NATIONAL STATUS AND TRENDS PROGRAM
FOR MARINE ENVIRONMENTAL QUALITY

BIOEFFECTS PROGRAM

INTERIM PROGRESS REPORT: SURVEY OF TOXICANTS AND MEASURES OF THEIR BIOLOGICAL EFFECTS IN TAMPA BAY, FLORIDA

August, 1992

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Ocean Resources Conservation and Assessment
Coastal Monitoring and Bioeffects Assessment Division
Rockville, MD 20852

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EXECUTIVE SUMMARY

Tampa Bay has been impacted by losses of sensitive habitats, filling of wetlands, nutrient enrichment, eutrophication, and losses of valuable living resources. Relatively little research has been conducted on toxic chemicals and their biological effects. In 1991 NOAA began surveys of the biological effects of toxicants in Tampa Bay. Data from NOAA's monitoring program had indicated that some portions of the estuary were contaminated. The biological studies were initiated to provide perspective to the degree of chemical contamination. This report is intended to provide a summary of progress attained by NOAA thus far in the Tampa Bay surveys.

A variety of tools is being used to assess the biological effects of toxicants in several individual surveys. They include a battery of tests, measures, and observations made with sediments, fish, crabs, and oysters. The intent is to develop a weight of evidence, based upon the results of all of the individual surveys. Some of the surveys have been completed, some are underway, and some have been postponed.

The data available thus far from the different studies indicate that toxicant-associated biological effects are apparent in the Tampa Bay estuary. An initial survey of sediment toxicity showed that sediments in some areas were highly toxic in laboratory tests. Additional surveys are continuing. Toxicant-associated effects were observed in some samples of oysters, fish, and crabs, but the data are too incomplete to draw general conclusions regarding the severity and extent of the effects. Generally, the pattern that is emerging from the individual surveys is that conditions are worst in northern Hillsborough Bay and in some harbors around the perimeter of the estuary, intermediate in middle Tampa Bay and Boca Ciega Bay, and best in much of Old Tampa Bay and lower Tampa Bay.

Some of the survey tasks that were originally planned have been postponed or are incomplete because of a lack of funds. For example, the survey of the extent of sediment toxicity, verification of sediment toxicity with resident biota, and identification of causative chemicals are incomplete. Additional surveys (e.g. of water column and surface microlayer toxicity) and sediment quality in Hillsborough Bay have not been initiated.

INTRODUCTION

The National Status and Trends (NS&T) Program of NOAA monitors the concentrations of potentially toxic chemicals in bivalve molluscs, fish, and sediments in the estuaries and coastal marine areas throughout the USA. The data from this monitoring program are used to determine trends in chemical concentrations in time and space. Also, the data are used to set national priorities for further intensive research on the possible biological effects (bioeffects) of toxicants in selected regions.

