th>
<th>Seagrass Present</th>
<th>Seagrass Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Shallow</td>
<td>0</td>
<td>103</td>
</tr>
<tr>
<td>Deep</td>
<td>0</td>
<td>0.06</td>
</tr>
</tbody>
</table>

95
Figure 51. Distribution of modified shorelines in Terra Ceia Bay and Manatee River. Base map data sources: NOAA; SWFWMD; Doyle et al, 1989.
Figure 52. Percentage of seagrass coverage adjacent to modified and unmodified shorelines as a function of distance from the shoreline in Old Tampa Bay.
Figure 53. Percentage of seagrass coverage adjacent to modified and unmodified shorelines as a function of distance from the shoreline in Middle Tampa Bay.
Figure 54. Percentage of seagrass coverage adjacent to modified and unmodified shorelines as a function of distance from the shoreline in Lower Tampa Bay.
Figure 55. Percentage of seagrass coverage adjacent to modified and unmodified shorelines as a function of distance from the shoreline in Boca Ciega Bay.
Figure 56. Percentage of seagrass coverage adjacent to modified and unmodified shorelines as a function of distance from the shoreline in Terra Ceia Bay.
indirect impacts related to the disturbance of bottom sediments, alterations of flow and wave energy patterns, existence of nearby stormwater or wastewater outfalls, and increased local boat traffic. The results for Terra Ceia Bay indicate that seagrass coverage declines with distance from unmodified shorelines, and this is due primarily to the relatively narrow shallow shelf located around the periphery of Terra Ceia Bay.

3.2.4 Prop Scar and Boat Traffic Surveys

As described above, an aerial survey was conducted to estimate the levels of prop scar damage in various areas of the bay. This survey was based on the judgement of the observers, and provides a qualitative description of the occurrence of prop scarring in the bay. The results from this survey, conducted in early March 1992, are shown in Figure 57. Those areas which reflected the greatest degree of prop scar damage included Mullet Key and the Fort DeSoto Park area, Bishop Harbor, Weedon Island, and the northeastern portion of Old Tampa Bay near Double Branch and Rocky creeks. No estimate of the prop scar damage within the narrow channels of Cockroach Bay was made during this broad scale survey. This area is widely known to be severely impacted by prop scars in localized areas, and portions of Cockroach Bay have been closed to motor boats until 1995 (TBRPC, 1993). By overlaying the prop scar damage map on the map showing the current extent of seagrasses in the bay, an estimate of the proportion of the seagrass meadows in each of the prop scar damage categories can be obtained. Figure 58 shows that approximately 35% of the total seagrass area in Tampa Bay was classified as being in the heavy damage and moderately heavy damage categories. More than 40% of the seagrass areas was classified as having sparse or no scar damage.

The data obtained from the boat traffic surveys conducted in early May are shown in Figures 59 and 60. Figure 59 shows that, on the first day, the majority of the boat traffic was found in the following areas: Buce's Pass, Egmont Key, Mullet Key, Anna Maria Island and Manatee River mouth, Weedon Island, and near the Courtney Campbell Causeway. On the second day, a similar pattern was observed with perhaps greater intensity of traffic in lower Boca Ciega Bay. Figure 61 shows the proportion of the total number of boats found in each bay segment. By overlaying the boat traffic map on the map showing the degree of prop scar damage, an estimate of the number of boats found in the various areas of prop scar damage was calculated. Figure 62 shows that most of the boats observed were found in the areas characterized as having either heavy or sparse prop scar damage (264 boats out of a total of 431 boats on day 2).
Figure 57. Relative scale of prop scar damage to seagrass in Tampa Bay.
Figure 58. Percentage of seagrass area within each prop scar damage category.
1992 TBNEP Boat Traffic Census
Saturday, May 9 - Slack Before Ebb

Seagrass Bed Scar Level:
- None - Sparse
- Sparse/Mod. - Moderate
- Mod./Heavy - Heavy

1 Boat 30 Boats

Scale 1:350,000
Projection UTM
Datum NAD 27

Map Prepared by Coastal Environmental, Inc.

