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SWF 208 BIOLOGICAL PRODUCTIVITY STUDY

BIG CYPRESS BASIN DRY SEASON SAMPLING

U.S. FISH AND WILDLIFE SERVICE

Southeastern Biological Research Station

OCTOBER 10, 1977

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BIG CYPRESS BASIN DRY SEASON SAMPLING

INTERIM REPORT TO

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL

OCTOBER 10, 1977

PROPERTY OF  
Southwest Florida  
Regional Planning Council

1. Figure 8, page 78, legend should read,  $\text{m}^3/\text{day}$ , not  $\text{g}/\text{m}^3$ .
2. Appendix Table G-1, page 191, footnote says "see Table G-2 for exact distribution;" strike that portion of note. Table G-2 does not give exact distribution. That data was not included.
3. Methods, page 28, equation five (5) should read:

$$(5) \text{ chlorophyll a (mg/m}^3) = \frac{26.7 (665_B - 665_A) \times v}{V \times 1}$$

4. Methods, page 29, equation six (6) should read:
- (6) phaeopigments  $(\text{mg/m}^3) = \frac{26.7 ([1.7} \times 665_A] - 665_B) \times v}{V \times 1}$
5. Methods, page 29, line 18, sentence should read: wavelength of 480 nm."
6. Methods, page 30, equation seven (7) should read:

$$(7) \text{ Plant carotenoids (MSPU/m}^3) = \frac{10.0 D_{480} \times v}{V \times 1}$$

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## EXECUTIVE SUMMARY

Biological field sampling and analysis have been an active part of Southwest Florida Regional Planning Council's 208 program since April, 1977. The value of biological information in water quality planning was approached on the basis of: (1) overall measures of productivity, biomass, and diversity as indicators of estuarine health; (2) potential incorporation of selected biological measurements into water quality monitoring programs; and (3) use of simplified ecosystems diagrams for calculating waste load allocations.

Methodologies and preliminary dry season results are presented for Chokoloskee, Naples, and Wiggins Pass estuarine bays of south Florida. Mean total community productivity measured for Naples Bay was 20.34  $\text{gO}_2/\text{m}^2/\text{day}$ . For those portions of the bay not considered highly influenced by sewage inflow, mean productivity was 10.63  $\text{gO}_2/\text{m}^2/\text{day}$ . Values measured for Wiggins Pass Area and Chokoloskee Bay were 6.06 and 9.87  $\text{gO}_2/\text{m}^2/\text{day}$  respectively. Gross plankton productivity was highest in Naples Bay (12.34  $\text{gO}_2/\text{m}^2/\text{day}$ , for sewage impact sites; 5.18  $\text{gO}_2/\text{m}^2/\text{day}$ , for sites with less impaction), and similar for Chokoloskee Bay (2.30  $\text{gO}_2/\text{m}^2/\text{day}$ ) and Wiggins Pass Area (2.78  $\text{gO}_2/\text{m}^2/\text{day}$ ). Biomass of benthic macroinvertebrates was 0.94  $\text{g/m}^2$  dry weight for Wiggins Pass Area, 0.67  $\text{g/m}^2$  for Chokoloskee Bay, and 0.64  $\text{g/m}^2$  for Naples Bay. Shannon-Weaver species diversity was generally high.

Results of field sampling and the literature search are summarized in evaluated ecosystem diagrams of each bay. These preliminary model evaluations indicate that although total community productivities are highest for Naples Bay, it is not a net producer of fish and macroinvertebrates. Large organic loading into Naples Bay appears to have altered the primary role of the bay from fish and shellfish production to phytoplankton and microbial production. This represents a shift from a nursery function to a waste assimilation function. Tentative calculations indicate at least 32 percent of total organic input to Naples Bay would have to be reduced before potential net fisheries capability could be regained. Chokoloskee Bay and Wiggins Pass Area exhibit net fish production. Tentative results indicate additional organic loads of 6 and 1-2 percent respectively could be added to these bays before net fish production may be lost.

All estuaries sampled are viable productive biological systems. They are all actively processing organic matter and show net organic reductions from inputs to outputs, which suggests that nutrient regeneration capabilities are still intact. As a waste assimilation system, Naples Bay is presently being maximized; as a fisheries production area, it is organically overloaded. Generally, these estuaries perform the following major biological roles in the coastal zone:

Chokoloskee Bay

1. Organic waste assimilation and nutrient regeneration, 6.2 g/m<sup>2</sup>/day;
2. Nutrient scrubbing and trapping, 0.02 g/m<sup>2</sup>/day;
3. Fisheries and related production, 0.56 g/m<sup>2</sup>/day.

Wiggins Pass

1. Organic waste assimilation and nutrient regeneration, 4.4  
g/m<sup>2</sup>/day;
2. Fisheries and related production, 0.86 g/m<sup>2</sup>/day.

Naples Bay

1. Organic waste assimilation and nutrient regeneration, 12.30  
g/m<sup>2</sup>/day

## INTRODUCTION

A water quality sampling program was begun in July, 1976, as part of the Southwest Florida 208 project. In April, 1977, additional biological sampling and analyses were added to the program to accomplish the overall goals of defining cause and effect relationships and assessing baseline conditions for water quality in selected estuaries. The additional sampling effort emphasized biological productivity measurements and the synthesis of biological, physical, and chemical information to assess estuarine health. The sampling effort was conducted to coincide with dry season, transition (dry to wet), and wet season conditions in certain estuaries, and on a one-time basis for others. This document presents a summary of the methods of sampling, data gathered, tools used for synthesis and preliminary synthesis results for estuaries sampled during April (dry season).

### BIOLOGICAL INFORMATION IN A WATER QUALITY PROGRAM

The 1972 Federal Water Pollution Control Act (FWPCA, Public Law 92-500) provided a novel philosophy for implementing water pollution control in the United States. The philosophy was to rely on nature's ability to maintain clean waters rather than on man's technological ability to "manage" them in a partially degraded state (Westman, 1977). Section 208 (PL 92-500) concerns the areawide planning for the elimination of discharge of wastes consistent with this philosophy.

Water quality in an estuary is a function of chemical, physical, and biological processes of man and nature. Water quality programs often concentrate on chemical and physical measures of these processes because sampling techniques are established and well-defined, laboratory analyses are routine, and the results are easily compared with a rapidly growing data base throughout the county. Biological parameters tend to be more elusive; data is usually more difficult to gather, is subject to less strict interpretation, and does not readily lend itself to guideline-type standardization. However, these factors do not make biological information any less important or accurate as an indication of water quality and estuarine health. Water quality programs which incorporate measures of all processes ongoing in an estuary will best lend themselves to the understanding and prediction of estuarine health, and subsequently the prediction of an estuary's ability to maintain clean waters. In this spirit, the Southwest Florida Regional Planning Council (SWFRPC) has incorporated biological investigation into a 208 Water Quality Planning Program.

#### MODELS FOR GAINING OVERVIEWS

The water column of an estuary is only one of its vital components. Others include the benthic communities, the sediments, the contributing systems (rivers, tidal creeks, surrounding mangrove forests, etc.) and the receiving systems. All these exist and operate in a dynamic system of flows, forcing functions, and storages. A model involves a synthesis of information which provides a way of monitoring, organizing, and visualizing this system.

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Figure 1 presents an energy circuit model of an estuarine ecosystem and its relationships to major external driving forces. (The symbols of the energy circuit language are explained in Appendix A.) This model represents the major components and processes thought to exist in the estuaries under study in the Southwest Florida 208 program. Five major compartments of energy storage are represented in this model: (1) the primary producers, composed of phytoplankton and benthic flora; (2) organic detritus with its associated microbial community; (3) zooplankton; (4) an aggregated compartment of benthic invertebrates and fish; and (5) a storage of limiting nutrients such as phosphorus. This storage can also represent accumulation of heavy metals or chemical contaminants as well. The natural driving forces are solar radiation, local and coastal currents, tides, external stocks of organisms and detritus, and ambient water temperature. Man's influence is shown in this system by imposing fishing pressure and by the addition of heavy metals, chemical contaminants, or nutrients.

The value and role of models of this type in a water quality planning program include the following:

1. They force the scientist to state his assumptions explicitly.
2. They organize information and data about the system under investigation. Developed as part of the plan of study, models aid in determining the relative importance of storages and processes and in identifying potential data gaps. This insight

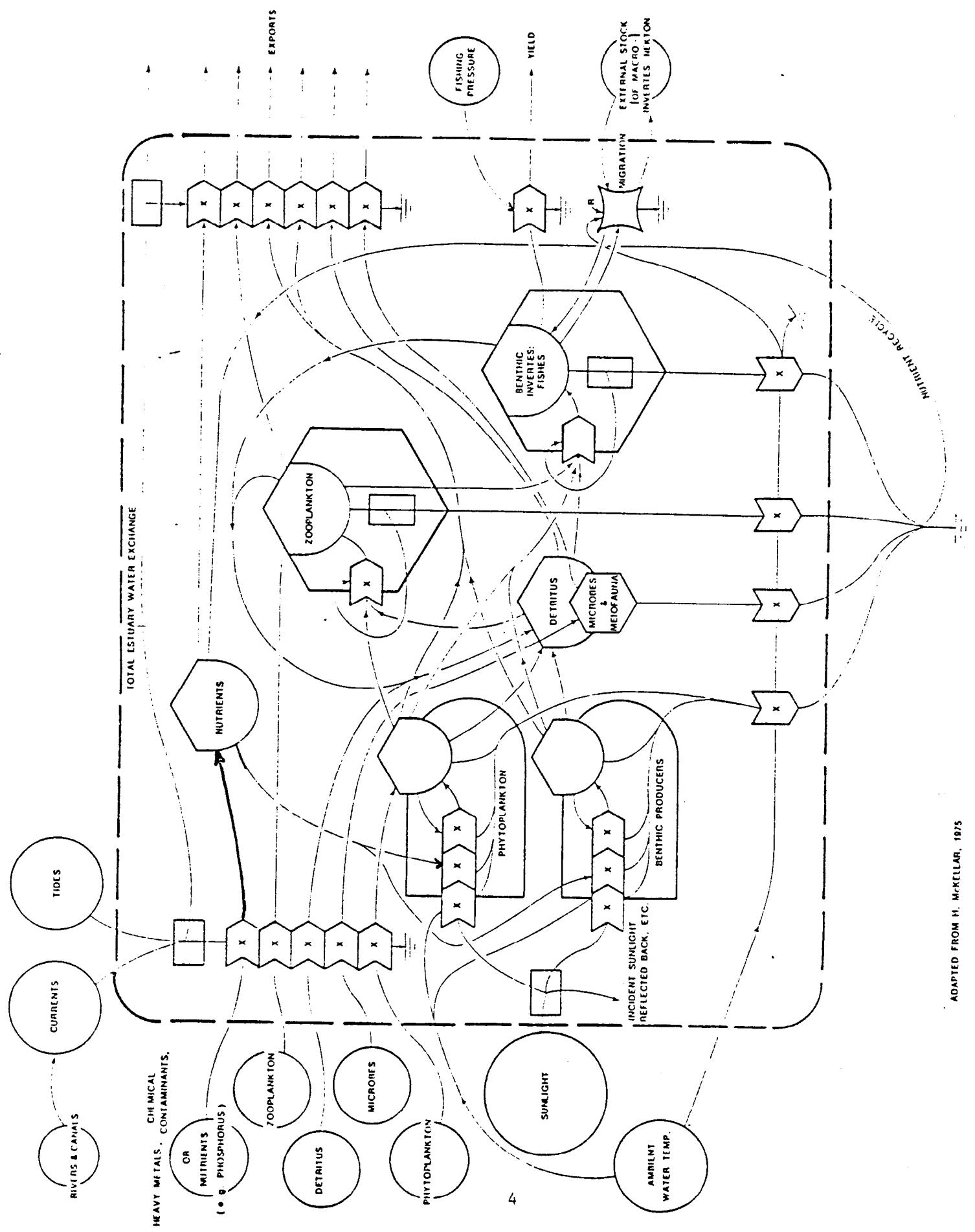


Figure 1 AN ENERGY CIRCUIT MODEL OF AN ESTUARINE BAY

is useful in prioritizing data gathering activities before going into the field.

3. Models serve as impact summaries. Lines from the outside forcing functions show causal actions that pass through main productive plant components to consumers. These lines allow the investigator to follow the impact of changing a forcing function along a given pathway through the various components. Secondary, tertiary, and so-called "hidden" impacts are not as easily overlooked.
4. Qualitative energy diagrams can be made quantitative by adding data gathered throughout the field activity so that relative magnitudes of flows can be seen. The quantification gives a basis for estimating properties of systems response such as turnover times (the ratio of a storage to a flow in or out of it). Turnover times are useful for assessing the ability of the estuary to maintain clean waters.
5. Evaluated models can be simulated to show the consequences of changes in the estuary over time. The predictive ability of a model is essential to good long-term water quality planning.

#### DESCRIPTION OF STUDY AREAS

Dry season productivity sampling was conducted in the Big Cypress Basin of the Southwest Florida Planning Council Region. This basin is comprised mostly of Collier County, and all of the estuaries sampled were within the coastal area of the county. The estuarine bays sampled were Chokoloskee Bay, Naples Bay, and Wiggins Pass Area (Figure 2).

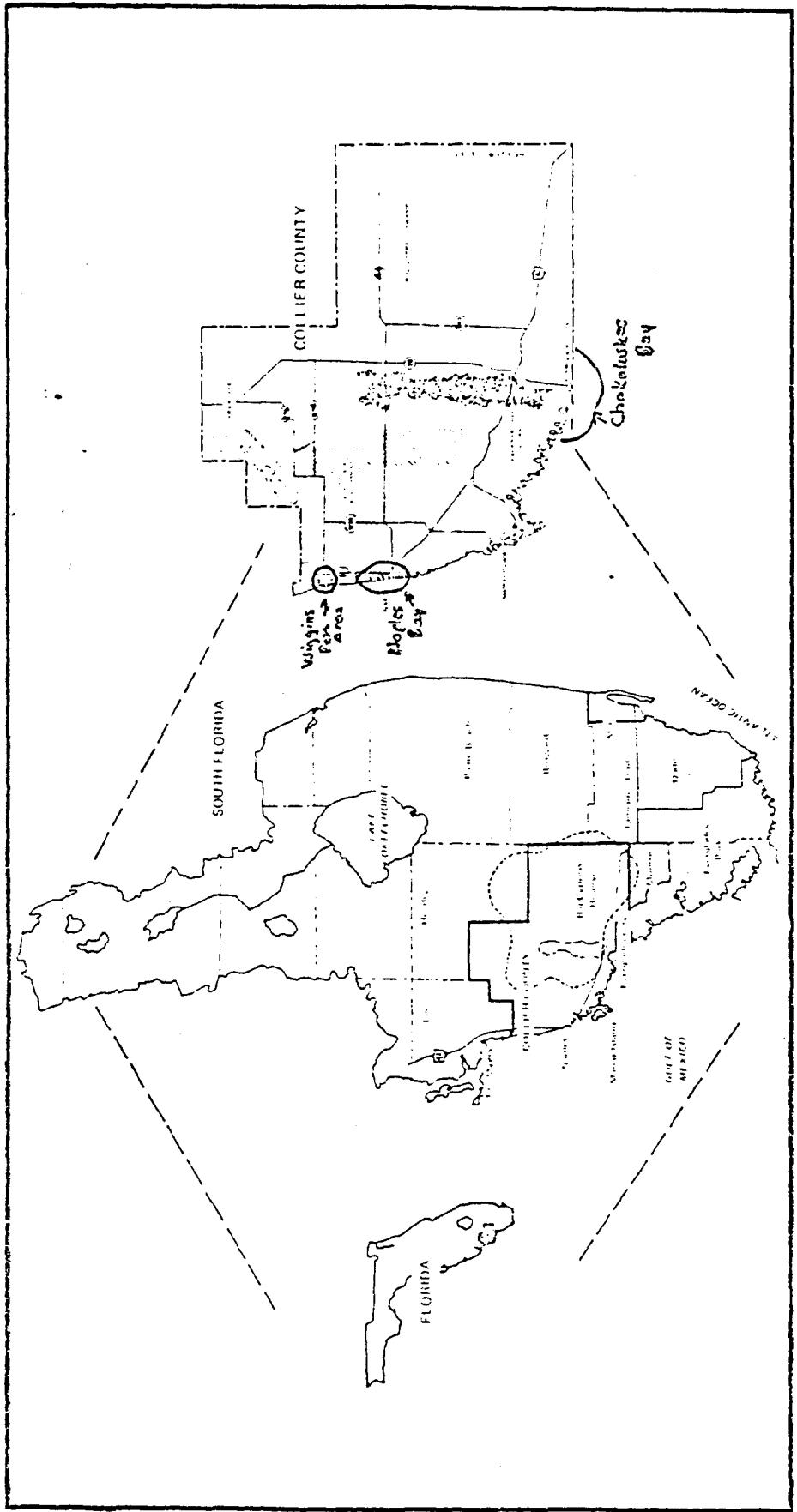


Figure 2. BIG CYPRESS BASIN STUDY AREAS IN COUNTY, REGIONAL, AND STATE-WIDE PERSPECTIVE (LEHMAN, 1976)

Chokoloskee Bay is the southernmost estuary of the three. This estuary is within the Ten Thousand Island coastal region of southwest Florida and is a shallow, mangrove-lined ecosystem. A portion of the estuary lies within Everglades National Park (see Figure 3). The area is mostly undeveloped: Everglades City, a small fishing community, lies on the east bank of the Barron River; Chokoloskee Island also supports a small fishing community and serves as a sport-fishing center and gateway to the national park. Plantation Island, another small development, is located along Halfway Creek. Man-induced impacts on water quality of this estuary would come from septic systems on Chokoloskee Island and in the Plantation Island Development. Everglades City introduces secondarily treated sewage into the canal outfall of Lake Placid. Other potential sources of impact are activities associated with marinas, yard maintenance, and seafood houses. Major impact to Chokoloskee Bay may come via the Barron River Canal, which was created as a result of dredging fill material for construction of a railroad bed during Big Cypress logging activities of the forties. The canal, which begins in the northern portion of Collier County and parallels State Highway 29 (which has replaced the railroad), terminates at Everglades City where it joins the Barron River. This canal drains significant agricultural and natural areas of the county. In the fifties, a causeway was built from Everglades City to Chokoloskee Island.

Naples Bay lies within the most developed area of all estuaries sampled (see Figure 4). It is surrounded by the Naples urban area of

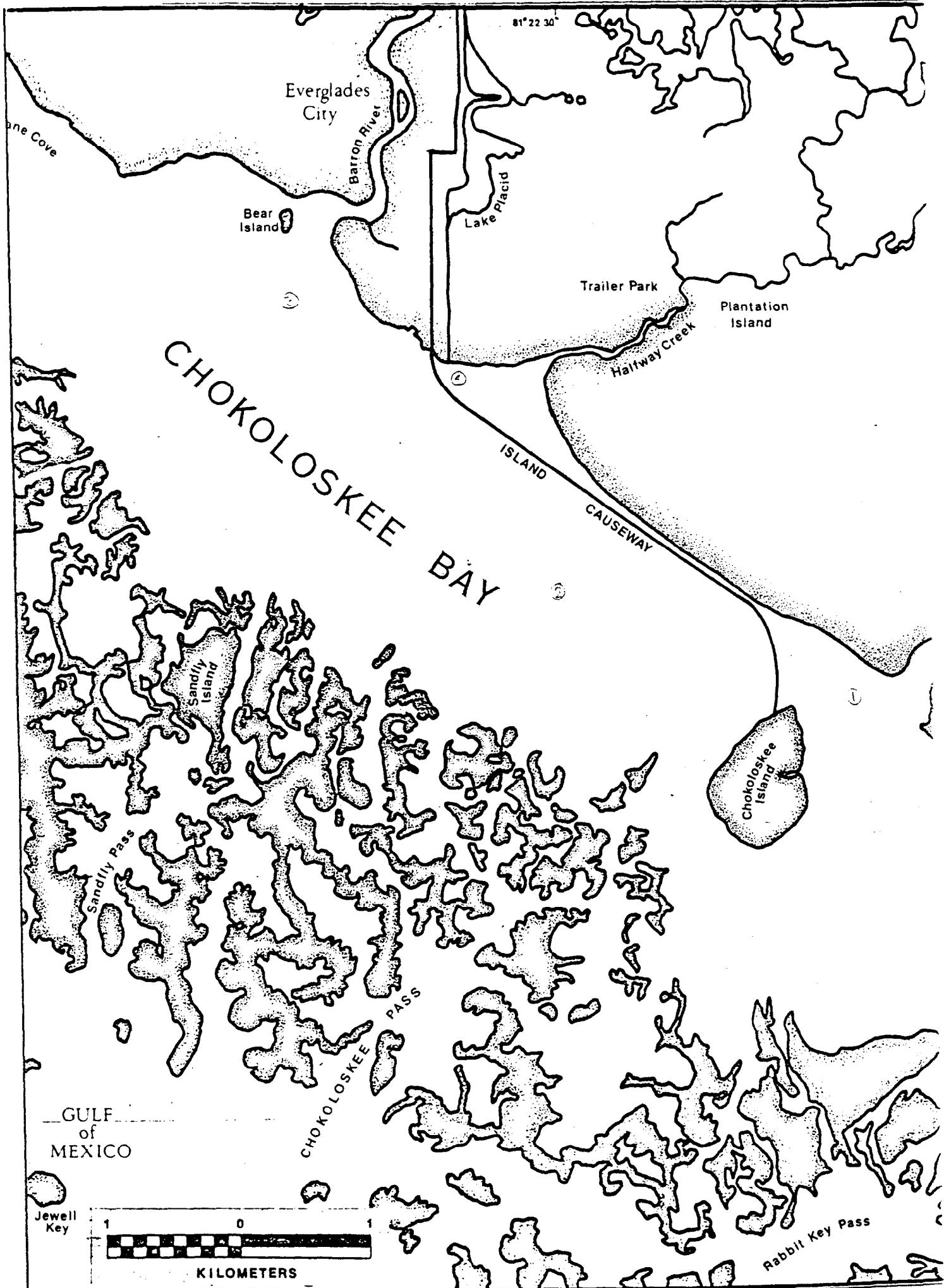


Figure 3. CHOKOLOOSKEE BAY AREA WITH SAMPLING STATIONS LOCATED



# GULF OF MEXICO

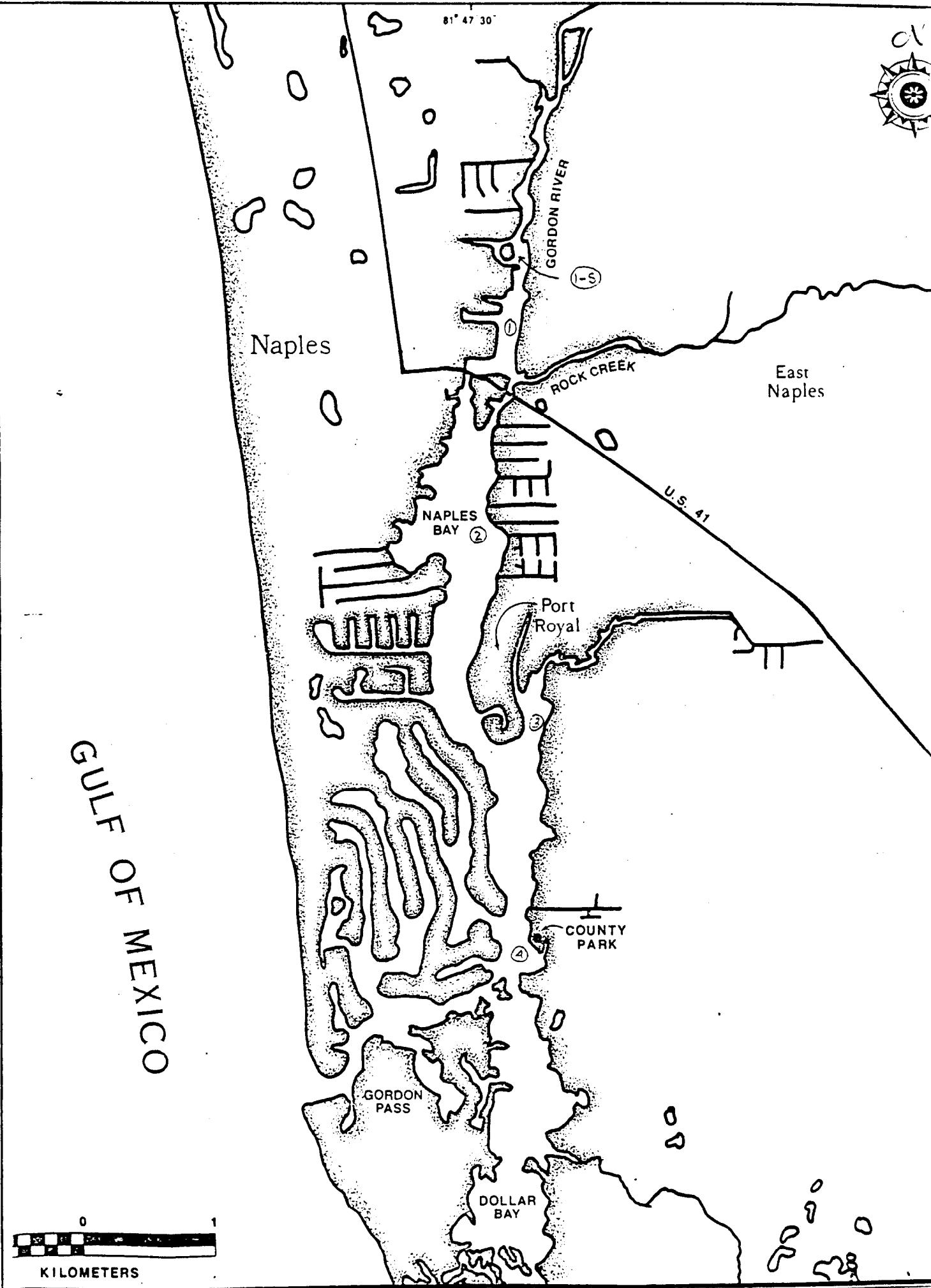


Figure 4. NAPLES BAY AREA WITH SAMPLING STATIONS LOCATED

approximately 60,000 residents, and only those portions immediately north and then south of the county park on the east side are undeveloped. The Naples urban area is a growing retirement and recreation community which is served both by septic systems and a secondary system which discharges into the upper reaches of the bay above U.S. Highway 41. This bay also receives major drainage waters from the Golden Gate Canal System which lies to the northeast, and from the Gordon River Basin to the north. The Gordon River Basin drainage includes golf course, agricultural, and residential effluent which combines with vast quantities of residential and natural area drainage from the Golden Gate Canal System.

Wiggins Pass area includes Wiggins Bay, Wild Turkey Bay, and the mouth of the Cocohatchee River (see Figure 5). It is an area of mangrove wetlands and shallow estuarine water. The Cocohatchee River drains residential, agricultural, and natural areas to the east. Vanderbilt Lagoon (to the south), surrounded by a finger canal residential and beach community, is flushed via Wild Turkey Bay through Wiggins Pass.

These three estuaries comprise a significant portion of the coastal area of value to Collier County. They are considered among the areas most likely to undergo changes in water quality due to present and future activities of man. Emphasis in this segment of the 208 program has been placed on assessing overall estuarine health as a basis for future planning, and on developing a water quality monitoring program that will serve the water quality managers of the area.

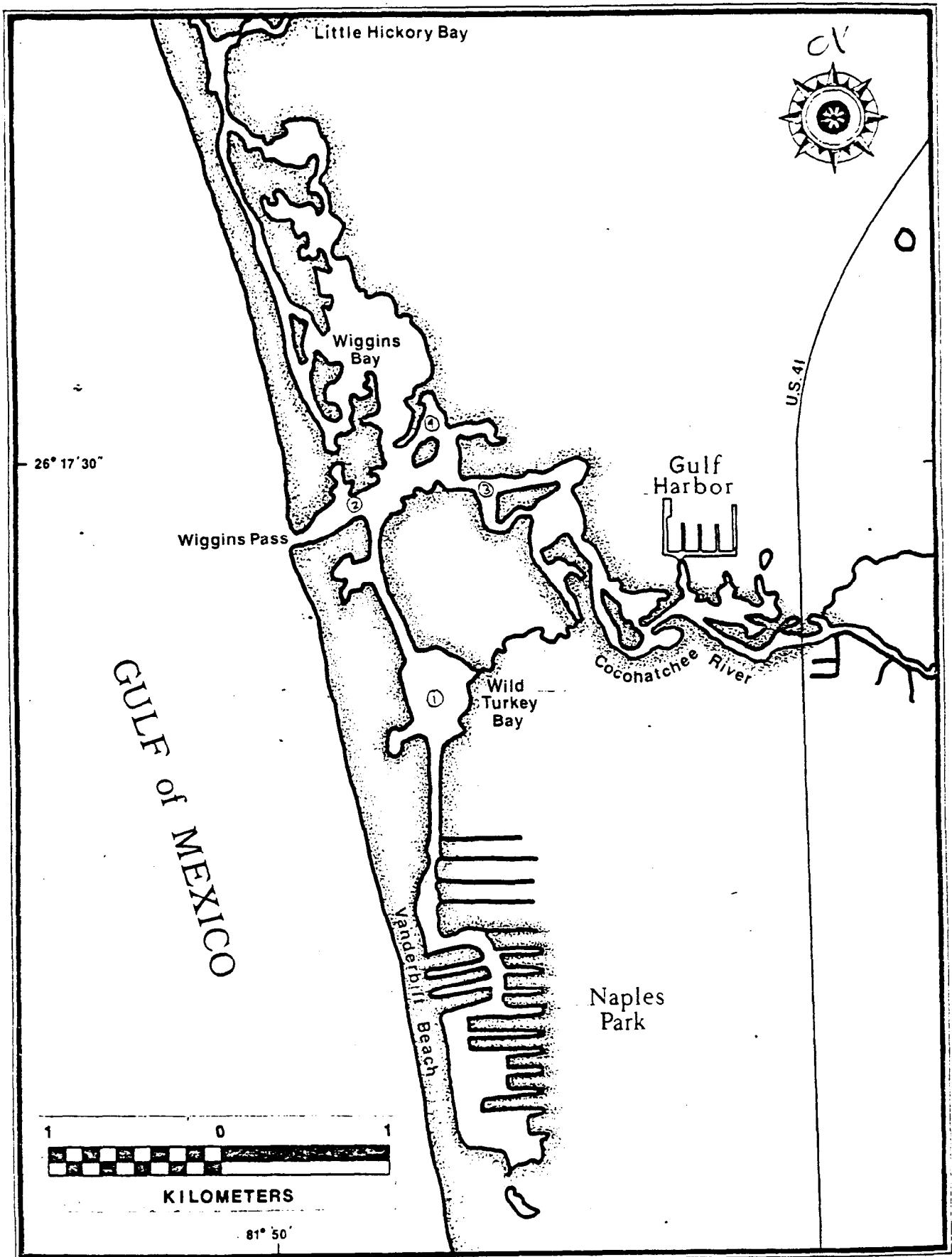


Figure 5. WIGGINS PASS AREA WITH SAMPLING STATIONS LOCATED

PLAN OF STUDY

Total community metabolism was determined from diurnal oxygen curves as an indication of total ecological energy flows in the bays. Comparisons of total community metabolism among bays gave a measure of the "magnitudes" of biological processes occurring in each. Magnitudes of these processes were considered indicators of an area's potential ability to handle wastes.

Characterization of an estuarine area with regard to its planktonic, benthic, and nektonic components was also considered important. Efforts were made to partition total metabolism between plankton and the collective metabolism of nekton and benthos. To augment interpretation of metabolism data, concentrations of zooplankton, phytoplankton, and chlorophyll, as well as solar radiation and light penetration in the water column, were measured.

This data, in conjunction with information in the literature, physical-chemical data from other 208 sampling activities and some necessary calculations and assumptions, were used to evaluate the energy circuit model in Figure 1 for each bay. The evaluated models provided a direct visual comparison of the difference in energy flows, storages, and rates of system turnover for Wiggins Pass, Naples, and Chokoloskee Bay estuaries.

## METHODS

### FIELD MEASUREMENTS

#### Total Community Metabolism

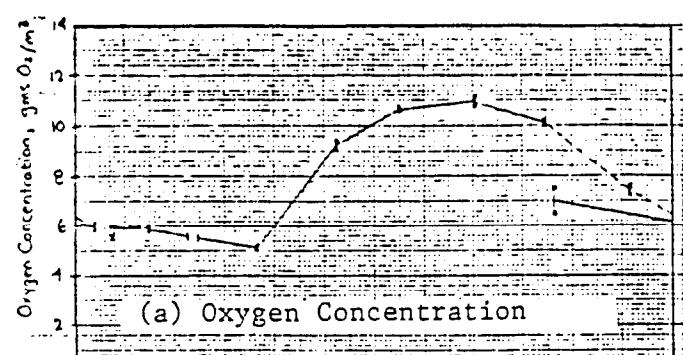
Total community metabolism of the estuarine areas studied was estimated by the free-water diurnal oxygen technique (Odum and Hoskin, 1958). This technique assumes that observed changes in dissolved oxygen concentration can be attributed to metabolic activity of aquatic biota in the water, to movement of oxygen across the air-water interface, or to advection of oxygen from one water mass to another. Adjustments were made to data to reflect only changes due to metabolic activity. Rates of diffusion were at first estimated and then later measured. The general procedure for calculating total metabolism did not involve a special correction for net water mass advection, so some error was involved. Similarity of oxygen concentrations at different stations within a study area was generally good, indicating similar metabolic histories of water masses. However, possible advection effects at some stations are still being analyzed.

Four stations were sampled diurnally in Chokoloskee Bay, five in Naples Bay, and four at Wiggins Pass. Each of these stations was monitored at intervals of approximately three hours for dissolved oxygen, temperature, salinity, and depth.

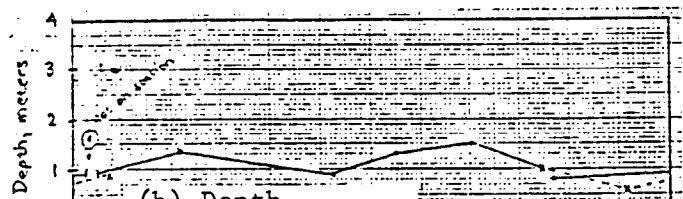
Dissolved oxygen was determined on duplicate water samples by the azide modification of the Winkler Iodometric Technique (American Public Health Association, 1975). Due to the large number of samples taken and a need for compactness, a mini-Winkler field kit described by Smith (1976) was used. This kit utilizes 125-milliliter sample bottles rather than standard 300-milliliter BOD bottles. Surface samples were collected by siphoning from a bucket, while samples from depth were taken with a Van-dorn or Kemmerer sampler. Care was taken to minimize turbulence, and bottles were flushed two to three times. Samples were fixed in the field with 0.5 milliliters each of manganous sulfide and alkali-azide-iodide reagent. Following acidification with 0.5 milliliter of concentrated sulfuric acid at the field lab, the 100-milliliter subsamples were titrated with 0.0125N sodium thiosulfate. Titrating with this normality allows an almost direct reading of milliliters of titrant as milligrams per liter dissolved oxygen. Concurrent oxygen measurements were made by oxygen probe (Yellow Springs Instruments Models 54 and 57) to facilitate oxygen determinations at various depths and for comparative analysis of the two techniques as a basis for later recommendations in outlining a county-level monitoring program.

Temperature and salinity data were used to calculate oxygen saturation values via the formula of Truesdale, Downing, and Lowden (1955). Salinity and temperature measurements were made with a Beckman RS5-3 portable salinometer or a Yellow Springs Instruments Model 33 S-C-T meter. For pH determinations, a Beckman, Orion, or Leeds-Northrup portable pH meter was used.