In 1990 NOAA selected the Tampa Bay estu-

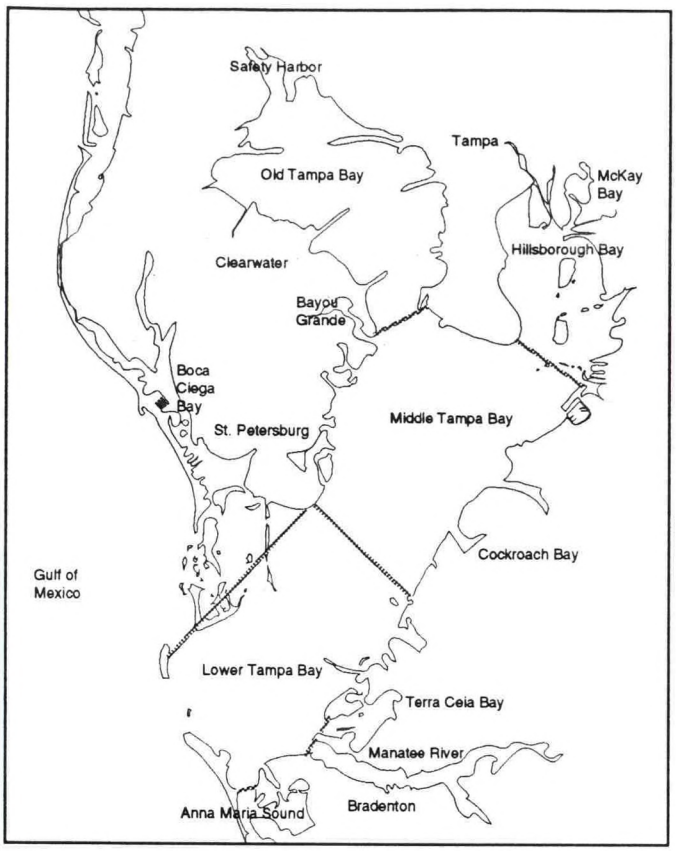

Figure 1. Tampa Bay Estuary and major regions.

ary as a location for a regional survey of the bioeffects of toxicants (Figure 1). The broad-scale, NS&T monitoring had shown that some parts of the estuary were relatively highly contaminated with trace metals and pesticides. Additional data published by local investigators also indicated that the concentrations of some trace metals and petroleum constituents were elevated in some portions of the estuary.

The objectives of the survey in Tampa Bay were: (1) to document the severity and geographic extent of chemical contamination; (2) to determine the severity and geographic extent of adverse biological effects associated with toxicants; and (3) to determine how the concentrations of toxicants have changed over time. This document reports interim results of the individual tasks performed thus far in Tampa Bay, identifies information gaps, and outlines future activities. The detailed findings of the survey will be published in technical reports expected in 1993 and 1994.

BACKGROUND

The research plan for Tampa Bay was outlined in a document titled "Proposed plan for intensive research on toxicants and measures of their biological effects in Tampa Bay, Florida" published by NOAA in October, 1990. The research plan consisted of nine technical tasks intended to satisfy the three stated objectives. The tasks were:

- Evaluation of Status and Trends
  This task involved the evaluation of status and trends in concentrations of toxicants and

measures of their biological effects in Tampa Bay, based upon a synopsis of existing, available data.

- Bivalve Contamination Survey
  Oysters and clams would be collected from many locations in the estuary and analyzed to determine the presence and concentrations of chemicals in their tissues.

- Bivalve Health Survey
  Oysters would be collected from selected areas and examined with a battery of assays to determine their health.

- Bioeffects among Fish and Crabs
  Resident bottom-dwelling fish and blue crabs would be analyzed to determine the presence and degree of toxicant-associated bioeffects.

- Sediment Toxicity Survey
  Sediments would be tested with laboratory bioassays to determine the distribution of toxicity throughout the estuary.

- Water Column/Microlayer Toxicity
  Water samples and sea surface microlayer samples would be tested to determine their toxicity to fish and invertebrates.

- History of Sediment Contamination
  The history of chemical contamination of Tampa Bay would be characterized by analyses of age-dated sediment cores and by evaluation of the data from long-term monitoring of chemical concentrations in effluents and resident biota.

- Resurvey of Sediment Quality
  A survey performed in 1986 would be repeated with similar methods to determine the degree of change in sediment quality following changes in the treatment of wastewaters.

- Data Evaluation and Summary Report
  This task involved the evaluation of individual data reports from each task and preparation of a final summary report that would provide an overview of all of the results.

The Research Plan outlined a chronological sequence for these tasks covering fiscal years 1990 through 1994.

INTERIM PROGRESS

Many of the tasks outlined in the research plan have been initiated, two have been combined, and one has been completed. Two tasks have been deferred because of a lack of necessary funds. Cumulatively, through its monitoring program and bioeffects program, NOAA has sampled most of the Tampa Bay estuary (Figure 2). Brief status reports are provided below for each task.

Evaluation of Status and Trends

Chemical data from many different documents were compiled; most of which reported the results of analyses of sediments and oysters. The available data were evaluated to determine temporal and spatial patterns in chemical concentrations and the potential for bioeffects. This information was reported in a NOAA technical memorandum (Long et al., 1991). Data were available from most parts of the Tampa Bay estuary for some chemicals, but were scarce for many other chemicals.