Figure 59. Midday distribution of Boats in Tampa Bay, May 9, 1992.
Figure 60. Midday distribution of Boats in Tampa Bay, May 10, 1992.
Figure 61. Percentage of boats in each bay segment.
Figure 62. Number of boats found in each prop scar damage category.
Figure 63. Number of boats per 100 ha in each prop scar damage category.
Since the surface area of those areas with various degrees of prop scar damage is not constant, the estimate of the number of boats in each damage category was weighted by the surface area of that category (Figure 63). This analysis shows that the boat traffic intensity was greatest in those areas characterized as having no scar damage. Examination of the nautical charts for Tampa Bay shows that these areas of high boat traffic intensity and little or no prop scar damage have well-marked channels, such as in upper Old Tampa Bay. Other areas, such as near the mouth of Bishop Harbor, which show much greater damage with lower boat traffic intensity, have channels which are apparently less well-marked. As discussed in the following text, it also possible that high levels of boating activity have occurred at sites such as Bishop Harbor and were not observed during this initial survey.

These results were intended to provide a first glimpse into the nature of a particularly large data gap for Tampa Bay. It should be noted here that these results, especially those related to boat traffic data, are exploratory in nature. There are a variety of factors which affect boat traffic intensity. Boat traffic can vary significantly due to factors such as season, day of the week, time of day, tides, and weather. Other factors such as depth and the presence of seagrass also influence the distribution of boat traffic associated with recreational fishing in seagrass meadows. Still other factors, such as locations of boat ramps and marinas affect the distribution of all recreational boat traffic.

3.2.5 Commercial Fisheries

Tampa Bay has historically been, and continues to be an active commercial fishing center. Fish and shellfish harvested from the bay and the surrounding waters of the Gulf of Mexico are commonly sold (i.e., landed) in the Tampa Bay region. Lombardo and Lewis (1985) reviewed the Tampa Bay historical landings data, and reported that landings of fish commonly caught in the bay totalled 11 million pounds in 1963. Recent commercial fishing activities in Tampa Bay were reviewed by Haddad (1989), and he estimated that fisheries landings for Tampa Bay in 1986 were 35 million pounds with a dockside value of over 24 million dollars. Commercial use codes are recorded at the time of registering a commercial vessel in the State of Florida. Although, a particular vessel may be used to fish for multiple types of fishing activities at various times throughout a year, these data provide useful information on the current status of the commercial fishing fleet registered in the immediate Tampa Bay region. The current vessel registration data indicate that the majority of vessels (1,620) in the vicinity of Tampa Bay have a recorded commercial use code for finfish harvesting, 11 vessels are currently registered as live bait harvesters, and 89 vessels are currently registered as blue crab harvesters (Norris, 1994).
Finfish species commonly harvested in the Tampa Bay region include mullet, menhaden, sheephead, and spotted seatrout (Haddad, 1989). It is likely that a portion of the seagrass meadow prop scar damage observed during the survey conducted for this project can be attributed to these commercial fishing activities. Many of the fishing vessels used in the fishery typically have propellers which are recessed into the vessel hull and do not contact the bottom. However, current data do not allow conclusions to be made regarding the proportion of prop scars caused by unprotected propellers, nets, and other gear which comes into contact with the bottom used by commercial v.s. recreational vessels. In recent times, regulations have been enacted to restrict the use of certain gears in certain areas of the bay. According to the Florida Department of Environmental Protection, these restrictions include the prohibition of fishing nets (other than hand cast nets, landing nets, and small bait nets) from areas including the Manatee River, Terra Ceia Bay and tributaries, bayous and inlets in Manatee County, all tributaries and inlets between Rock Creek and Double Branch Creek, E.G. Simmons Park. The regulations also prohibit mullet fishing in areas including Riviera Bay, Bayou Grande, Papy’s Bayou, Placido Bayou, Snell Island Harbor, and Coffee Pot Bayou.