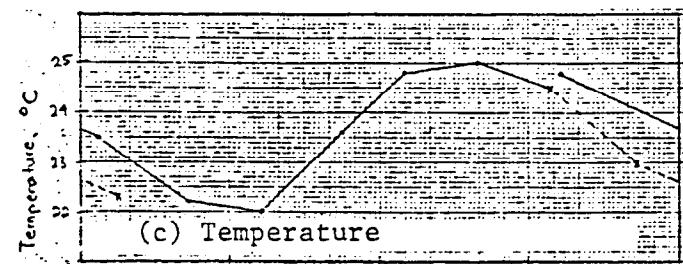
Typical diurnal variations in the parameters measured are shown in Figure 6. Observed changes in oxygen concentrations (see Figure 6a) for a sampling interval were multiplied by the average depth of water during that time interval (Figure 6b) to obtain the rate-of-oxygen change in grams per square meter per hour (see Figure 6f). Atmospheric exchange was determined (see the following section on oxygen diffusion), and corrections were made for changes due to diffusion. During periods when the oxygen content of the water is below saturation, oxygen diffuses into the water column, and atmospheric exchange must be subtracted from the observed rate-of-change curve. During periods of supersaturation, oxygen is lost and must be added to the change curve. The corrected curve (Figure 6f, dashed line) represents oxygen changes due to net effects of photosynthesis and respiration. The area (area 2) above the zero rate-of-change line represents net daytime photosynthesis (NDP). The area (areas 1 and 3) below the line represents nighttime respiration (NR). Daytime respiration (DR) can be estimated by three general approaches: (1) The assumption that DR is at least equal to nighttime respiration (McKellar, 1975; and Smith, 1976); (2) Average the value of nighttime respiration and project it over the daytime segment or the rate-of-change graph; the area enclosed by this line becomes DR (Odum, 1956); and (3) Where pre-sunrise and post-sunset respiration differ, a line connected diagonally between the dawn respiration rate and the sunset rate encloses an area which is daytime respiration (Odum and Wilson, 1962). In this study, the pre-sunrise/post-sunset method was used (area 4). This method usually gave a slightly higher value for



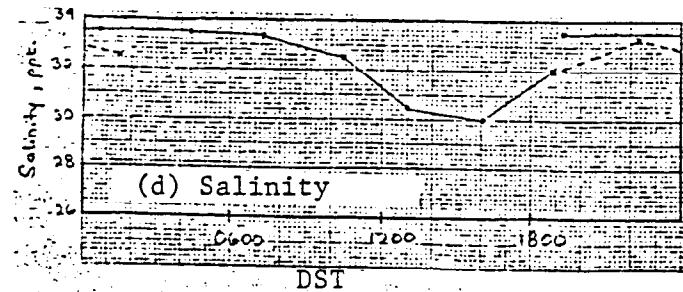
— ~ (a)



(b)

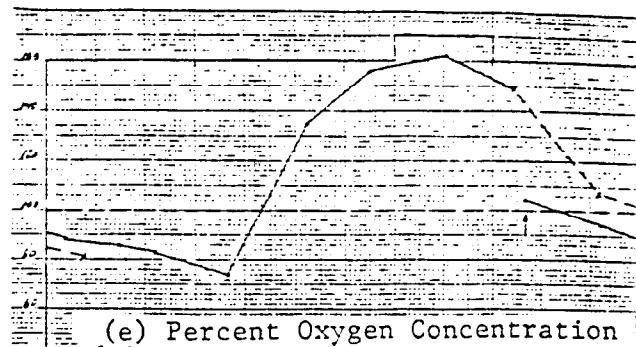


(c)

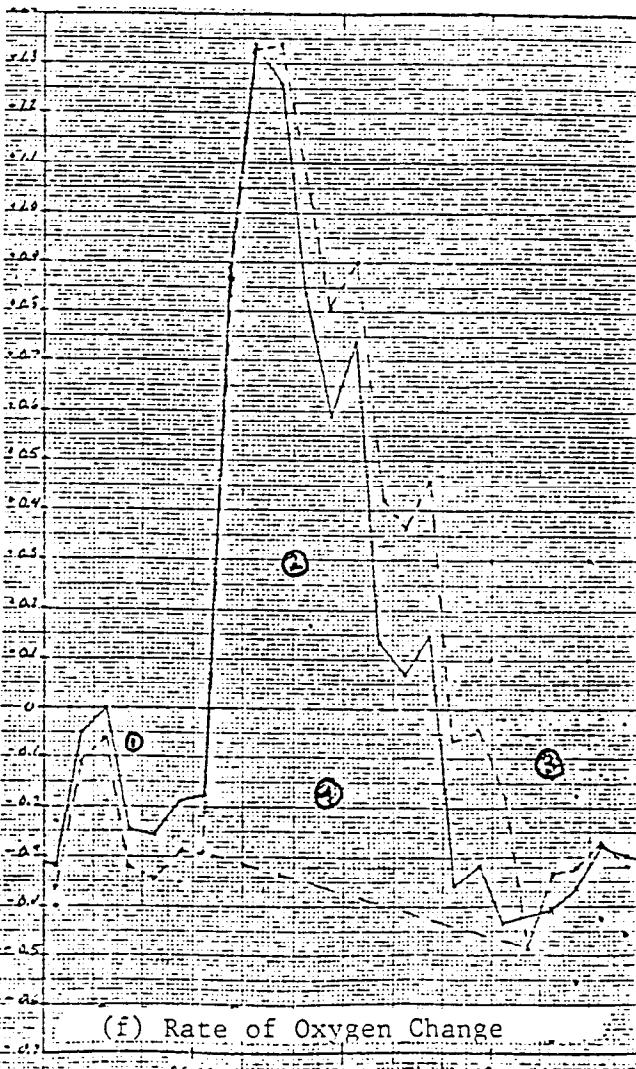


DST

(d)



(e)



(f)

Figure 6. RESULTS OF A FULL DIURNAL STUDY AT STATION 2, CHOKOLOOSKEE BAY, APRIL, 1977. (a) DISSOLVED OXYGEN CONCENTRATION, (b) WATER DEPTH, (c) TEMPERATURE, (d) SALINITY, (e) PERCENT OXYGEN SATURATION, AND (f) RATE OF OXYGEN CHANGE

daytime respiration than that which was measured for nighttime. Total Community Production (TCP) is the sum of total respiration (TR) plus net daytime photosynthesis (NPD). The following sample calculation is offered as an example of a productivity estimate from the respective integrated areas of Figure 6f:

Area 1

1.61 g O<sub>2</sub>/m<sup>2</sup>;

Area 2

5.89 g O<sub>2</sub>/m<sup>2</sup>;

Area 3

1.96 g O<sub>2</sub>/m<sup>2</sup>

Area 4

4.46 g O<sub>2</sub>/m<sup>2</sup>;

$$\text{Total Respiration (TR)} = \text{Daytime Respiration (DR)} + \text{Nighttime Respiration (NR)}$$

$$\text{Total Respiration (TR)} = 4.46 + 3.57 = 8.03 \text{ g O}_2/\text{m}^2$$

$$\text{Total Community Productivity (TCP)} = \text{Total Respiration (TR)} + \text{Net Daytime Photosynthesis (NPD)}$$

$$\text{Total Community Productivity (TCP)} = 8.03 + 5.89 = 13.92 \text{ g O}_2/\text{m}^2/\text{day}$$

#### Oxygen Diffusion and Other Physical Parameters

Oxygen diffusion rates used to correct oxygen rate-of-change curves were initially taken from the literature available for Florida west-coast estuaries (McKellar, 1976; Boynton, 1975; and Lehman, 1974) and compared with broad-based approximations by Odum and Wilson (1962). These rates were later site validated by measurements of oxygen diffusion in June. The methodology and results of the June measurements will be detailed in later reports.

The following relationships provided the factors necessary to correct observed oxygen rate-of-change curves for diffusion:

$$D = Ks = zks$$

where:

D is the rate of oxygen diffusion in grams per square meter per hour;

K is the gas transfer coefficient in grams per square meter per hour at zero percent saturation (100 percent saturation deficit);

s is the average percent saturation deficit between the water and the air during the sample interval expressed as a decimal;

k is the gas transfer coefficient in grams per cubic meter per hour at zero percent saturation; and

z is the mean depth for the sample interval, in meters.

For the initial productivity estimates made in April, a coefficient, K = 0.5 g/m<sup>2</sup>/hr at 100 percent saturation deficit, was used for diffusion corrections for all tidal stages. The diffusion corrections using this value usually represented less than 20 percent of the observed oxygen changes.

Other physical parameters measured in addition to temperature and salinity were wind and current velocity, solar insolation, and light penetration in the water column. Wind velocities were measured with a Dwyer W-1 hand-held wind gauge. Solar insolation during the study period was recorded by a Weather Measure R401 mechanical pyranograph. Drogues and fluorescein dye were used for current velocity measurements.

The penetration of sunlight through the water column was determined from Secchi disc observations. Definition of the euphotic zone was made by calculation of light extinction coefficients from Secchi disc data:

$$K = 1.7/d \text{ (Poole and Atkins, 1928, 1929)}$$

where:

$d$  = depth at which the disc disappeared, meters

$K$  = light extinction coefficient, meters<sup>-1</sup>

Light extinction coefficients were used to interpret light-dark bottle data for calculations of plankton metabolism.

#### Plankton Metabolism

The planktonic contribution to total aquatic community metabolism was estimated by the oxygen light and dark bottle method developed by Gaarder and Gran in 1927. This method involves the isolation and in situ incubation of samples in clear bottles and bottles which have been covered to exclude light. Dark bottles were prepared by completely covering bottles with one layer of black electrical tape and a second layer of silver duct tape. Tops were covered with a double layer of aluminum foil during experiments. Light, dark, and initial samples were taken in duplicate at various depths in the water column. Initial samples were fixed for the determination of initial oxygen concentration while light and dark samples were suspended at the depth from which they were collected and incubated for 24 hours. Following this incubation period, these samples were fixed and oxygen concentrations measured. All samples were taken in standard 300 milliliter BOD bottles and oxygen

concentrations determined by the azide modification of the Winkler Iodometric technique.

The change in oxygen content of the clear or light bottles is a result of net oxygen production (photosynthesis minus respiration), while in the dark bottle, only respiration occurs. This procedure allows estimates of gross and net planktonic primary productivity and respiration. Formulae used in calculations are:

$$\text{Gross primary productivity (g O}_2/\text{m}^3/\text{time)} = \frac{\text{LB} - \text{DB}}{\text{t}}$$

$$\text{Net primary productivity (g O}_2/\text{m}^3/\text{time)} = \frac{\text{LB} - \text{IB}}{\text{t}}$$

$$\text{Respiration (g O}_2/\text{m}^3/\text{time)} = \frac{\text{IB} - \text{DB}}{\text{t}}$$

where:

LB is the dissolved oxygen concentration in g/m<sup>3</sup> (mg/l at specific gravity of 1.0) in the light bottle after incubation;

DB is the dissolved oxygen concentration in g/m<sup>3</sup> in the dark bottle after incubation;

IB is the initial dissolved oxygen concentration in g/m<sup>3</sup> prior to incubation; and

t is the incubation period.

A sample calculation using light-dark data for the station represented in Figure 6 is as follows:

Chokoloskee Bay. Station 2. April 18 and 19. 1977

<u>Depth</u>	<u>Initials</u>	<u>Bottles Light</u>	<u>Dark</u>
Surface	8.82	10.09	7.76
0.75 meters	8.80	9.86	7.87

1.09 meters to bottom (depth of water column)

Gross Primary Productivity (GPP) of surface values

$$= \frac{10.09 - 7.76}{24 \text{ hrs}} = 2.23 \text{ g O}_2/\text{m}^3/\text{day}$$

Gross Primary Productivity (GPP) of 0.75 meter values

$$= \frac{9.86 - 7.87}{24 \text{ hrs}} = 1.99 \text{ g O}_2/\text{m}^3/\text{day}$$

Average GPP for first 0.75 meters of water column (surface down to  
0.75 meters)

$$\begin{aligned} \overline{\text{GPP}}_{\text{surface}} &= \frac{\text{GPP} (\text{surface}) + \text{GPP} (0.75 \text{ meter})}{2} \times (0.75 \text{ meter}) \\ &= \frac{(2.33 + 1.99)}{2} \times (0.75) = 1.62 \text{ g O}_2/\text{m}^2/\text{day} \end{aligned}$$

Average GPP for remainder of water column

$$(1.09 \text{ meters} \text{ minus } 0.75 \text{ meters} = 0.34 \text{ meters})$$

$$\begin{aligned} &= \overline{\text{GPP}}_{\text{bottom}} = \text{GPP} (0.75 \text{ meter}) \times (0.34 \text{ meter}) \\ &= (1.99) \times (0.34) = 0.68 \text{ g O}_2/\text{m}^2/\text{day} \end{aligned}$$

$$\begin{aligned} \text{Total } \overline{\text{GPP}} \text{ on area basis} &= \overline{\text{GPP}}_{\text{surface}} + \overline{\text{GPP}}_{\text{bottom}} \\ &= 1.62 + 0.68 = 2.3 \text{ g O}_2/\text{m}^2/\text{day} \end{aligned}$$

Net Primary Productivity (NPP) of surface values

$$= \frac{10.09 - 8.82}{24 \text{ hrs.}} = 1.27 \text{ g O}_2/\text{m}^3/\text{day}$$

Net Primary Productivity (NPP) of 0.75 meter values

$$= \frac{9.86 - 8.80}{24 \text{ hrs.}} = 1.06 \text{ g O}_2/\text{m}^3/\text{day}$$

Average NPP for first 0.75 meters of water column

$$= \overline{\text{NPP}}_{\text{surface}} = \frac{\text{NPP} (\text{surface}) + \text{NPP} (0.75 \text{ meters})}{2} \times (0.75 \text{ meters})$$

$$= \frac{1.27 + 1.06}{2} \times (0.75) = 0.87 \text{ g O}_2/\text{m}^2/\text{day}$$

Average NPP for remainder of water column

$$= \overline{\text{NPP}}_{\text{bottom}} = \text{NPP} (0.75 \text{ meters}) \times (0.34 \text{ meters})$$

$$= (1.06) \times (0.34) = 0.36 \text{ g O}_2/\text{m}^2/\text{day}$$

Total  $\overline{\text{NPP}}$  on an area basis =  $\overline{\text{NPP}}_{\text{surface}} + \overline{\text{NPP}}_{\text{bottom}}$

$$= 0.87 + 0.36 = 1.23 \text{ g O}_2/\text{m}^2/\text{day}$$

Respiration (R) of surface values

$$= \frac{8.82 - 7.76}{24 \text{ hrs.}} = 1.06 \text{ g O}_2/\text{m}^2/\text{day}$$

Respiration (R) of 0.75 meter values

$$= \frac{8.80 - 7.87}{24 \text{ hrs.}} = 0.93 \text{ g O}_2/\text{m}^3/\text{day}$$

Average R for first 0.75 meters of water column

$$= \overline{R}_{\text{surface}} = \frac{R(\text{surface}) + R(0.75 \text{ meters})}{2} \times (0.75 \text{ meters})$$

$$= \frac{(1.06) + (0.93)}{2} \times (0.75) = 0.75 \text{ g O}_2/\text{m}^2/\text{day}$$

Average R for remainder of water column

$$= \overline{R}_{\text{bottom}} = R(0.75 \text{ meters}) \times (0.34 \text{ meters})$$

$$= (0.93) \times (0.34) = 0.32 \text{ g O}_2/\text{m}^2/\text{day}$$

Total  $\overline{R}$  on an area basis =  $\overline{R}_{\text{surface}} + \overline{R}_{\text{bottom}}$

$$= 0.75 + 0.32 = 1.07 \text{ g O}_2/\text{m}^2/\text{day}$$

### Phytoplankton Measurements

Phytoplankton samples were taken in one-liter volume from a depth of approximately 0.5 meter at each station sampled. These whole water samples were taken in duplicate at one high and one low tide. One sample from each tidal stage was analyzed, and the other kept for reference. A few selected replicates were analyzed to determine sampling and population variability. Phytoplankton samples were preserved in a solution of 5 percent (volume/volume) formalin neutralized to pH 7.8 with sodium tetraborate.

The Utermohl technique (Lund, et al., 1958) utilizing the inverted microscope and sedimentation chambers was used for all microscopic work. The use of the inverted scope which enables plankton to be settled and examined directly in the Utermohl sedimentation chamber, minimizes the necessary working distance resulting in greater resolution and facilitating taxonomic work. This technique also minimizes sample manipulation, allowing the enumeration of both nannoplankton and macroplankton without biasing counts against the more fragile forms (Lund et al., 1958; Hobbie, 1971; U.S.G.S., 1973).

Ten milliliter aliquots were settled. Counts and identifications were made at a magnification of 450 times. Counts were converted to and were reported as cells per milliliter. A minimum of 100 cells were counted from each sample. This procedure yields an accuracy of approximately  $\pm$  20 percent at the 95 percent confidence interval (Lund, et al., 1958).

Cell volumes were determined by making optical measurements (in microns) of 20 representative individuals of each major species at each location. In cases where average species size varied between stations or where additional significant species were present, additional cellular measurements were made. The average cell volume for each major species was then calculated and multiplied by species density to obtain species biovolume. Biovolume was converted to biomass by assuming a specific gravity of unity. Biomass was reported as milligrams per liter.

#### Zooplankton Measurements

Samples were collected with a 30-centimeter diameter, Number 10 mesh (150  $\mu$  aperture) net equipped with a General Oceanics (Model 2030) digital flowmeter. Nets were towed at the surface for 5 minutes, rinsed, and the sample preserved in 5 percent buffered formalin. In the laboratory, aliquots for counting were obtained by using a Folsom plankton splitter. Organisms were enumerated and identified under a dissecting microscope. Among the major taxonomic references used were Ward and Whipple (1959), Gosner (1971), and Wilson (1932). To obtain weights, samples were washed in tap water, filtered on preweighed filters, and placed in a tared crucible. Samples were then dried to a constant weight (60 to 80°C) and weighed on a microanalytical balance.

#### Benthic Studies

Benthic samples were taken in duplicate at each station using a Ponar dredge (0.25 square foot bite). After collection, samples were sieved in a Number 30 mesh bucket and stained with rose bengal. Once returned to

the laboratory, one sample from each station was resieved (Number 30 mesh) and detrital material discarded while replicates were kept for reference. Organisms were counted and identified using a Heerburg-Wild stereoscope. The major taxonomic works consulted include Miner (1950), Abbott (1968), Gosner (1971), Day (1973), and Dance (1974).

Following counting and identification, gastropods (snails), pelycypods (bivalves), and echinoderms (primarily ophiuroidea; brittle stars) were decalcified using 20 percent HCl. All organisms were then dried at 105°C for 24 hours and biomass determined on a microanalytical balance.

#### Diversity

Diversity was calculated for phytoplankton, zooplankton, and benthic invertebrates by using the Shannon-Weaver Index (1963). The machine formula for this index is:

$$\bar{d} = \frac{C}{N} (N \log N - n_i \log n_i)$$

where:

$\bar{d}$  = mean diversity;

C = 3.321928 [converts base 10 to base 2 (bits)];

N = total number of individuals; and

$n_i$  = total number of individuals in the  $i^{\text{th}}$  taxon.

Phytoplankton were generally identified to the species level, while broader groupings were made of zooplankton and benthic invertebrates. Mean diversity,  $\bar{d}$ , is a measure of both the richness of taxa and the distribution of individuals among the taxa and may range from 0 to  $3.321928 \log N$  (Environmental Protection Agency, 1973).

#### Photosynthetic Pigments

Samples for pigment analyses were collected in duplicate at each station from a depth of 0.5 meter on one high and one low tide. Samples were collected in one liter volume and kept on ice in the dark during transportation to the field laboratory. They were filtered through 0.80  $\mu$  Millipore filters (Type AA), extracted into 90 percent acetone, and kept in the dark at  $0^{\circ}\text{C}$ .

The absorbance of the 10 milliliter pigment extracts was measured in a 4 centimeter cuvette on a Beckman DB Spectrophotometer. Chlorophyll analyses were made following the trichromatic procedure described by Strickland and Parsons (1972). Chlorophyll a was measured at 665 nanometers, chlorophyll b at 645 nanometers, and chlorophyll c at 630 nanometers. A measurement at 750 nanometers was used as a turbidity correction for all pigment analyses. Chlorophyll levels in the extract were determined by inserting the absorbance measurements into the following equations (Parsons and Strickland, 1972):

$$(1) C_a = 11.6 D_{665} - 1.31 D_{645} - 0.14 D_{630}$$

$$(2) C_b = -4.34 D_{665} + 20.7 D_{645} - 4.42 D_{630}$$

$$(3) C_c = -4.64 D_{665} - 16.3 D_{645} + 55 D_{630}$$

where:

$C_a$ ,  $C_b$ , and  $C_c$  represent concentrations of chlorophyll a, b, and c, respectively, in the extract; and  $D_{663}$ ,  $D_{645}$ , and  $D_{630}$  are the one-centimeter optical densities at the respective wavelengths, after subtracting the 750 nanometer blank.

The concentration of chlorophyll in the original sample was then computed from the following equation:

$$(4) \text{ milligrams pigment per liter} = \frac{C}{V}$$

where  $C$  was the value obtained from the previous equations and  $V$  was the volume of sea water filtered in liters.

For example, the absorbances measured from one of the pigment samples taken at high tide at Wiggins Pass, Station One, on April 26, were as follows:

750 nm	665 nm	645 nm	630 nm
0.012	0.054	0.035	0.035

Subtracting the 750 nm turbidity correction from the pigment absorbance values allows the use of these values in the above equations (1, 2 and 3). Multiplication by a factor (2.5) adjusts the values obtained with a 4 cm cuvette to those expected with a 10 cm cuvette.

$$C_a = 11.6(0.042) - 1.31(0.023) - 0.14(0.023) = 0.454 \times 2.5 = 1.135 \text{ mg/l}$$

$$C_b = -4.34(0.042) + 20.7(0.023) - 4.42(0.023) = 0.192 \times 2.5 = 0.480 \text{ mg/l}$$

$$C_c = -4.64(0.042) - 16.3(0.023) + 55(0.023) = 0.695 \times 2.5 = 1.738 \text{ mg/l}$$

Then, knowing the volume filtered was 400 ml, the concentration of these pigments in the original sample can be calculated using equation (4).

$$\text{mg chlorophyll } \underline{a}/\text{m}^3 = 1.135/0.4 = 2.84$$

$$\text{mg chlorophyll } \underline{b}/\text{m}^3 = 0.480/0.4 = 1.20$$

$$\text{mg chlorophyll } \underline{c}/\text{m}^3 = 1.738/0.4 = 4.35$$

Because chlorophyll degradation products may interfere with chlorophyll determinations, phaeopigments were estimated and a corrected chlorophyll a value was calculated after Strickland and Parsons (1972). Following the trichromatic absorbance readings, two drops of dilute hydrochloric acid were added to the cuvette and the absorbance was again read at 665 nanometers and 750 nanometers. Each 750 nanometer reading was then subtracted from the corresponding 665 nanometer reading and the concentrations of phaeophytin-corrected chlorophyll a and phaeopigments were calculated from the following formulae:

$$(5) \text{ chlorophyll } \underline{a} (\text{mg/m}^3) = \frac{26.7 (665_B) \times v}{v \times 1}$$

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$$(6) \text{ Phaeopigments (mg/m}^3\text{)} = \frac{26.7 ([1.7 \times 665_A] - 665_B)}{v \times l} \times v$$

where,

665<sub>B</sub> and 665<sub>A</sub> = extinction values before and after  
acidification respectively

v = volume of acetone used for extraction, milliliters

V = volume of water filtered, liters

l = pathlength of the cuvette, centimeters.

The use of these formulae may be illustrated using the absorbance values from the previous example with the addition of the following readings taken after extract acidification.

750 <sub>A</sub>	665 <sub>A</sub>
0.009	0.038

$$\text{Chlorophyll a (mg/m}^3\text{)} = \frac{26.7 (0.042 - 0.029) \times 10}{0.4 \times 4} = 2.17$$

$$\text{Phaeo-pigments (mg/m}^3\text{)} = \frac{26.7 (1.7 [0.029] - 0.042) \times 10}{0.4 \times 4} = 1.22$$

Once again, the turbidity correction at 750 nm must be subtracted prior to using the 665 absorbance values in the equations.

Plant carotenoids were also determined spectrophotometrically at a wavelength of 480 nm. Plant carotenoid concentrations expressed in milli-specific plant units (MSPU) were calculated as follows:

$$(7) \text{ Plant carotenoids (MSPU/m}^3) = \frac{10.0 \text{ D480} \times v}{v \times l}$$

where

D480 = the extinction coefficient at 480 nm (corrected for turbidity)

v = the volume of acetone extract, milliliters

V = the volume filtered, liters

l = the cuvette pathlength, centimeters.

Referring again to the same sample for illustrative purposes, the absorbance reading at 480 nm was 0.148. Due to higher extinction at the 480 nm wavelength, the turbidity correction is made by subtracting three times the 750 nm value (0.012). Thus, drawing on equation (7),

$$\text{Plant carotenoids (MSPU/m}^3) = \frac{10[0.148 - (3 \times 0.012)] \times 10}{0.4 \times 4} = 7.0$$

#### SYSTEMS COMPARISON

##### General Structure and Function

Comparisons of the general properties of each estuarine bay ecosystem were made through the use of energy circuit diagrams (Odum, 1971; Odum and Odum, 1976; Hall and Day, 1977). The initial comparisons were conceptual. Differences in major components and processes that may exist among the three areas studied would be made apparent as a simplified conceptual diagram of each area was developed. A second level of comparison came as each of the components of the diagrams was quantified. Magnitudes of storages and flows were compared. To facilitate

comparisons, compartment storages were generally expressed in units of grams organic matter/m<sup>2</sup>. Accordingly, flows were expressed in grams/m<sup>2</sup>/day.

#### Metabolism and Turnover

Ratios of content to throughput broadly define ecological turnover and offer insight into nutrient recycling and related metabolic processes (Lehman, 1974). Some definitions suggest turnover is a measure of persistence; ecosystems with long turnover time stabilize the environment. Others suggest that an ecosystem with short turnover time can react more quickly to environmental changes. Where data were available, turnover times were calculated and compared for major components such as zooplankton, phytoplankton, and benthic producers and consumers. An initial effort was made to calculate a turnover time for each estuary as a whole, based on total community metabolism measurements.

#### Numbers, Biomass, and Diversity

Phytoplankton and zooplankton data on numbers and biomass were compared for each bay. Values of plankton standing crop were calculated for each bay and were used in evaluating the model diagrams. Diversity as a comparative measure was calculated (see Diversity in previous section) and a species listing (Appendices E,F,G) contrasts the organisms collected in the three estuarine areas.

RESULTS

FIELD MEASUREMENTS

Total Community Metabolism

Table 1 gives the preliminary productivity results. These results may change slightly as more recent diffusion data and certain data artifacts are analyzed. Future refinements would not be expected to alter these values more than 10 percent. Appendix B presents graphically the results of all diurnal data collected during April.

Naples Bay calculations are summarized by two possible data reduction capabilities. One is the reduction of data by hand calculation and graphing with the final oxygen rate-of-change curve (see Figure 6f.) developed from hourly changes in oxygen concentration determined from the oxygen concentration curve (see Figure 6a.). The second procedure uses the same methodology but the data are computer reduced and graphed based on the rate-of-change over the actual sampling increment (usually 2-4 hours) rather than hourly increments. The results of both techniques give consistent and comparable values. Development of a computer program to reduce tedious data reduction and graphing times to a minimum was determined essential if productivity measurements were to be considered feasible in monitoring programs. Results of computer program development will be presented in the final report due October 21, 1977.

Table 1. Productivity Calculations Summary for Big Cypress Basin, April, 1977

Station No.	Process	Chokoloskee Bay		Wiggins Pass Area		Naples Bay*	
		g O <sub>2</sub> /m <sup>2</sup> /day					
1-S	NR	NA	NA	NA	NA	7.16	9.99
	DR					14.81	11.99
	NDP					16.26	16.86
	TCP					38.23	38.84
1	NR	2.02	1.56	3.73	3.15		
	DR	3.43	1.03	7.54	7.96		
	NDP	3.24	1.17	9.39	10.27		
	TCP	8.69	3.76	20.66	21.38		
2	NR	3.57	3.65	3.36	3.83		
	DR	4.46	3.92	5.76	6.17		
	NDP	5.89	3.40	5.34	5.38		
	TCP	13.92	10.97	14.46	15.38		
3	NR	4.22	1.87	6.45	7.53		
	DR	2.10	1.75	10.32	8.49		
	NDP	3.62	1.13	7.77	5.90		
	TCP	9.94	4.75	24.52	21.92		
4	NR	2.87	1.29	1.17	2.20		
	DR	2.08	2.71	1.18	2.18		
	NDP	1.98	0.75	1.47	1.50		
	TCP	6.93	4.75	3.82	5.88		
	$\bar{x}$	$\overline{\text{TCP}}$	$9.87 \pm 1.49$	$6.06 \pm 1.65$	$20.34 \pm 5.67$	$20.68 \pm 5.37$	

NR = Nighttime Respiration

NDP = Net Daytime Production

DR = Daytime Respiration

TCP = Total Community Production

\* Based on hand graphics interpreted from hourly rate-of-change.

† Based on computer graphics interpreted from sampling interval rate-of-change.

NA = Not applicable to this location.

The data presented in Table 1 are within ranges reported for Gulf Coast estuaries (Odum and Hoskins, 1958; Smith et al., 1974). Stations 1-S, 1, and 3 in Naples are subject to nutrient enrichment (see Figure 4). Station 1-S is immediately downstream of the City of Naples Sewage Treatment Plant outfall. Station 1 is less than 0.5 kilometer downstream of Station 1-S. Station 3 is near the mouth of Halderman Creek, which receives septic and package plant sewage from its drainage area in East Naples. This sewage discharge may be the reason for high values at those stations during the study period. The mean total community productivity for those stations in Naples Bay not considered highly influenced by sewage (Stations 2 and 4) input was 9.14 (10.63) g O<sub>2</sub>/m<sup>2</sup>/day. This mean is comparable to that of Chokoloskee Bay and Wiggins Pass Area--areas not considered impacted by sewage.

#### Oxygen Diffusion and Other Physical Parameters

Oxygen diffusion in g O<sub>2</sub>/m<sup>2</sup>/hr was calculated as a linear function of the dissolved oxygen concentration from saturation, D = KS, where S was the percent dissolved oxygen deficit and K was the oxygen diffusion coefficient (reaeration coefficient) in g O<sub>2</sub>/m<sup>2</sup>/hr at 100 percent saturation deficit (see Oxygen Diffusion, Methods Section). Odum and Wilson (1962) gave relationships of reaeration constants with water depth and wind velocity for Texas Bays, and McKeller (1975) gave data on reaeration coefficients for different tidal stages at Crystal River, Florida. The physical data given in Table 2 were used in conjunction

Table 2. Mean Wind Velocities and Water Depths for Big Cypress Basin Estuaries During Diurnal Measurements,  
April 16-23, 1977

Station No.	Chokoloskee Bay			Wiggins Pass Area			Naples Bay		
	Wind Velocity, mph	Water Depth, meters	Wind Velocity, mph						
1-S	NA	NA	NA	NA	NA	NA	5.0+0.9	2.0+0.1	
1	6.8+1.1	0.9+0.1	4.1+1.1	0.9+0.1	3.8+0.8	1.4+0.9			
2	7.8+0.6	1.1+0.1	5.1+0.9	2.4+0.1	4.0+1.1	1.5+0.1			
3	4.6+0.4	1.3+0.1	4.4+0.9	1.1+0.1	5.8+0.9	3.3+0.2			
4	6.2+0.6	0.7+0.1	2.3+1.0	0.9+0.1	6.2+0.7	1.1+0.1			
*									
$\bar{u}$	6.4	1.0	4.0	1.3	5.0	1.9			
S.E. †	$\pm 0.4$	$\pm 0.1$	$\pm 0.50$	$\pm 0.1$	$\pm 0.4$	$\pm 0.1$	$\pm 0.4$	$\pm 0.1$	

NA = Not applicable to this location

\* Mean,  $\bar{u}$ , of means  $\bar{x}_1-s$ ,  $\bar{x}_1$ ,  $\bar{x}_2$ ,

$\bar{x}_3$ , and  $\bar{x}_4$ .

† S.E. = one standard error about the mean,  $\bar{u}$ .

with these references (see Appendix C) to estimate a reaeration rate of  $0.5 \text{ g O}_2/\text{m}^2/\text{hr}/100$  percent saturation deficit for the estuaries studied. Two current velocities were measured in Chokoloskee Bay for this period--0.5 meter/sec. and 0.6 meter/sec. were recorded for an ebb and flood tide respectively. No current velocity measurements were made in the other bays. Diffusion rates may vary throughout a given day, and application of a constant rate may introduce some error into productivity calculations. In the absence of substantial diffusion data, how much error is not known at this time.

Secchi disc data are given in Table 3. Only one secchi disc reading was obtained in Chokoloskee Bay due to its shallow depth (see Table 2). For Naples Bay and Wiggins Pass Area, mean ( $\bar{u}$ ) extinction coefficients ( $K$ ) were the same. Light penetration increased (extinction decreased) as measurements were made progressively from the Gordon River to Gordon Pass. The shallowness of the bays studied required use of a submarine photometer for more complete light penetration data during subsequent diurnal studies. The photometer data will be presented at a later date.

Solar insolation graphs for each diurnal sampling period are given in Appendix C. These graphs were integrated to determine insolation in  $\text{Kcal/m}^2/\text{day}$ . Integration data are presented in Table 4, along with some estimated photosynthetic efficiencies. Insolation values are similar to those measured in Florida for past years in April (Smith, 1976). Efficiencies are consistent with those given by E. P. Odum

Table 3. Light Extinction Coefficients from Secchi Disc Data, Big Cypress Basin, April 16-23, 1977

Station No.	Chokoloskee Bay		Wiggins Pass Area		Naples Bay	
	$k, m^{-1}$	Water depth, d, in meters †	$k, m^{-1}$	Water depth, d, in meters	$k, m^{-1}$	Water depth, d, in meters
1-S	NA	NA	NA	NA	2.1	0.8
1	VOB	*	2.4	0.7	2.3	0.7
2	1.7	1.0	1.3	1.3	1.9	0.9
3	VOB	*	2.1	0.8	1.6	1.1
4	VOB	*	VOB	*	1.6	1.1
—	1.7	1.0	1.9	0.9	1.9	0.9
S.E.	--	--	$\pm 0.3$	$\pm 0.2$	$\pm 0.1$	$\pm 0.1$

NA = Not Applicable to this location.

VOB = Secchi disc visible on bottom over entire tidal cycle.

\* See mean water column data for this station, Table 2.

† At time of secchi disc reading.

Table 8. Descriptive Parameters for Zooplankton Collected at Wiggins Pass Area, Chokoloskee Bay, and Naples Bay in April, 1977.

Location	Tow	Concentration (individuals/m <sup>3</sup> )	Dry Weight (mg/m <sup>3</sup> )	Ash-Free Dry Weight (mg/m <sup>3</sup> )	Estimated Percent Detritus	Shannon-Weaver Diversity
Wiggins Pass	1-3**	8,690	135.1	30.6	15	2.72
	2	15,368	53.6	13.7	5	2.59
	4	9,371	33.1	9.1	5	1.60
	Average	11,143+2,124	73.9+31.2	17.8+6.5		2.30+0.35
Chokoloskee Bay	1	1,679	*	*	> 95	2.14
	2	984	*	*	> 95	2.41
	3	2,278	61.9	12.6	5	2.87
	4	676	162.8	36.3	70	3.30
	Average	1,404+359	112.4+50.6	24.5+11.8		2.68+0.26
Naples Bay	1S-1***	35	138.0	21.4	> 95	2.92
	2	492	307.1	42.1	> 80	2.73
	3	1,142	29.6	4.9	10	3.08
	4	31,034	178.8	53.9	5	3.03
	Average	8,176+7,623	163.4+57.3	30.6+10.9		2.94+0.08

\* Due to the presence of grasses and algal mats in these samples reliable weights could not be obtained.

\*\* Tow was made from Station 1 to Station 3.

\*\*\* Tow was made from Station 1S to Station 1.

This is typical of estuarine waters (Hopkins, 1966; Bellis, 1974; Reeve, 1975). The copepods were dominated in abundance by the calanoid Acartia tonsa, although the calanoid Paracalanus parvus, the harpacticoid Euterpina acutifrons, and the cyclopoid Oithona sp. also comprised a significant fraction of this group.

The term "meroplankton" refers to organisms which are only temporarily members of the plankton community, usually larval forms. Meroplankton accounted for a large fraction of the zooplankton enumerated. Barnacle nauplii and bivalve larvae were the most frequently observed members of this group. Detailed zooplankton data is given in Appendix F.

### Benthic Studies

Results of ponar samples taken are given in Table 9. Total number of individuals/square meter was highest for Chokoloskee Bay, more than twice that of the other two areas. Polychaetes and crustacea made up the majority of the macroinvertebrate communities in terms of numbers. In Naples and Chokoloskee Bays, polychaetes dominated, while in Wiggins Pass area, numbers of crustacea were most prominent.

Species diversity was highest in Wiggins Pass area, with the class Poly-chaeta exhibiting the most species. Station 1-S, the sewage impacted station in Naples Bay, was among the stations with higher diversities. Chokoloskee Bay, although highest in numbers, was lowest in biomass and also exhibited the lowest diversity.

The Wiggins Pass area was highest in biomass. Pelecypoda contributed the most biomass in Wiggins Pass and Naples Bay estuaries. Polychaetes were the predominant biomass contributor in Chokoloskee Bay.

Detailed benthic data are given in Appendix Tables G-1 and G-2.

Table 9. Biomass, Abundance, and Species Diversity of Benthic Macroinvertebrates, Big Cypress Basin, April 16-23, 1977

Location	Total Number of Individuals/m <sup>2</sup>	Species Diversity	Biomass g/m <sup>2</sup> Dry Weight*
<b>Wiggins Pass Area</b>			
Station 1	978	3.76	0.58
Station 2	822	1.06	0.10
Station 3	4,022	3.62	2.61
Station 4	1,911	3.56	0.49
$\bar{x}$ , of all stations	1,933	3.00	0.94
S.E.	<u>+737</u>	<u>+0.65</u>	<u>+0.56</u>
<b>Chokoloskee Bay</b>			
Station 1	6,599	1.59	0.86
Station 2	822	1.99	0.52
Station 3	2,644	2.06	0.66
Station 4	6,933	2.58	0.65
$\bar{x}$ , of all stations	4,250	2.06	0.67
S.E.	<u>+1,501</u>	<u>+0.20</u>	<u>+0.07</u>
<b>Naples Bay</b>			
Station 1-S	1,422	3.02	0.32
Station 1	2,778	1.50	0.27
Station 2	1,733	3.10	0.65
Station 3	111	1.92	0.01
Station 4	3,333	3.04	2.17
$\bar{x}$ , of all stations	1,875	2.52	0.68
S.E.	<u>+5,593</u>	<u>+0.34</u>	<u>+0.38</u>

\* Dry weight includes meat plus protein matrix of shell of Class Arthropoda.

### Diversity

According to Wade (1972), species diversity in a tropical estuary was inversely related to environmental stress levels--the greater the stress, the lower the diversity. E.P. Odum (1971) states species diversity tends to be low in physically controlled ecosystems and high in biologically controlled ones. Generally, as ecological turnover of an ecosystem increases, diversity decreases. Diversity may be one parameter of a monitoring program that could serve as an indicator of stress and of metabolic (turnover) fluctuations. Table 10 gives comparative results for diversities calculated for the plankton and benthic invertebrate components of the ecosystems studied.

Table 10. Mean Shannon-Weaver Diversities for the Phytoplankton, Zooplankton, and Benthic Invertebrate Communities of the Estuaries Studied in April 1977.

	Wiggins Pass	Chokoloskee Bay	Naples Bay
Phytoplankton	1.76	1.65	0.64
Zooplankton	2.30	2.68	2.97
Benthic Invertebrates	3.00	2.06	2.52

*111*

Photosynthetic Pigments

Chlorophyll a concentrations found in samples taken in April at Wiggins Pass, Chokoloskee Bay, and Naples Bay were generally low. Chlorophyll a and accessory pigment concentrations are summarized in Table 11.

Lowest overall pigment concentrations were found at Wiggins Pass. Mean chlorophyll a concentrations (corrected for phaeopigments) at this location ranged from a low of  $1.46 \text{ mg/m}^3$  (where the influence of Gulf waters on the estuary is greatest) to a high of  $3.17 \text{ mg/m}^3$  at station 3 (where the Cocohatchee River empties into the estuary). The overall mean corrected chlorophyll a concentration at this location was  $2.45 \text{ mg/m}^3$ .

Chokoloskee Bay also exhibited low pigment concentrations with an overall mean corrected chlorophyll a concentration of  $3.18 \text{ mg/m}^3$ . Chlorophyll a concentrations were lowest,  $1.92 \text{ mg/m}^3$ , at station 3 near the mouth of the Barron River and highest,  $5.30 \text{ mg/m}^3$ , at station 2 in the middle of Chokoloskee Bay.