Overall, the data indicated that the lower Hillsborough River, northern Hillsborough Bay, and some of the peripheral harbors of the estuary generally were most contaminated and that Old Tampa Bay and lower Tampa Bay usually were least contaminated (Table 1). Some areas in middle Tampa Bay and Boca Ciega Bay were

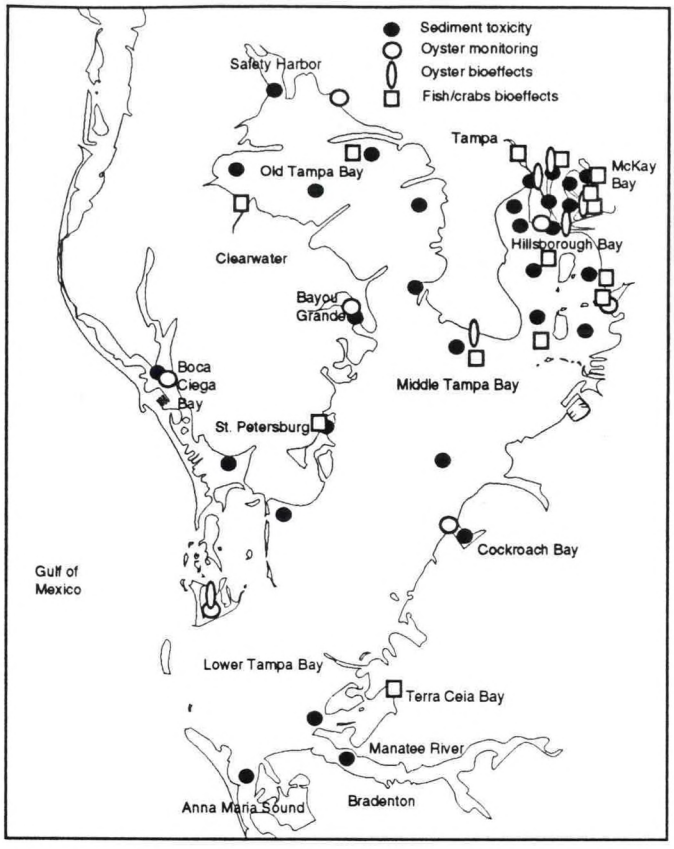

Figure 2. Locations of NOAA sampling sites.

intermediate in chemical concentrations. The concentrations of lead and polynuclear aromatic hydrocarbons (PAHs) were particularly high in and near the lower Hillsborough River.

Very few data from long-term studies were available with which to determine temporal trends in contamination. The few data available indicated that the concentrations of the pesticide DDT in oysters had decreased remarkably from the 1960's to the 1990's. The concentrations of lead in sediment cores increased slightly in recent years at one location, but varied over the years with no clear pattern at another location. Similarly, the concentrations of PAHs in sediment cores showed no consistent patterns over time at the locations that were sampled.

Table 1. Degrees of chemical contamination in different regions of Tampa Bay, surmised from available data (Long et. al., 1991).

Highly Contaminated Regions	Intermediate Regions	Cleanest Regions
lower Hillsborough River	middle Tampa Bay	Old Tampa Bay
northern Hillsborough Bay	Boca Ciega Bay	lower Tampa Bay
Bayboro Harbor	Manatee River	Terra Ceia Bay
other peripheral harbors	McKay Bay	Safety Harbor

The potential for bioeffects was estimated by comparing the Tampa Bay chemical data with the chemical concentrations observed by other investigators in association with measures of toxicity. The potential for toxicity in sediments was highest in the lower Hillsborough River and northern Hillsborough Bay, mainly as a result of the high concentrations of lead and PAH. Several other trace metals and pesticides also occurred in some samples in these two adjacent areas at concentrations equivalent to those previously associated with toxicity. The concentrations of PCBs, lead and zinc in some bivalve molluscs from Tampa Bay were equivalent to those previously associated with adverse effects. Based upon this evaluation, chemicals of potential concern in Tampa Bay include:

- **lead**
- **mercury**
- **chromium**
- **zinc**
- **Polynuclear aromatic hydrocarbons (PAHs)**
- **Polychlorinated biphenyls (PCBs)**

The high concentrations of these chemicals do not necessarily mean that they are causing toxicity. Many complex factors control their bioavailability and toxicity. Surveys, such as those described in the following tasks, are needed to confirm (or refute) the potential for toxicity.