Food shrimping activities occur within Tampa Bay South of the Gandy Bridge typically in deep waters in the Spring. The Florida Department of Environmental Protection has issued approximately 25 to 28 permits to conduct food shrimping activities in this area (Ohio, 1994). These permits are not transferable from the current permit holder to any other, and will be phased out through attrition upon the cessation of food shrimping activities by the current holders. Food shrimping activities in Tampa Bay may contribute to physical impacts of the bay by direct disturbance of bottom habitats and resuspension of sediments. As discussed in the channels and dredge spoil areas portion of this report, Schoellhammer (1991) reported that resuspension of bottom sediments by large vessel traffic contributed significantly to increased turbidity at specific locations and times within the bay. The Environmental Protection Commission of Hillsborough County has reported a generally increasing trend for turbidity from 1989 through the 1991 period of this study (EPCHC, 1991). The EPCHC also indicates that no specific reason for the apparent trend was identified, and that possibilities included vessel traffic, maintenance dredging, algal blooms, suspended solids in runoff, and wind driven resuspension from shallow areas of the bay. The relative contribution of commercial fishing activities to the overall turbidity of the bay remains equivocal.

The shellfish species most commonly harvested in the Tampa Bay region is the bait shrimp (Haddad, 1989). Following World War II, an increase in sport fishing and tourism was followed by the development of the bait shrimp fishery in the Lower Tampa and Boca Ciega Bays (Joyce and Eldred, 1966; Hartley, 1993). The bait shrimp fishing fleet grew to greater than 55 vessels in the early 1980s, and has subsequently declined to a current 1992 to 1993 level of 10 to 11 vessels (Hartley, 1993; Norris, 1994). Bait shrimp harvesting activities occur primarily within the
shallow seagrass meadows in the middle and lower portions of the bay. Small nets equipped with roller bars are used in these areas to minimize damage to the seagrass meadows. Areas where bait shrimp activities primarily occur include the seagrass meadows of lower Boca Ciega Bay (except where restricted inside Mullet Key), and the seagrass meadows adjacent to Anna Maria Island, Pinellas Point, Terra Ciea Bay, Bishop Harbor, and Weedon Island (Hartley, 1993).

Several studies have been conducted to assess the impacts of shrimp trawling in Florida (CSA, 1992a; CSA, 1992b, Meyer et al., 1991; Coleman et al., 1992). Two of these studies (CSA, 1992a, Meyer et al. 1991) examined the specific physical impacts of bait shrimp trawls on *Thalassia* meadows. The studies were conducted by examining the physical condition of the seagrass plants before and after being subjected to repeated trawling by standard bait shrimp roller trawls. Results were equivocal for both studies. Meyer and others (1991) reported that no statistically significant change in mean shoot density, number of blades per shoot, longest blade, total blade length, or below ground biomass were observed for experimentally trawled seagrass beds in Lower Tampa Bay. CSA (1992a) reported a temporary (approx. 140 minutes) increase in local turbidity following trawling in Pine Island Sound, and no significant decrease in shoot density, leaf blade length, leaf blade area, or number of blades per shoot. Neither of these two studies reported the statistical power of the test used to assess significant impacts. The power of the test quantifies the magnitude of change in seagrass meadows which could have been caused by the trawling treatments but not detected by the experiment due to the natural variability in characteristics such as blade length from seagrass plant to seagrass plant. However, no physical impacts to seagrass meadows from the experimental trawling were readily apparent from the reported results of either study (Meyer et al., 1991; CSA, 1992a).