Chlorophyll measurements for Naples Bay made in April are still being analyzed due to a possible instrument miscalibration in the laboratory. Measurements were re-run in June. The June values in Naples Bay (chlorophyll a) cannot be characterized as high, levels at this location were markedly elevated in relation to the other estuaries studied. These

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Table 11. Mean\* Pigment Concentrations in Samples Taken at Wiggins Pass,\*\* Chokoloskee Bay,†† and Naples Bay††

Location	Station	Corrected†		Uncorrected†		Carotenoids	
		Chlorophyll a (mg/m <sup>3</sup> )	Phaeopigments (mg/m <sup>3</sup> )	Chlorophyll a (mg/m <sup>3</sup> )	Chlorophyll b (mg/m <sup>3</sup> )	Chlorophyll c (mg/m <sup>3</sup> )	Carotenoids (MSPV/m <sup>3</sup> )
<b>Wiggins Pass</b>							
1	2.80	1.73	3.74	1.76	4.83	8.52	
	1.46	0.67	1.80	1.07	3.60	2.50	
	3.17	2.00	4.31	1.54	4.06	6.19	
	2.46	1.19	3.10	1.47	4.01	5.31	
	2.38	1.48	2.86	1.66	4.43	2.00	
Avg.	2.45±0.28	1.41±0.23	3.16±0.42	1.50±0.12	4.19±0.21	4.90±1.20	
<b>Chokoloskee Bay</b>							
1	2.25	1.22	2.93	1.19	3.24	5.00	
	5.30	1.91	6.46	1.03	6.07	9.78	
	1.92	1.26	2.61	1.27	3.97	4.31	
	3.25	1.94	4.35	1.55	5.14	6.30	
	3.18±0.59	1.58±0.20	4.09±0.76	1.26±0.11	4.61±0.63	6.35±1.05	
Avg.	5.58±0.85	4.61±1.09	8.19±1.45	3.63±0.53	7.31±0.83	15.53±2.53	
<b>Naples Bay</b>							
1-SA	7.13	6.24	10.71	4.13	7.83	18.95	
	7.43	7.67	11.79	5.08	9.55	22.64	
	6.34	6.77	10.20	4.42	8.27	18.47	
	6.68	3.81	8.78	4.06	8.62	17.36	
	3.38	1.94	4.43	2.22	5.16	8.80	
	2.54	1.25	3.20	1.84	4.44	6.98	
Avg.	5.58±0.85	4.61±1.09	8.19±1.45	3.63±0.53	7.31±0.83	15.53±2.53	

\* Means of four samples at each station; duplicates being taken at one high and one low tidal stage.

† Corrected chlorophyll a values have been adjusted for the presence of phaeopigments. Uncorrected chlorophyll a values have been derived directly from the trichromatic equations and have not been adjusted for phaeopigments.

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elevated levels are primarily due to concentrations found at the stations located on the Gordon River and the upper reaches of Naples Bay. A definite trend in pigment concentration over this estuary can be seen. Mean corrected chlorophyll a values range from 7.43 mg/m<sup>3</sup> at station 1-S (located just downstream of the effluent discharge for the Naples sewage treatment plant) to 2.54 mg/m<sup>3</sup> at station 4 (located near the mouth of the estuary). The overall mean corrected chlorophyll a level for samples taken at this location was 5.58 mg/m<sup>3</sup>.

## SYSTEMS COMPARISON

Case studies of the three estuarine bays considered in this report are summarized in this section. Systems diagrams are used as a basis for summary, and each diagram represents a preliminary, though comprehensive, look at the important processes and components. Evaluation of the diagrams was based on the best known available data and is intended to represent a dry season. Some data, however, was only available in annual averages.

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Figure 7 is the evaluated ecosystem diagram for Chokoloskee Bay estuary. Description and calculation of each value on the diagram is given in Table 12. Some general highlights of the evaluation included the following:

1. The bay is primarily benthic-dominated rather than plankton dominated;
2. Benthic producers provide 45 percent of all inputs into the detrital pool, plus 58 percent of primary production to benthic invertebrates and fish;
3. The bay is a net exporter of benthic invertebrates and fish, exporting up to 8 percent of its gross primary production along this pathway;
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	3	2,278	61.9	12.6	5	2.87
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<b>Wiggins Pass</b>							
1	2.80	1.73	3.74	1.76	4.83	8.52	
	1.46	0.67	1.80	1.07	3.60	2.50	
	3.17	2.00	4.31	1.54	4.06	6.19	
	2.46	1.19	3.10	1.47	4.01	5.31	
	2.38	1.48	2.86	1.66	4.43	2.00	
Avg.	2.45±0.28	1.41±0.23	3.16±0.42	1.50±0.12	4.19±0.21	4.90±1.20	
<b>Chokoloskee Bay</b>							
1	2.25	1.22	2.93	1.19	3.24	5.00	
	5.30	1.91	6.46	1.03	6.07	9.78	
	1.92	1.26	2.61	1.27	3.97	4.31	
	3.25	1.94	4.35	1.55	5.14	6.30	
	3.18±0.59	1.58±0.20	4.09±0.76	1.26±0.11	4.61±0.63	6.35±1.05	
Avg.	5.58±0.85	4.61±1.09	8.19±1.45	3.63±0.53	7.31±0.83	15.53±2.53	
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1-SA	7.13	6.24	10.71	4.13	7.83	18.95	
	7.43	7.67	11.79	5.08	9.55	22.64	
	6.34	6.77	10.20	4.42	8.27	18.47	
	6.68	3.81	8.78	4.06	8.62	17.36	
	3.38	1.94	4.43	2.22	5.16	8.80	
	2.54	1.25	3.20	1.84	4.44	6.98	
Avg.	5.58±0.85	4.61±1.09	8.19±1.45	3.63±0.53	7.31±0.83	15.53±2.53	

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4. The plankton component plays an important secondary role in primary production and nutrient recycling that may lend much stability to the overall ecosystem; and
5. Benthic invertebrates and fish feed at both levels of primary production, phytoplankton and benthic.

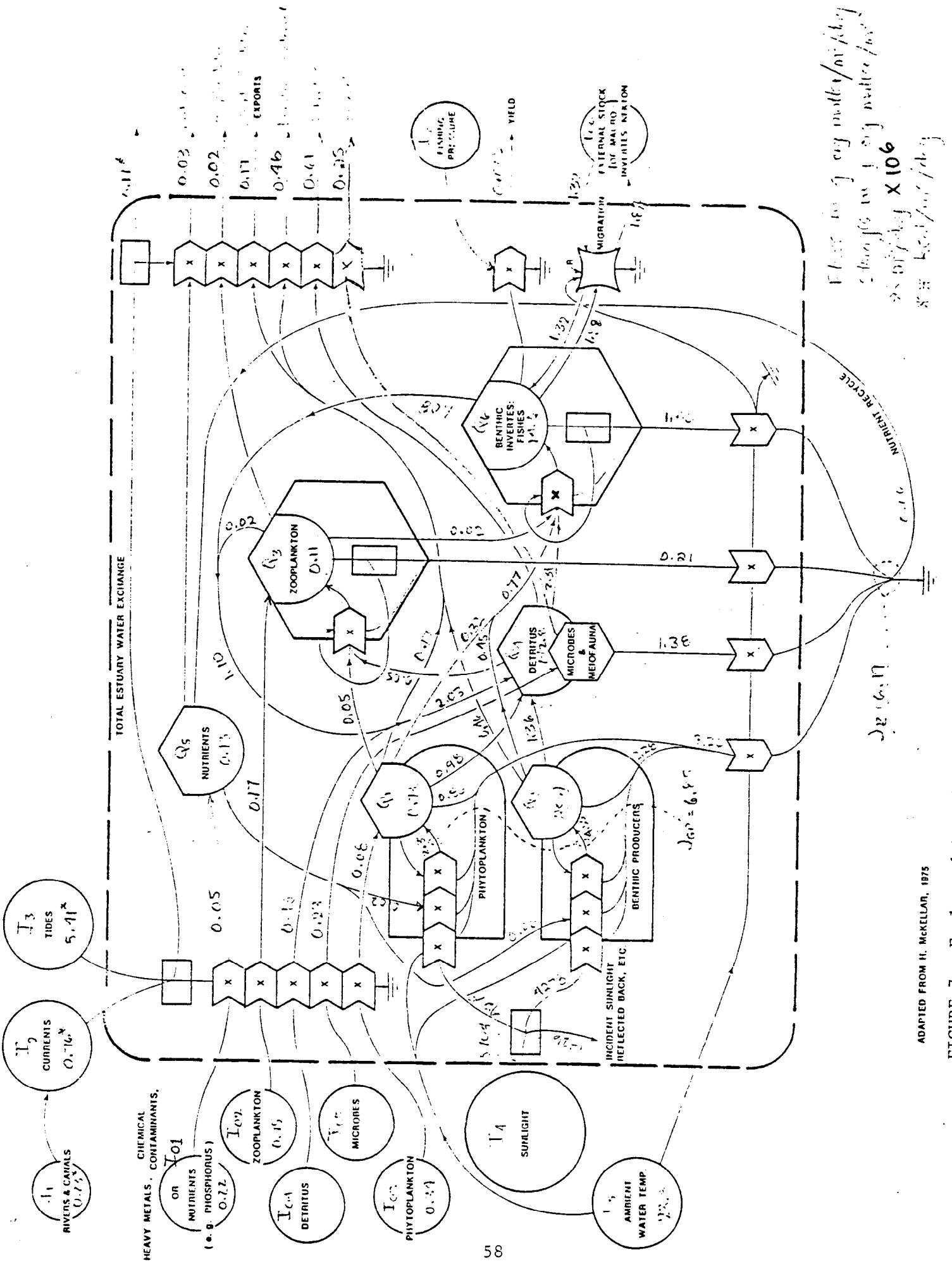


FIGURE 7. Evaluated Ecosystem Model for Chokoloskee Bay

ADAPTED FROM H. MCKELLAR, 1975

Table 12. Values for Chokoloskee Bay Model

Description	Notation	Calculations and Assumptions	References
<b>EXTERNAL DRIVING FORCES:</b>			
Freshwater flow from rivers and canals into estuary	I <sub>1</sub>	Average of 1970, 1974, and 1975 Barron River flow data. I <sub>1</sub> = 2.33 x 105 m <sup>3</sup> /day	U.S. Geological Survey, 1970, 1974, 1975
Current flows (advective water exchange)	I <sub>2</sub>	$  \begin{aligned}  I_2 &= (\text{mean longshore current velocity}) \\  &\quad \times (\text{average depth of bay}) \times \\  &\quad (\text{length of bay boundary}) \times \\  &\quad (\text{advection coefficient}) \\  &= (3.4 \times 10^{-3} \text{ m/sec})^a \times (1.0 \text{ m}) \times \\  &\quad (1.03 \times 10^4)^c \times (0.25)^d \\  &= (8.76 \text{ m}^3/\text{sec}) (8.64 \times 10^4 \text{ sec/day}) \\  &= 75.69 \times 10^4 = 7.57 \times 10^5 \text{ m}^3/\text{day}  \end{aligned}  $	(a) see Footnote 1 (b) see Results (c) NOAA, 1976 (d) assumed
Tidal water exchange	I <sub>3</sub>	$  \begin{aligned}  I_3 &= (\text{average tidal range}) \times (\text{area} \\  &\quad \text{of bay}) \times (\text{tides per day}) \times \\  &\quad (\text{tidal exchange coefficient}) \\  &= (1.26 \text{ m})^a \times (2.72 \times 10^7 \text{ m}^2) \times \\  &\quad (2) \times (0.079)^b \\  &= 5.41 \times 10^6 \text{ m}^3/\text{day}  \end{aligned}  $	(a) NOAA, 1976 (b) see Footnote 2
Sunlight	I <sub>4</sub>	I <sub>4</sub> = insolation measured = 5,704 kcal/m <sup>2</sup> /day	see Results, Table 4
Ambient water	I <sub>5</sub>	I <sub>5</sub> = average temperature measured = 23.5°C	see Appendix Table D-1
Fishing pressure	I <sub>6</sub>	I <sub>6</sub> = assumed to be proportional to the number of boats registered in Collier County	= unevaluated

Table 12. Values for Chokoloskee Bay Model (Continued, page 2 of 13)

Description	Notation	Calculations and Assumptions	References
<u>EXTERNAL DRIVING FORCES:</u>			
External concentration of nutrient (or contaminant or heavy metal)	I01	I01 = (total nutrient concentration in Barron River Canal water) <sup>a</sup> and (total nutrient concentration in Gulf) <sup>b</sup>	(a) Dry season data, ESE, 1977 (b) Dry season data, ESE, 1977, see Footnote 3
Total phosphorus		(a) I01TP = 0.04 g/m <sup>3</sup>	
Total nitrogen		I01TN = 0.57 g/m <sup>3</sup>	I01TP = 0.22 g/m <sup>3</sup>
Total organic carbon		I01TOC = <1.00 g/m <sup>3</sup>	I01TN = 2.49 g/m <sup>3</sup>
		I01TOC = 1.70 g/m <sup>3</sup>	
60 Input of nutrient due to water exchange	J01	J01 = [(I01, Barron River) x (I1)] + [(I01, Gulf) x (I3 + (I2 - I1))] (bay area)	
Total phosphorus		J04 = [(0.04 g/m <sup>3</sup> ) x (2.33 x 105 m <sup>3</sup> /day)] + [(0.22 g/m <sup>3</sup> ) x (5.93 x 106 m <sup>3</sup> /day)] 2.72 x 10 <sup>7</sup> m <sup>2</sup>	
		= $\frac{1.31 \times 10^6 \text{ g/day}}{2.72 \times 10^7 \text{ m}^2} = 0.048 \text{ g/m}^2/\text{day}$	
External concentration of zooplankton	I02	I02 = (Zooplankton concentration in nearshore Gulf water) = 0.75 g/m <sup>3</sup>	see Footnote 4

Table 12. Values for Chokoloskee Bay Model (Continued, page 3 of 13)

Description	Notation	Calculations and Assumptions	References
<u>EXTERNAL DRIVING FORCES:</u>			
Import of zooplankton due to water exchange	J02	$J_{02} = \frac{(I_{02}, \text{ above}) \times (I_{12} + I_{13}, \text{ above})}{(\text{bay area})}$ $= \frac{(0.75 \text{ g/m}^3) + (6.17 \times 10^6 \text{ m}^3/\text{day})}{(\text{bay area})}$ $= 0.17 \text{ g/m}^2/\text{day}$	(a) see Footnote 5 (b) Steele and Baird, 1965 (c) E.P. Odum, 1971
External concentration of phytoplankton	I03	$I_{03} = (\text{chlorophyll-a concentration in nearshore Gulf})_a \times (\text{carbon: chlorophyll-a ratio})_b \times (\text{organic matter: carbon})_c$ $= (1.69 \text{ mg/m}^3) \times (100) \times (2)$ $= 0.338 \text{ g/m}^3$	(a) see Footnote 5 (b) Steele and Baird, 1965 (c) E.P. Odum, 1971
Import of phytoplankton due to water exchange	J03	$J_{03} = \frac{(I_{03}, \text{ above}) + (I_{12} + I_{13}, \text{ above})}{(\text{bay area})}$ $= \frac{(0.338 \text{ g/m}^3) \times (6.17 \times 10^6 \text{ m}^3/\text{day})}{(2.72 \times 10^7 \text{ m}^2)}$ $= 0.077 \text{ g/m}^2/\text{day}$	(a) Dry season TOC data, ESE, 1977 (b) see Footnote 6
External concentration of detritus	I04	$I_{04} = (\text{average concentration of detritus in river runoff})_a \text{ and } (\text{average concentration in nearshore Gulf})_b$ $(a) I_{04} = 39.7 \text{ g/m}^3$ $(b) I_{04} = 2.71 \text{ g/m}^3$	(a) Dry season TOC data, ESE, 1977 (b) see Footnote 6

Table 12. Values for Chokoloskee Bay Model (Continued, page 4 of 13)

Description	Notation	Calculations and Assumptions	References
<b>EXTERNAL DRIVING FORCES:</b>			
Import of detritus due to water exchange	$J_{04}$	$J_{04} = \frac{[(I_{04}, \text{ river runoff}) \times (I_1) + (I_{04}, \text{ nearshore gulf}) \times (I_3 + (I_2 - I_1))]}{(\text{bay area})}$ $= \frac{[(39.7 \text{ g/m}^3) \times (2.33 \times 10^5 \text{ m}^3/\text{day})] + [(2.71 \text{ g/m}^3) \times (5.93 \times 10^6 \text{ m}^3/\text{day})]}{(2.72 \times 10^7 \text{ m}^2)}$ $= \frac{(9.25 \times 10^6 \text{ g/day}) + (16.07 \times 10^6 \text{ g/day})}{(2.72 \times 10^7 \text{ m}^2)}$ $= \frac{(25.32 \times 10^6 \text{ g/day})}{(2.72 \times 10^7 \text{ m}^2)} = 0.93 \text{ g/m}^2/\text{day}$	
External concentration of microbes	$I_{05}$	$I_{05} = \frac{(\text{concentration in nearshore Gulf water})^a \text{ and } (\text{concentration in river runoff})^b}{(\text{bay area})}$ $(a) I_{05} = 1.06 \text{ g/m}^3 \quad (b) I_{05} = 0.01 \text{ g/m}^3$	(a) see Footnote 7 (b) see Footnote 8
Import of microbes due to water exchange	$J_{05}$	$J_{05} = \frac{[(I_{05}, \text{ river runoff}) \times (I_1) + (I_{05}, \text{ nearshore gulf}) \times (I_3 (I_2 - I_1))]}{(\text{bay area})}$ $= \frac{[(0.01 \text{ g/m}^3) \times (2.33 \times 10^5 \text{ m}^3/\text{day})] + [(1.06 \text{ g/m}^3) \times (5.93 \times 10^6 \text{ m}^3/\text{day})]}{(2.72 \times 10^7 \text{ m}^2)}$	

Table 12. Values for Chokoloskee Bay Model (Continued, page 5 of 13)

Description	Notation	Calculations and Assumptions	References
<b>EXTERNAL DRIVING FORCES:</b>			
Import of microbes due to water exchange, cont.	J05	$= \frac{(.0023 \times 10^6) + (6.29 \times 10^6)}{(2.72 \times 10^7 \text{ m}^2)}$ $= 2.31 \times 10^{-1} \text{ g/m}^2/\text{day} = 0.23 \text{ g/m}^2/\text{day}$	(a) see Results, Table 9 (b) see Footnote 9
<b>INTERNAL STOREAGES:</b>			
External density of macrobenthic invertebrates and fish	I06	$I06 = (\text{invertebrates})_a + (\text{fish})_b$ $= (0.67 \text{ g/m}^2) + (12.54 \text{ g/m}^2)$ $= 13.21 \text{ g/m}^2$	
Invertebrate and fish	J06	$J06 \text{ assumed to be about 10 percent of the external stock of invertebrates and fish}$ $= (I06, \text{ above}) (0.10)$ $= (13.21 \text{ g/m}^2) (0.10)$ $= 1.32 \text{ g/m}^2/\text{day}$	McKellar, 1975
<b>INTERNAL STOREAGES:</b>			
Phytoplankton biomass	Q1	$Q_1 = \text{standing stock of phytoplankton}$ $= (\text{concentration}) \times (\text{mean depth})$ $= (0.73 \text{ g/m}^3) \times (1.0 \text{ m})$ $= 0.73 \text{ g/m}^2$	see Results, Table 7
Benthic biomass	Q2	$Q_2 = \text{standing stock of benthic macrophytes}$ $= 20.1 \text{ g/m}^2$	see Footnote 10
Zooplankton biomass	Q3	$Q_3 = \text{standing stock of zooplankton}$ $= (\text{concentration}) \times (\text{average depth})$ $= (0.112 \text{ g/m}^3) \times (1.0 \text{ m})$ $= 0.11 \text{ g/m}^2$	see Results, Table 8

Table 12. Values for Chokoloskee Bay Model (Continued, page 6 of 13)

Description	Notation	Calculations and Assumptions	References
<u>INTERNAL STORAGE:</u>			
Detritus stock with associated microbes	$Q_4$	$Q_4 = (\text{water column detritus})^a \text{ and}$ $(\text{bottom detritus})^b$ (a) $4.50 \text{ g/m}^2$ (b) $138.3 \text{ g/m}^2$ $= (138.3) + (4.5) = 142.8 \text{ g/m}^2$	(a) see Footnote 11 (b) see Footnote 12
Total nutrient concentration in water	$Q_5$	$Q_5 = (\text{total nutrient concentration})^a \times$ $(\text{bay depth})^b$ $Q_5\text{TP} = (0.13 \text{ g/m}^3) \times (1.0 \text{ m}) =$ $0.13 \text{ g/m}^2$ $Q_5\text{TN} = (1.33 \text{ g/m}^3) \times (1.0 \text{ m}) =$ $1.33 \text{ g/m}^2$	(a) Dry season data, ESE, 1977 (b) see Results, Table 2
Benthic invertebrates and fish biomass	$Q_6$	$Q_6 = (\text{benthic invertebrates})^a + (\text{fish})^b$ = $(2.01 \text{ g/m}^2) + (12.54 \text{ g/m}^2)$ $= 14.55 \text{ g/m}^2 = 14.6 \text{ g/m}^2$	(a) see Footnote 13 (b) see Footnote 9
<u>INTERNAL FLOWS:</u>			
Light used in photosynthesis	$J_1$	$J_1 = (.75)(I_4) = (.75)(5,704)$ $= 4,278 \text{ kcal/m}^2/\text{day}$	see Footnote 14
Light remaining for additional work	$J_r$	$J_r = I_4 - J_1$ $= 5,704 - 4,278 \text{ kcal/m}^2/\text{day}$ $= 1,426 \text{ kcal/m}^2/\text{day}$	
Total community gross primary production	$J_{GP}$	$J_{GP} = (\text{net daytime production}) +$ $(\text{nighttime respiration})$ = $\text{NDP} + \text{NR}$ $= 6.85 \text{ g/m}^2/\text{day}$	see Results, Table 1

Table 12. Values for Chokoloskee Bay Model (Continued, page 7 of 13)

Description	Notation	Calculations and Assumptions	References
<b>INTERNAL FLOWS:</b>			
Phytoplankton gross primary production	$J_{GP1}$	$J_{GP1} = P_{gross\ 24} = 2.30\ g/m^2/day$	see Results, Table 5
Benthic producer gross primary production	$J_{GP2}$	$\begin{aligned} J_{GP2} &= J_{GP} - J_{GP1} \\ &= (6.85\ g/m^2/day) - (2.30\ g/m^2/day) \\ &= 4.55\ g/m^2/day \end{aligned}$	
Total community respiration	$J_R$	$\begin{aligned} J_R &= (\text{nighttime respiration}) + \\ &\quad (\text{daytime respiration}) \\ &= NR + DR \\ &= 6.19\ g/m^2/day \end{aligned}$	see Results, Table 1
Phytoplankton respiration	$J_{R1}$	$J_{R1} = 0.86\ g/m^2/day$	see Footnote 16
Benthic producer respiration	$J_{R2}$	$\begin{aligned} J_{R2} &= (J_{GP2}) \times (0.50) \\ &= (4.55) \times (0.50) \\ &= 2.28\ g/m^2/day \end{aligned}$	see Footnote 15
Zooplankton respiration	$J_{R3}$	$J_{R3} = 0.21\ g/m^2/day$	see Footnote 16
Benthic invertebrate and fish respiration	$J_{R4}$	<p><math>J_{R4}</math> = assumed to reflect a metabolic turnover time of 10 days</p> $\begin{aligned} &= (Q_6, \text{ this table})/10\ \text{days} \\ &= 1.46\ g/m^2/day \end{aligned}$	

Table 12. Values for Chokoloskee Bay Model (Continued, page 8 of 13)

Description	Notation	Calculations and Assumptions	References
<u>INTERNAL FLOWS:</u>			
Respiration of detritus	$J_{R5}$	$J_{R5} = J_R - (J_{R1} + J_{R2} + J_{R3} + J_{R4})$ $= (6.19) - (0.86 + 2.28 + 0.21 + 1.46)$ $= 1.38 \text{ g/m}^2/\text{day}$	
Nutrient recycle from community respiration	$J_N$	$J_N = \text{percent of respired organic matter}$ $\text{that nutrient comprises}$ $J_{NTP} = \text{assuming resired organic matter}$ $\text{was 1% phosphorus}$ $= (.01) \times (J_R) = (.01) \times (6.19)$ $= 0.06 \text{ g/m}^2/\text{day}$	
Export of phytoplankton due to water exchange	$J_{EI}$	$J_{EI} = \frac{(\text{phytoplankton stock})^a \times (I_2 + I_3)}{(\text{Bay area}) \times (\text{Bay depth})}$ $= \frac{(0.73 \text{ g/m}^2) \times (6.17 \times 10^6 \text{ m}^3/\text{day})}{(2.72 \times 10^7 \text{ m}^2) \times (1.0 \text{ m})}$ $= \frac{4.50 \times 10^6 \text{ g/m/day}}{2.72 \times 10^7 \text{ m}^3}$ $= 0.17 \text{ g/m}^2/\text{day}$	(a) see $Q_1$ , this table

Table 12. Values for Chokoloskee Bay Model (Continued, page 9 of 13)

Description	Notation	Calculations and Assumptions	References
<b>INTERNAL FLOWS:</b>			
Zooplankton export	$J_{E2}$	$J_{E2} = \frac{(\text{zooplankton stock})^a \times (I_2 + I_3, \text{ this table})}{(\text{Bay area}) \times (\text{Bay depth})}$ $= \frac{(0.11 \text{ g/m}^2) \times (6.17 \times 10^6 \text{ m}^3/\text{day})}{2.72 \times 10^7 \text{ m}^3}$ $= 0.02 \text{ g/m}^2/\text{day}$	(a) see $Q_3$ , this table
Nutrient export due to tidal exchange	$J_{E3}$	$J_{E3} = \frac{(\text{nutrient stock})^a \times (I_2 + I_3)^b}{(\text{Bay area}) \times (\text{Bay depth})}$ $= \frac{(0.13 \text{ g/m}^2) \times (6.17 \times 10^6 \text{ m}^3/\text{day})}{2.72 \times 10^7 \text{ m}^3}$ $= 0.03 \text{ g/m}^2/\text{day}$	(a) $Q_5$ , this table (b) this table
Benthic plant material exported due to fragmentation and tidal exchange	$J_{E4}$	$J_{E4} = \frac{(10\% \text{ of standing rock assumed to fragment})^a \times (I_2 + I_3)^b}{(\text{Bay area}) \times (\text{Bay depth})}$ $= \frac{(0.10) \times (2.01) \times (6.17 \times 10^6)}{2.72 \times 10^7}$ $= 0.46 \text{ g/m}^2/\text{day}$	(a) $Q_2$ , this table (b) this table

Table 12. Values for Chokoloskee Bay Model (Continued, page 10 of 13)

Description	Notation	Calculations and Assumptions	References
<b>INTERNAL FLOWS:</b>			
Export of detritus due to tidal exchange	$J_{E5}$	$J_{E5} = \frac{(\text{detrital conc.})^a \times (I_2 + I_3)^b}{(\text{Bay area})}$ $= \frac{(2.71) \times (6.17 \times 10^6)}{2.72 \times 10^7}$ $= 0.61 \text{ g/m}^2/\text{day}$	(a) $I_{04}$ , this table (b) this table
Export of microbes due to tidal exchange	$J_{E6}$	$J_{E6} = \frac{(\text{microbe conc.})^a \times (J_2 + I_3)^b}{(\text{Bay area})}$ $= \frac{(1.06 \text{ g/m}^3)^3 \times (6.17 \times 10^6 \text{ m}^3/\text{day})}{2.72 \times 10^7 \text{ m}^2}$ $= 0.25 \text{ g/m}^2/\text{day}$	(a) $I_{05}$ , this table (b) this table
Fishing yield due to commercial and sport fishing	$J_F$	$J_F = (\text{commercial yield}) + (\text{sport fishing yield})$ $= (0.0014) + (0.0007)$ $= 0.002 \text{ g/m}^2/\text{day}$	see Footnote 17
Zooplankton grazing upon phytoplankton	$J_2$	$J_2 = \text{calculated to give an organic balance to compartment}$ $= 0.05 \text{ g/m}^2/\text{day}$	see Footnote 18c

Table 12. Values for Chokoloskee Bay Model (Continued, page 11 of 13)

Description	Notation	Calculations and Assumptions	References
<u>INTERNAL FLOWS:</u>			
Zooplankton grazing upon detritus	$J_3$	$J_3 = \text{calculated to give an organic balance to compartment}$ $= 0.05 \text{ g/m}^2/\text{day}$	see Footnote 13c
Nutrient uptake by phytoplankton	$J_4$	$J_4 = \text{uptake based on amount of nutrient in organic matter produced}$ $J_{4TP} = \text{assuming organic matter fixed is 1% phosphorus}$ $= (0.01) \times (J_{GP1}, \text{ this table})$ $= (0.01) \times (2.30) = 0.02 \text{ g/m}^2/\text{day}$	
Nutrient uptake by benthic procedures	$J_5$	$J_5 = \text{same as } J_4 \text{ above}$ $J_{5TP} = \text{same as } J_4 \text{ above, however calc. to give balance in nutrient compartment}$ $= (\text{inputs}) - (\text{outputs})$ $= (0.11) - (0.05) = 0.06 \text{ g/m}^2/\text{day};$ $\text{approximately equal to 1% fixed as phosphorus}$	see Footnote 13a
Benthic invertebrates and fish grazing on phytoplankton	$J_6$	$J_6 = \text{calculated to give an organic balance in compartment}$ $= \text{Inputs } (J_{03} + J_{GP1}) - \text{Outputs } \frac{(J_{RI} + J_{EI} + J_{2})}{4}$ $= \frac{(2.38) - (1.03)}{4} = 0.325$ $= 0.32 \text{ g/m}^2/\text{day}$	

Table 12. Values for Chokoloskee Bay Model (Continued, page 12 of 13)

Description	Notation	Calculations and Assumptions	References
<b>INTERNAL FLOWS:</b>			
Phytoplankton death and transfer to detritus	$J_7$	$J_7 = \text{calculated to give an organic balance in compartment}$ $= \text{three times } J_6, \text{ above}$ $= (3) \times (0.325) = 0.975 = 0.98 \text{ g/m}^2/\text{day}$	see Footnote 18a
Benthic invertebrates and fish grazing on benthic producers	$J_8$	$J_8 = \text{calculated to give an organic balance in compartment}$ $= \text{Inputs (J}_{GP2}) - \text{Outputs (J}_{R2} + J_{E4})$ $= \frac{(4.55) - (2.74)}{4} = 0.4 \text{ g/m}^2/\text{day}$	see Footnote 18a
Benthic producers death and transfer to detritus	$J_9$	$J_9 = \text{calculated to give an organic balance in compartment}$ $= \text{three times } J_8, \text{ above}$ $= (3) \times (0.45) = 1.36 \text{ g/m}^2/\text{day}$	see Footnote 18a
Benthic invertebrates and fish grazing on detritus	$J_{10}$	$J_{10} = \text{three times rate of grazing on phytoplankton (J}_6) \text{ and benthic producers (J}_8)$ $= (3) \times (J_6 + J_8, \text{ above})$ $= (3) \times (0.77) = 2.31 \text{ g/m}^2/\text{day}$	see Footnote 18b
Zooplankton death and feces transfer to detritus	$J_{11}$	$J_{11} = \text{calculated to give an organic balance in compartment}$ $= 50\% \text{ of inputs (J}_{O2} + J_3 + J_2)^b -$ $\text{outputs (J}_{R3} + J_{E2})^6$ $= (0.50) \times [(0.27) - (0.23)]$ $= 0.02 \text{ g/m}^2/\text{day}$	(a) see Footnote 18 (b) this table

Table 12. Values for Chokoloskee Bay Model (Continued, page 13 of 13)

Description	Notation	Calculations and Assumptions	References
<u>INTERNAL FLOWS:</u>			
Benthic invertebrates and fish grazing on zooplankton	$J_{12}$	$J_{12} = \text{calculated to give an organic balance in compartment}^a$ $= \text{Inputs } (J_{O2} + J_3 + J_2)^b - \text{outputs}$ $(J_{R3} + J_{E2} + J_{11})^b$ $= (0.27) - (0.25) = 0.02 \text{ g/m}^2/\text{day}$	(a) see Footnote 13 (b) this table
Benthic invertebrate and fish death and feces transfer to detritus	$J_{13}$	$J_{13} = \text{calculated to give an organic balance to detrital compartment}^a$ $= \text{Inputs } (J_{O4} + J_9 + J_{11} + J_7)^b -$ $\text{Outputs } (J_{E5} + J_{R5} + J_3 + J_{10})^b$ $= (3.19) - (4.14) = -0.95 \text{ g/m}^2/\text{day}$ $= \text{deficit in detrital compartment}$ $= 0.95 \text{ g/m}^2/\text{day}$	(a) see Footnote 13 (b) this table
Benthic invertebrate and fish out-migration	$J_{14}$	$J_{14} = \text{calculated to give an organic balance in compartment}^a$ $= \text{Inputs } (J_{O6} + J_6 + J_8 + J_{10} + J_{12}) -$ $\text{Outputs } (J_{R4} + J_F + J_{13})$ $= (4.42) - (2.54) = 1.88 \text{ g/m}^2/\text{day}$	(a) see Footnote 13

Table 12 Footnotes

1. Longshore current velocity estimated by modified Longuet-Higgins equation (U.S. Army Coastal Eng. Res. Center, 1973):

$$v = 2.3M_1 m(gH_b)^{1/2} \sin 2^\alpha b$$

where,  $v$  = longshore current velocity, ft/sec  
 $m$  = beach slope  
 $g$  = acceleration due to gravity, ft/sec<sup>2</sup>  
 $H_b$  = breaker height, ft.  
 $\alpha_b$  = angle between breaker crest and shore degrees,  
and  $M_1 = \frac{0.694\Gamma(2\beta)^{-1/2}}{f_f}$

$\Gamma$  = mixing coefficient which ranges between 0.17 (little mixing) and 0.5 (complete mixing)  
 $\beta$  = depth-to-height ratio of breaking waves (in shallow water 1.2)  
 $f_f$  = coefficient of friction, taken to be 0.01

$$\text{so, } M_1 = \frac{0.694(0.2)(2.4)^{-1/2}}{0.01} = 8.96$$

$$\begin{aligned} \text{thus, } v &= (2.3)(8.96)(1.97 \times 10^{-4})(32.2 \text{ ft/sec}^2)(2 \text{ ft})^{1/2} \sin 20^\circ \\ &= (0.111 \text{ ft/sec})(0.3048 \text{ m/ft}) = 0.0034 \text{ m/sec} \\ &= 3.4 \times 10^{-3} \text{ m/sec} \end{aligned}$$

Table 12 Footnotes (Continued, page 2 of 5)

2. Tidal exchange coefficient =  $\frac{\text{volume of water entering the bay}}{\text{volume of water necessary to maintain a certain salinity (tidal prism)}}$  =  $\frac{V_T}{V_A}$

where,  $V_A$  = (average tidal amplitude)  $\times$  (area of bay)  $\times$  (tides per day)

$$V_T = \frac{\text{salinity of bay}}{\text{salinity of gulf}} (\text{freshwater discharge into bay})$$

$$\frac{1 - \frac{\text{salinity of bay}}{\text{salinity of gulf}}}{}$$

$$\text{so, } V_A = (1.26 \text{ m}) \times (2.72 \times 10^7 \text{ m}^2) \times (2) = 6.85 \times 10^7 \text{ m}^3/\text{day}$$

$$\text{and, } V_T = \frac{32.6}{34.0} (2.33 \times 10^5 \text{ m}^3/\text{day})$$

$$\frac{1 - \frac{32.6}{34.0}}{}$$

$$= \frac{(0.96)(2.33 \times 10^5 \text{ m}^3/\text{day})}{(0.0412)} = 5.43 \times 10^6 \text{ m}^3/\text{day}$$

$$\text{then, } \frac{V_T}{V_A} = \frac{5.43 \times 10^6}{6.85 \times 10^7} = 0.793 \times 10^{-1} = .0793$$

Table 12 Footnotes (Continued, page 3 of 5)

3. Data from SWF 208 Charlotte Harbor Data. Station II-B18, located west of Boca Grande Pass.
4. Zooplankton concentration is based on an average of McKellar, 1975, Gulf Shelf data for March 18 and 19, 1972. Average stock = 1.37 g dry wt/m<sup>2</sup> mean depth for nearshore (10 nautical mile strip of Gulf Shelf immediately paralleling Chokoloskee Bay) was estimated as 1.83 meters. Zooplankton concentration = (1.37 g/m<sup>2</sup>)/(1.82 m) = 0.75 g/m<sup>3</sup>.
5. Gulf shelf chlorophyll-a concentration = 1.69 mg/m<sup>3</sup>. Mean of values measured by McKellar, 1975. Data from Gulf Shelf cruise, March 18-19, 1973.
6. Average of data for Fahkahatchee Pass, West Pass, and Fahka Union South on flooding tide, October 18, 1972. Carter et al., 1973. Detrital fraction = 2.71 mg/l = 2.71 g/m<sup>3</sup>.
7. Average of gulf water near beach zone and near shore above diplanthera bed, Oppenheimer and Jannasch, 1963, taken off Texas coast, May 1958. Concentration = 1.06 g/m<sup>3</sup>.
8. Values for total aerobic bacteria for some canals and rivers of south Florida range from  $3.5 \times 10^3$  to  $1.6 \times 10^5$  cells/ml (Fox and Brezonik, 1976). Using the mass  $2 \times 10^{-13}$  g for one bacterium taken from Kriss (1959), biomass ranges from 0.0007 g/m<sup>3</sup> to .032 g/m<sup>3</sup>. Assume Barron River is one-third of upper value; concentration = 0.01 g/m<sup>3</sup>.
9. Mean fish biomass of the Ten Thousand Islands = 6.27 g/m<sup>2</sup> (Snedaker and Lugo, 1972). Drop-net method used by Snedaker and Lugo assumed to be 50% efficient; fish biomass = 12.54 g/m<sup>2</sup>.
10. Mean of values for Fahkahatchee Bay, March and July, 1972, Carter et al., 1973.  $\bar{x} = 20.1$  g/m<sup>2</sup>.
11. Water column detritus similar to those from Carter et al. 1973; mean of all values listed during July and October, 1972.  $\bar{x} = 5.84$  mg/l = 5.84 g/m<sup>3</sup>. (concentration)  $x$  (mean depth) = (5.84 g/m<sup>3</sup>)  $x$  (1.0 m) = 5.84 g/m<sup>2</sup>. Average of TOC (Total Organic Carbon) values from SWF 208 sampling in Chokoloskee estuary = 5.3 g/m<sup>2</sup> minus plankton = (5.3 g/m<sup>2</sup>) - (.8 g/m<sup>2</sup>) = 4.5 g/m<sup>2</sup>
12. Standing stock of bottom detritus is based on sedimentation rates given by Carter et al., 1973. Sediment deposition was given as 2.31 cm/yr for Fahkahatchee Bay. This was based on a daily rate of 160.1 g/m<sup>2</sup> at a density of 2.23. The organic content of the material being deposited was about 20% for the dry season. The top 10 cm of the bay bottom revealed a similar organic content of about 20%. The ratio of bottom layer/deposition = 10/2.31 = 4.32, so applying the same ratio to the daily rate (4.32)  $x$  (160.1 g/m<sup>2</sup>) = 691.6  $x$  (percent organic material) = (691.6)  $x$  (0.20) = 138.3 g/m<sup>2</sup>.