Bivalve Contamination Survey

The research plan outlined an intensive survey of chemical concentrations in oysters and clams throughout the entire estuary. It included the collection of bivalve molluscs at 31 locations and analyses of their tissues for numerous chemicals. Because of the high costs associated with this task, it was not initiated per se; rather, it was reduced in scope and merged with the Bivalve Health Survey task.

Through the monitoring efforts of its contractor, Texas A&M University, the NS&T Program has quantified chemical concentrations in oysters collected at seven sites in Tampa Bay (Figure 2). Those sampling sites represent conditions in Double Branch Creek (a tributary to Old Tampa Bay), northern Hillsborough Bay, southern Hillsborough Bay, Bayou Grande, upper Boca Ciega Bay, lower Boca Ciega Bay at Mullet Key, and Cockroach Bay. Among these seven sites, the overall degree of chemical contamination was highest in oysters from the northern Hillsborough Bay site and lowest in oysters from the Mullet Key site. Relative to approximately 50 other sites along the entire Gulf Coast, Tampa Bay oysters ranked very high in the concentrations of arsenic, lead, mercury, zinc, total PCBs, mirex and alpha chlordane (Long et al., 1991).

Oysters collected in 1991 as a part of the Bivalve Health Survey have been saved for chemical analyses in 1992/3. They were collected at six locations in northern Hillsborough Bay, middle Tampa Bay, and lower Boca Ciega Bay on Mullet Key (Figure 2). In addition, oysters will be collected in 1992 and 1993 at 10 to 15 locations as a part of additional work under the Bivalve Health Task and will be subjected to chemical analyses. The data from the monitoring activities coupled with the data to be generated under the Bivalve Health Survey activities will provide a broad representation of conditions within all the major regions of the estuary.

Bivalve Health Survey

This task is being performed as a cooperative project with the U.S. Environmental Protection Agency laboratory in Gulf Breeze, Florida. The research plan outlined a broad-scale survey of oyster health in the estuary. However, it was determined that before such a survey could be conducted, a comparative evaluation of candi-

date measures of bioeffects must be performed first. In collaboration with the EPA scientists, many candidate measures of effects previously reported elsewhere by other investigators were considered. Of those considered, a battery of the most promising measures was selected for investigation in Tampa Bay. The measures of oyster health included:

Physical and Metabolic Conditions
- Condition indices
- Gonadal indices
- Biochemical composition of energy reserves
- Histopathological disorders

Parasite, Disease, and Microbial Burden
- Prevalence of macroscopic parasites
- Prevalence of *Perkinsus marinus*, a protozoan
- Prevalence of *Vibrio vulnificus*, a bacterial pathogen

Cytogenetic Anomalies
- Hemocyte neoplasia
- Organ neoplasia
- Micronuclei prevalence
- Chromosomal aberrations
- DNA unwinding

Immunological Competence
- Protein and lectin content of hemolymph
- Hemocyte types
- Phagocytic capabilities
- Hemocyte spreading, activity

Oysters were collected in July, 1991 from six sites (Figure 2). They were examined and tested to determine the relative sensitivity of the candidate measures of effects over the range of pollution conditions at the six sites. The data indicated that differences in health occurred among the oysters from the six sampling sites. Due to failure of an analytical instrument, the analyses of DNA damage have not been performed thus far. Many of the candidate measures of bioeffects indicated differences among sites that generally corresponded with the expected pattern in pollution. Some of the measures, when considered collectively, provided evidence that the health of some of the oysters was impaired. Based upon previous studies, the oysters from northern Hillsborough Bay were expected to be most contaminated. As expected, some of the measures of bioeffects suggested that, indeed, the health of these oysters differed from that of oysters collected elsewhere.

Stress Indicators In Northern Hillsborough Bay Oysters :
- Condition indices reduced significantly
- Gonadal indices reduced significantly
- Protein content reduced significantly
- Digestive gland structures atrophied
- Vesicular connective tissue structures altered
- Bacterial body burdens elevated
- Serum protein/lectin content reduced significantly.