Hard clam and oyster fisheries are very limited in Tampa Bay due to closures of shellfish beds in areas where bacterial contamination have been associated with urban development (Hesselman and Seagle, 1991). Major shellfish harvesting areas within Tampa Bay are used primarily by recreational clam harvesters, and these areas are lower Tampa Bay between Bishop Harbor and Perico Bayou, Boca Ciega Bay clam areas adjacent to Mullet and Cabbage Keys, Cockroach Bay (oyster beds and offshore clam beds), and Passage Key clam areas between Egmont Key and Perico Island (Seagle, 1992). There are currently no active shellfish leases in Tampa Bay (Seagle, 1992).
In addition to the physical impacts discussed above, there are other impacts to the bottom habitats in Tampa Bay which are related to water and sediment quality. Two studies recently published by Long et al. (1991) and Brooks and Doyle (1991) examined the distribution of metal and organics contamination of Tampa Bay sediments. The former study concluded that Tampa Bay sediments had considerably higher concentrations of such contaminants as mirex, dieldrin, chlordane, DDT, PCB's, silver (Ag), Copper (Cu), and Lead (Pb) than have been observed in other Gulf Coast sites in Florida. High concentrations of Cadmium (Cd) and Zinc (Zn) were also found in Tampa Bay. Figures 64 through 67 present the contaminant concentration and distribution data presented by Long et al. (1991). Brooks and Doyle also found metals concentrations that exceeded those expected in relatively uncontaminated sediments. Figures 68 through 73 present the sites in Tampa Bay with possible anthropogenic inputs of Cd, Chromium (Cr), Cu, Pb, Nickel (Ni), and Zn, respectively. Both of these studies point to Hillsborough Bay, and in some cases, Middle Tampa Bay, as having sediments that are relatively the most contaminated, with little contamination found in Lower Tampa Bay.

The Environmental Protection Commission of Hillsborough County has conducted extensive water quality monitoring in Tampa Bay since the mid-1970's, and the Pinellas County Department of Environmental Management has reported surface water quality monitoring data for 1990 and 1991 (PCDEM, 1992). Included in these data are measurements at fixed stations of bottom dissolved oxygen (DO) concentrations on a monthly basis. Figure 74 presents a summary of the recent (1986-1991) bottom DO data for these fixed stations, expressed as the percentage of months sampled for which bottom DO was less that 5 mg/L. Although statistically unbiased estimates of bottom DO should not be extrapolated for areas adjacent to a set of fixed stations, a useful general pattern is presented in this figure. This summary indicates that the areas with greater propensity for low DO include the deeper portions of lower Hillsborough Bay, the northern navigational channels, and several localized areas in upper Tampa Bay. The low levels of dissolved oxygen and toxic contamination of sediments have created conditions which may be unsuitable for supporting a healthy and diverse assemblage of benthic organisms. The spatial extent of low dissolved oxygen levels in Tampa Bay is likely to be underestimated by these data due to the daily occurrence of depressed oxygen levels when plant respiration rates exceed photosynthesis rates. This is particularly true of the shallow areas of the bay.
Figure 64. Mean Ag, Cd, Cr, and Cu concentrations (ppm dw) in the surficial sediments from Tampa Bay, 1984-1988. From Long et al. (1991).
Figure 65. Mean Hg, Pb, and Zn concentrations (ppm dw) and percent fines in the surficial sediments from Tampa Bay, 1984-1988. From Long et al. (1991).
Figure 66.  Mean concentrations (ppm dw) of chlordane, dieldrin, tDDT, and mirex in the surficial sediments from Tampa Bay, 1984-1988. From Long et al. (1991).
Figure 67. Mean concentrations (ppm dw) of tPCB in the surficial sediments from Tampa Bay, 1984-1988. From Long et al. (1991).
Figure 68. Stations with possible anthropogenic inputs of Cd as determined by metal to aluminum ratios. From Brooks and Doyle (1992).
Figure 69. Stations with possible anthropogenic inputs of Cr as determined by metal to aluminum ratios. From Brooks and Doyle (1992).
Figure 70. Stations with possible anthropogenic inputs of Cu as determined by metal to aluminum ratios. From Brooks and Doyle (1992).
Figure 71. Stations with possible anthropogenic inputs of Pb as determined by metal to aluminum ratios. From Brooks and Doyle (1992).
Figure 72. Stations with possible anthropogenic inputs of Ni as determined by metal to aluminum ratios. From Brooks and Doyle (1992).
Figure 73. Stations with possible anthropogenic inputs of Zn as determined by metal to aluminum ratios. From Brooks and Doyle (1992).
Figure 74. Bottom dissolved oxygen data measured by the EPC of Hillsborough County from 1986 to 1990.
3.3 DATA GAPS

This project also entailed identifying, and where possible, filling data gaps in the available data concerning potential physical impacts in Tampa Bay. One of the major data gaps encountered by this project involved the live bottom habitats in Tampa Bay. As discussed above, mapping of these particular habitats will be completed in another project funded by TBNEP.