Table 12 Footnotes (Continued, page 4 of 5)

13. Total benthic invertebrate standing stock was represented by benthic macroinvertebrates (as listed in Results, Table 9) plus large meiofauna. McKellar, 1975, assumed meiofauna biomass to be twice that of other macroinvertebrates (based on work by Snedaker, et al., 1973). Total benthic invertebrate standing stock was taken as three times the values listed in Table 9.  $(0.67 \text{ g/m}^2) \times (3) = 2.01 \text{ g/m}^2$ .
14. Assuming that peak production during the dry season was 75% of incident solar radiation (based on simulation results, McKellar, 1975).
15. Assuming that respiration is 50% of production.
16. Total plankton respiration was found to be  $1.07 \text{ g/m}^2/\text{day}$  (Results, Table 5). Assuming  $1 \text{ g/02}$  is equivalent to  $1 \text{ g}$  organic matter, and using ratio of phytoplankton biomass to total plankton biomass, it was assumed that 80% of total plankton respiration was due to phytoplankton and remaining 20% due to zooplankton.

17. Commercial fishery landings in Collier County for 1973 were:

$$\begin{aligned}
 \text{Finfish} &= (2.89 \times 106 \text{ lbs/year}) \times (0.2 \text{ dry wt/wet wt}) \times (0.9 \text{ g org. matter/dry wt}) \\
 &= 0.52 \times 106 \text{ lbs org. matter/year} \\
 \text{Shellfish} &= (1.03 \times 106 \text{ lbs/year}) \times (0.5 \text{ dry wt/wet wt}) \times (0.56 \text{ g org. matter/dry wt}) \\
 &= 0.29 \times 106 \text{ lbs org. matter/year} \\
 \text{Shrimp} &= (0.017 \times 106 \text{ lbs/year}) \times (0.3 \text{ dry wt/wet wt}) \times (0.8 \text{ g org. matter/dry wt}) \\
 &= .004 \text{ lbs. org. matter/year} \\
 \text{Total} &= 0.814 \times 106 \text{ lbs/year} \\
 &= 3.69 \times 108 \text{ g/year} = 1.01 \times 106 \text{ g/day}
 \end{aligned}$$

For 1973 the following calculations were made:

$$\begin{aligned}
 \text{Finfish} &= (2.89 \times 106 \text{ lbs/year}) \times (0.2 \text{ dry wt/wet wt}) \times (0.9 \text{ g org. matter/dry wt}) \\
 &= 0.52 \times 106 \text{ lbs org. matter/year} \\
 \text{Shellfish} &= (1.03 \times 106 \text{ lbs/year}) \times (0.5 \text{ dry wt/wet wt}) \times (0.56 \text{ g org. matter/dry wt}) \\
 &= 0.29 \times 106 \text{ lbs org. matter/year} \\
 \text{Shrimp} &= (0.017 \times 106 \text{ lbs/year}) \times (0.3 \text{ dry wt/wet wt}) \times (0.8 \text{ g org. matter/dry wt}) \\
 &= .004 \text{ lbs. org. matter/year} \\
 \text{Total} &= 0.814 \times 106 \text{ lbs/year} \\
 &= 3.69 \times 108 \text{ g/year} = 1.01 \times 106 \text{ g/day}
 \end{aligned}$$

Using the total area of Collier County estuaries of approximately  $101.3 \text{ square miles}$ , the commercial fisheries landings amount to  $1.01 \times 106 \text{ g/day} / 7.16 \times 108 \text{ m}^2 = 0.0014 \text{ g/m}^2/\text{day}$ . Sport fishing landings based on literature cited by Taylor et al., 1973, may be as high as 50% of commercial landings =  $0.0007 \text{ g/m}^2/\text{day}$ .

Total landings =  $0.0014 \text{ g/m}^2/\text{day} + 0.0007 \text{ g/m}^2/\text{day}$ .

Table 12 Footnotes (Continued, page 5 of 5)

18. The total metabolic energy budget of the estuary was indicated by total community metabolism. Component respiration was calculated based on assumptions JR through JR5. Considered together, this information indicated certain limits on the internal energy exchanges for each compartment if an organic balance existed. The evaluation of the internal organic exchanges was subjected to an organic balance and certain judgments as follows:
- (a) Much energy flow through estuaries occurs via detrital pathways. For this evaluation, the flow rate of producer biomass into detritus was assumed to be 3 times the grazing rate by higher consumers.
  - (b) Higher consumers were assumed to graze on detrital material at twice the rate of grazing on plant material.
  - (c) Zooplankton were assumed to feed on producers (phytoplankton) and detritus particles in equal proportions at a rate about equal to their body weight per day.

The major roles of this estuary appear to be fish production and some export of benthic plant material as food to nearshore Gulf areas.

Naples Bay Ecosystem

The Naples Bay estuary is represented in Figure 8. Calculations and assumptions are given in Table 13. Naples Bay exhibits some interesting characteristics in contrast to Chokoloskee Bay:

1. Primary production is plankton dominated rather than benthic dominated; however, this production does not go into the detrital pool, but is lost through export;
2. The bay receives a large detrital input which is an order of magnitude greater than that for Chokoloskee Bay. The detrital input supports a substantial detrital pool which is the basis for a large microbial population;
3. The bay is a net consumer of fish and benthic invertebrates in that its detrital stocks attract primarily bottom-feeders into the bay from outside areas. Feeding at the primary production level is significant only for the benthic producers.

This estuary appears to be a less efficient nutrient trap (1.2 percent versus 40 percent) than Chokoloskee Bay. Its most prominent roles in the coastal zone may be microbial-detrital production and net export to the nearshore. As an estuarine area, it is more of a fish consumer than a producer. The large export of phytoplankton production could play an important role in nearshore fisheries food chains.

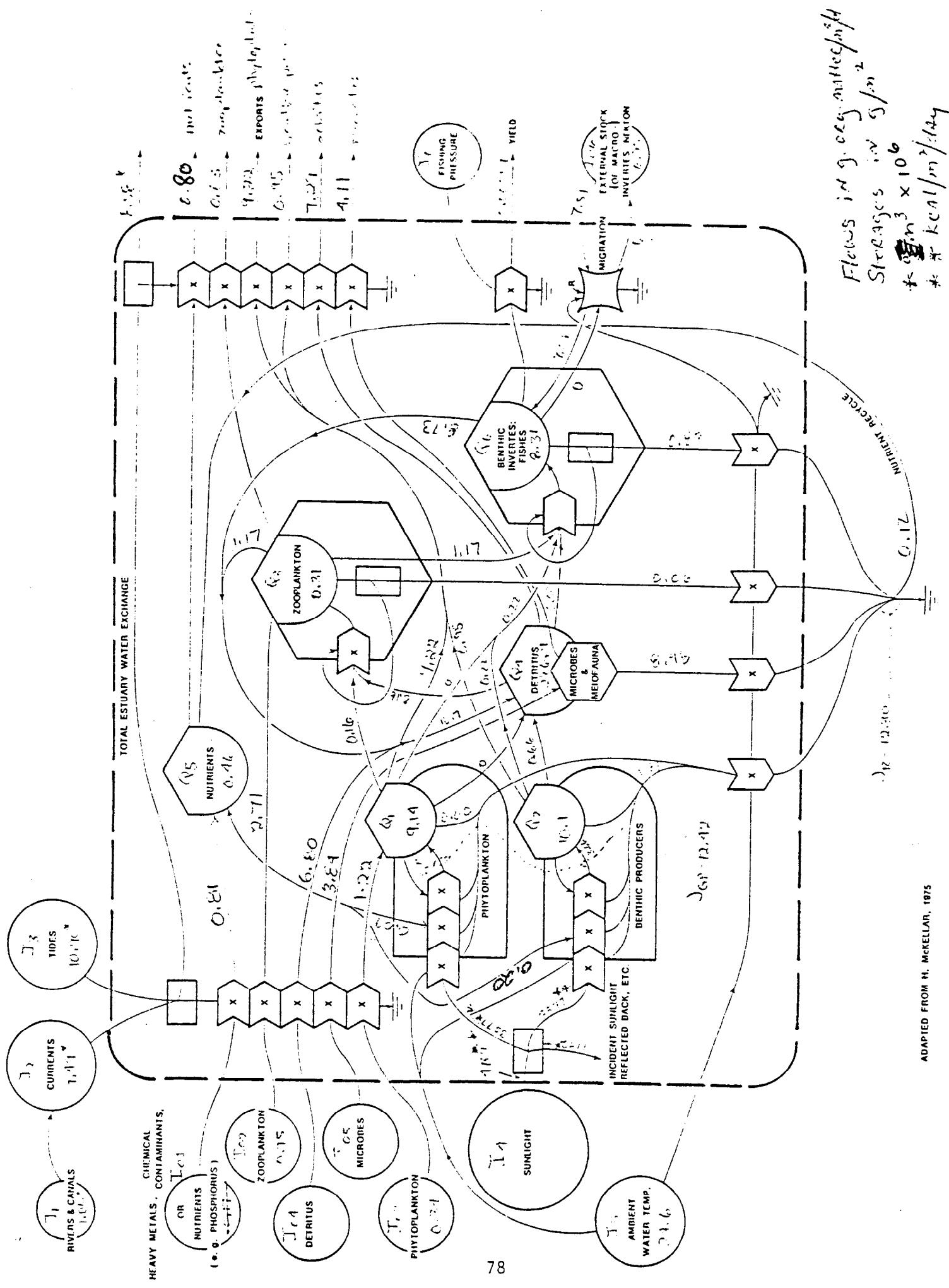


FIGURE 8. Evaluated Eccezional Model for Hand as Viscous

Table 13. Values for Naples Bay Model

External Driving Forces: Description	Notation	Calculations and Assumptions	References
Freshwater flows from rivers and canals into estuary	I <sub>1</sub>	$\begin{aligned} I_1 &= \text{Sum of Golden Gate Canal } a \text{ (IIGC)} \\ &\quad \text{Henderson } a \text{ Creek (IIHC), and Gordon} \\ &\quad \text{River } b \text{ (IIGR) flow data} \\ &= (8.43 \times 10^5, \text{ m}^3/\text{day}) + (0.57 \times 10^5 \\ &\quad \text{m}^3/\text{day}) + (1.55 \times 10^5 \text{ m}^3/\text{day}) \\ &= 10.55 \times 10^5 \text{ m}^3/\text{day} \\ &= 1.06 \times 10^6 \text{ m}^3/\text{day} \end{aligned}$	(a) Black, Crow and Eidness, 1973 (b) Odum, Littlejohn and Huber, 1972
Current flows (advective water exchange)	I <sub>2</sub>	$\begin{aligned} I_2 &= (\text{mean longshore current velocity})^a \times \\ &\quad (\text{average depth bay}) \times (\text{length of bay} \\ &\quad \text{boundary}) \times (\text{advection exchange} \\ &\quad \text{coefficient}) \\ &= (7.38 \times 10^{-3} \text{ m/sec})^b \times (1.9 \text{ m})^c \\ &\quad \times (6.18 \times 10^3 \text{ m})^d \times (1.0)^e \\ &= (86.66 \text{ m}^3/\text{sec}) \times (8.64 \times 10^4 \text{ sec/day}) \\ &= 748.7 \times 10^4 = 7.49 \times 10^6 \text{ m}^3/\text{day} \end{aligned}$	(a) see footnotes to Table 12, Footnote 1. (b) see (a) above, and Footnote 1, this table (c) see Results, Table 2 (d) Assumed
Tidal Water Exchange	I <sub>3</sub>	$\begin{aligned} I_3 &= (\text{average tidal range}) \times (\text{area of bay}) \\ &\quad \times (\text{tides per day}) \times (\text{tidal exchange} \\ &\quad \text{coefficient})^a \\ &= (1.26 \text{ m})^b \times (4.79 \times 10^6 \text{ m}^2) \times \\ &\quad (2 \text{ tides/day}) \times (0.90)^c \\ &= 10.90 \times 10^6 \text{ m}^3/\text{day} \end{aligned}$	(a) see footnotes to Table 12, Footnote 2. (b) NOAA, 1976. (c) see (a) above, and Footnote 2, this table

Table 13. Values for Naples Bay Model (Continued, page 2 of 15)

<u>External Driving Forces:</u> Description	Notation	Calculations and Assumptions	References
Sunlight	I <sub>4</sub>	I <sub>4</sub> = insolation measured = 4769 kcal/m <sup>2</sup> /day	see Results, Table 4
Ambient Water Temperature	I <sub>5</sub>	I <sub>5</sub> = average water temperature measured = 24.6 °C	see Appendix, Table D-1
Fishing Pressure	I <sub>6</sub>	I <sub>6</sub> = assumed to be proportional to number of sport and commercial boats registered in Collier County.	see Footnote 3
External Concentration of nutrient (or containment or heavy metal)	I <sub>01</sub>	I <sub>01</sub> = (Total nutrient concentration in fresh- water inflow) <sup>a</sup> and (Total nutrient concentration in Gulf) <sup>b</sup> (a) Halderman Creek I <sub>01TP</sub> = 0.35 mg/l I <sub>01TN</sub> = 0.97 mg/l I <sub>01TOC</sub> = 7.43 mg/l (b) Gulf I <sub>01TP</sub> = 0.22 g/m <sup>3</sup> I <sub>01TN</sub> = 2.49 g/m <sup>3</sup> I <sub>01TOC</sub> = 1.70 g/m <sup>3</sup> (a) Gordon River I <sub>01TP</sub> = 0.11 mg/l I <sub>01TN</sub> = 0.61 mg/l I <sub>01TOC</sub> = 10.43 mg/l (a) GAC Canal I <sub>01TP</sub> = 0.04 mg/l I <sub>01TN</sub> = 1.18 mg/l I <sub>01TOC</sub> = 1.30 mg/l	(a) Dry season data, ESE, 1977 (b) see Table 12, Footnote 3

Table 13. Values for Naples Bay Model (Continued, page 3 of 15)

External Driving Forces: Description	Notation	Calculations and Assumptions	References
Input of nutrient due to water exchange	$J_{01}$	$J_{01} = \frac{[(I_{01} \times I_{IHC}), Halderman Creek] + [(I_{01}) \times (I_{IGC}), Golden Gate Canal] + [(I_{01}) \times (I_{IGR}), Gordon River] + [(I_{01}, Gu1F) \times ((I_{13}) + (I_{12} - I_{IHC} - I_{IGL} - I_{IGR}))]}{(bay area)}$	
		$J_{01TP} = \frac{[(0.35 \text{ g/m}^3) \times (0.57 \times 10^5 \text{ m}^3/\text{day})] + [(0.11 \text{ g/m}^3) \times (1.55 \times 10^5 \text{ m}^3/\text{day})] + [0.04 \text{ g/m}^3) \times (8.43 \times 10^5 \text{ m}^3/\text{day})] + [(0.22 \text{ g/m}^3) \times (10.90 \times 10^6 + 6.43 \times 10^6 \text{ m}^3/\text{day})]}{(4.79 \times 10^6 \text{ m}^2)}$ $= \frac{(0.20 \times 10^5 \text{ g/day}) + (0.17 \times 10^5 \text{ g/day})}{(4.79 \times 10^6 \text{ m}^2)} + \frac{(0.34 \times 10^5 \text{ g/day}) + (38.13 \times 10^5 \text{ g/day})}{(4.79 \times 10^6 \text{ m}^2)}$ $= \frac{38.84 \times 10^5 \text{ g/day}}{4.79 \times 10^6 \text{ m}^2} = 0.81 \text{ g/m}^2/\text{day}$	see Table 12, Footnote 4
External concentration of zooplankton	$I_{02}$	$I_{02} = (\text{Zooplankton concentration in nearshore Gulf water}) = 0.75 \text{ g/m}^3$	

Table 13. Values for Naples Bay Model (Continued, page 4 of 15)

External Driving Forces: Description	Notation	Calculations and Assumptions	References
Import of zooplankton due to water exchange	$J_{02}$	$J_{02} = \frac{(I_{02}, \text{ above}) \times (I_3 + (I_2 - I_1), \text{ this table}}{\text{(bay area)}}$ $= \frac{(0.75 \text{ g/m}^3) \times (17.33 \times 10^6 \text{ m}^3/\text{day})}{(4.79 \times 10^6 \text{ m}^2)}$ $= \frac{13.00 \times 10^6 \text{ g/day}}{4.79 \times 10^6 \text{ m}^2}$ $= 2.71 \text{ g/m}^2/\text{day}$	see Table 12, $I_{03}$ calculation
External concentration of phytoplankton	$I_{03}$	$I_{03} = 0.338 \text{ g/m}^3$	
Import of phytoplankton due to water exchange	$J_{03}$	$J_{03} = \frac{(I_{03}, \text{ above}) \times (I_3 + (I_2 - I_1), \text{ this table}}{\text{(bay area)}}$ $= \frac{(0.338 \text{ g/m}^3) \times (17.33 \times 10^6 \text{ m}^3/\text{day})}{4.79 \times 10^6 \text{ m}^2}$ $= 1.22 \text{ g/m}^2/\text{day}$	(a) Haldeman Creek $I_{04\text{TOC}} = 7.43 \text{ g/m}^3$ (a) Gorden River $I_{04\text{TOC}} = 10.43 \text{ g/m}^3$ (a) Golden Gate Canal $I_{04\text{TOC}} = 1.30 \text{ g/m}^3$

Table 13. Values for Naples Bay Model (Continued, page 5 of 15)

External Driving Forces: Description	Notation	Calculations and Assumptions	References
Import of detritus due to water exchange	$J_{04}$	<p>(b) near-shore gulf</p> $I_{04TOC} = 1.70 \text{ g/m}^3$ $J_{04} = [(7.43 \text{ g/m}^3 \times (0.57 \times 10^5 \text{ m}^3/\text{day})] + [10.43 \text{ g/m}^3 \times (1.55 \times 10^5 \text{ m}^3/\text{day})] + [1.30 \text{ g/m}^3 \times (8.48 \times 10^5 \text{ m}^3/\text{day})] + [(1.70 \text{ g/m}^3 \times (17.33 \times 10^6 \text{ m}^3/\text{day})]$ $= (4.79 \times 10^6 \text{ m}^2)$ $= (4.24 \times 10^5 \text{ g/day}) + (16.17 \times 10^5 \text{ g/day}) +$ $+ \frac{(10.96 \times 10^5 \text{ m}^3/\text{day}) + (29.46 \times 10^6 \text{ m}^3/\text{day})}{(4.79 \times 10^6 \text{ m}^2)}$ $= 6.80 \text{ g/m}^2/\text{day}$	<p>see Table 12, Footnote 7</p> <p>see Table 12, Footnote 8, and this table, Footnote 4</p>
External concentration of microbes	$I_{05}$	$I_{05} = (\text{concentration in near-shore gulf}$ $\text{water})^a \text{ and } (\text{concentration in}$ $\text{river runoff})^b$ <p>(a) <math>1.06 \text{ g/m}^3</math> (b) <math>0.016 \text{ g/m}^3</math></p>	<p>(a) see Table 12,</p> <p>(b) see Table 12, Footnote 8, and this table, Footnote 4</p>

Table 13. Values for Naples Bay Model (Continued, page 6 of 15)

<u>External Driving Forces:</u> Description	Notation	Calculations and Assumptions	References
Import of microbes due to water exchange	$J_{05}$	$J_{05} = [I_{05}, \text{ rivers}] \times (I_1) +$ $[I_{05}, \text{ gulf}] \times ((I_2 - I_1) + (I_3))$ <hr/> (bay area)	
		$= [(1.06 \text{ g/m}^3) \times (17.33 \times 10^6 \text{ m}^3/\text{day})] +$ $[(0.016 \text{ g/m}^3) \times (1.06 \times 10^6 \text{ m}^3/\text{day})]$ <hr/> (bay area)	
		$= (18.37 \times 10^6 \text{ g/day}) + (0.017 \times 10^6 \text{ g/day})$ <hr/> $(4.79 \times 10^6 \text{ m}^2)$ $= 3.84 \text{ g/m}^2/\text{day}$	(a) see Results, Table 9 (b) see Footnote 5
External density of macroinvertebrates and fish	$I_{06}$	$I_{06} = (\text{invertebrates})^a + (\text{fish})^b$ $= (0.68 \text{ g/m}^2) + (6.27 \text{ g/m}^2)$ $= 6.95 \text{ g/m}^2$	
Invertebrate and fish in-migration	$J_{06}$	$J_{06} = \text{calculated to give organic balance to compartment}$ $= (2.05) - (9.56) = -7.51 \text{ g/m}^2/\text{day}$ $= 7.51 \text{ g/m}^2/\text{day}$	see Footnote 12

Table 13. Values for Naples Bay Model (Continued, page 7 of 15)

<u>Internal Storages:</u> Description	Notation	Calculations and Assumptions	References
Phytoplankton biomass	$Q_1$	$Q_1 = \text{standing stock of phytoplankton}$ $= (\text{concentration}) \times (\text{mean depth})$ $= (4.81 \text{ g/m}^3) \times (1.9 \text{ m})$ $= 9.14 \text{ g/m}^2$	see Results, Table 7
Benthic producer biomass	$Q_2$	$Q_2 = \text{standing stock of benthic macrophytes}$ $= 10.1 \text{ g/m}^2$	see Footnote 6
Zooplankton biomass	$Q_3$	$Q_3 = \text{standing stock of zooplankton}$ $= (\text{concentration}) \times (\text{average depth})$ $= (0.163 \text{ g/m}^3) \times (1.9 \text{ m})$ $= 0.31 \text{ g/m}^2$	see Results, Table 8
Detritus stock with associated microbes	$Q_4$	$Q_4 = (\text{water column detritus})^a \text{ and } (\text{bottom}$ $\text{detritus})^b$ $(a) 1.9 \text{ g/m}^2 \quad (b) 285 \text{ g/m}^2$ $= (1.9) + (285) = 286.9 \text{ g/m}^2$	(a) see Footnote 7 (b) see Footnote 8
Total nutrient stock in water	$Q_5$	$Q_5 = (\text{nutrient conc.})^a \times (\text{bay depth})^b$ $Q_{5\text{TP}} = (0.24 \text{ g/m}^3) \times (1.9 \text{ m})$ $= (0.46 \text{ g/m}^2)$	(a) Dry season data, ESE, 1977 (b) see Appendix Table D-1

Table 1.3. Values for Naples Bay Model (Continued, page 8 of 15)

<u>Internal Storages:</u>	Notation	Calculations and Assumptions	References
Description			
Benthic invertebrates and benthic biomass	$Q_6$	$Q_6 = (\text{benthic macroinvertebrates})^a +$ $(\text{fish})^b$ $= (2.04 \text{ g/m}^2) + (6.27 \text{ g/m}^2)$ $= 8.31 \text{ g/m}^2$	(a) see Table 12, Footnote 13 (b) see Footnote, 5

Table 13. Values for Naples Bay Model (Continued, page 9 of 15)

<u>Internal Flows:</u> Description	Notation	Calculations and Assumptions	References
Light used in photo-synthesis	$J_1$	$J_1 = (0.75)(I_4) = (0.75)(4769)$ $= 3577 \text{ kcal/m}^2/\text{day}$	see Table 12, Footnote 14
Light remaining for additional work	$J_r$	$J_r = I_4 - J_1$ $= (4769) - (3577) \text{ kcal/m}^2/\text{day}$ $= 1192 \text{ kcal/m}^2/\text{day}$	
Total community gross primary production	$J_{GP}$	$J_{GP} = (\text{net daytime production}) +$ $(\text{nighttime respiration})$ $= \text{NDP} + \text{NR}$ $= 12.42 \text{ g/m}^2/\text{day}$	see Results, Table 1
Phytoplankton gross primary production	$J_{GP1}$	$J_{GP1} = P_{gross} 24 = 8.76 \text{ g/m}^2/\text{day}$	see Results, Table 5
Benthic producer gross primary production	$J_{GP2}$	$J_{GP2} = J_{GP} - J_{GP1}$ $= (12.42) - (8.76) \text{ g/m}^2/\text{day}$ $= 3.66 \text{ g/m}^2/\text{day}$	

Table 13. Values for Naples Bay Model (Continued, page 10 of 15)

<u>Internal Flows:</u>	Description	Notation	Calculations and Assumptions	References
Total community respiration		$J_R$	$\begin{aligned} J_R &= (\text{nighttime respiration}) + \\ &\quad (\text{daytime respiration}) \\ &= \text{NR} + \text{DR} \\ &= 12.30 \text{ g/m}^2/\text{day} \end{aligned}$	see Results, Table 1
Phytoplankton respiration		$J_{R1}$	$J_{R1} = 0.60 \text{ g/m}^2/\text{day}$	see Footnote 9
Benthic producer respiration		$J_{R2}$	$\begin{aligned} J_{R2} &= (J_{GP2}) \times (C.4) \\ &= (3.66) \times (0.5) \\ &= 1.83 \text{ g/m}^2/\text{day} \end{aligned}$	see Table 12, Footnote 15 and Footnote 16
Zooplankton respiration		$J_{R3}$	$J_{R3} = 0.06 \text{ g/m}^2/\text{day}$	see Table 12, Footnote 16 and this table, Footnote 9
Benthic invertebrate and fish respiration		$J_{R4}$	$\begin{aligned} J_{R4} &= \text{assumed to reflect a metabolic} \\ &\quad \text{turnover time of 10 days} \\ &= (Q_6, \text{ this table})/10 \text{ days} \\ &= 8.31 \text{ g/m}^2/10 \text{ days} \\ &= 0.83 \text{ g/m}^2/\text{days} \end{aligned}$	

Table 13. Values for Naples Bay Model (Continued, page 11 of 15)

<u>Internal Flows:</u> Description	Notation	Calculations and Assumptions	References
Respiration of detritus with associated organisms	$J_{R5}$	$J_{R5} = J_R - (J_{R1} + J_{R2} + J_{R3} + J_{R4})$ $= (12.30) - (3.32) \text{ g/m}^2/\text{day}$ $= 8.98 \text{ g/m}^2/\text{day}$	McKellar, 1975
Nutrient recycle from community respiration	$J_N$	$J_N = \text{percent of respired organic matter that nutrient comprises}$ $J_{NTP} = \text{assuming respired organic matter was 1% phosphorus}$ $= (0.01) \times (J_R)$ $= (0.01) \times (12.30) \text{ g/m}^2/\text{day}$ $= 0.12 \text{ g/m}^2/\text{day}$	
Export of phytoplankton due to water exchange	$J_{E1}$	$J_{E1} = \frac{(\text{phytoplankton stock})^a \times (I_2 + I_3)}{(\text{bay area}) \times (\text{bay depth})}$ $= \frac{(9.14 \text{ g/m}^2) \times (18.39 \times 10^6 \text{ m}^3/\text{day})}{(4.79 \times 10^6 \text{ m}^2)(1.9 \text{ m})}$ $= \frac{16.81 \times 10^7 \text{ g/m/day}}{9.10 \times 10^6 \text{ m}^3}$ $= 18.47 \text{ g/m}^2/\text{day}^1$	(a) Q, this table (b) see Footnote 11

Table 13. Values for Naples Bay Model (Continued, page 12 of 15)

<u>Internal Flows:</u> Description	Notation	Calculations and Assumptions	References
Zooplankton export due to water exchange	J <sub>E2</sub>	$J_{E2} = \frac{(0.31 \text{ g/m}^2) \times (18.39 \times 10^6 \text{ m}^3/\text{day})}{(9.10 \times 10^6 \text{ m}^3)}$ $= 0.63 \text{ g/m}^2/\text{day}$	see Table 12, J <sub>E2</sub>
Nutrient export due to water exchange	J <sub>E3</sub>	$J_{E3} = \frac{(0.46 \text{ g/m}^2) \times (18.39 \times 10^6 \text{ m}^3/\text{day})}{(9.10 \times 10^6 \text{ m}^3)}$ $= 0.93 \text{ g/m}^2/\text{day}^a$ $= 0.80 \text{ g/m}^2/\text{day}$	see Table 12, J <sub>E3</sub> (a) see Footnote 13
Benthic plant export due to fragmentation and exchange	J <sub>E4</sub>	$J_{E4} = \frac{(0.10) \times (10.1 \text{ g/m}^2) \times (18.39 \times 10^6)}{9.10 \times 10^6 \text{ m}^3}$ $= 2.04 \text{ g/m}^2/\text{day}^a$ $= 0.95 \text{ g/m}^2/\text{day}$	see Table 12, J <sub>E4</sub> see Footnote 14
Export of detritus due to water exchange	J <sub>E5</sub>	$J_{E5} = \frac{(1.9 \text{ g/m}^2) \times (18.39 \times 10^6 \text{ m}^3/\text{day})}{(4.79 \times 10^6 \text{ m}^2)}$ $= 7.29 \text{ g/m}^2/\text{day}$	see Table 12, J <sub>E5</sub> and this table
Export of microbes due to water exchange	J <sub>E6</sub>	$J_{E6} = \frac{(1.07 \text{ g/m}^3) \times (18.39 \times 10^6 \text{ m}^3/\text{day})}{(4.79 \times 10^6 \text{ m}^2)}$ $= 4.11 \text{ g/m}^2/\text{day}$	Footnote 7

Table 13. Values for Naples Bay Model (Continued, page 13 of 15)

<u>Internal Flows:</u> Description	Notation	Calculations and Assumptions	References
Fishing yield due to commercial and sport fishing	$J_F$	$J_F = (\text{commercial yield}) + (\text{sport fishing yield})$ $= 0.00007 \text{ g/m}^2/\text{day}$	see Table 12, Footnote 17, and this table, Footnote 10
Zooplankton grazing upon phytoplankton	$J_2$	$J_2 = \text{calculated to give an organic balance to compartment}$ $= 0.16 \text{ g/m}^2/\text{day}$	see Table 12, Footnote 18c
Zooplankton grazing upon detritus	$J_3$	$J_3 = \text{calculated to give an organic balance to compartment}$ $= 0.16 \text{ g/m}^2/\text{day}$	see Table 12, Footnote 18c
Nutrient uptake by phytoplankton	$J_4$	$J_{4\text{TP}} = (0.01) \times (8.76) \text{ g/m}^2/\text{day}$ $= 0.09 \text{ g/m}^2/\text{day}$	see Table 12, $J_4$
Nutrient uptake by benthic producers	$J_5$	$J_{5\text{TP}} = \text{same as } J_4 \text{ above, however calculated to give balance in nutrient compartment}$ $= 0.02 \text{ g/m}^2/\text{day}$	see Table 12, $J_5$
Benthic invertebrates and fish grazing upon phytoplankton	$J_6$	$J_6 = \text{calculated to give an organic balance in compartment}$ $= 0$	see Table 12, $J_6$ and this table, Footnote 11

Table 13. Values for Naples Bay Model (Continued, page 14 of 15)

<u>Internal Flows:</u> Description	Notation	Calculations and Assumptions	References
Phytoplankton death and transfer to detritus	J <sub>7</sub>	J <sub>7</sub> = calculated to give an organic balance in compartment = 0	see Table 12, J <sub>7</sub> and this table, Footnote 11
Benthic invertebrates and fish grazing on benthic producers	J <sub>8</sub>	J <sub>8</sub> = calculated to give an organic balance in compartment = 0.22 g/m <sup>2</sup> /day	see Table 12, J <sub>8</sub>
Benthic producers death and transfers to detritus	J <sub>9</sub>	J <sub>9</sub> = calculated to give an organic balance in compartment = 0.66 g/m <sup>2</sup> /day	see Table 12, J <sub>9</sub>
Benthic invertebrates and fish grazing on detritus	J <sub>10</sub>	J <sub>10</sub> = (3) x (0.22) = 0.66 g/m <sup>2</sup> /day	see Table 12, J <sub>10</sub>
Zooplankton death and feces transfer to detritus	J <sub>11</sub>	J <sub>11</sub> = (0.50) x (2.34 g/m <sup>2</sup> /day) = 1.17 g/m <sup>2</sup> /day	see Table 12, J <sub>11</sub>
Benthic invertebrates and fish grazing on zooplankton	J <sub>12</sub>	J <sub>12</sub> = (3.03) - (1.86) g/m <sup>2</sup> /day = 1.17 g/m <sup>2</sup> /day	see Table 12, J <sub>12</sub>
Benthic invertebrates and fish death and feces transfer to detritus	J <sub>13</sub>	J <sub>13</sub> = (12.47) - (21.20) g/m <sup>2</sup> /day = 8.73 g/m <sup>2</sup> /day	see Table 12, J <sub>13</sub>

Table 13. Values for Naples Bay Model (Continued, page 15 of 15)

<u>Internal Flows:</u> Description	Notation	Calculations and Assumptions	References
Benthic invertebrate and fish out-migration	$J_{14}$	$J_{14} = 0$ see Footnote 12	

Footnotes to Table 13

1. Given  $M_1 = 8.96$ , then:
 
$$V = (2.3 \times (8.96) \times (4.28 \times 10^{-4}) \times [(32.2)(2)]^{1/2} \sin 20^\circ$$

$$= (88.20 \times 10^{-4}) \times (8.02) \times (0.3420)$$

$$= (2.42 \times 10^{-4} \text{ ft/sec}) \times (0.3048 \text{ m/ft}) = 73.8 \times 10^{-4} \text{ m/sec}$$

$$= 7.38 \times 10^{-3} \text{ m/sec}$$
2.  $V_A = (1.26 \text{ m}) \times (4.79 \times 10^6 \text{ m}^2) \times (2 \text{ tides/day}) = 1.21 \times 10^7 \text{ m}^3/\text{day}$ 

$$V_T = \frac{31.0}{34.0} (10.55 \times 10^5 \text{ m}^3/\text{day})$$

$$1 - \frac{31.0}{34.0}$$

$$= \frac{(0.91) \times (10.55 \times 10^5 \text{ m}^3/\text{day})}{(0.0882)} = 1.09 \times 10^7 \text{ m}^3/\text{day}$$
- then,  $\frac{V_T}{V_A} = \frac{1.09 \times 10^7}{1.21 \times 10^7} = 0.901$
3. Due to the large amount of development around Naples Bay, very little fishing was observed or was thought to take place within the bay. Access to nearby undeveloped areas is easy, and most fishermen were observed to go outside of the bay. This pathway remains unevaluated.
4. Based on the values given in Table 1.2, note 7; a slightly higher concentration was used for Naples Bay due to higher coliform values measured (ESE, 1976, dry season data).  $(0.032 \text{ g/m}^3) \times (0.50) = 0.016 \text{ g/m}^3$ .

Footnotes to Table 13 (Continued, page 2 of 3)

5. Assumed to be 50% that of Fahkatchee based on relative fish abundance data for Fahkatchee and Rookery Bay (Yokel, 1975). (12.54 g/m<sup>2</sup>), see Table 12, footnote 9. (12.54 g/m<sup>2</sup>) x (.5) = 6.27 g/m<sup>2</sup>.
6. Assumed to be 50% of that used for Chokoloskee Bay, (20.1 g/m<sup>2</sup>) x (0.50) = 10.1 g/m<sup>2</sup>. Based on light extinction coefficients (Results, Table 9) when compared with mean depths in the bays (Appendix Table D-1).
7. TOC value from dry season sampling in Naples Bay, (SWF 208, ESE, 1977) TOC = 5.3 mg/1 minus plankton (near station 2 where TOC was taken); (5.3 g/m<sup>3</sup>) - (4.3 g/m<sup>3</sup>) = 1.0 g/m<sup>3</sup>) x (mean depth)  
= (1.0) x (1.9) = 1.90 g/m<sup>2</sup>.
8. Based on estimated percent detritus composition of zooplankton samples (see Results, Table 8), it was assumed detrital water column stocks of Naples Bay to be similar to those for Chokoloskee Bay. No bottom detritus data were available for Naples Bay. Assumed to be twice that of Fahkatchee based on organic matter inflow = 285 g/m<sup>2</sup>/day.
9. Total plankton respiration was 0.66 g/m<sup>2</sup>/day (Results, Table 5). Assuming 1 g O<sub>2</sub> = 1 g organic matter and using ratio of phytoplankton to total plankton biomass, it was assumed that 90% of total plankton respiration was due to phytoplankton. (0.90) x (0.66) = 0.60 g/m<sup>2</sup>/day.
10. Based on Footnote 3, virtually no commercial fishing is done in Naples Bay, and sport fishing was assumed to be 10% of value given in Table 12, Footnote 17. (0.10) x (0.0007) = 0.00007 g/m<sup>2</sup>/day, which is insignificant compared to other flows.

Footnotes to Table 13 (Continued, page 3 of 3)

11.  $18.47 \text{ g/m}^2/\text{day}$  plus  $J_{R1} + J_2$  (phytoplankton respiration + zooplankton grazing on phytoplankton) is greater than all inputs into phytoplankton stock. To maintain an organic balance this is not possible; the theoretical maximum value in this case being  $9.22 \text{ g/m}^2/\text{day}$ , determined by inputs minus outputs. This allows no benthic fish or invertebrate grazing on phytoplankton, and no phytoplankton death and transfer to detritus.
12. Food chain relationships based on metabolism data suggest that in order for an organic balance to exist in-migration of fish and benthic invertebrates occurs to balance the detrital cycle; for this evaluation, no significant out-migration can occur if the compartment is to balance.
13.  $0.93 \text{ g/m}^2/\text{day}$  plus  $J_4 + J_5$  (nutrient uptake by phytoplankton and zooplankton) would be in excess of nutrient input. For purposes of a nutrient balance, this is not possible, the highest value being  $0.80 \text{ g/m}^2/\text{day}$  based on inputs minus outputs.
14. This number is the amount that could be "washed out" of the bay if available; however, to maintain an organic balance, the maximum amount available is  $0.95 \text{ g/m}^2/\text{day}$ .