The causes of stress among the oysters are unknown at this point. Some natural factors, such as low water salinity or high temperatures, could have been important. Chemical analyses of stored tissues are planned and should provide information on which toxicants may have been associated with the stress.

Some of the candidate measures of effects appeared to be relatively insensitive to conditions in Tampa Bay and/or showed no obvious pattern among the sampling sites.

No Obvious Patterns Among Sites:
- Prevalence of parasitism
- Micronuclei prevalence

- Nuclear anomalies
- DNA unwinding - no data available
- Hemic neoplasia - none found
- Organ neoplasia - none found
- Some indices of phagocytic capability elevated, some reduced.

It is too early to assert that the health of Tampa Bay oysters has been impaired as a result of exposure to toxicants or to assess the magnitude and extent of toxicant-associated bioeffects. The second phase of the survey planned for 1992/93 should provide some answers to these questions.

Bioeffects among Fish and Crabs

Collection and analyses of bottom-dwelling fish and crabs in Tampa Bay have been conducted by the National Marine Fisheries Service of NOAA in Seattle, Washington. Fish and crabs have been collected at four or five sites each year in 1990, 1991, and 1992 (Figure 2). The species sampled and the types of analyses performed thus far include:

Hardhead Catfish and Blue Crabs

- Sampled in 1990, 1991, 1992
- Toxicant concentrations in tissues
- Fluorescent metabolites of aromatic hydrocarbons in fish bile
- Histopathological disorders of internal organs

Killifish

- Sampled in 1991, 1992
- Toxicant concentrations in tissues and sediments
- Fluorescent metabolites of aromatic hydrocarbons in bile
- Histopathological disorders of internal organs

Killifish and Red Drum

- Sampled in 1992
- Toxicant concentrations in tissues
- Fluorescent metabolites of aromatic hydrocarbons in bile
- Histopathological disorders of internal organs
- DNA-toxicant adducts in liver cells
- Toxicant-metabolizing enzymes in liver cells

Only preliminary information is available thus far from this task. The initial results indicate that total DDT and total PCB concentrations in the fish and crabs generally were elevated in northern Hillsborough Bay relative to other regions of Tampa Bay and relative to Sarasota Bay, a reference area. Also, the concentrations of aromatic hydrocarbons in the stomach contents and the metabolites of these compounds in the bile were highest in fish from northern Hillsborough Bay. Fish from Old Tampa Bay and Sarasota Bay had among the lowest concentrations of DDT and aromatic hydrocarbons. Changes in the prevalence of altered liver cells are indicators of toxicant effects that have been observed in fish elsewhere in the USA in association with exposure to a variety of toxic chemicals. In Tampa Bay the highest prevalence of this disorder occurred in fish collected in Hillsborough Bay, and the lowest prevalences occurred in fish from Old Tampa Bay and Sarasota Bay, following the trend in the concentrations of organic pollutants.

The research on the health of fish and crab will continue through the remainder of 1992 and into 1993 as analyses of previously collected specimens are completed. Killifish and juvenile red drum were collected in the spring of 1992 from several areas that were suspected to be worst-case, highly polluted areas. The