Two other major data gaps were also identified. These included information on the geographic extent and degree of prop scar damage to seagrasses and spatial and temporal variation in recreational boat traffic in Tampa Bay. Over the last several years, a great deal of concern has been voiced over the damage to seagrass beds caused by scarring by boat props. Areas where the damage was particularly severe, such as Cockroach Bay and Weedon Island, are widely recognized. However, a uniform assessment and mapping of prop scar damage at a bay-wide scale had not been conducted. The Florida Department of Natural Resources (FDNR) Marine Research Institute has conducted some assessment and mapping of prop scar damage in Tampa Bay and is currently conducting detailed bay-wide assessments. The initial results are being revised, and the results are expected to be released in May of 1994 (personal communication, Frank Sargent, FDEP). Pinellas County is also currently conducting prop scar damage studies in the Mullet Key area. However, none of these data sources had been available during the completion of the work for this project. Therefore, as described above, a bay-wide survey of prop scar damage in Tampa Bay was conducted to fill the data gap that existed at the time. It may be fruitful to repeat this simple bay-wide survey as a means of monitoring future changes in prop scar damage in the bay. However, the methods outlined in the Tampa Bay Monitoring Plan (Squires et al., 1994) for seagrass monitoring can be modified to provide data that would support a more statistically robust assessment of temporal trends in prop scar damage.

The boat traffic data gap was particularly evident. Over twenty agencies and local groups were contacted for information on boat traffic in Tampa Bay. Little if any information was available from these sources and many of those contacted expressed that such data would be of great interest and utility. Therefore, it was decided to attempt to obtain at least some information on boat traffic intensity in Tampa Bay, and the survey was conducted as described above. Clearly, there are important sources of variability that could not be fully incorporated in the survey conducted in May 1992. Such sources include time of day, day of week, month or season, tidal state, and weather conditions. If future surveys are attempted, then those surveys should include estimates that reflect the influence of those sources of variation. Therefore, the sampling effort should be stratified to ensure that estimates are obtained under a wide range of conditions. For example, sampling should be conducted on both weekends and weekdays, in several months or seasons, and under several tidal states.
4. DISCUSSION

The transformation of Tampa Bay from an undeveloped estuary to a major urban center has impacted the benthic habitats which it encompasses. The transformation has occurred rapidly and on an immense scale. The Tampa Bay Regional Planning Council reports that the bay area population has grown nearly 24 percent since 1970, and that it is the nation’s third fastest growing urban area (TBRPC, 1993). The citizens of the bay area rely on the economic benefits of the Bay, build their homes on its shores, make their living on its waters, and have an active interest in the health of its living resources. The 1992 State of Tampa Bay Report (TBRPC, 1993) summarizes many of the activities which the community is currently undertaking to protect the resources of the Bay. This physical impacts study report provides a baywide accounting of the magnitude of the development of the Bay to date. By examining the results and using the GIS data sets in further analyses, the Tampa Bay National Estuary Program, in cooperation with the citizens of the bay area, will be able to establish goals for the protection, restoration, and enhancement of the valuable living resources of the Bay.

The original shoreline of Tampa Bay consisted primarily of mangrove forests and salt marshes growing around a periphery of broad seagrass meadows. These structurally diverse habitats support a large number of benthic organisms and other associated fauna (e.g., snook, red drum), reduce nonpoint source sediment loading, and stabilize shorelines. The life histories of species utilizing these areas were summarized for the TBNEP by Killam and colleagues (Killam et al., 1992).