### Wiggins Pass Area Ecosystem

Wiggins Pass Area exhibits characteristics common to both of the other two areas (Figure 9). Like Naples Bay its primary production is mostly due to phytoplankton during this period of the year. However, the plankton stocks are more comparable to those of Chokoloskee Bay. Like Chokoloskee Bay, the Wiggins Pass Area serves as a net exporter of fish and invertebrates, exporting up to 23 percent of its gross primary production. Benthic invertebrates and fish in the Wiggins Pass area feed at the plankton levels with very little benthic primary production being grazed or converted to the detrital pool. Similar to Naples Bay, detrital stocks are maintained primarily from stocks outside the bay system, rather than generated within by primary production as in Chokoloskee Bay. Although large exports occur via this bay, it is not a large net-exporter (inputs minus outputs) of anything other than fish and invertebrates. Its primary roles appear similar to those of Chokoloskee Bay, fish and plant material production and export to nearshore Gulf areas. Calculations of values used in model evalution are given in Table 14.

### Ecosystems Summary

Table 15 summarizes information on the three evaluated ecosystem diagrams. Gross primary productivity was highest in Naples Bay, as was total community respiration. Although Naples Bay exhibited highest total community productivity, net production of fish does not appear to occur. Benthic invertebrates and fish (bottom feeders) outside the bay are most likely attracted into the bay by the large detrital pool. Productivity values of magnitudes measured for Naples Bay are not

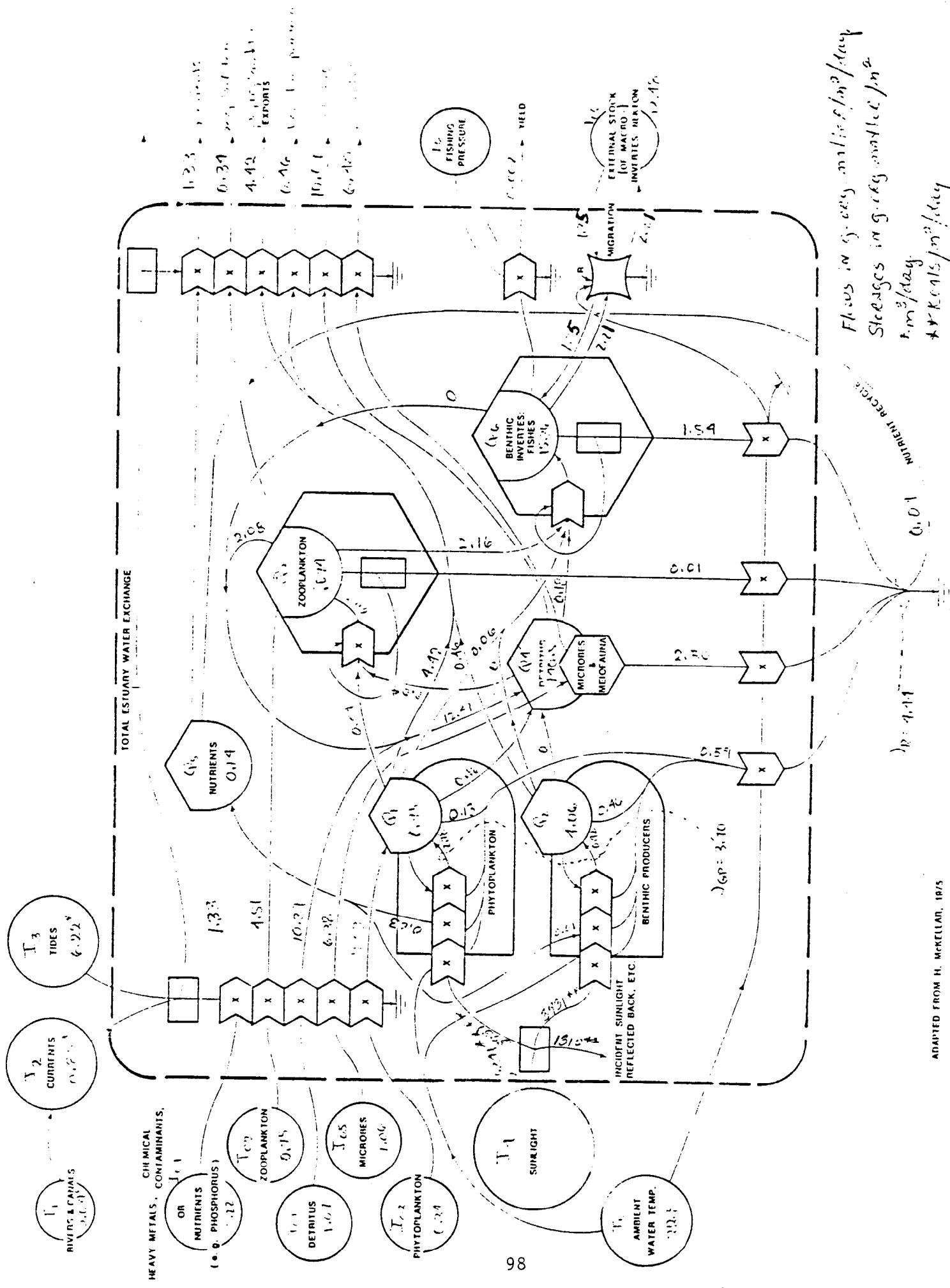


Table 14. Values for Wiggins Pass Area Model

External Driving Forces:		Notation	Calculations and Assumptions	References
Description				
Freshwater flow from rivers and canals into estuary	I <sub>1</sub>	Average of 1970, 1974, and 1975 Cocohatchee River Flow. I <sub>1</sub> = 3.76 x 10 <sup>4</sup> m <sup>3</sup> /day = 0.376 x 10 <sup>5</sup> m <sup>3</sup> /day		U.S. Geological Survey, 1970, 1974, 1975.
Current flows (advectional water exchange)	I <sub>2</sub>	I <sub>2</sub> = (7.38 x 10 <sup>-3</sup> m/sec) <sup>a,b</sup> x (1.3) <sup>c</sup> x (2.06 x 10 <sup>3</sup> m) x (0.50) <sup>d</sup> = (9.88 m <sup>3</sup> /sec) x (8.64 x 10 <sup>4</sup> sec/day) = 85.36 x 10 <sup>4</sup> = 8.54 x 10 <sup>5</sup> m <sup>3</sup> /day = 0.854 x 10 <sup>6</sup> m <sup>3</sup> /day	(a) see Table 12, Footnote 1 (b) and Table 13, Footnote 1 (c) see Results, Table 2 (d) Assumed	
Tidal water exchange	I <sub>3</sub>	I <sub>3</sub> <sup>a</sup> = (1.26 m) x (1.17 x 10 <sup>6</sup> m <sup>2</sup> ) <sup>b</sup> x 2/day x (2.11) <sup>c</sup> = 6.22 x 10 <sup>6</sup> m <sup>3</sup> /day	(a) see Table 12, Footnote 2 (b) NOAA, 1976 (c) see Footnote 1, this table	
Sunlight	I <sub>4</sub>	I <sub>4</sub> = insolation measured = 5241 kcal/m <sup>2</sup> /day	Results, Table 4	
Ambient water temperature	I <sub>5</sub>	I <sub>5</sub> = average water temperature measured = 22.8°C	Appendix, Table D-1	

Table 14. Values for Wiggins Pass Area Model (Continued, page 2 of 11)

External Driving Forces: Description	Notation	Calculations and Assumptions	References
Fishing pressure	$I_6$	$I_6 = \text{assumed to be proportional to number of boats registered in Collier County}$ = unevaluated	
External concentration of nutrient (or contaminant or heavy metal)	$I_{01}$	$I_{01}^a = (\text{conc. in Gulf})^b + (\text{conc. in freshwater})$ (a) see Table 12, (b) $I_{01TP} = 0.22 \text{ g/m}^3$ (c) $I_{01TP} = 0.11 \text{ g/m}^3$ $I_{01TN} = 2.49 \text{ g/m}^3$ $I_{01TN} = 0.88 \text{ g/m}^3$ $I_{01TOC} = 1.70 \text{ g/m}^3$ $I_{01TOC} = 4.95 \text{ g/m}^3$ (c) Dry season data, ESE, 1977.	101 see Table 12, Footnote 3
Input of nutrient due to water exchange	$J_{01}$	$J_{01} = \frac{(I_{01} \times I_1, \text{ freshwater}) +}{[(\frac{I_{01}}{I_1}) \times (\frac{I_3 + (I_2 - I_1)}{\text{bay area}}), \text{ gulf}]}$ $J_{01TP} = [(0.11 \text{ g/m}^3) \times (3.76 \times 10^4)] +$ $\frac{[(0.22 \text{ g/m}^3) \times (7.04 \times 10^6)]}{(1.7 \times 10^6 \text{ m}^2)}$ $= \frac{(0.004 \times 10^6) + (1.55 \times 10^6)}{(1.17 \times 10^6 \text{ m}^2)} \text{ g/day}$ = 1.33 g/m <sup>2</sup> /day	

Table 14. Values for Wiggins Pass Area Model (Continued, page 3 of 11)

<u>External Driving Forces:</u>	<u>Description</u>	<u>Notation</u>	<u>Calculations and Assumptions</u>	<u>References</u>
External concentration of zooplankton	I02	$I_{02} = \text{zooplankton concentration in near-shore Gulf water}$ = $0.75 \text{ g/m}^3$		see Table 12, Footnote 4
Import of zooplankton due to water exchange	J02	$J_{02} = \frac{(I_{02}, \text{ above}) \times (I_3 + (I_2 - I_1), \text{ this table})}{(\text{bay area})}$ $= \frac{(0.75) \times (7.04 \times 10^6)}{(1.17 \times 10^6)}$ $= 4.51 \text{ g/m}^2/\text{day}$		
External concentration of phytoplankton	I03	$I_{03} = 0.338 \text{ g/m}^3$		see Table 12, 103
Import of phytoplankton	J03	$J_{03} = \text{same as } J_{02} \text{ calculation above,}$ but with $I_{03}$ $= \frac{(0.338 \text{ g/m}^3) \times (7.04 \times 10^6 \text{ m}^3/\text{day})}{(1.17 \times 10^6)}$ $= \frac{2.38 \times 10^6 \text{ g/day}}{1.17 \times 10^6} = 2.03 \text{ g/m}^2/\text{day}$		

Table 14. Values for Wiggins Pass Area Model (Continued, page 4 of 11)

<u>External Driving Forces:</u> <u>Description</u>	<u>Notation</u>	<u>Calculations and Assumptions</u>	<u>References</u>
External concentration of detritus	I <sub>04</sub>	I <sub>04</sub> = see TOC values, I <sub>01</sub> , this table	
Import of detritus due to water exchange	J <sub>04</sub>	$J_{04} = [(4.95 \text{ g/m}^3) \times (3.76 \times 10^4 \text{ m}^3/\text{day})]$ $+ \frac{[(1.70 \text{ g/m}^3) \times (7.04 \times 10^6 \text{ m}^3/\text{day})]}{(1.17 \times 10^6 \text{ m}^2)}$ $= 10.39 \text{ g/m}^2/\text{day}$	
External concentration of microbes	I <sub>05</sub>	I <sub>05</sub> = see values, Table 12, I <sub>05</sub>	
Import of microbes due to water exchange	J <sub>05</sub>	$J_{05} = [(0.01 \text{ g/m}^3) \times (3.76 \times 10^4 \text{ m}^3/\text{day})]$ $+ \frac{[(1.06 \text{ g/m}^3) \times (7.04 \times 10^6 \text{ m}^3/\text{day})]}{(1.17 \times 10^6 \text{ m}^2)}$ $= 6.38 \text{ g/m}^2/\text{day}$	

Table 14. Values for Wiggins Pass Area Model (Continued, page 5 of 11)

<u>External Driving Forces:</u>	<u>Description</u>	<u>Notation</u>	<u>Calculations and Assumptions</u>	<u>References</u>
External density of macroinvertebrates and fish		I <sub>06</sub>	$I_{06} = (0.94 \text{ g/m}^2)^a + (12.54 \text{ g/m}^2)^b$ $= 13.48 \text{ g/m}^2$	(a) Results, Table 9 (b) Table 12, Footnote 9
Invertebrate and fish in-migration		J <sub>06</sub>	$J_{06} = \text{assumed to be } 10\% \text{ of external stock}$ $= 1.35 \text{ g/m}^2/\text{day}$	McKellar, 1975
<hr/>				
Internal Storages:				
Phytoplankton biomass		Q <sub>1</sub>	$Q_1 = \text{standing stock of phytoplankton}$ $= (\text{concentration}) \times (\text{mean depth})$ $= (0.73 \text{ g/m}^3) \times 1.3 \text{ m}$ $= 0.95 \text{ g/m}^2$	Results, Table 7
Benthic producer biomass		Q <sub>2</sub>	$Q_2 = \text{standing stock of benthic macrophytes}$ $= 4.06 \text{ g/m}^2$	see Footnote 3

Table 14. Values for Wiggins Pass Area Model (Continued, page 6 of 11)

<u>External Driving Forces:</u> Description	Notation	Calculations and Assumptions	References
Zooplankton biomass	$Q_3$	$Q_3 = \text{standing stock of zooplankton}$ $= (\text{concentration}) \times (\text{average depth})$ $= 0.074 \text{ g/m}^2$	Results, Table 8
Detritus stock with associated microbes	$Q_4$	$Q_4 = (\text{water column detritus})^a \text{ and } (\text{bottom}$ $\text{detritus})^b$ (a) $2.17 \text{ g/m}^2$ $= (2.17) + (138.3) = 140.5 \text{ g/m}^2$ $(b) 138.3 \text{ g/m}^2$	(a) see Table 13, Footnote 7 (b) see Table 12, Footnote 12
Total nutrient stock in water	$Q_5$	$Q_5 = (\text{nutrient conc.})^a \times (\text{bay depth})$ $Q_{5TP} = (0.11 \text{ g/m}^3) \times (1.3 \text{ m})$ $= 0.14 \text{ g/m}^2$	(a) see 101, this table
Benthic invertebrates and fish biomass	$Q_6$	$Q_6 = (\text{benthic macroinvertebrates})^a + (\text{fish})^b$ $= (2.82 \text{ g/m}^2) + (12.54 \text{ g/m}^2)$ $= 15.36 \text{ g/m}^2$	(a) see Table 12, Footnote 13 (b) see Table 12, Footnote 9

Table 14. Values for Wiggins Pass Area Model (Continued, page 7 of 11)

Description	Notation	Calculations and Assumptions	References
<u>INTERNAL FLOWS:</u>			
Light used in photosynthesis	J <sub>1</sub>	$J_1 = (0.75) \times (I_4) = (0.75) \times (5,241)$ = 3,931 kcal/m <sup>2</sup> /day	see Table 12, Footnote 14
Light remaining for additional work	J <sub>r</sub>	$J_r = I_4 - J_1 = (5,241) - (3,931)$ = 1,310 kcal/m <sup>2</sup> /day	
Total community gross primary production	J <sub>GP</sub>	$J_{GP} = (\text{net daytime production}) +$ (nighttime respiration) = NDP + NR = 3.70 g/m <sup>2</sup> /day	Results, Table 1
Phytoplankton gross primary production	G <sub>GP1</sub>	$J_{GP1} = P \text{ gross } 24 = 2.78 \text{ g/m}^2/\text{day}$	Results, Table 5
Benthic producer gross primary production	J <sub>GP2</sub>	$J_{GP2} = J_{GP} - J_{GP1}$ = (3.70) - (2.78) = 0.92 g/m <sup>2</sup> /day	
Total community respiration	J <sub>R</sub>	$J_r = (\text{nighttime respiration}) +$ (daytime respiration) = NR + DR 2/day = 4.44 g/m <sup>2</sup>	Results, Table 1
Phytoplankton respiration	J <sub>R1</sub>	$J_{R1} = (0.14 \text{ g/m}^2/\text{day}) \times (0.90)$ = 0.13 g/m <sup>2</sup> /day	see Footnote 2
Benthic producer respiration	J <sub>R2</sub>	$J_{R2} = (J_{GP2}) \times (0.5)$ = (0.92) × (0.5) = 0.46 g/m <sup>2</sup> /day	see Table 12, Footnotes 15 and 16

Table 14. Values for Wiggins Pass Area Model 1 (Continued, page 8 of 11)

Description	Notation	Calculations and Assumptions	References
<b>INTERNAL FLOWS:</b>			
Zooplankton respiration	J <sub>R3</sub>	J <sub>R3</sub> = 0.01 g/m <sup>2</sup> /day	see Footnote 2
Benthic invertebrate and fish respiration	J <sub>R4</sub>	$\begin{aligned} J_{R4} &= \text{assumed to reflect metabolic} \\ &\quad \text{metabolic turnover time of} \\ &\quad 10 \text{ days} \\ &= Q_6, \text{ this table) / 10 days} \\ &= 15.36/10 = 1.54 \text{ g/m}^2/\text{day} \end{aligned}$	McKellar, 1975
Respiration of detritus with associated organisms	J <sub>R5</sub>	$\begin{aligned} J_{R5} &= J_R - (J_{R1} + J_{R2} + J_{R3} + J_{R4}) \\ &= (4.44) - (2.14) = 2.30 \text{ g/m}^2/\text{day} \end{aligned}$	see Table 12, J <sub>N</sub>
Nutrient recycle from community respiration	J <sub>N</sub>	$\begin{aligned} J_N &= J_{NTP} = (0.01) \times (J_R) \\ &= (0.01) \times (4.44 \text{ g/m}^2/\text{day}) \\ &= 0.04 \text{ g/m}^2/\text{day} \end{aligned}$	see Table 12, J <sub>N</sub>
Export of phytoplankton	J <sub>E1</sub>	$\begin{aligned} J_{E1} &= (Q_1, \text{ this table}) \times (I_2 + I_3, \\ &\quad \text{this table}) \\ &= \frac{(0.95 \text{ g/m}^2) \times (7.07 \times 10^6 \text{ m}^3/\text{day})}{(1.17 \times 10^6 \text{ m}^2) \times (1.3 \text{ m})} \\ &= 4.42 \text{ g/m}^2/\text{day} \end{aligned}$	
Zooplankton export due to water exchange	J <sub>E2</sub>	$\begin{aligned} J_{E2} &= (Q_3, \text{ this table}) \times (I_2 + I_3, \\ &\quad \text{this table}) \\ &= \frac{(0.074) \times (7.07 \times 10^6)}{1.52 \times 10^6} \\ &= 0.34 \text{ g/m}^2/\text{day} \end{aligned}$	

Table 14. Values for Wiggins Pass Area Model (Continued, page 9 of 11)

Description	Notation	Calculations and Assumptions	References
<b>INTERNAL FLOWS:</b>			
Nutrient export due to water exchange	JE3	$\begin{aligned} JE3 &= \frac{(0.14 \text{ g/m}^2) \times (7.07 \times 10^6)}{1.52 \times 10^6} \\ &= 0.65 \text{ g/m}^2/\text{day}^a \\ &= 1.33 \text{ g/m}^2/\text{day} \end{aligned}$	<p>Similar calculation as for JE1 and JE2 (a) see Footnote 5</p>
Benthic plant export due to fragmentation and water exchange	JE4	$\begin{aligned} JE4 &= \frac{(0.10) \times (4.06 \text{ g/m}^2) \times}{(7.07 \times 10^6 \text{ m}^3/\text{day})} \\ &\quad 1.52 \times 10^6 \text{ m}^3 \\ &= 1.89 \text{ g/m}^2/\text{day}^a \\ &= 0.46 \text{ g/m}^2/\text{day} \end{aligned}$	<p>see Table 12, JE4 (a) see Footnote 4</p>
Export of detritus due to water exchange	JE5	$\begin{aligned} JE5 &= \frac{(Q_4, \text{ this table}) \times (I_2 + I_3,}{\text{this table})} \\ &\quad 1.52 \times 10^6 \text{ m}^3 \\ &= \frac{(2.17 \text{ g/m}^2) \times (7.07 \times 10^6 \text{ m}^3/\text{day})}{1.52 \times 10^6 \text{ m}^3} \\ &= 10.09 \text{ g/m}^2/\text{day} \end{aligned}$	<p>see Table 12, JE5</p>
Export of microbes due to water exchange	JE6	$\begin{aligned} JE6 &= \frac{(I_5, \text{ this table}) \times (I_2 + I_3,}{\text{this table})} \\ &\quad (\text{bay area}) \\ &= \frac{(1.06 \text{ g/m}^3) \times (7.07 \times 10^6 \text{ m}^3/\text{day})}{1.17 \times 10^6 \text{ m}^2} \\ &= 6.40 \text{ g/m}^2/\text{day} \end{aligned}$	<p>see Table 12, JE6</p>

Table 14. Values for Wiggins Pass Area Model (Continued, page 10 of 11)

Description	Notation	Calculations and Assumptions	References
<b>INTERNAL FLOWS:</b>			
Fishing yield due to commercial and sport fishing	$J_F$	$J_F = (\text{commercial yield}) + (\text{sport fishing field})$ = 0.002 g/m <sup>2</sup> /day	see Table 12, Footnote 17
Zooplankton grazing upon phytoplankton	$J_2$	$J_2 = \text{calculated to give organic balance to compartment}$ = 0.04 g/m <sup>2</sup> /day	see Table 12, Footnote 18c
Zooplankton grazing upon detritus	$J_3$	$J_3 = \text{calculated to give organic balance to compartment}$ = 0.04 g/m <sup>2</sup> /day	see Table 12, Footnote 18c
Nutrient uptake by phytoplankton	$J_4$	$J_4 = J_{4TP} = (0.01) \times (2.78)$ = 0.03 g/m <sup>2</sup> /day	see Table 12, J <sub>4TP</sub>
Nutrient uptake by benthic producers	$J_5$	$J_5 = J_{5TP} = (0.01) \times (0.42)$ = 0.01 g/m <sup>2</sup> /day	see Table 12, J <sub>5TP</sub>
Benthic invertebrates and fish grazing on phytoplankton	$J_6$	$J_6 = \text{calculated to give an organic balance in compartment}$ = $(4.81 - 4.59)/4 = 0.22/4 = 0.055$ = 0.06 g/m <sup>2</sup> /day	see Table 12, J <sub>6</sub>
Phytoplankton death and transfer to detritus	$J_7$	$J_7 = \text{calculated to give an organic balance in compartment}$ = $3 \times (J_6, \text{ above})$ = $3 \times 0.055 = 0.16 \text{ g/m}^2/\text{day}$	see Table 12, J <sub>7</sub>

Table 14. Values for Wiggins Pass Area Model (Continued, page 11 of 11)

Description	Notation	Calculations and Assumptions	References
<b>INTERNAL FLOWS:</b>			
Benthic invertebrates and fish grazing on benthic producers	J <sub>8</sub>	J <sub>8</sub> = calculated to give organic balance in compartment = 0	see Table 12, J <sub>8</sub> and this table, Footnote 4
Benthic producers death and transfer to detritus	J <sub>9</sub>	J <sub>9</sub> = calculated to give organic balance in compartment = 0	see Table 12, J <sub>9</sub> and this table, Footnote 4
Benthic invertebrates and fish grazing on detritus	J <sub>10</sub>	J <sub>10</sub> = 3 x 0.06 = 0.18 g/m <sup>2</sup> /day	see Table 12, J <sub>10</sub>
Zooplankton death and feces transfer to detritus	J <sub>11</sub>	J <sub>11</sub> = 0.50 x 4.16 = 2.08 g/m <sup>2</sup> /day	see Table 12, J <sub>11</sub>
Benthic invertebrates and fish grazing on zooplankton	J <sub>12</sub>	J <sub>12</sub> = 4.59 - 2.43 g/m <sup>2</sup> /day = 2.16 g/m <sup>2</sup> /day	see Table 12, J <sub>12</sub>
Benthic invertebrate and fish death and feces transfer to detritus	J <sub>13</sub>	J <sub>13</sub> = 19.01 - 19.01 g/m <sup>2</sup> /day = 0	see Table 12, J <sub>13</sub>
Benthic invertebrate and fish out-migration	J <sub>14</sub>	J <sub>14</sub> = 3.75 - 1.54 g/m <sup>2</sup> /day = 2.21 g/m <sup>2</sup> /day	see Table 12, J <sub>14</sub>

FOOTNOTES TO TABLE 14

1.  $V_A = (1.26 \text{ m}) \times (1.17 \times 10^6 \text{ m}^2) \times (2) = 2.95 \times 10^6 \text{ m}^3/\text{day}$

$$V_T = \frac{(33.8/34.0)}{1 - (33.8/34.0)} \frac{(3.76 \times 10^4 \text{ m}^3/\text{day})}{= (0.994) \frac{(3.76 \times 10^4 \text{ m}^3/\text{day})}{0.006} \frac{3.74 \times 10^4}{0.006} = 6.23 \times 10^6 \text{ m}^3/\text{day}}$$

$$\text{then, } V_T/V_A = \frac{6.23 \times 10^6 \text{ m}^3/\text{day}}{2.95 \times 10^6 \text{ m}^3/\text{day}} = 2.11$$

2. Total plankton respiration was 0.14 g/m<sup>2</sup>/day; using ratio of zooplankton to phytoplankton biomass (0.074/0.95), phytoplankton respiration was estimated to 90 percent of total. See also Table 13, Footnote 9.

3. Based on metabolism data (Results, Tables 1 and 5), the standing stock of benthic invertebrates was estimated to give a JGP2/Q2 ratio similar to that for Chokoloskee Bay. Chokoloskee Bay (Table 12) (4.55)/(20.1) = 22.64%; then, 0.92/x = 0.2264, and x = 4.06 g/m<sup>2</sup>.

4. 1.89 g/m<sup>2</sup>/day plus JR2 (benthic plant respiration) sum to be greater than all inputs. This is not possible if an organic balance is assumed, therefore the value based on a balance becomes 0.46 g/m<sup>2</sup>/day.

5. In order to achieve organic balance in nutrient compartment, export must be equal to import = 1.33 g/m<sup>2</sup>/day. This rate would give a TOC concentration in the bay of 0.29 g/m<sup>2</sup> (0.21 g/m<sup>3</sup>). These values are within the ranges found in Wiggins Pass area during dry season sampling.

unknown for Gulf Coast estuaries (Odum and Wilson, 1962); however, compared to data for Chokoloskee Bay, Wiggins Pass Area, and Crystal River (Smith, et al., 1974), are very high and indicative of a nutrient enriched system. High productivities in Naples Bay result in a major net export of phytoplankton and detritus with associated microbes at a rate estimated to be  $8.8 \text{ g/m}^2/\text{day}$ . Moderate productivities of the other two areas reflect roles more commonly associated with estuarine areas. Net fish and invertebrate production occurs in both Chokoloskee and Wiggins Pass estuaries, indicative of the nursery function. Wiggins Pass is a very physical system being flushed at every turn of the tide. This fact, in conjunction with a less-developed benthic community, does not give it the nutrient scrubbing capability apparent in Chokoloskee Bay.

Balance of organic inputs and outputs is an essential assumption for the use of models of this type for estimating organic loads into an estuary. A first attempt at projecting theoretical loading alternatives was made based on a steady-state organic balance and the following corollary assumptions:

1. Net fish production is considered a high management priority for estuaries;
2. Imbalances in the organic budget of an estuary are most likely compensated for by in- or out-migration of benthic invertebrates or fish as the most mobile of estuarine state variables; and

3. Increased organic loads into an estuary attract or encourage increased microbial populations which demand even more organic material [often measured as Biological Oxygen Demand (BOD)].

Ecosystem demand on benthic invertebrates and fish stocks to balance the detrital pool were considered proportional to the net difference in migration. The difference between where an estuary is now (in net fish production or consumption) and where it would be at the null point (no net loss or gain) is the order-of-magnitude change in organic loading that may serve to guide a management decision. For example, in Naples Bay net consumption of fish is estimated as  $7.5 \text{ g/m}^2/\text{day}$ . To balance the ecosystem in favor of net fish production, it is hypothesized that organic loading (detritus) into the system must be reduced by at least  $7.5 \text{ g/m}^2/\text{day}$ , or 32 percent of the total  $2.5 \times 10^6 \text{ pounds/day}$  it is presently receiving. Similar calculations for Chokoloskee Bay and Wiggins Pass indicate organic loads to those systems could be increased 6 and 1-2 percent, respectively, before net fish production may be lost. These projections are considered very tentative and are offered here as one example of one way in which ecosystem models may be used as a basis for wasteload allocation.

Table 15. Summary of Results of Systems Comparison Based on Evaluated Diagrams for Big Cypress Estuaries, † April, 1977

Estuarine Bay (area, $m^2$ )	Gross Primary Production $g/m^2/day$	Total Respiration $g/m^2/day$	Metabolic Turnover of State Variables, ** Days			Physical Turnover of Bay, *** Days			
			P/R*	Benthic Producers	Zooplankton				
Chokoloskee ( $27.2 \times 10^7 m^2$ )	6.85	6.19	1.11	0.8	8.8	0.5	103.5	10	4.4
Naples ( $4.79 \times 10^6 m^2$ )	12.42	12.30	1.01	15.2	5.5	5.2	32.0	10	1.1
Wiggins Pass Area ( $1.17 \times 10^6 m^2$ )	3.70	4.44	0.84	7.3	8.8	7.4	61.0	10	0.2

\*  $\Delta \text{C} / (\Delta \text{C} + \Delta \text{O}_2) / (\Delta \text{C} + \Delta \text{O}_2) \text{ P.D.}$

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Nutrients TP	Turnover of Components Due to Combined Physical and Biological Processes, *** Days			Percent Organic Matter Removed					
	Benthic Producers	Zooplankton	Fish						
Chokoloskee ( $27.2 \times 10^7 m^2$ )	1.2	0.3	4.4	0.4	31.0	3.3	9.58	3.37	65
Naples ( $4.79 \times 10^6 m^2$ )	0.5	0.9	2.8	0.1	13.5	0.9	34.50	22.20	36
Wiggins Pass Area ( $1.17 \times 10^6 m^2$ )	0.1	0.2	4.4	0.02	7.4	4.1	28.33	23.93	16

Table 15. Summary of Results of Systems Comparison Based on Evaluated Diagrams for Big Cypress Estuaries,<sup>†</sup>  
April, 1977 (Continued, page 2 of 2)

		Organic Input (Loading) Alternatives		
		Percent of Total Input Case I	Case II	Case III
Chokoloskee ( $27.2 \times 10^7 \text{ m}^2$ )		3.7	6	3
Naples ( $4.79 \times 10^6 \text{ m}^2$ )		1.3	32	35
Wiggins Pass Area ( $1.17 \times 10^6 \text{ m}^2$ )		0.1	1-2	0.5-1

<sup>†</sup> Based on data presented for Chokoloskee Bay (Figure 7), Naples Bay (Figure 8), and Wiggins Pass Area (Figure 9).

\* P/R is the ratio of gross primary production ( $J_{GP}$ ) to total respiration ( $J_R$ ). May indicate present tendency for accumulation of organic matter.

\*\* Metabolic turnover is determined by dividing daily respiration ( $J_{Ri}$ ) of a specific component into its standing stock ( $Q_i$ ). Turnover due to organism respiration.

†† Values in this column were set equal to 10 as a basic assumption for evaluation purposes.  
\*\*\*\* Turnover of bay due to advective and tidal water exchange; water exchange in and out of a given bay with a certain volume.

\*\*\*\*\* Turnover of each component calculated as a ratio of throughput (inputs or outputs) to content (standing stock).  
††† Case I: Percent of organic input estimated to bring bay to the point of null fish production. For Chokoloskee Bay and Wiggins Pass Area, this value is the estimated percent additional organic load the bay could receive before net fish production is lost. For Naples Bay, this value is the estimated percent organic load must be reduced before net production of fish is possible. These values should be considered extremely tentative.

†††† Case II: Percent of organic input estimated to sustain fish production at 50 percent of its present rate. For Chokoloskee Bay and Wiggins Pass Area, this value is the estimated percent additional organic load the bay could sustain with a resultant 50 percent in fish production. For Naples Bay this value represents the estimated percent present organic load must be reduced before a fish production rate equivalent to 50 percent of those for Chokoloskee and Wiggins Pass estuary could be achieved. These values should be considered extremely tentative.

## DISCUSSION

### General Estuarine Productivity

This document presents the status of ongoing investigation in the Big Cypress Basin Area of the Southwest Florida Regional Planning Council. Relative to coastal areas of Florida, it is undeveloped, and some portions can be considered undisturbed by activities of man. Comparisons of the final results in this area will be made substantially in the final report; however, some highlights of results to date should be re-emphasized:

1. All three estuarine bays studied have viable productive biological systems. Man-induced organic impacts on Naples Bay have probably altered its primary role from fish and shellfish production to one of organic waste processing and subsequent microbial production. Fish-production remains a major role of Chokoloskee Bay and Wiggins Pass Area. Chokoloskee Bay also appears to have certain nutrient scrubbing capabilities as a benthic-dominated system.
2. All three estuarine bays are actively turning over organic material and show net reduction of organic matter from inputs to outputs. This organic removal capability operates at various degrees of efficiency, with Chokoloskee Bay showing highest percent removal (Table 14). Organic removal efficiencies appear to be (at least, in part) inversely proportional to physical turnover or dominance of the bay system. Organic decomposition and subsequent nutrient regeneration is a function found in estuarine areas under natural conditions (Odum, et al., 1967-1974).

3. All of the estuaries contain component stocks that are essentially similar; however, these stocks vary in diversity and magnitude.

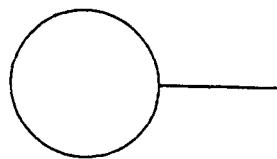
State of the Study

Biological portions of the Southwest Florida 208 program will be completed by November 1, 1977. This document represents an interim report to the final report for the Big Cypress Basin estuaries of Chokoloskee Bay, Naples Bay, and Wiggins Pass Area. The final report will include additional field data for these areas collected in June and September. It will also include results of one-time sampling efforts at Estero Bay. All field work has been completed. Data are being reduced and are in varying stages of analysis. Data analysis and reduction is estimated to be 70 percent complete at this time. No delays are anticipated, although potential problem areas may exist in simulation and validation of the Naples Bay model within the remaining time.

**APPENDIX A**  
**EXPLANATION OF THE ENERGY SYMBOLS USED**

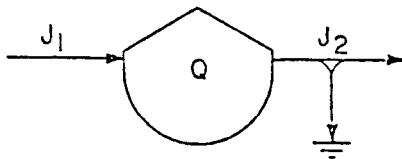
FURTHER DETAILS OF THE ENERGY SYMBOLS  
PRESENTED IN THIS SECTION CAN BE FOUND IN  
ODUM, 1971, AND, ODUM AND ODUM, 1976

### Energy Source Module



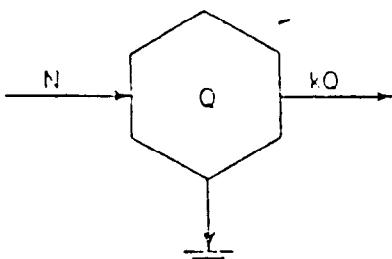
A source of energy or material external to the boundaries of the system of interest. The driving force may be constant or time varying and is independent of behavior of the system within the boundary.

### Storage Module



Storage of energy or material within a system. The quantity in storage fluctuates with time as a function of the inflows and outflows ( $dQ/dt = J_1 - J_2$ ), where depreciation losses are included in outflow pathway.

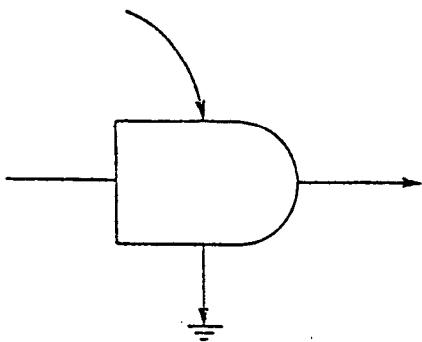
### Self-Maintaining Consumer Module



An aggregated module representing a consumer unit. Included inside are at least one storage module and one work gate interacting to do work on input energy to that unit, providing a logistic

response. When used only as a visual symbol for organizing model components no pathways are implied beyond those actually shown.

#### Production and Regeneration Module

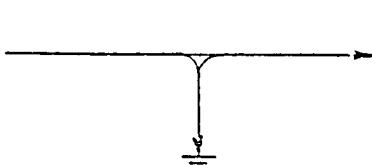


An aggregated module representing the combination of the capture of pure energy such as light feeding a self-maintaining module, and a work feedback loop controlling inflow processes. Usually used to depict green plants. When used as a visual symbol only, it may represent the production and consumption of entire ecosystems.

#### Heat Sink



Energy conversion to heat with each work process.

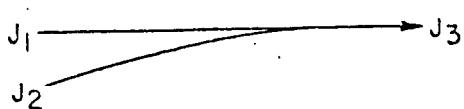


#### Pathway of Energy Exchange

Flow of energy or materials.

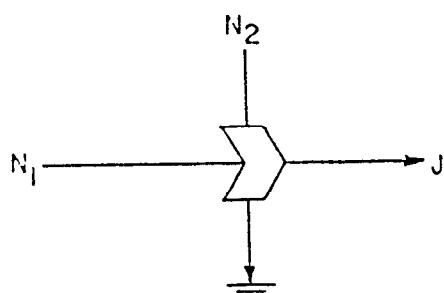
Barb indicates a one-way flow; no

barb indicates back forces acting along the pathway. Heat sink represents frictional and back force losses.



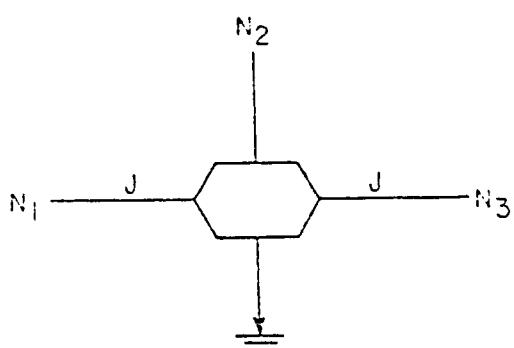
#### Adding Junction

Adding of two flows, where  $J_3 = J_1 + J_2$ .



#### Work Gate

An interaction in which the resultant flow is some specific function of the interacting forces. Often the function is considered multiplicative, giving  $J = kN_1N_2$ . N<sub>1</sub> and N<sub>2</sub> may be external driving forces, internal storages, or forces caused by flows.