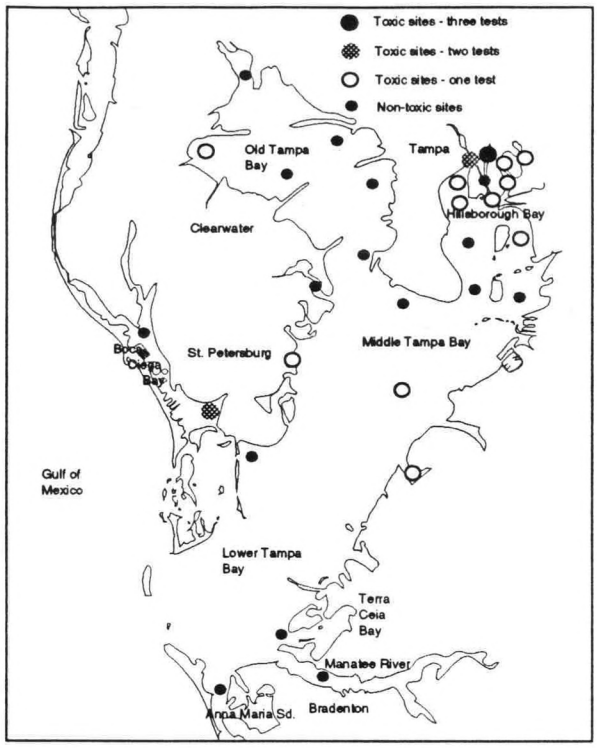

Figure 3. Sampling sites in the Tampa Bay estuary in which sediments were determined to be not toxic in any test, or significantly toxic in one, two, or three toxicity tests.

analyses of these fish are underway.

Sediment Toxicity Survey

In 1991 sediment samples were collected from 30 sites (3 stations per site, total of 90 samples) and tested for toxicity with a battery of three tests. Science Applications International Corporation in Narragansett, Rhode Island collected the samples and performed two of the tests. The U.S. Fish and Wildlife Service in Corpus Christi, Texas performed the third test. The Skidaway Institute of Oceanography at Savannah, Georgia performed chemical analyses of many of the samples with funding from the Florida Department of Environmental Regulation.

The sampling plan included the collection of sediments from all of the major regions of the estuary (Figures 2 and 3). Sediments were collected in the mouth of Hillsborough River, northern Hillsborough Bay, and Bayboro Harbor where relatively high toxicity was expected. Sediments were collected in Safety Harbor, Old Tampa Bay, Cockroach Bay, Terra Ceia Bay, and lower Tampa Bay where toxicity was not expected. In addition, samples were collected in southern Hillsborough Bay, middle Tampa Bay, lower Manatee River, upper Boca Ciega Bay, and lower Boca Ciega Bay near Gulfport where intermediate conditions were expected.

Three types of tests were performed:

- **Amphipod survival test with solid-phase sediments**
  - Test species - *Ampelisca abdita*, (resident of Tampa Bay)

Table 2. Numbers of stations and sites for which sediments were significantly toxic in Tampa Bay.

Toxicity Test	Number of Toxic Stations (N=90)	Number of Toxic Sites (N=30)
Amphipod	17	6
Microtox^{tm}	24	2
Sea urchin (100% porewater)	82	25
Sea urchin (50% porewater)	76	11
Sea urchin (25% porewater)	42	10

- 10-day test
- **Sea urchin egg fertilization test with sediment porewaters**
  - Test species - *Arbacia punctulata*, (resident of Gulf of Mexico)
  - 1-hour test
- **Microtox^{tm} bioluminescence test with organic extracts**
  - Test species - *Photobacterium phosphoreum* (in culture)
  - 5- and 15-min. tests

The three tests were intended to provide complementary data from three different approaches to the testing of toxicity. The amphipod test was performed with a resident species exposed to unaltered sediments, and provided data with relatively high ecological significance. The sea urchin test was performed with the highly sensitive eggs and sperm which were exposed to the porewater extracted from the sediments. The highly important dissolved fraction of toxicants are thought to occur in the porewater. The Microtox^{tm} test was performed with an organic (solvent) extract of the sediments, in which natural confounding factors should not cause toxicity, and with a quick screening test known to be highly efficient, but of limited ecological significance.

The mean results from each station and each site were compared to those from tests of non-toxic controls to determine statistically significant differences. All three tests indicated that some of the Tampa Bay sediments were significantly toxic (Table 2). The porewater test with the sea urchin gametes proved to be the most sensitive. Full-strength porewater was extremely toxic in many of the samples, sometimes resulting in zero fertilization success. Out of the 90 samples tested, 82 were significantly toxic in this test. Each of the samples was sequentially diluted twice to further identify the most toxic samples. Even at 25% strength, 42 of the samples still were toxic. The amphipod and Microtox^{tm} tests were roughly equivalent in sensitivity, indicating that 17 and 24 of the 90 samples, respectively, were significantly toxic.