Much of the existing shoreline has been hardened by the construction of seawalls, jetties, piers, and backfilled land areas. These modified shorelines include both the original shoreline that was modified and the new shorelines created during the construction of filled areas. The results of the modified shoreline analysis indicate that modifications to shorelines have directly and indirectly impacted adjacent benthic habitats. Approximately half of the shoreline existing in Tampa Bay is estimated to be of the modified type. In some areas, such as Boca Ciega Bay, as much as 73 percent of the shoreline is of the modified type. Much of the original benefits of the non-hardened shoreline such as shoreline stabilization, reduction of suspended solids loads, and diverse estuarine habitats have been lost. The TBNEP is currently working on plans for protecting remaining areas of the original shoreline.

In addition to direct impacts to the living resources of the bay, the filled areas in Tampa Bay have caused changes to circulation patterns and have decreased the total volume of the bay. Goodwin (1987) has modeled the physical effects on the tidal circulation within the Tampa Bay caused by the filling of a substantial portion of the
bay. Goodwin’s results indicate that the physical changes have caused a reduction in the quantity of water that enters and leaves the bay on each tidal cycle. This volume of tidal flow has been reduced by an estimated 4 percent between 1880 and 1972 and by 1 percent between 1972 and 1985. Goodwin’s results indicate that the tidal prism for Hillsborough Bay has been reduced by an estimated 8 percent between 1880 and 1972 and by 7 percent between 1972 and 1985. With the exception of Hillsborough Bay, Goodwin indicates that in most of the areas of Tampa Bay flushing by tidal action exceeds flushing by surface water stream flow inputs, and that physical alterations to the bay have resulted in conditions where the bay can now more rapidly exchange water with the Gulf of Mexico. Goodwin concludes that these physical changes may have caused an increase in salinity in some areas of the bay.

In some areas, the seagrass meadows of Tampa Bay have experienced heavy levels of scarring. These scars are likely to have been caused by a combination of recreational and commercial activities. Also, a large part of the original shallow seagrass meadows have been buried during the construction of filled areas for transportation networks, commercial facilities, residential areas, and dredge disposal sites. An estimated total of 13,161 acres have been filled since the early 1900's. With the exception of the principal causeways, the majority of these areas (approximately 12,000) acres have been filled in shallow waters which formerly supported seagrass. It is encouraging to note that many of the areas adjacent to these filled areas continue to support seagrass today. Pinellas County and Hillsborough County have recently enacted regulations to protect severely scarred seagrass meadows (TBRPC, 1993), and the TBNEP is currently coordinating a baywide effort to establish further protection and restoration goals.

The major navigational features which have been developed in Tampa Bay are channels and spoil disposal areas. These navigational features have provided the economic basis for much of the development the bay area has experienced. There have been two principle types of dredging activities within Tampa Bay. The first type is the dredge and spoil disposal activities associated with the construction of major shipping channels and the development of port facilities. Most of this activity has been associated with the navigational features developed within deep, coarse grained areas lacking in seagrass (approximately 11,000 acres). The second principle type of navigational feature development which has occurred within the bay has been the construction of small boat channels, marinas, and finger canals associated with residential development and recreational boating facilities. The most extensive development of these channels and spoil areas in shallow habitats has occurred within Boca Ciega Bay.

As discussed in the introduction, the objective for this project was to develop a GIS data base on permanently altered areas (i.e., physical impacts) of the targeted benthic living resources in Tampa Bay. Mapping the extent of physical impacts in the Bay provides a key input to the process of developing living resource restoration and
protection targets. The next step of the restoration and protection target setting process will be to relate the current and historical resource distributions of the targeted habitats using a geographic information system (GIS). The non-restorable areas identified by this project will then be overlaid with these distributions and areas which previously supported a living resource, no longer support a living resource, and have not been permanently altered by the physical impacts delineated by this project will be deemed potentially restorable. This report provides an accounting of the magnitude of non-restorable areas on a bay-wide basis. This accounting will provide a management perspective which incorporates the magnitude of the restoration targets in relation to the extent of living resources which have been lost to development and its related physical impacts.