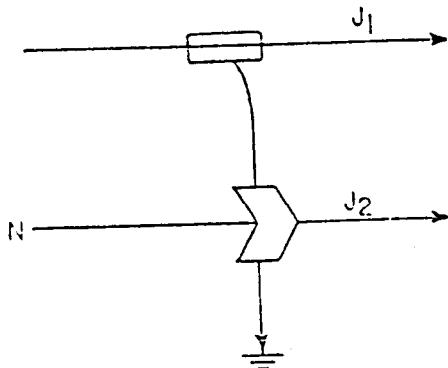
#### Two Way Work Gate

Flow along pathway driven by N<sub>2</sub> may be in either direction depending on conditions determined by N<sub>1</sub>, N<sub>2</sub>, and N<sub>3</sub>:

$$J = kN_2(N_1 - N_3). \quad N_1 \text{ and } N_3$$

may be sources or sinks external to the system or storages within the system.  $N_2$  may be a flow, internal storage or external source.

#### Force Delivered From A Flow

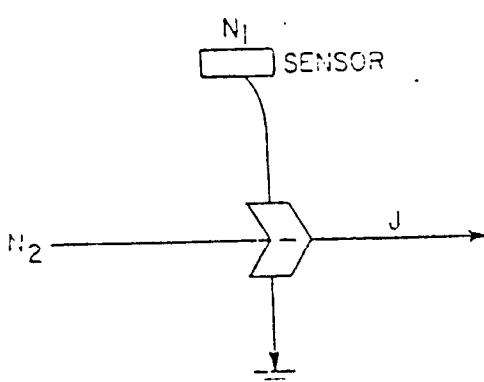


An interaction in which a flow of energy along one pathway ( $J_1$ ) delivers a force for driving an energy flow along a second pathway ( $J_2$ ). The delivered force is proportional to the flow from which it is derived ( $J_1$ )

$$J_2 = kNJ_1$$

An example is transport of suspended material by a water flow.

#### Drag Action Work Gate



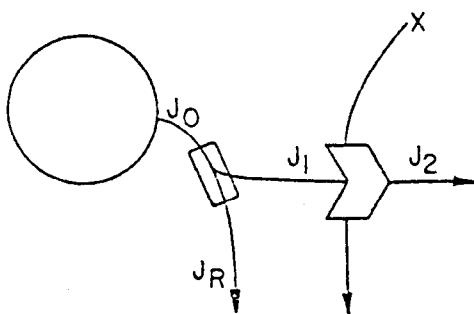
Special type of work gate in which an increase in one flow,

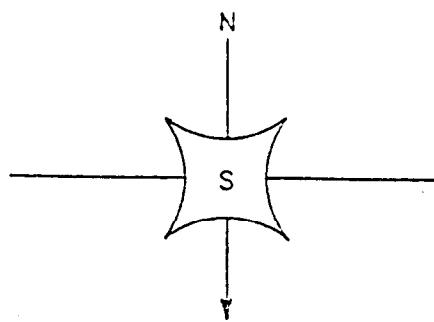
internal storage, or external source ( $N_1$ ) has a retarding effect on the output flow ( $J$ ) of another source or storage ( $N_2$ ). Sensor symbols indicates that there is no appreciable loss from  $N_1$  in this interaction.

$$J = k_2 N_2 (1 - k_1 N_1)$$

#### Flow-Limited Interaction

An interaction in which the resultant flow ( $J_2$ ) is a function of a constant flow ( $J_o$ ).  $J_2$  may be limited by  $J_o$  because as  $X$  increases,  $J_2$  may increase only to the point at which all of  $J_o$  is being utilized. Since  $J_o$  is an independently fixed quantity of flow,  $J_2$  cannot draw more energy from the source ( $S$ ) than is flowing per unit of time.



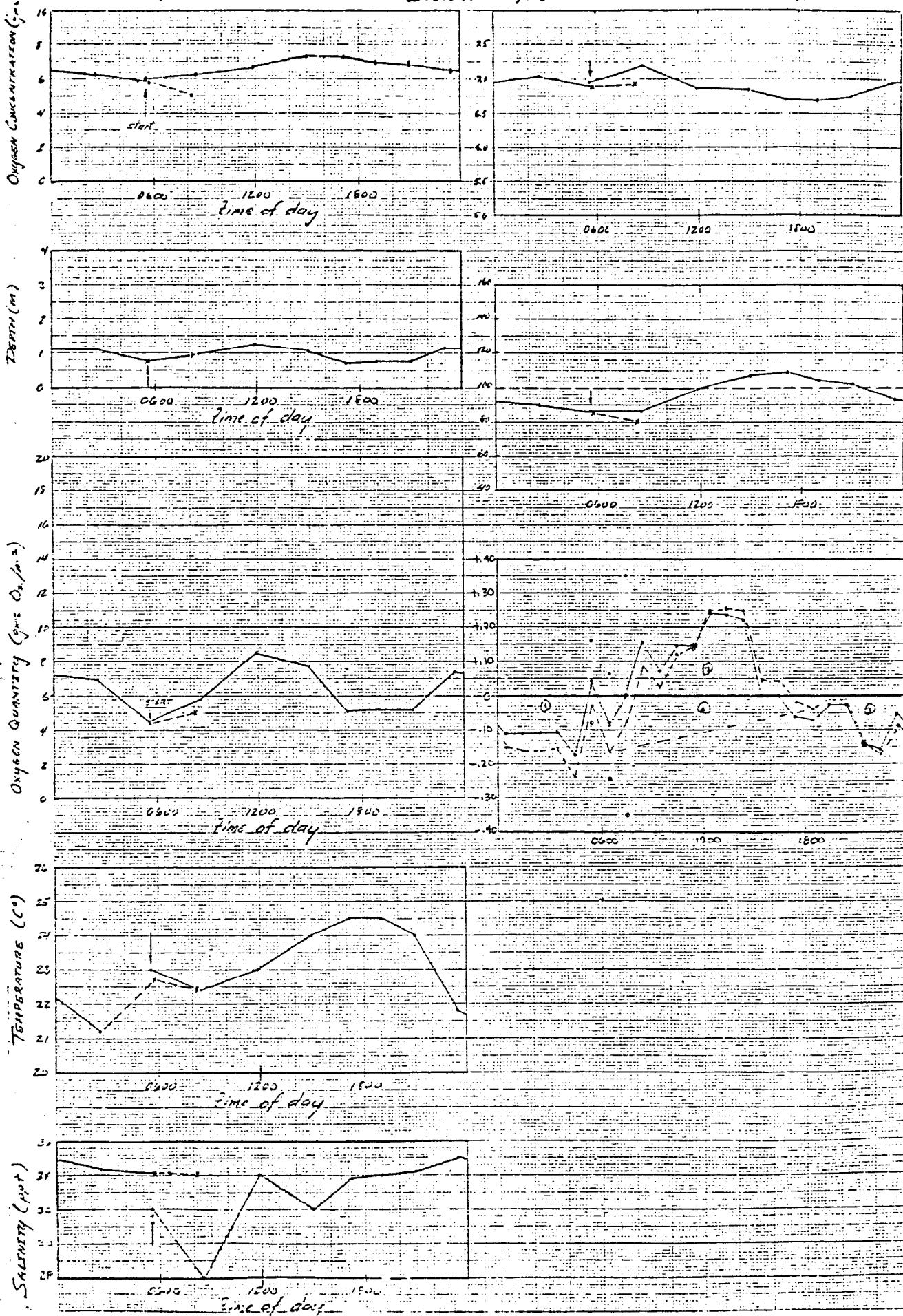


Logic Switch

Flow J is turned on or off by  
logic processes within S,  
controlled by processes of N.

**APPENDIX B**  
**COMMUNITY METABOLISM DATA**

**FIGURE B-1, WIGGINS PASS AREA DIURNAL DATA GRAPHS**

STATION 1  
APRIL 17 & 18, 1977GEOGRAPHIC ANALYSIS OF TOWARD STUDIES  
WIGGINS PASS, FLLog - H. THILLING  
Met Lehman

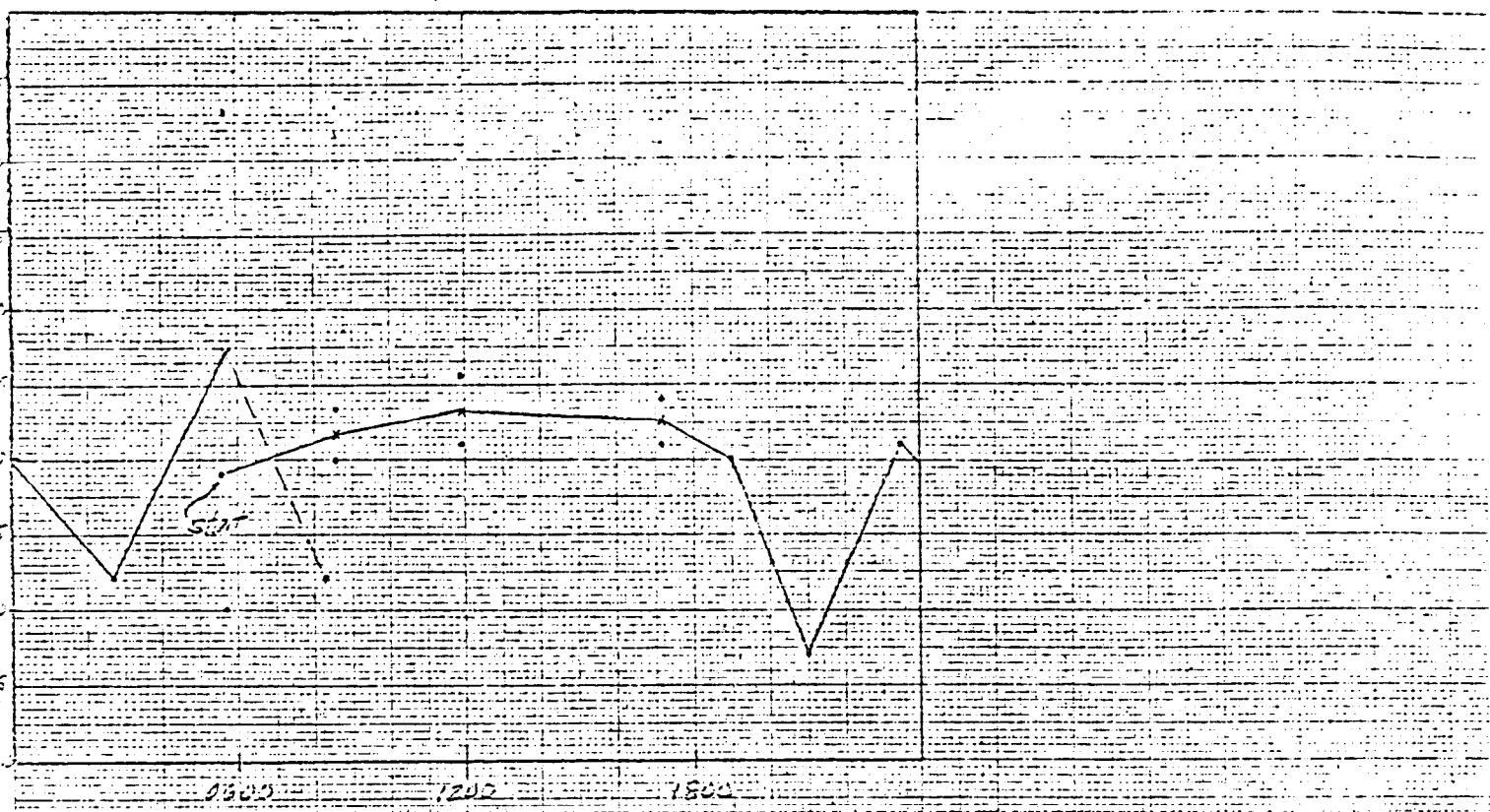
STATION 1

U.S. GATINGS AND SURVEYING INSTITUTE  
MILLIMETERS

EUDON'S SURVEY CO.  
PACIFIC RAILROAD

APRIL 17, 1977

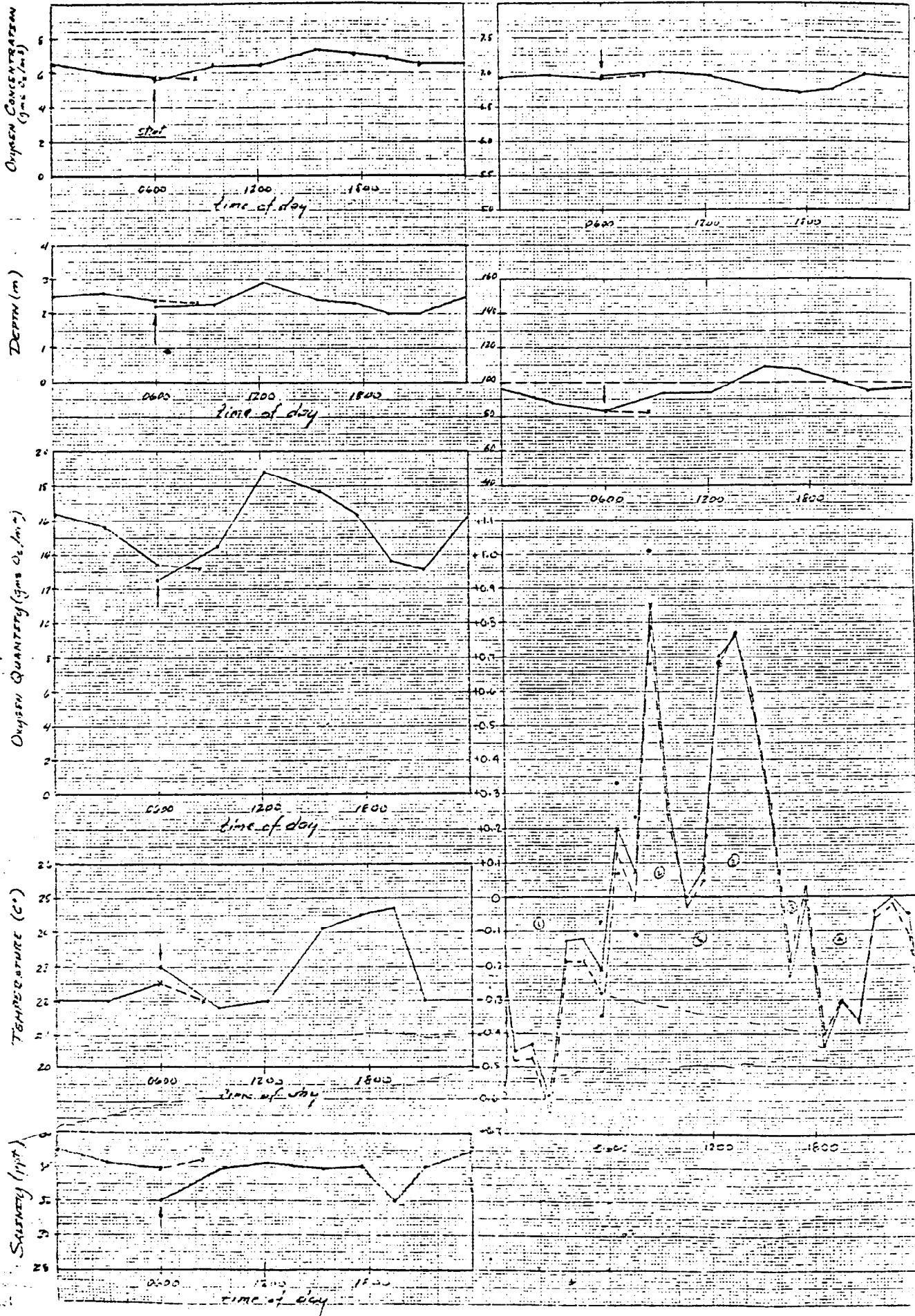
GRAPHIC ANALYSIS OF TENSILE STRESSES  
LESTER PASS, E.



STATION 2  
APRIL 17/18, 1977

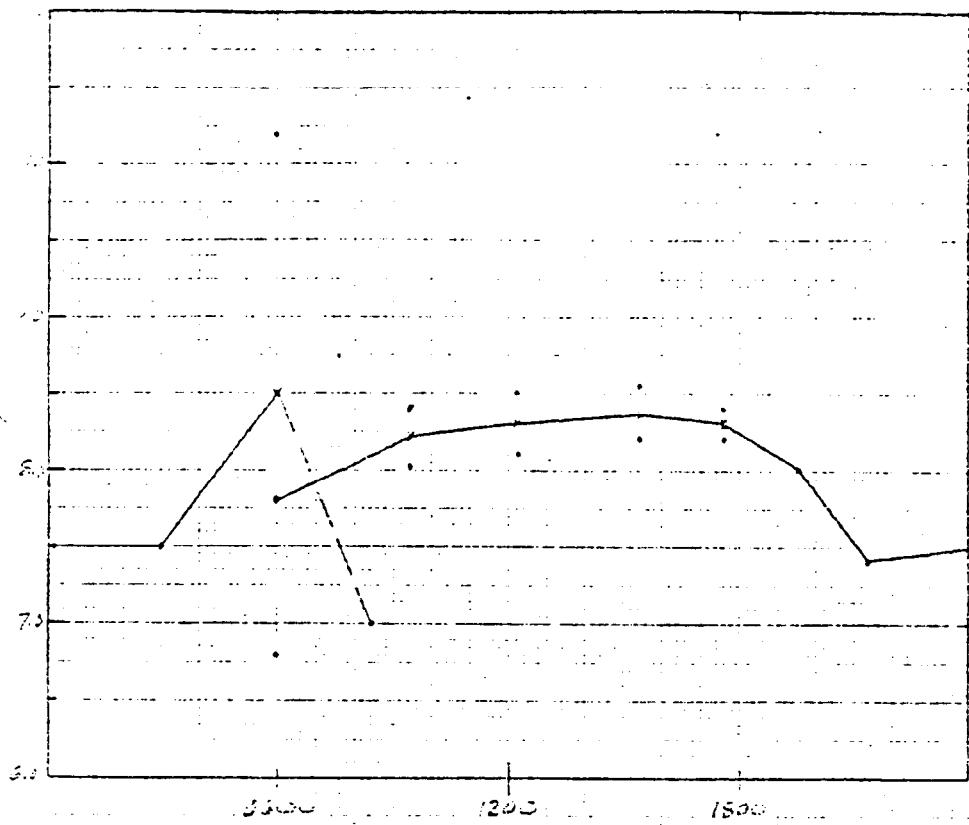
GRAPHIC ANALYSIS OF DAILY STUDIES  
L'IGORNE PASS, FL

By - M. Phillips  
Mel Lehman



STATION 2  
MAY 1968

GRANITE MOUNTAIN - STANDARD CURVE



Time of day 1200 1300 1400 1500 1600 1700 1800

Salinity (psu)

Temperature ( $^{\circ}$ C)

Oxygen Quantity ( $\text{mg/l}$ )

Time of day 1200 1300 1400 1500 1600 1700 1800

Salinity (psu)

Temperature ( $^{\circ}$ C)

Oxygen Quantity ( $\text{mg/l}$ )

Time of day 1200 1300 1400 1500 1600 1700 1800

Salinity (psu)

Temperature ( $^{\circ}$ C)

Oxygen Quantity ( $\text{mg/l}$ )

Time of day 1200 1300 1400 1500 1600 1700 1800

Salinity (psu)

Temperature ( $^{\circ}$ C)

Oxygen Quantity ( $\text{mg/l}$ )

Time of day 1200 1300 1400 1500 1600 1700 1800

Salinity (psu)

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Salinity (psu)

Temperature ( $^{\circ}$ C)

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Temperature ( $^{\circ}$ C)

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Salinity (psu)

Temperature ( $^{\circ}$ C)

Oxygen Quantity ( $\text{mg/l}$ )

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Salinity (psu)

Temperature ( $^{\circ}$ C)

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Salinity (psu)

Temperature ( $^{\circ}$ C)

Oxygen Quantity ( $\text{mg/l}$ )

Time of day 1200 1300 1400 1500 1600 1700 1800

Salinity (psu)

Temperature ( $^{\circ}$ C)

Oxygen Quantity ( $\text{mg/l}$ )

Time of day 1200 1300 1400 1500 1600 1700 1800

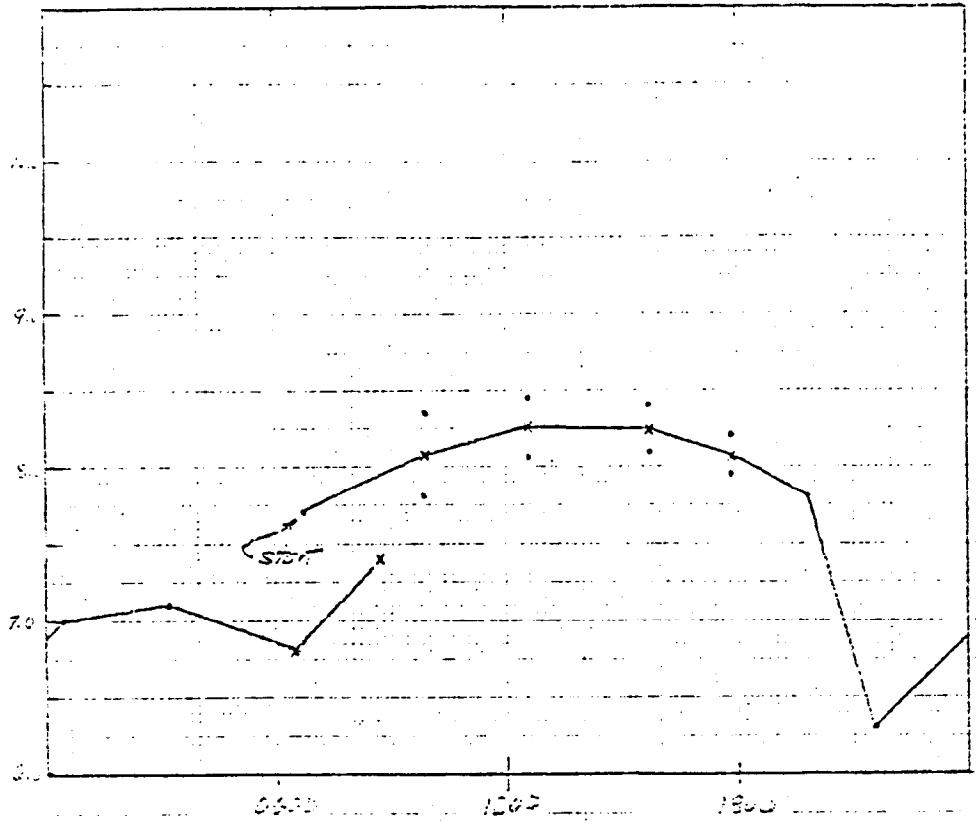
Salinity (psu)

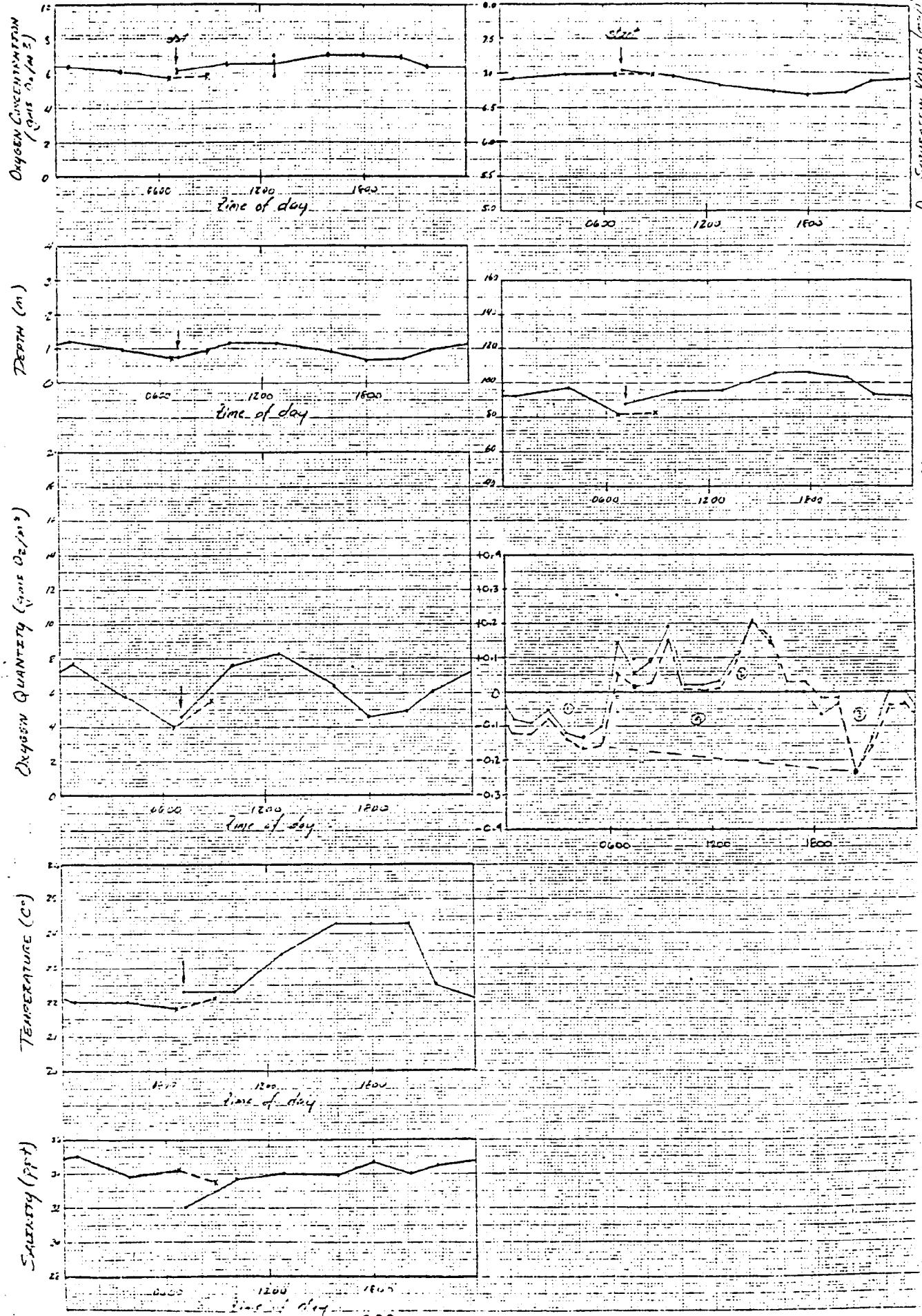
Temperature ( $^{\circ}$ C)

Oxygen Quantity ( $\text{mg/l}$ )

STATION 3  
Apr 22, 1970, 1970

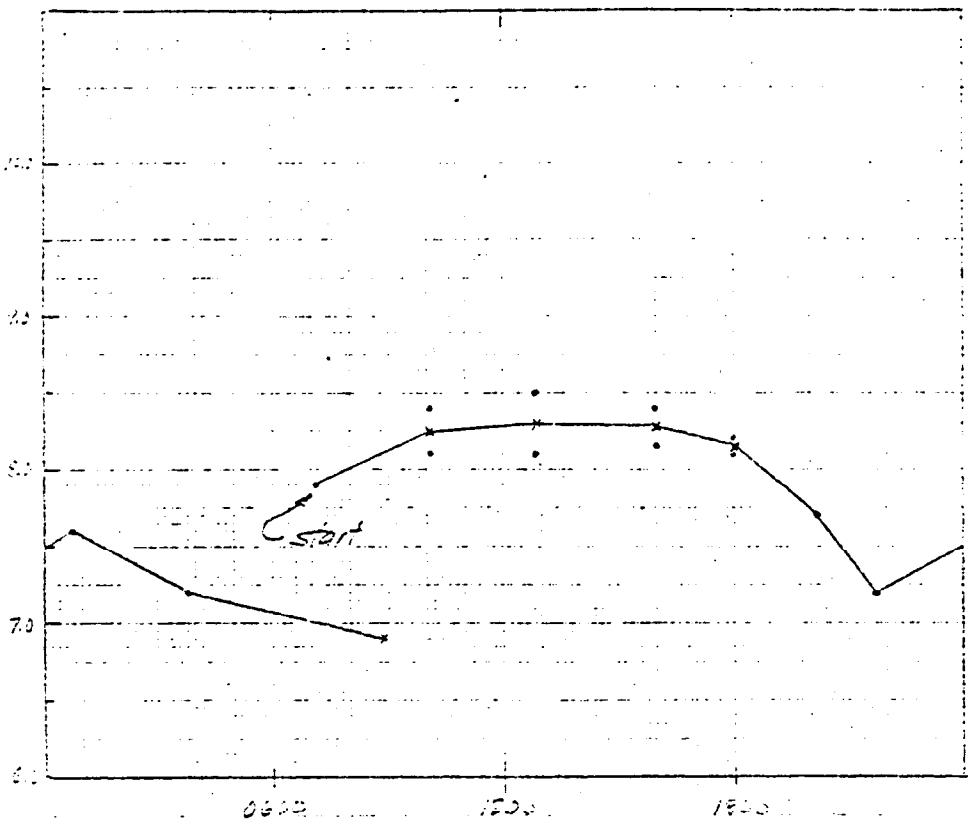
Garrison River near Laramie River  
Elevation 7,200 ft.



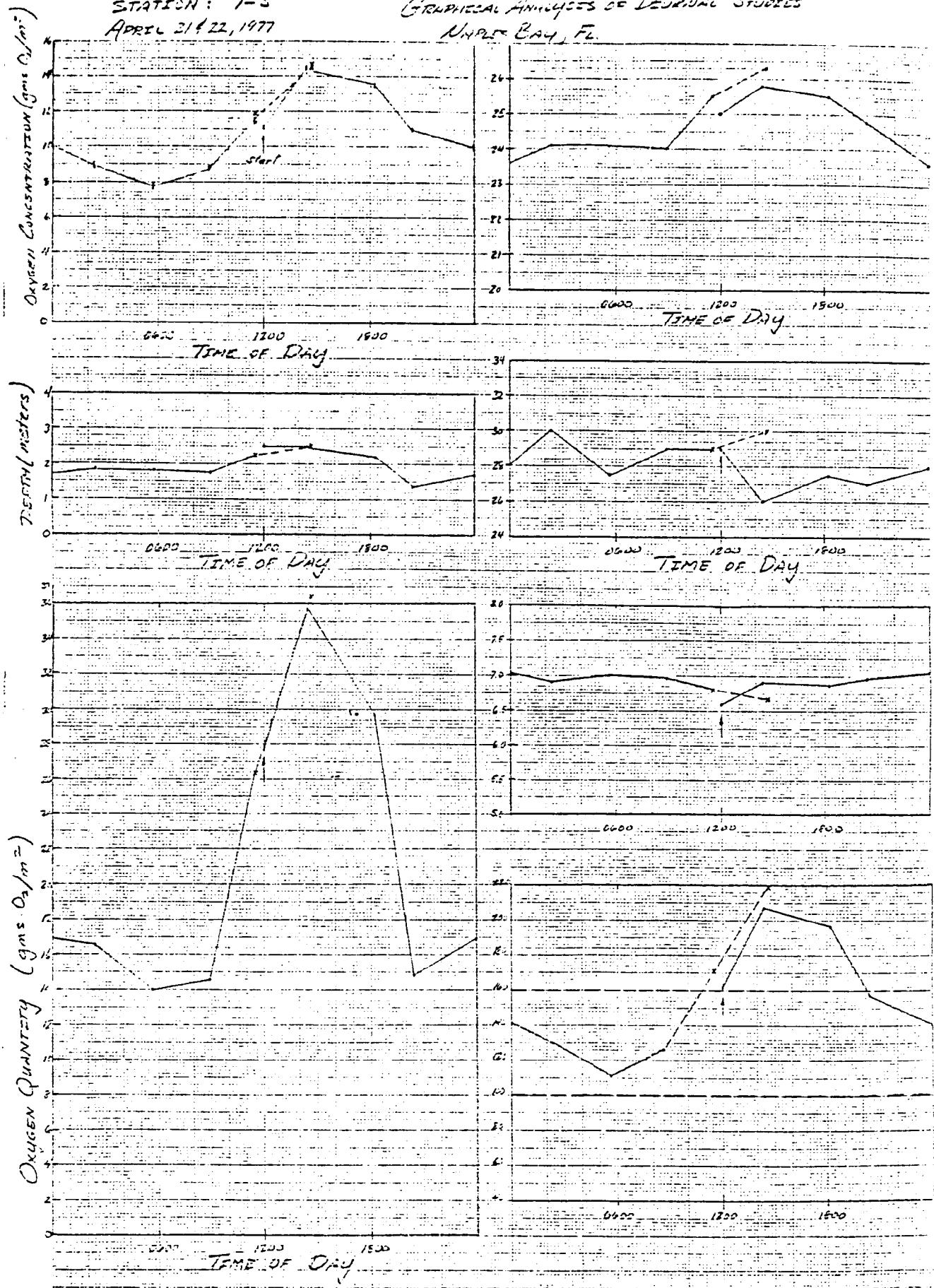
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JULY 16, 1977GRAPHIC ANALYSIS OF ENVIRONMENTAL STUDIES  
WATERS FALLS, FL.4-11-1977  
F. M. Lehman

STATION 4  
2000 FATHOMS

Graphical Analysis of Secchi Depth  
Station 4000 fms.