Based upon the means of the three stations at each site, it was possible to distinguish site means from control means. This evaluation takes into account the environmental variability within the site. The results of the amphipod and Microtox^{tm} tests indicated that sediments from 6 and 2 sites, respectively, were significantly toxic. In the sea urchin tests, the 100%, 50%, and 25% porewater tests indicated that 25, 11, and 10 sites, respectively, were toxic.

The three tests indicated slightly different, but overlapping, patterns in toxicity. By examining the data from the amphipod test, the Microtox^{tm} test, and the 25% dilution sea urchin test, patterns in overall toxicity emerge (Figure 3). All three tests indicated that sediments from a site in Ybor Channel in northern

Hillsborough Bay were the most toxic, the only site so indicated. Sediments collected in the mouth of the Hillsborough River and near Gulfport also were relatively toxic as indicated by two of the tests. Toxicity was indicated by one of the tests in sediments from McKay Bay, East Bay, other parts of northern Hillsborough Bay, western Old Tampa Bay, Bayboro Harbor, Cockroach Bay, and middle Tampa Bay. The sediments from most of Old Tampa Bay, Safety Harbor, Bayou Grande, and lower Tampa Bay were the least toxic.

Water Column/Microlayer Toxicity

This task was deferred because of a lack of necessary funds.

History of Sediment Contamination

Some initial work on this task was conducted, but with limited success. Two sediment cores were collected and preliminary chemical analyses were performed. Problems arose in the interpretation of the data due to the poorly structured condition of the samples and further analyses were abandoned. No effort to retrospectively piece together the history of effluent discharges into Tampa Bay has been initiated. No work has been conducted beyond that of Long et al. (1991) to evaluate temporal trends in the NS&T Program oyster tissue data.

Resurvey of Sediment Quality

This task was deferred because of a lack of necessary funds.

Data Evaluation and Summary Report

As data have been gathered from the different tasks, they have been evaluated, entered into data bases, and examined for patterns. Interim progress has been reported orally to the Tampa Bay National Estuary Program and to other groups. Sections to be included in a final summary report have been prepared as new data were generated.

FUTURE ACTIVITIES

A number of research tasks are being considered, or are still underway, or are planned as a part of the program. In each case, the necessary funds are available and have been committed to conduct the work.

•Bivalve Health Survey

A second year of research on the health of oysters is underway. It will involve the analysis of oysters at six sites on a monthly or bimonthly basis. The periodic sampling at these six sites will provide information on the seasonal cycles of the reproductive capability and general health of the oysters. It will provide a basis for understanding how the health of these animals may change during the seasons. Following the periodic sampling at the six sites, oysters from up to 15 sites will be collected and examined for the full battery of biological and chemical analyses. This effort will provide data on an estuary-wide basis and will represent the definitive survey outlined in the research plan. The biological and chemical data will be examined to determine which potentially toxic chemicals were associated with the observed adverse effects.

•Sediment Toxicity Survey

A second phase of the sediment toxicity survey will be conducted in 1992. In the second phase emphasis will be placed upon determining the severity and extent of toxicity in selected areas that either proved to be toxic in the first phase or that have not yet been sampled. Four areas will be sampled: (1) Ybor Channel and vicinity in northern Hillsborough Bay; (2) western Old Tampa Bay near Clearwater; (3) the marinas, yacht basins, and harbors along the St. Petersburg shore; and (4) lower Boca

Ciega Bay near Gulfport. Toxicity will be determined with two of the tests performed in the first phase: the amphipod test of solid-phase sediments and the sea urchin fertilization test of porewaters. Samples will be collected in a cooperative effort of NOAA and Florida Department of Environmental Regulation (FDER). NOAA will fund the U.S. Fish and Wildlife Service to perform the toxicity tests and FDER will fund the Skidaway Institute of Oceanography to conduct chemical analyses of the samples. Both agencies will share in the interpretation of the data.

•Bioeffects among Fish and Crabs

During the three years of sample collections, fish and crabs have been collected at numerous locations, thereby providing a representation of conditions within most of the major regions. No additional sampling is expected. The analyses of existing samples will be completed in FY 93 and the results published in technical reports.