The final phase of the TBNEP program will include the generation and assessment of specific management options for the restoration, protection, and enhancement of targeted living resources. The management options may include endorsement of specific regulations such as the limiting of motorized vessel use in areas prone to prop scarring, or the protection of remaining seagrass meadows from channelization. The management options may include physical restoration efforts such as the softening of hardened shorelines, the protection of naturally colonizing emergent wetlands, or the posting of boater warning signs in particularly sensitive shallow habitats. The management options may also include education initiatives to inform the public about the potential physical impacts of their actions in the bay. Ultimately, The TBNEP and cooperating agencies will present these options as prioritized and cost evaluated management recommendations within a Comprehensive Conservation and Management Plan for Tampa Bay.
5. LITERATURE CITED


6. DATA SOURCES FOR GIS COVERAGES
Habitat and Background Elements

Data Layer: Bathymetry

Source: National Ocean Service (Formerly Coast and Geodetic Survey)
National Oceanographic and Atmospheric Administration
(Soundings)

Southwest Florida Water Management District
1990 Seagrass Survey
(Shoreline)

Data Type: Digital Hydrographic Soundings (mean low water)
Corrected for tide or water level, vessel draft, and sound velocity.
Vertical datum - Gulf Coast low water datum
Digitized by NOS from original survey plots

Period: 357,130 soundings from Tampa Bay vicinity, 1947-1958
1991 Shoreline

Reduction/Refinement: Corrected portion of 1957 data for horizontal error.
Computed bathymetry from point data and shoreline.

Data Layer: Seagrass Meadows

Source: Southwest Florida Water Management District
1990 Seagrass Survey

Data Type: Seagrass Bed Polygons
Photo-interpreted from 1:24,000 Scale, Natural Color Photographs

Period: Photographs made December, 1990

Reduction/Refinement: None
Data Layer: Tampa Bay Digital Shoreline

Source: Southwest Florida Water Management District
1990 Seagrass Survey Data

Data Type: Land Mass Polygons
Photo-interpreted from 1:24,000 scale, natural color photography

Period: Photographs made December, 1990

Reduction/Refinement: G.I.S. Operation to classify survey polygons as land or water

Data Layer: Historic shorelines
(Used to deduce impacted areas)

Source: National Ocean Service (formerly U.S. Coast and Geodetic Survey)
National Oceanographic and Atmospheric Administration
Navigational Surveys

Data Type: Navigational Charts and Topography Survey Sheets
Various Scales

Period: 1:80,000 Scale charts for Tampa Bay, 1900 to 1961
1:40,000 Scale charts for Tampa Bay, 1926
1:40,000 Scale charts for Southern Tampa Bay, 1885 to 1881

Reduction/Refinement: None

Data Layer: ca 1950 Land Cover Data
(Used to Generate G.I.S. quality check of impact identifications)

Source: Florida Department of Natural Resources
and U.S. Fish and Wildlife Service Cooperative Study

Data Type: Land use/land cover polygons
Photo-interpreted from 1:24,000 scale photographs

Period: ca 1950
Reduction/Refinement: G.I.S. operation converted from raster to vector data

Data Layer: Mangroves

Source: Southwest Florida Water Management District
1990 Land Use Data

Data Type: Mangrove forest polygons
Photo-interpreted from 1:24,000 scale and 1:40,000 scale, color, infrared photos

Period: Photographs made December, 1990

Reduction/Refinement: None

Data Layer: Salt Marshes

Source: Southwest Florida Water Management District
1990 Land Use Data

Data Type: Salt marsh polygons
Photo-interpreted from 1:24,000 scale and 1:40,000 scale, color, infrared photos

Period: Photographs made December, 1990

Reduction/Refinement: None

Data Layer: Sediment Texture
Tampa Bay, except for Hillsborough Bay

Source: Doyle et al, 1989, literature compilation of sediment studies

Data Type: Percent sediment < 63 μm grain size

1971-1989 compilation of surveys

Reduction/Refinement: Digitized point data
Computed response surface from point data