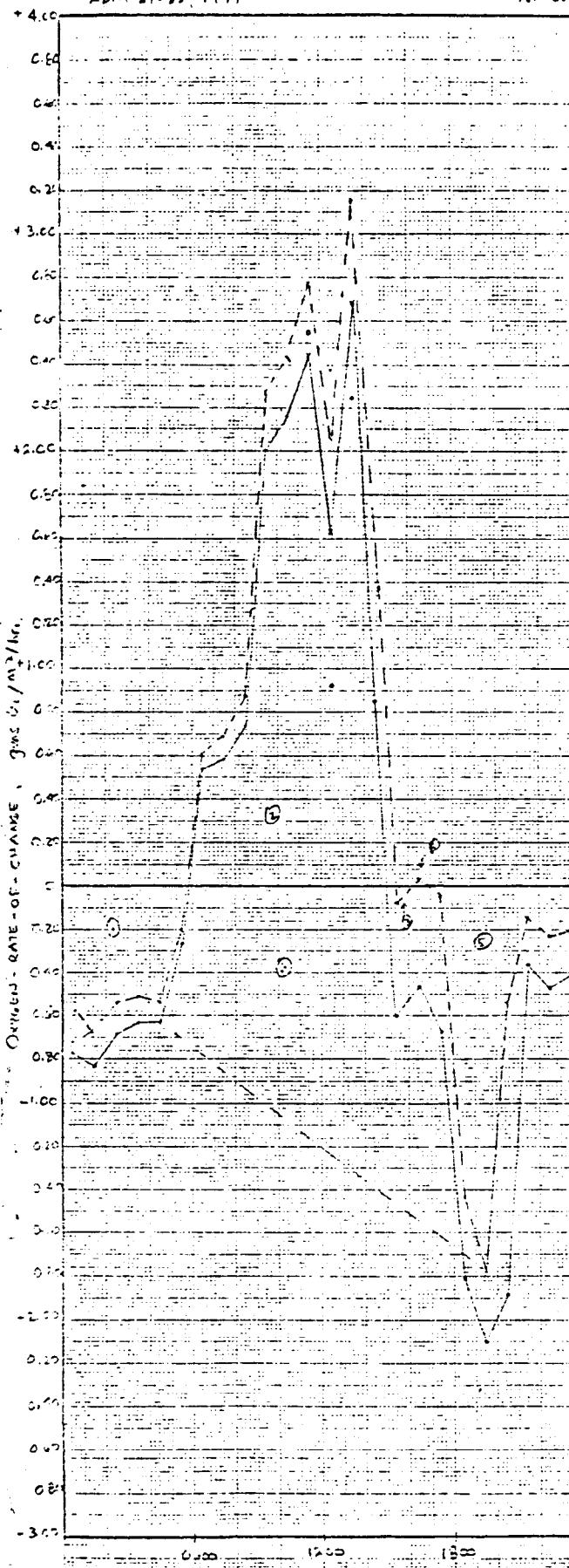


**FIGURE B-2, NAPLES BAY DIURNAL DATA GRAPHS**

STATION: 1-S  
APRIL 21 & 22, 1977GRAPHICAL ANALYSES OF DESTRUCTIVE STUDIES  
NAPLES BAY, FL

Station: I-S  
Apr. 1 21-77, 1977GRAPHICAL ANALYSIS of DIURANT STUDIES  
NAUTILUS BAY, FICRICA

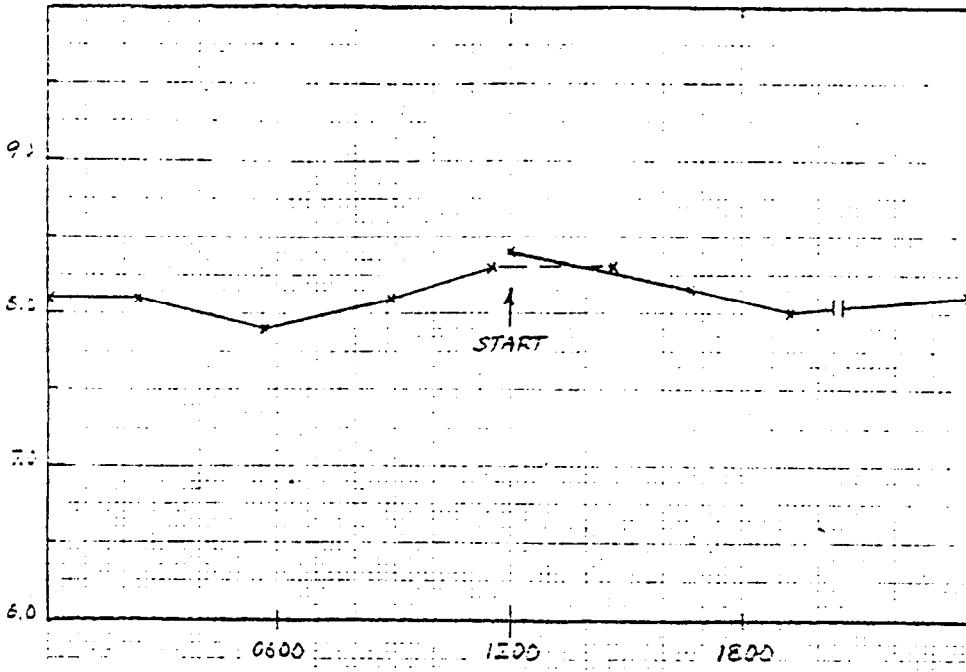
by - Mr. Lehman

{ 0.40 smc O<sub>2</sub>/m<sup>2</sup>/h

1.0 hr

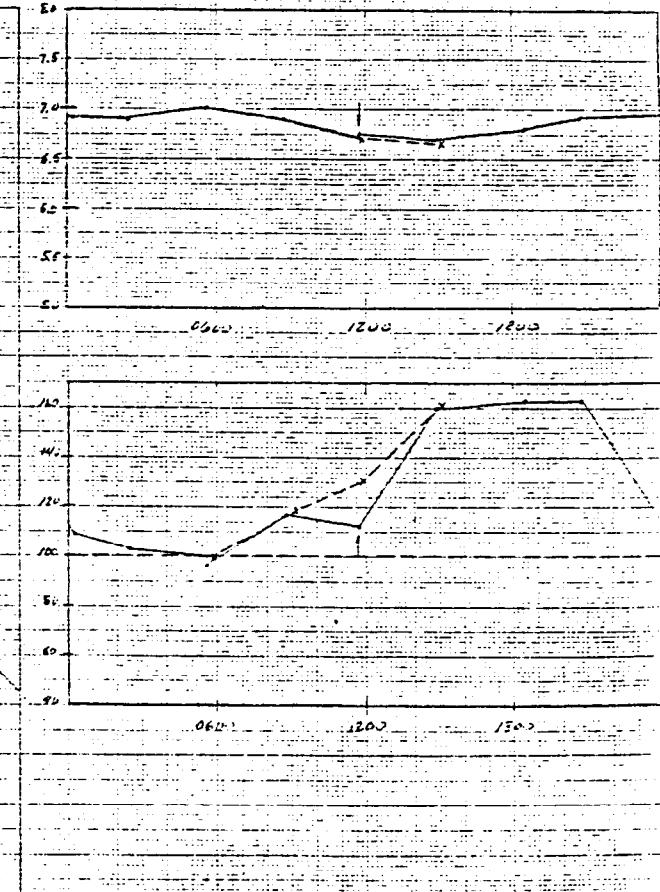
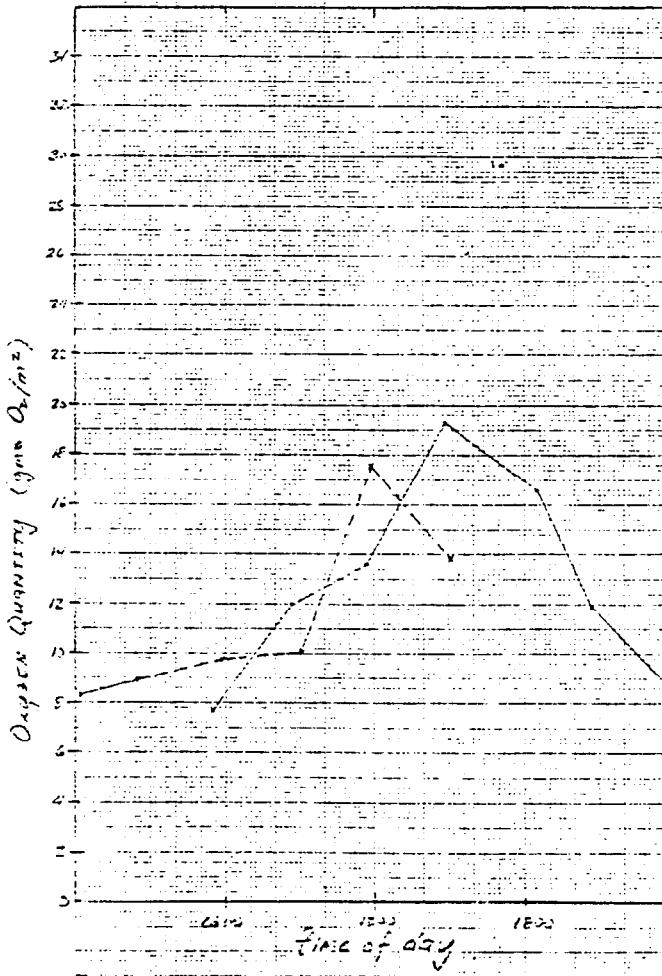
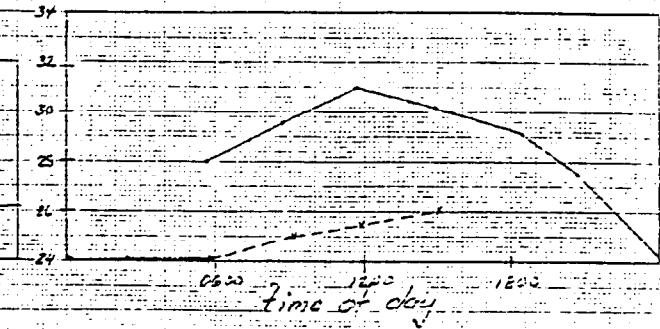
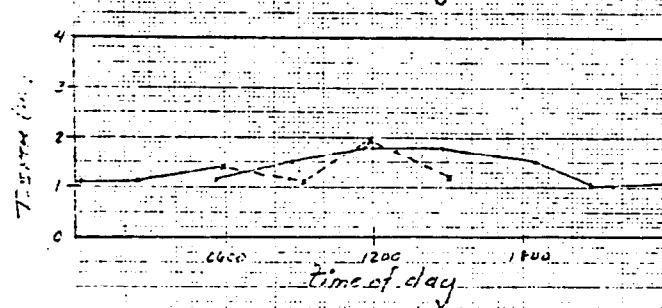
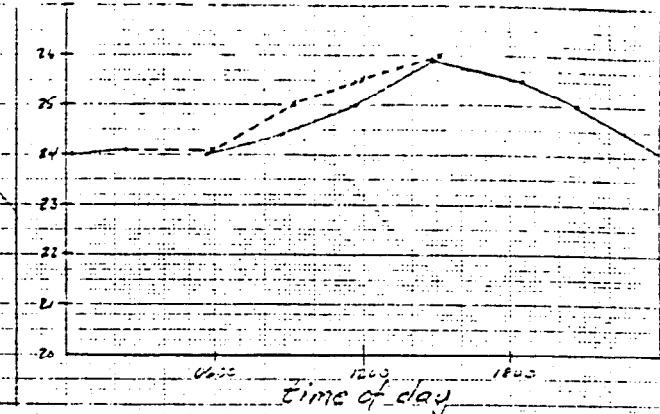
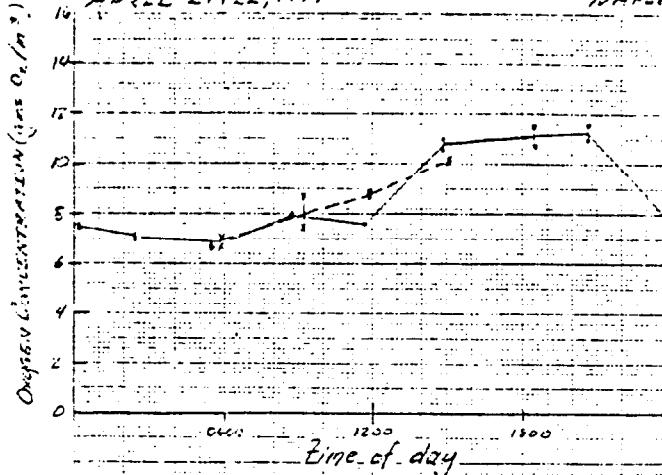
STATION 1-S  
FEB 21 1977

GRAPHICAL ANALYSIS OF DOWNTIME STUDIES  
CLARKSBURG, W. Va.



STATION 1  
APRIL 21/22, 1977GRAPHIC ANALYSIS OF THERMAL GRADIENTS  
NAPLES BAY, FL.

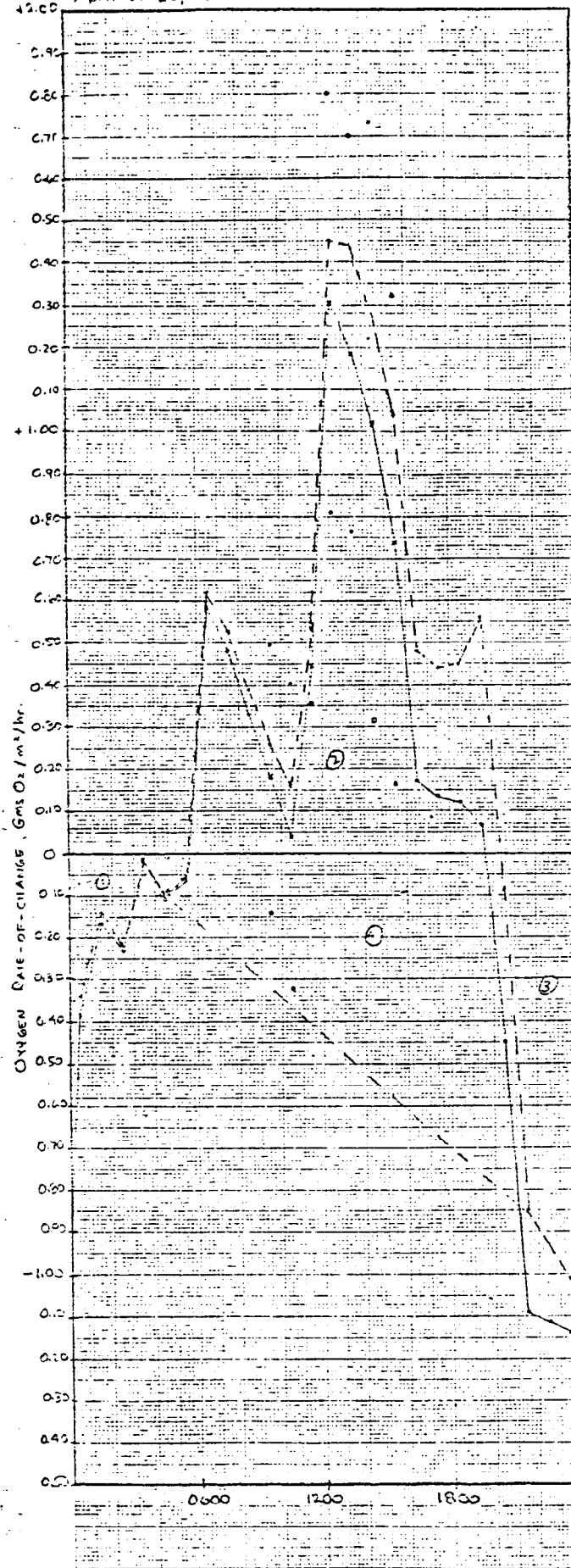
- b. Mike Phillips



Section 1  
April 21-22, 1977

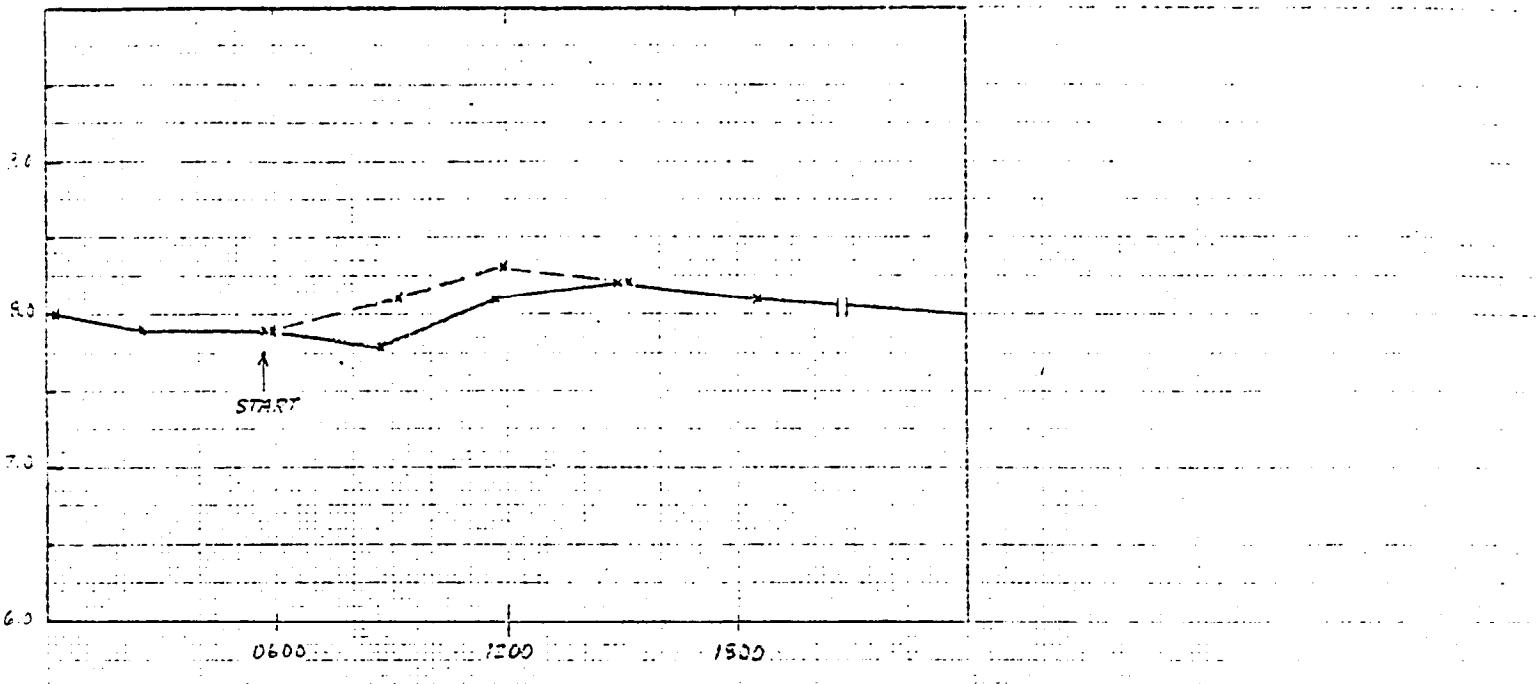
GRAPHIC ANALYSIS OF DIURNAL STUDIES  
NAPLES BAY, FLORIDA

- by Mel Lehman

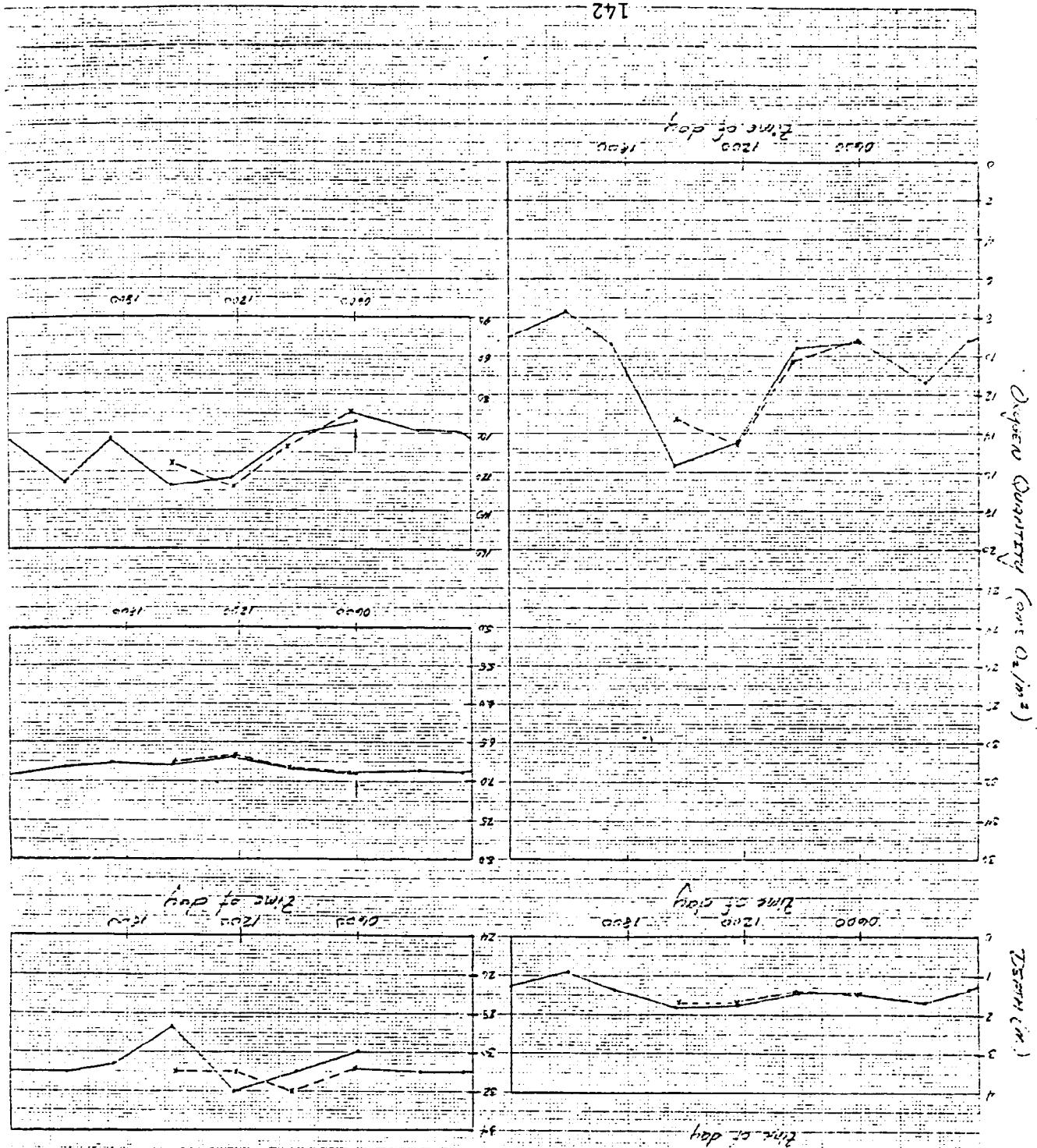


STATION 1  
April 21, 1977

Geometric Analysis of Seismic Waves  
Phase Ray, E

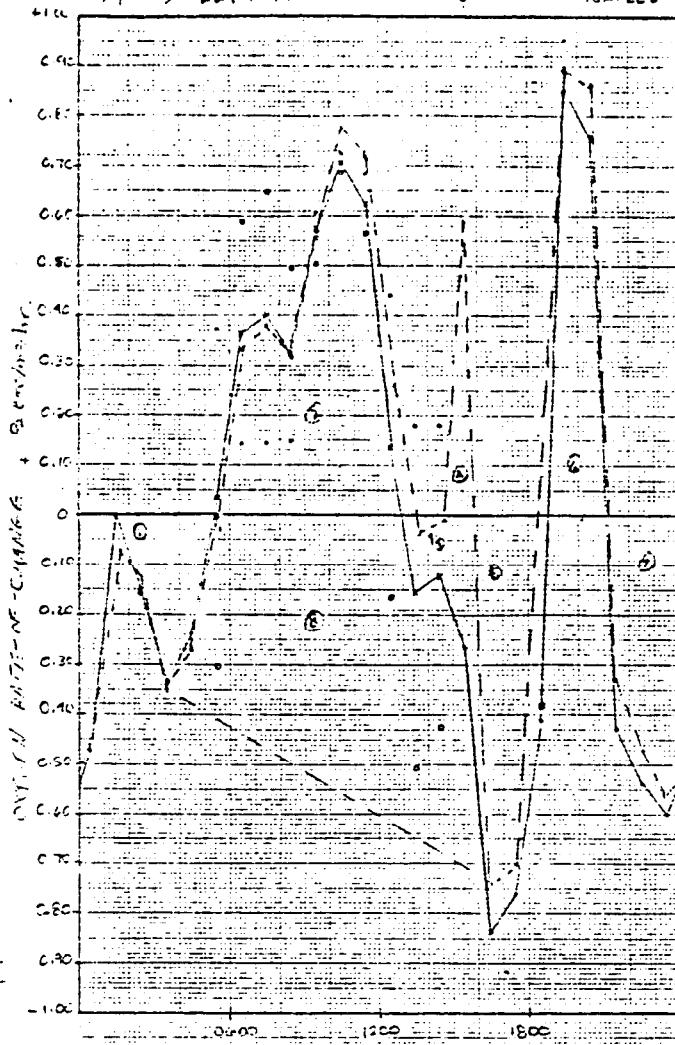


142



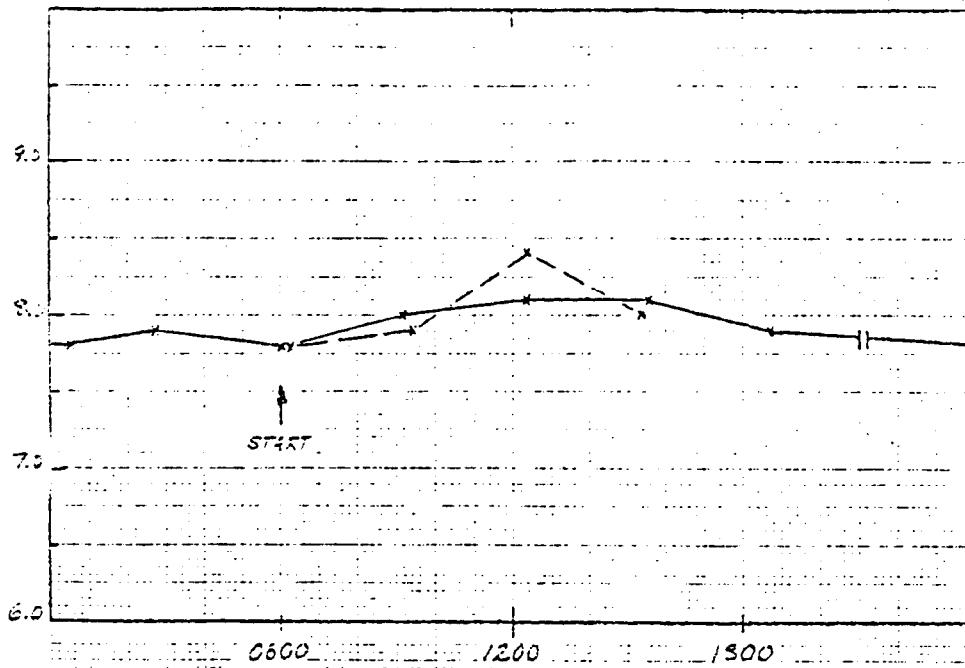
Station 2  
April 31-22, 1977GRAPHICAL ANALYSIS OF DIURNAL STUDIES  
NAPLES BAY, FLORIDA

- by M.E. Lehman

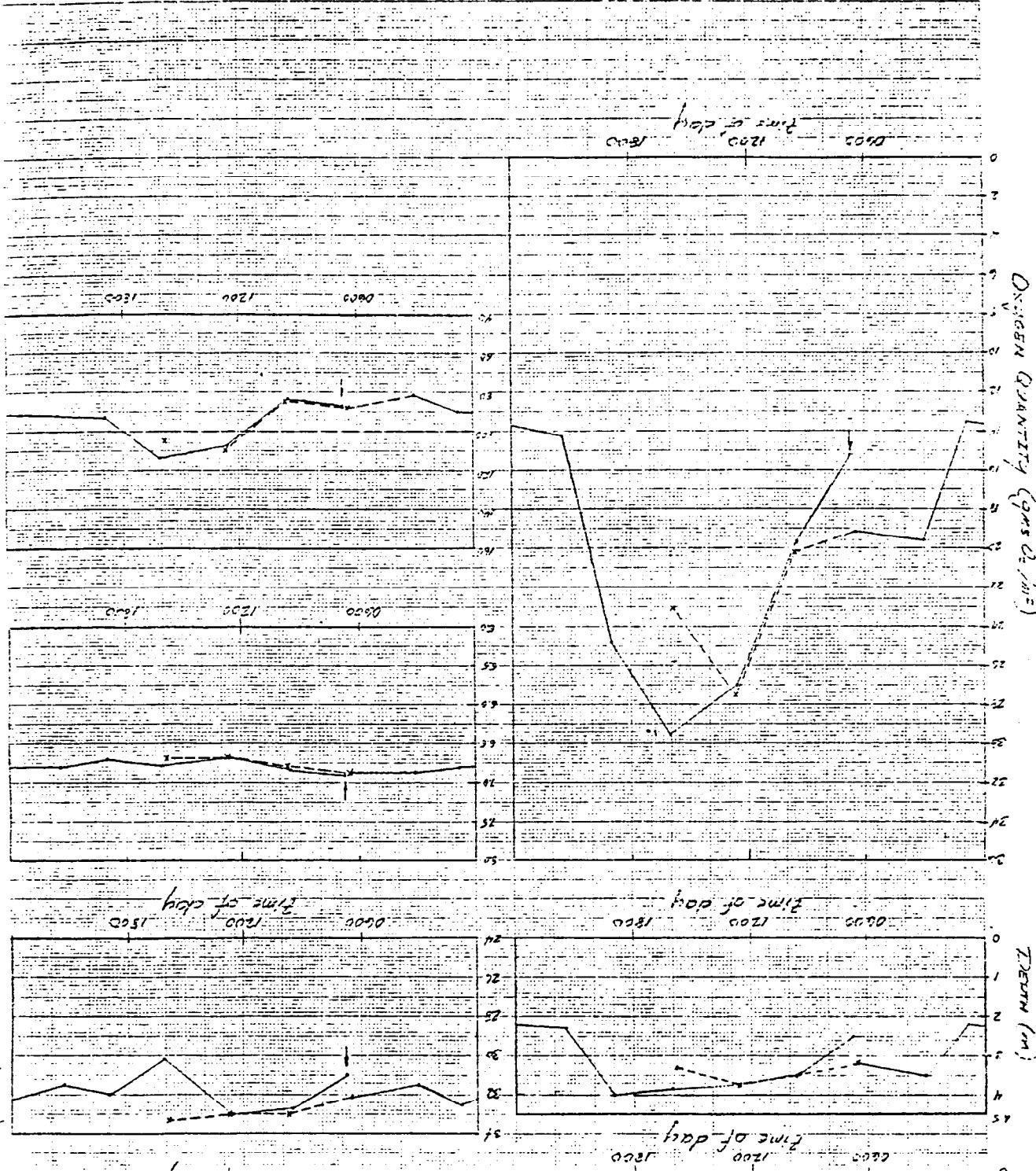


STATION 2  
APRIL 21, 1977

Geographic Analysis of Dredged Sediment  
Biscayne Bay, FL

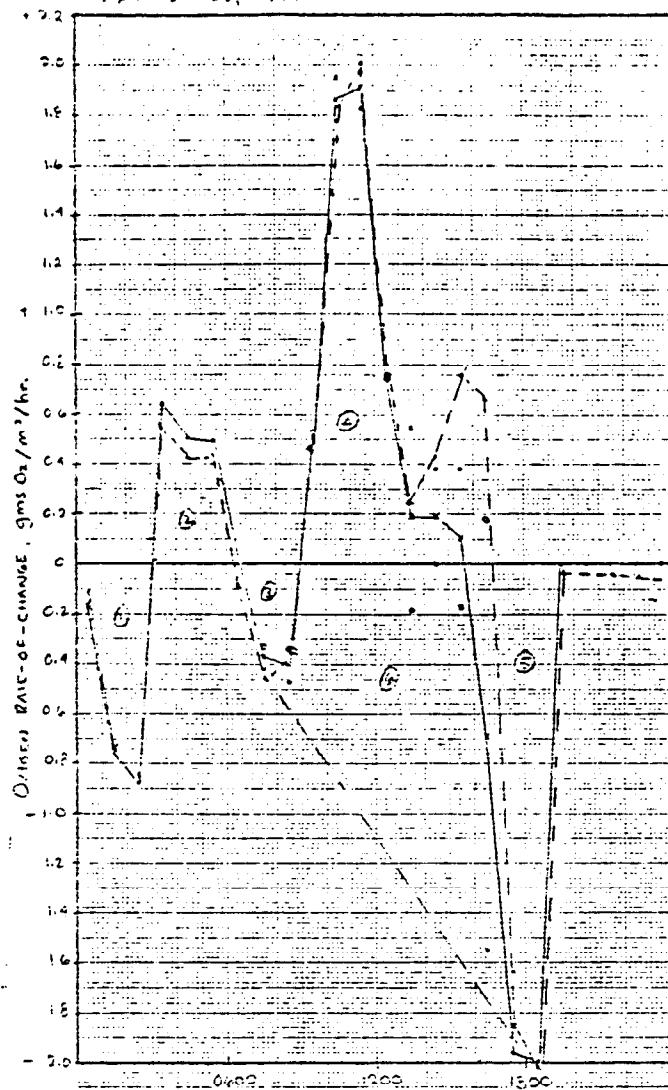


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Station 3  
April 21-22, 1977GRAPHICAL ANALYSIS OF DIURNAL STUDIES  
NAPLES BAY, FLORIDA

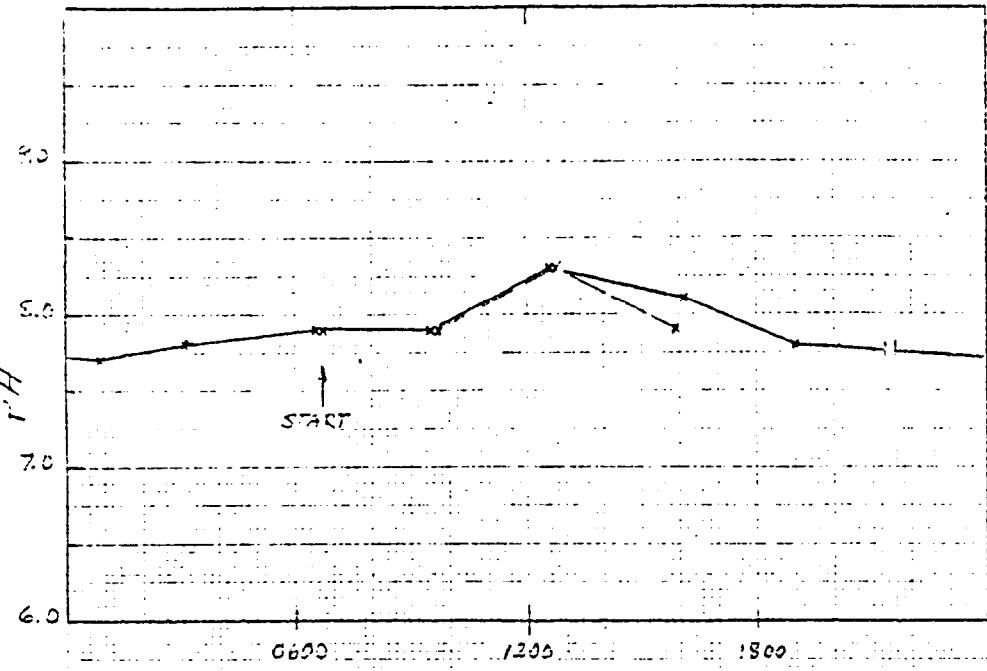
- by Mel Lehman



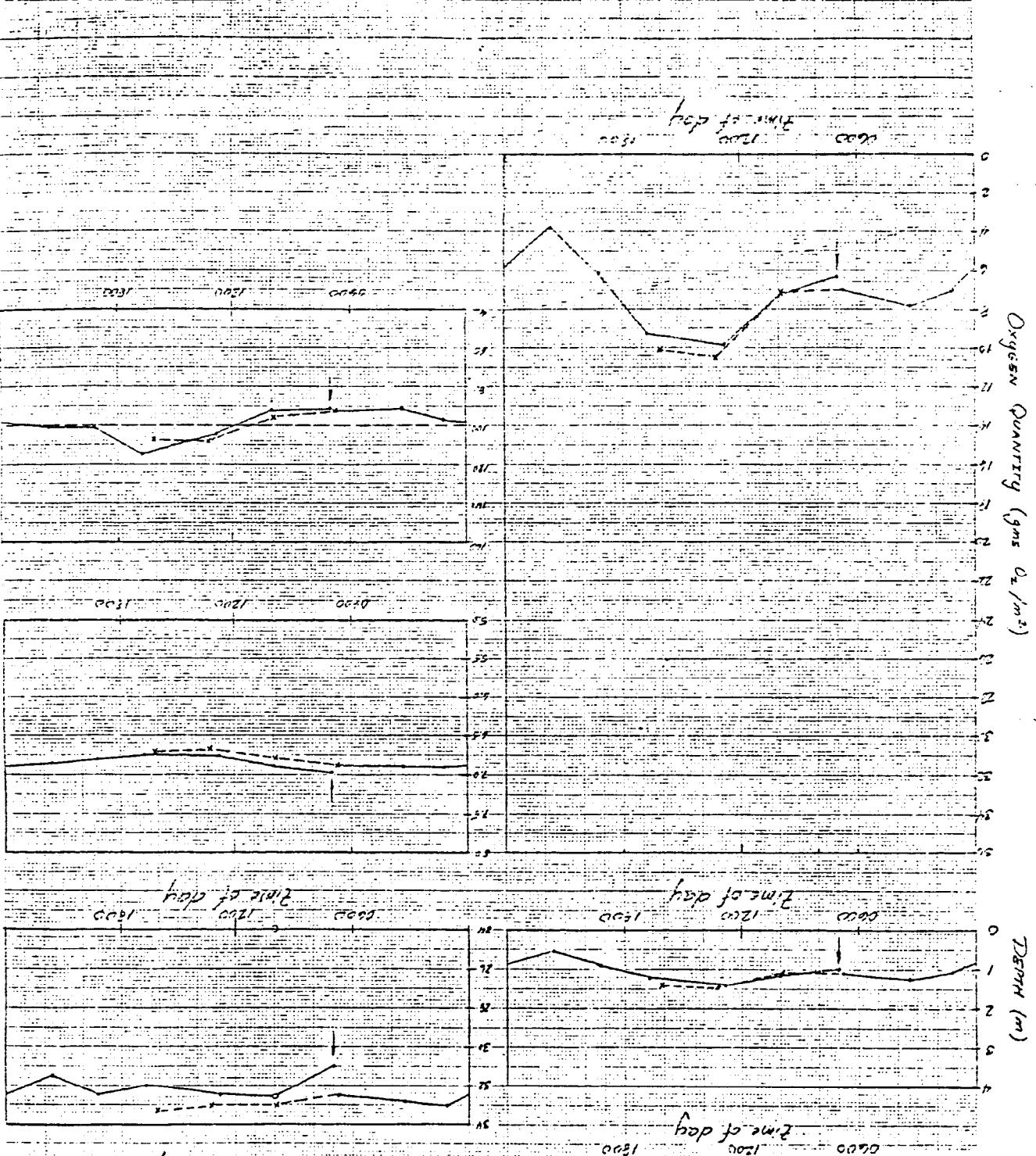
STATION 5

APRIL 21, 1977

Geotrac Analysis of Dredge Samples  
Naples Bay, FL



148



149

0000 0000 0000

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STATION 4  
APRIL 21, 1977

ANALYSIS OF DEDUCED DATA  
WATER SURFACES

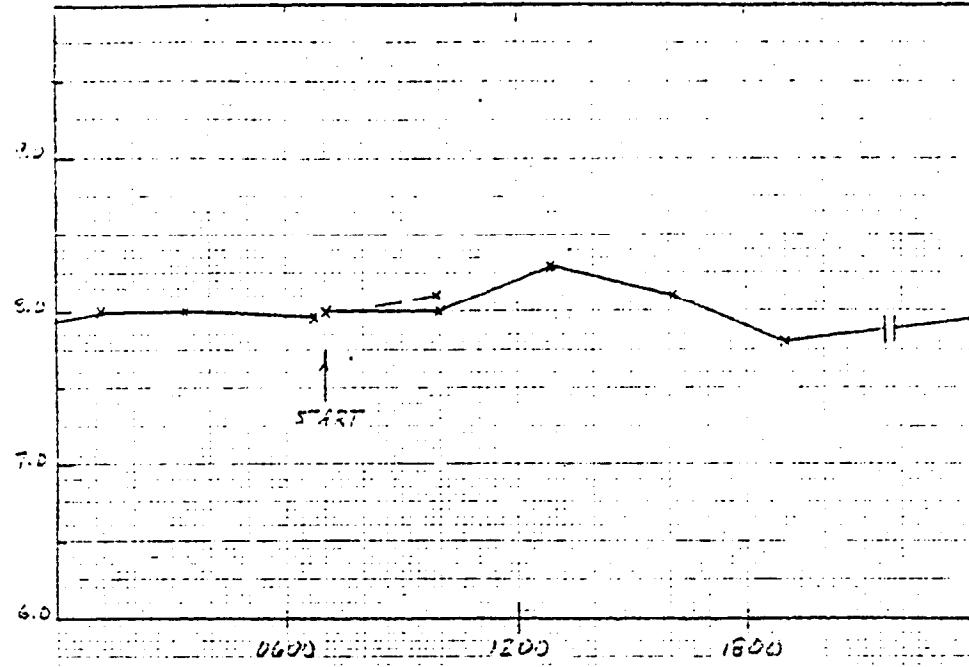
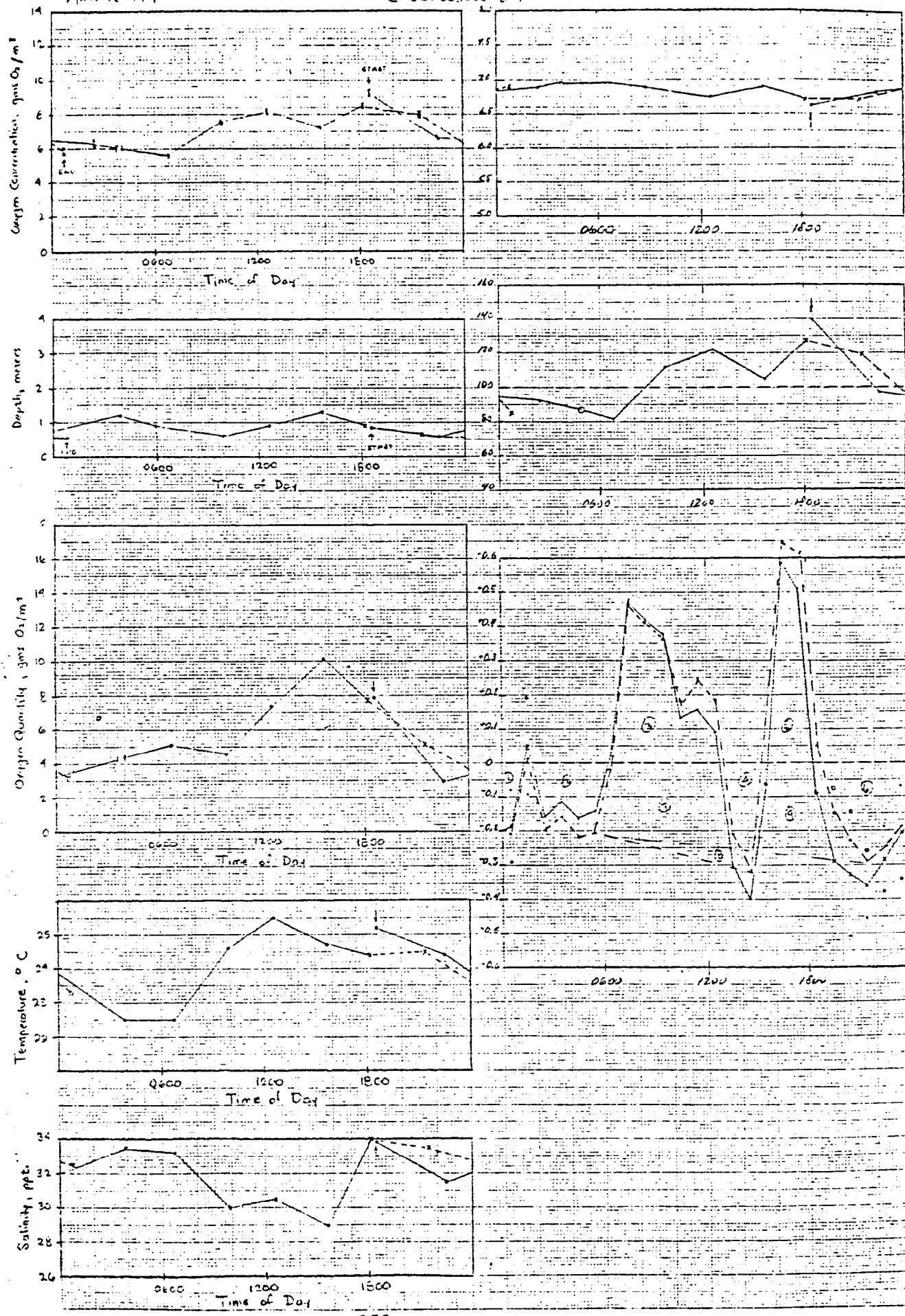
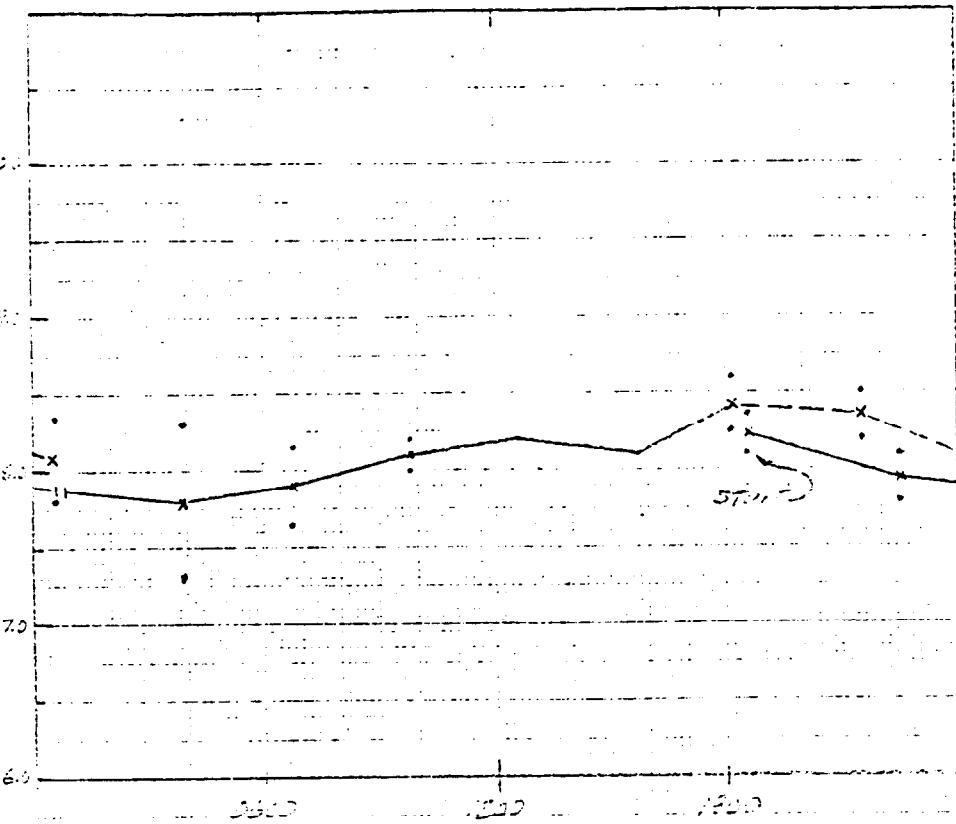