RESEARCH GAPS

A number of tasks initially outlined in the Research Plan were curtailed in scope or deferred due to a lack of necessary funds. Also, the research that has been conducted thus far has lead to the observation that additional work is needed to thoroughly complete some of the tasks. The following tasks should be completed to develop a comprehensive understanding of the distribution and biological effects of toxic chemicals in Tampa Bay:

•Task 5. Survey of Sediment Toxicity

The data from the initial estuary-wide survey of sediment toxicity indicated that some parts of the estuary were very toxic in laboratory tests. Before this survey was conducted, it was unknown whether Tampa Bay sediments were toxic or not. Now, it appears, indeed, that they are toxic. Before this survey, the distribution of toxicity was unknown. Now, it appears that several areas, especially the industrialized northern Hillsborough Bay area, are toxic. The data from the second-phase survey in four selected areas will add a considerable amount to our knowledge of toxicity in the estuary. However, several research activities have not yet been completed:

a) Complete the Survey of Sediment Toxicity. The degree and spatial extent of toxicity in many areas have not been determined, yet these areas may be as toxic as other parts of the estuary. They include the lower Palm River, Port Sutton, Port Tampa harbor, Port Manatee harbor, the eastern shore of Old Tampa Bay, Allen Creek, Cross Bayou Canal, upper Boca Ciega Bay, lower Alafia River, and the lower Manatee River near Bradenton. Sediments from these areas should be tested for toxicity with the same tests used in the initial survey to ensure comparability of the results. The data from these tests would be useful in completing the picture of the extent and severity of toxicity problems in sediments in Tampa Bay.

b) Verify Sediment Toxicity with Resident Biota. Sediment toxicity tests are performed under worst-case conditions in laboratory bioassays. The test animals are afforded no opportunity to avoid the test sediments or escape exposure to them. The data from the toxicity tests can be put into perspective by comparisons with data from the examination of the communities of animals living in the sediments. Sediments that are extremely toxic may not support any living organisms. On the other hand, they may support depauperate communities or very healthy communities. The examination of benthic community structure in some of the samples tested for toxicity and chemical concentrations would add considerably to the significance and utility of the toxicity data.

c) Determine which Chemicals are Associated with Toxicity. The tests used to determine sediment toxicity are responsive to a wide variety of toxic chemicals. Toxicity observed in Tampa Bay could be caused by any number of chemicals, most likely, acting as mixtures. The causative chemicals may differ from one part of the estuary to another, depending upon the types of nearby sources. While the technology may not exist yet to determine precisely the cause(s) of toxicity, it is possible to determine which chemicals are most likely and least likely contributing to the toxicity. This information can be used by local regulatory agencies in effecting source controls and clean-up actions. The highest priority chemicals of concern can be determined by examining statistical relationships between toxicity and concentrations of chemicals and by conducting toxicity identification evaluation experiments.

•Task 6. Water Column/Microlayer Toxicity. This task was included in the original Research Plan, but was never undertaken. Water column and microlayer toxicity may be a problem in Tampa Bay, because many of the toxic chemicals enter the system through freshwater storm drains and streams. Therefore, they enter the estuary in the surface waters. The eggs and larvae of many important resource species, such as red drum, spend part of their life cycle in the surface waters or in the microlayer. Therefore, they may be exposed to and susceptible to the effects of toxic chemicals. This task could be performed with methods used previously in similar research conducted in Puget Sound, southern California, Chesapeake Bay, and elsewhere. Tests could be conducted with eggs and/or larvae of economically important species such as red drum. The results would be useful in identifying the risks that valued marine resources encounter in Tampa Bay when exposed to toxicants as eggs, larvae or juveniles.

•Task 8. Resurvey of Sediment Quality. This task was included in the Research Plan, but was never undertaken. A battery of measures of sediment quality were made in a survey of Hillsborough Bay in 1986, using a specialized benthic camera. Since that time a number of changes in wastewater treatment have been made that should have resulted in improved sediment quality. This task would involve resurveying the same locations sampled in 1986, using the same methods, to document changes that may have occurred over the intervening time period. The information from this task would be useful in describing the changes (hopefully, improvements) in sediment quality following changes in wastewater management.

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