Data Layer: Sediment Texture
Hillsborough Bay

Source: Johansson and Squires, 1989
Remote sensing survey of sediments

Data Type: Percent sediment < 63 μm grain size

Period: 1986 synoptic survey of Hillsborough Bay
and ground truthing samples

Reduction/Refinement: Digitized 1:40,000 scale survey drawing

Data Layer: Bottom Salinity and Bottom Dissolved Oxygen

Source: Environmental Protection Commission of Hillsborough County
Water quality monitoring data

Pinellas County
Department of Environmental Management
Water quality monitoring data

Florida Department of Natural Resources
Marine Fisheries Independent Monitoring Program
Water quality monitoring data

Data Type: Salinity and Dissolve Oxygen grab samples

Period: EPC of Hillsborough Co., 55 stations, from 1986 to 1990
Pinellas Co. DEM, 11 stations, from 1990 to 1991
FDNR MARFIM, samples from non-fixed stations, from 1990 to 1991
Reduction/Refinement: Computed cumulative frequency distributions by geographic point
Computed response surfaces from point data

Data Layer: Benthic Organisms

Source: Hall and Saloman, 1975
Benthic Survey

Data Type: Presence or absence of 20 key taxa


Reduction/Refinement: Taxonomic data/counts, None
Station locations digitized from reported charts

Data Layer: Tidal Flats

Source: Southwest Florida Water Management District
1990 Seagrass Survey

Data Type: Tidal flat polygons
Photo-interpreted from 1:24,000 scale, true color photography

Period: Photographs made December, 1990

Reduction/Refinement: None
Physical Impacts

Data Layer: Dredged Areas, Borrow Areas, Dredge Spoil Areas, Channels, Channel Markers

Source: National Ocean Service (formerly U.S. Coast and Geodetic Survey) National Oceanographic and Atmospheric Administration Navigational Surveys

Data Type: Feature polygons and points

Period: 1:40,000 Scale charts for Tampa Bay, 1991

Reduction/Refinement: Digitized from 1:40,000 scale charts

Data Layer: Filled Areas

Source: National Ocean Service (formerly U.S. Coast and Geodetic Survey) National Oceanographic and Atmospheric Administration Navigational Surveys

Data Type: Navigational Charts

Period: 1:40,000 Scale charts for Tampa Bay, 1991

Reduction/Refinement: Filled areas deduced by comparison of modern and historical charts Identified impacted habitat digitized
Data Layer: Modified Shorelines

Source: National Ocean Service (formerly U.S. Coast and Geodetic Survey)  
National Oceanographic and Atmospheric Administration  
Navigational Surveys  
U.S. Geological Survey  
1:24,000 Scale topographic maps

Data Type: Linear identification of modified shoreline

Period: 1:40,000 Scale charts for Tampa Bay, 1991  
Current topographic maps

Reduction/Refinement: Modified shorelines deduced by comparison of modern and historical charts and by seawall construction readily apparent on maps and charts. Identified impacted habitat digitized

Data Layer: Seagrass Prop Scars

Source: Tampa Bay National Estuary Program  
1992 Prop Scar Survey  
Southwest Florida Water Management District  
1990 Seagrass Survey

Data Type: Prop scar level classification of seagrass meadow polygons  
Survey from fixed wing aircraft  
500 ft. flight elevation over water, 1000 ft. over land

Period: Synoptic survey, March 6, 1992

Reduction/Refinement: Scar levels used to classify existing SWFWMD seagrass polygons
Data Layer: Recreational Boating Intensity

Source: Tampa Bay National Estuary Program
1992 Boat Traffic Survey

Data Type: Boat counts and positions recorded to within approximately 0.25 miles
of true position
Survey from fixed wing aircraft
500 ft. flight elevation over water, 1000 ft. over land

Period: Two replicated instantaneous (2 hour) counts, May 11 and 12, 1992 of
bay perimeter (seagrass meadows)
Two single counts, May 11 and 12, 1992 of bay mouth and bay center

Reduction/
Refinement: Count data recorded on 1:40,000 scale NOAA charts
Data digitized as point data