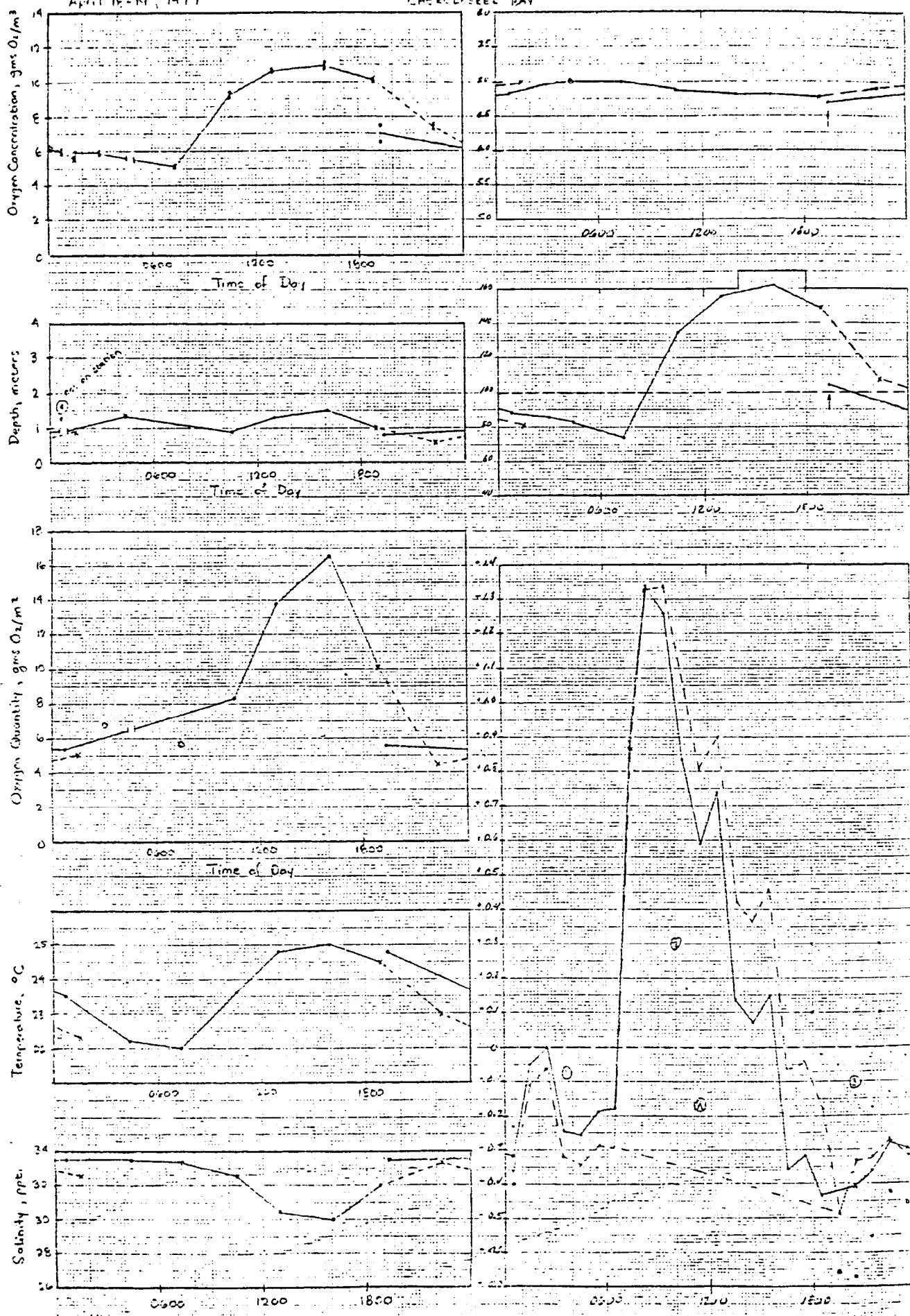
FIGURE B-3, CHOKOLOSKEE BAY DIURNAL DATA GRAPHS

STATION 1  
April 18-19, 1977GRAPHICAL ANALYSIS OF DIURNAL STUDIES  
CHEROKEE BAY61-11' LEHARAU  
J. F. WELCARS

STATION 1  
100 FT DEPT

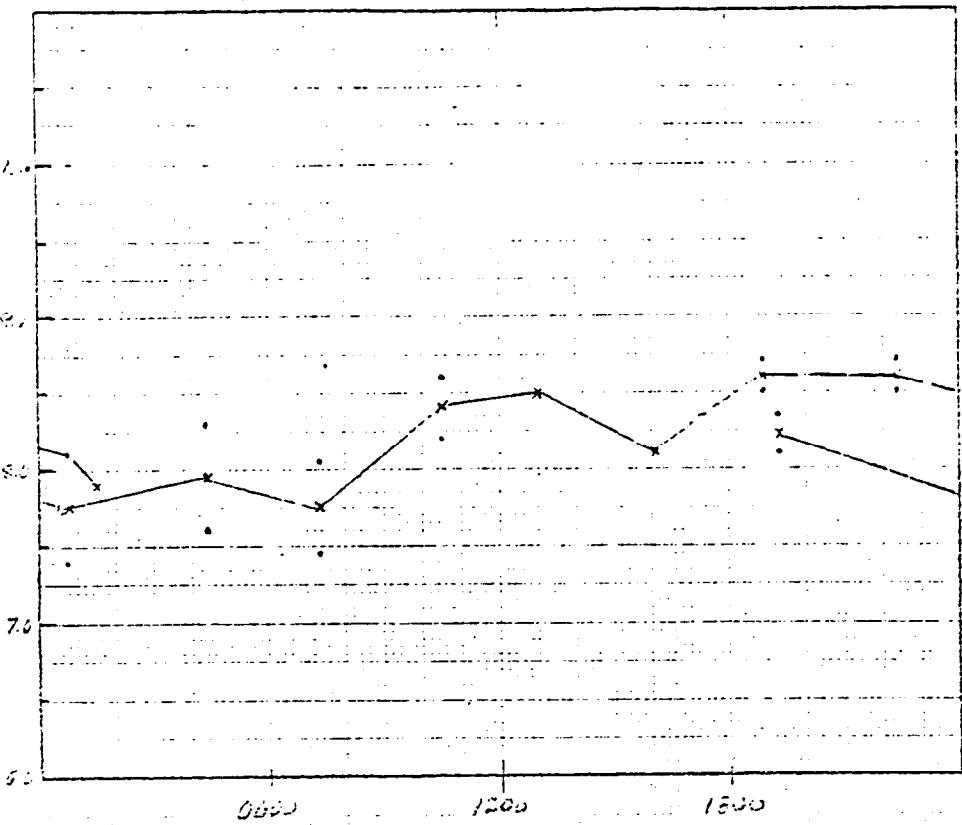
GRAPHIC LOG OF DRAWDOWN TEST

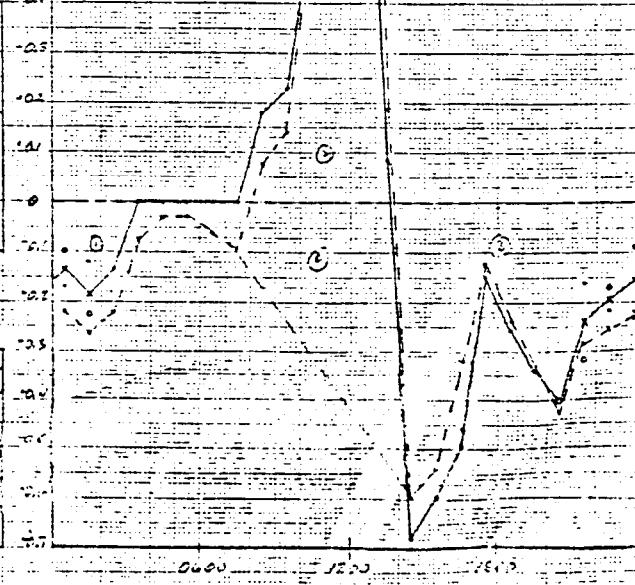
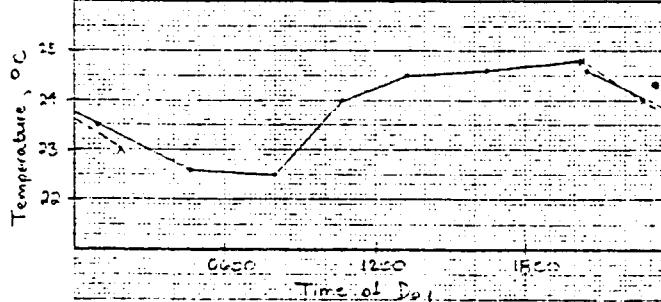
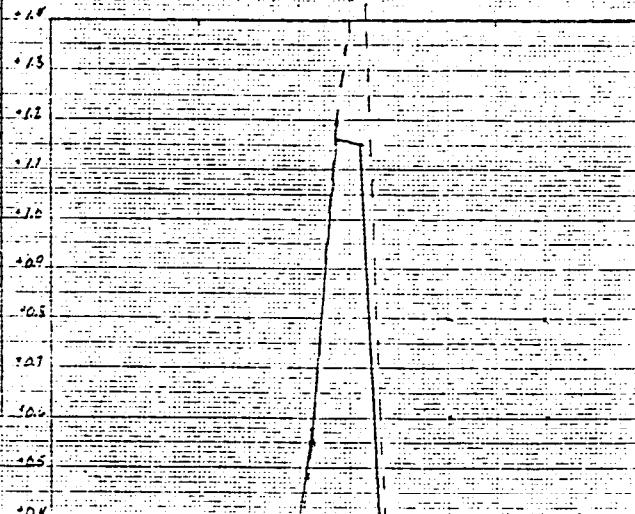
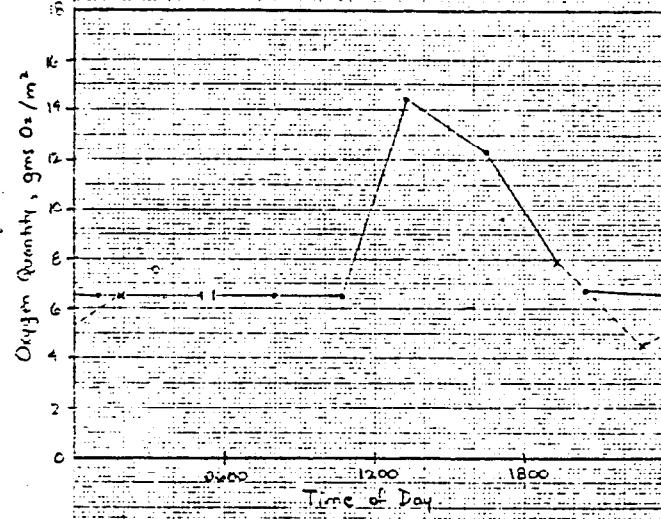
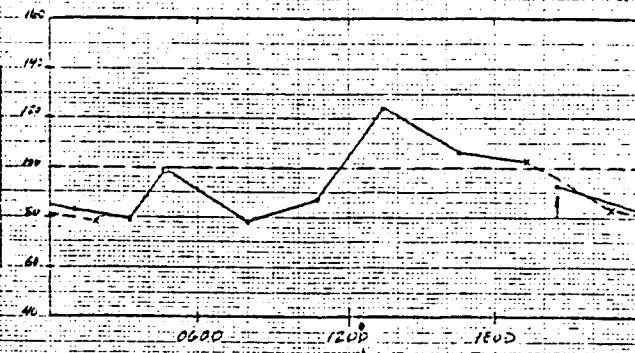
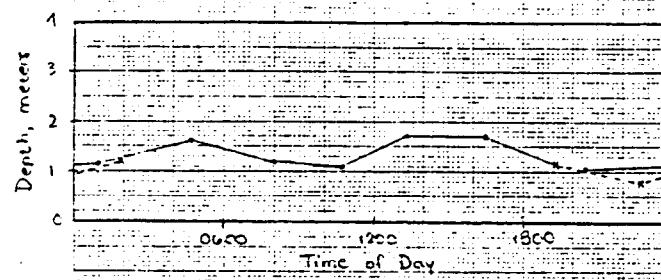
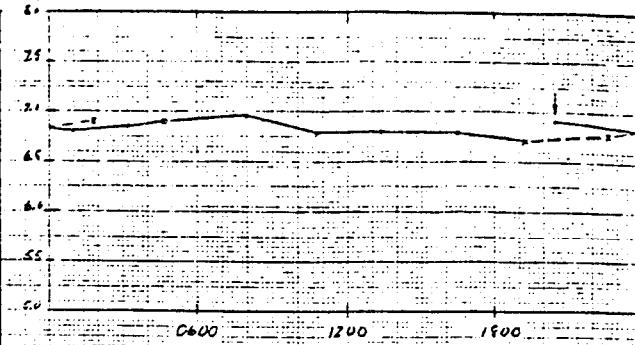
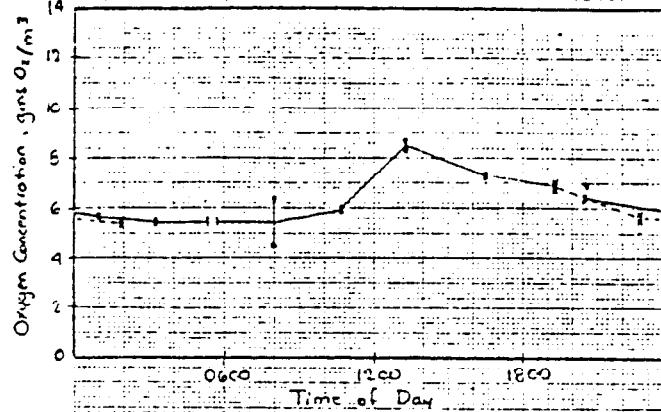


STATION 2  
April 18-19, 1977GRAPHICAL ANALYSIS OF DIURNAL STUDIES  
CHOKOLISKEE BAY

STATION 2  
Aug. 18, 1971

Estuaries Monitors at Barataria Estuary  
Chauvinate Bay, LA



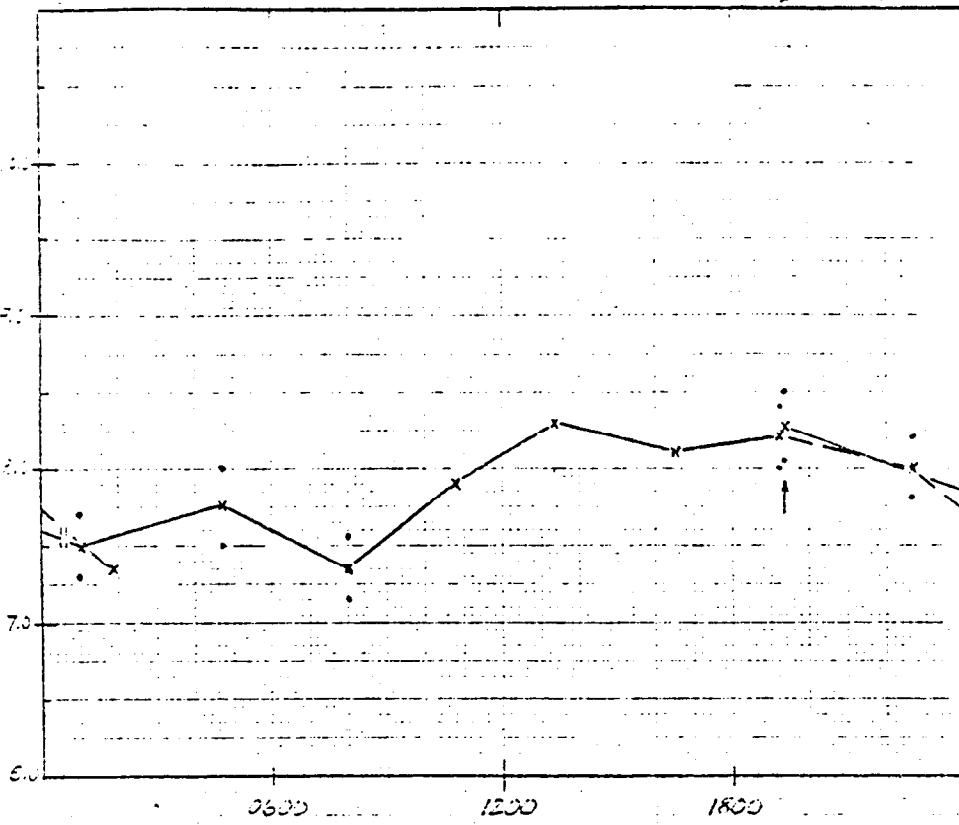
STATION 3  
April 18-19, 1977GRAPHICAL ANALYSIS OF DIURNAL STUDIES  
CHOCOLOSKEE BAY

STATION 3

DRYADALE, HUNTER MOUNTAIN, NEW YORK

NOV. 10, 1957

1957



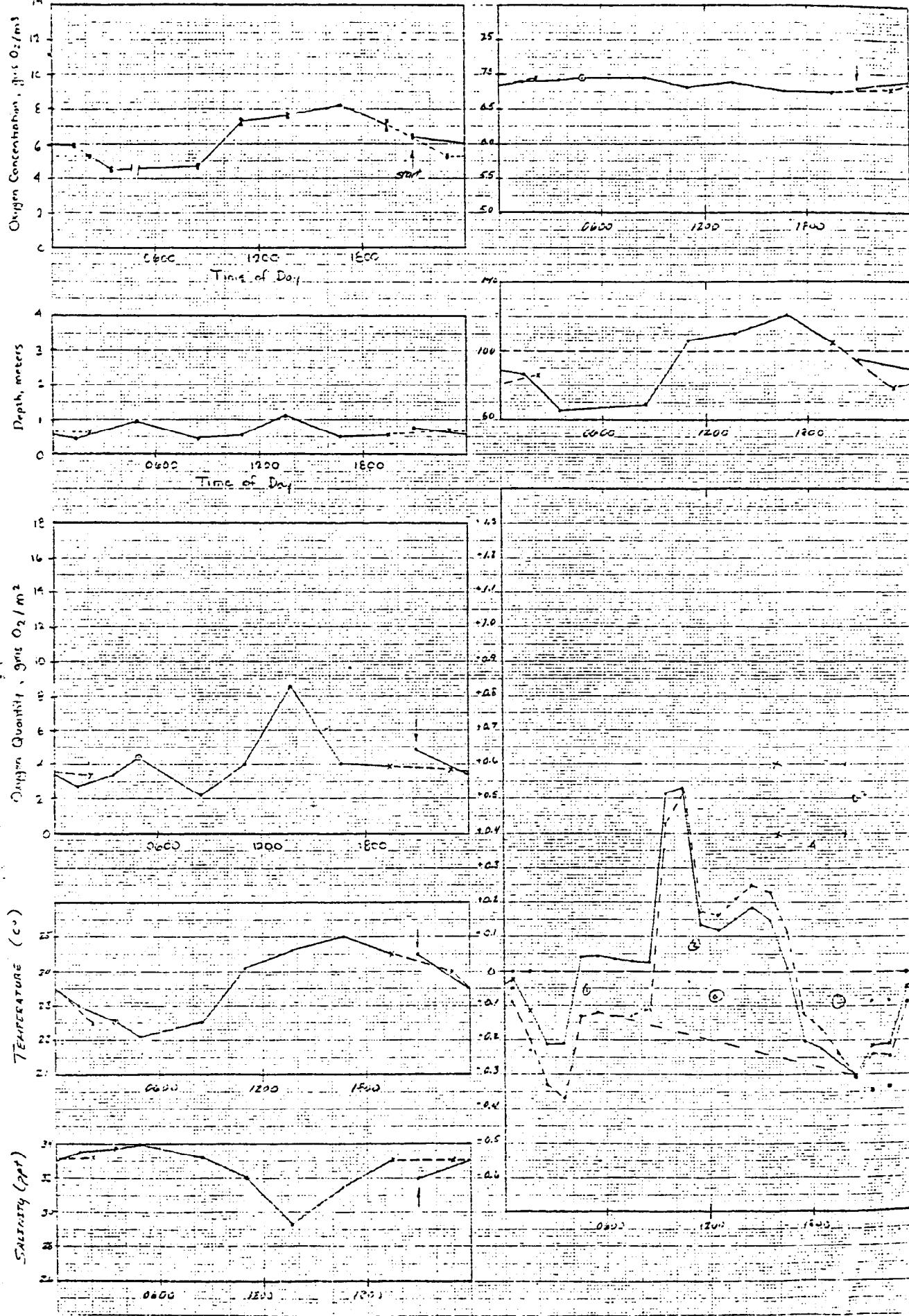
STATION 4  
APRIL 19/19, 1977

NO SCALE NO DENSITY UNKN. RIVER  
WATER

LUCILLE LUTZEN CO.  
DATE 4-19-77

GRAPHICAL ANALYSIS OF DIURNAL STUDIES  
CHORULOCHE Bay, FL.

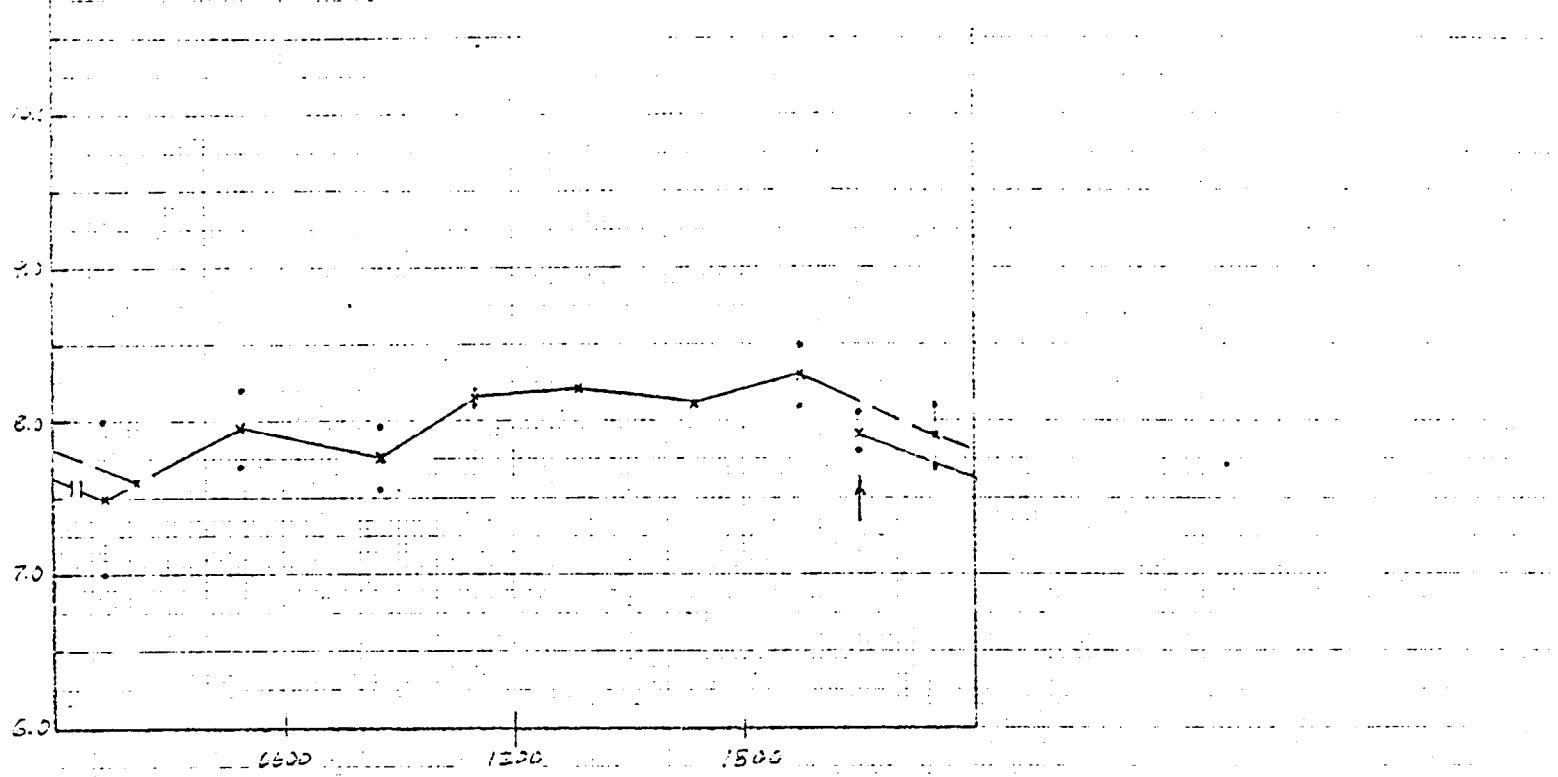
C. H. PRELLS  
H. LEMMEN



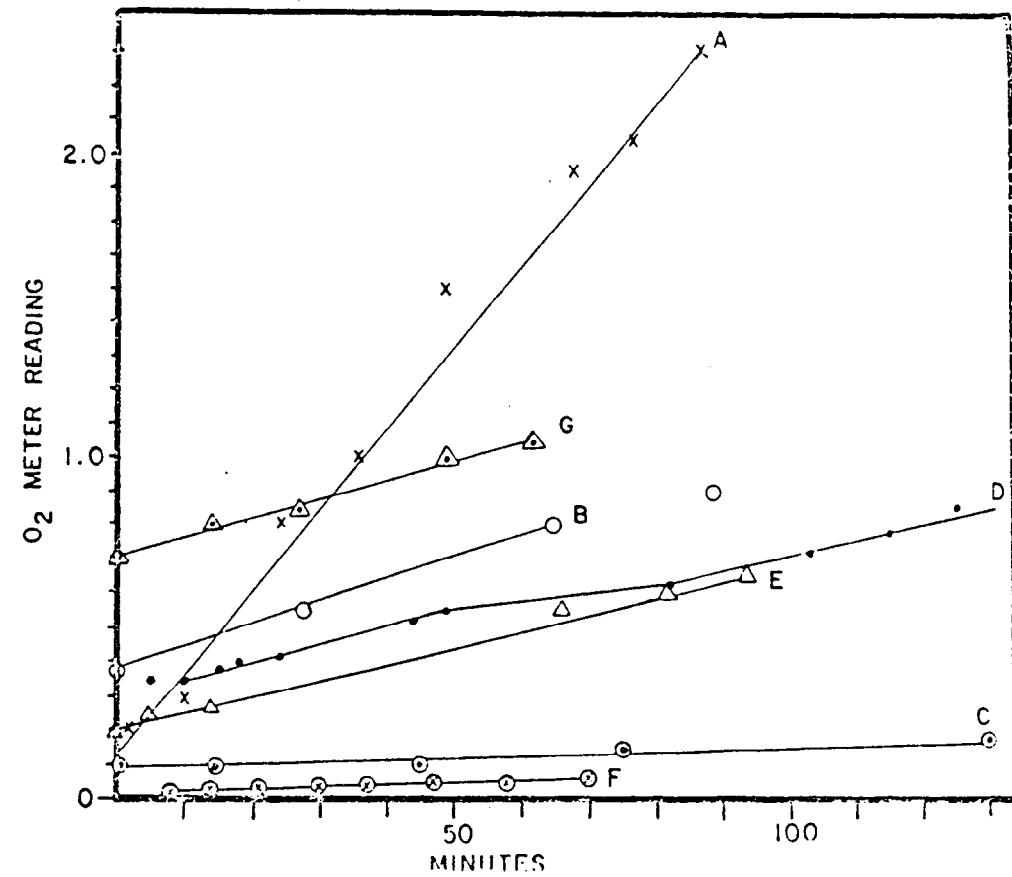
STATION 4

Feb 22 1962 1855

Georges Bank, N.E. Subarea  
Sandy Bay, N.E.



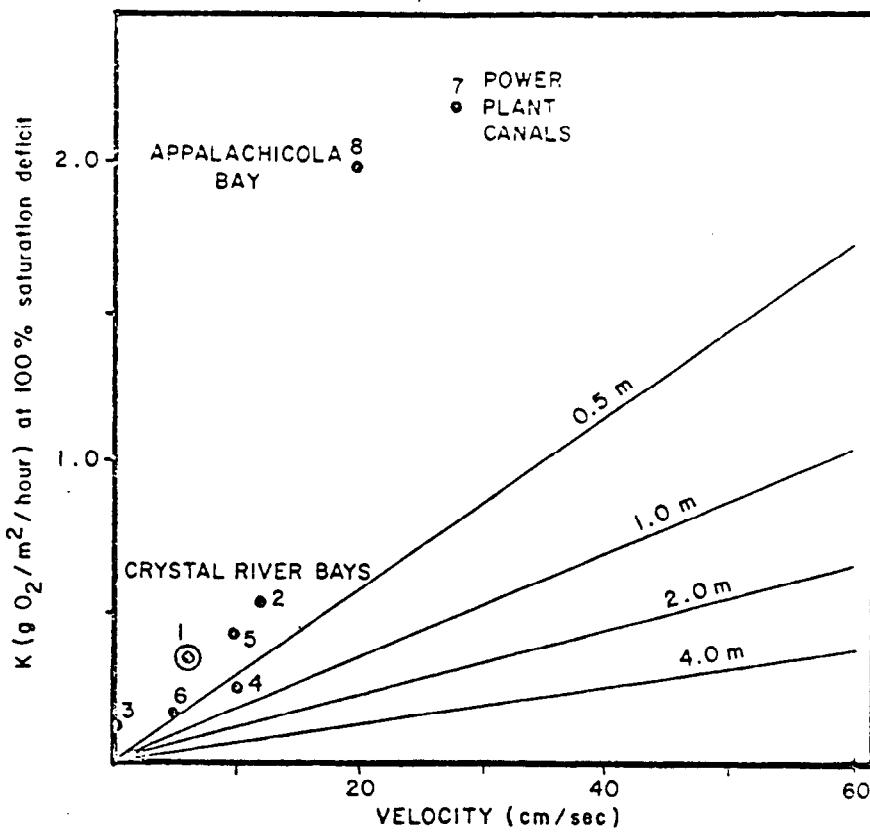
**APPENDIX C**  
**OXYGEN DIFFUSION AND OTHER PHYSICAL DATA**



Oxygen return to a nitrogen-filled plastic dome in experiments to determine oxygen diffusion coefficients ( $K$ , g O<sub>2</sub>/m<sup>2</sup>/hr at 100% saturation deficit).

Key	Area	Date	Tide	K
A	Outer Discharge Area ( $D_2$ )	13 Dec., 1972	Ebb	4.75
B	Outer Discharge Area ( $D_2$ )	13 Dec., 1972	Slack	0.98
C	Outer Discharge Area ( $D_2$ )	13 Dec., 1972	Flood	0.07
D	Outer Discharge Area ( $D_1$ )	10 July, 1973	Ebb	0.39
E	Outer Discharge Area ( $D_1$ )	10 July, 1973	Flood	0.31
F	Outer Discharge Area ( $D_1$ )	20 Oct., 1973	Early Flood	0.04
G	Outer Control Area ( $C_1$ )	11 July, 1973	Slack	0.38

Figure C-1. Oxygen Diffusion Coefficients as a Function of Tidal Stage, McKellar, 1975.



The relationships among current velocity, depth, and oxygen diffusion coefficients ( $K$ ) as predicted by the formula of Churchill, Elmore, and Buckingham (1962). Oxygen saturation used in the formula was calculated for a 25°C temperature and a 20‰ salinity. Data points are for observed relationships between  $K$  and currents measured in areas near the Crystal River Power Plant and in Appalachicola Bay.

- (1) Outer Bays at Crystal River (depth = 2m) with average current measured by Carder *et al.*, 1973.
- (2-6) Inner Bay at Crystal River (depth = 0.5 - 1.5) Smith, 1975.
- (7) Intake Canal at Crystal River (depth = 7m) Kemp, 1975.
- (8) Appalachicola Bay (depth = 2m) Boynton, 1975.

Figure C-2. Relationship of Oxygen Diffusion Coefficients to Current Velocity and Depth, McKellar, 1975.

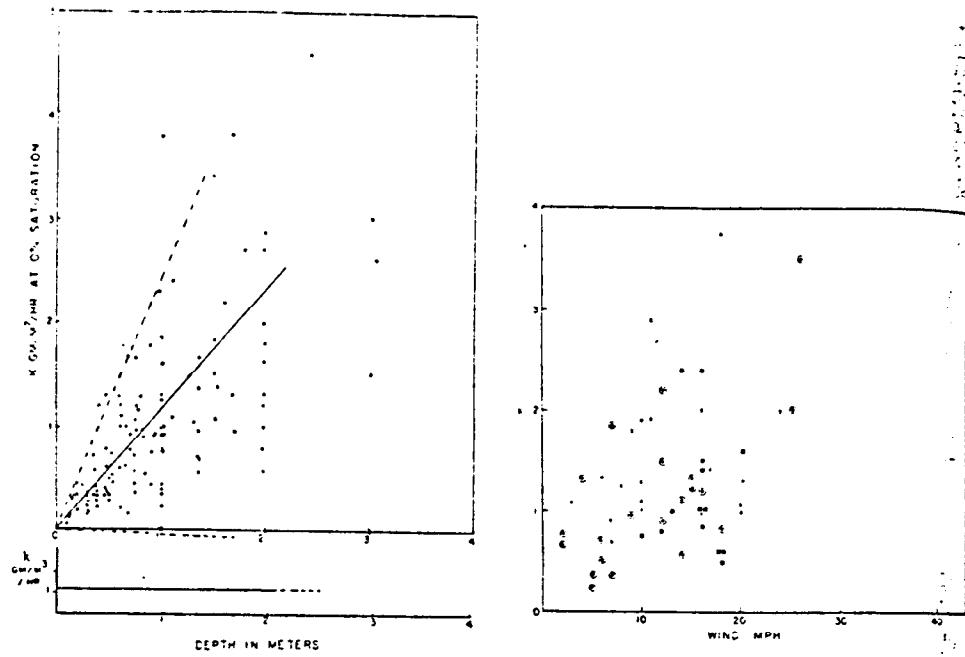


FIG. 3. Reaeration constants on an area basis ( $K$  in  $\text{gm}/\text{m}^2/\text{hr}/100\%$  deficit) as a function of the bottom depth (in meters). A linear regression line is plotted as computed from the data points. Dashed lines form boundaries for 95% confidence. Also plotted is the same regression line expressed as a volume basis ( $k = K/z$  in units  $\text{mg}/\text{l}/\text{hr}/100\%$  deficit). Each point in this figure was computed from a diurnal curve using changing rates of change at night following the procedure of Odum and Hoskin (1958).

(a)

(b)

FIG. 4. Reaeration constants on a volume basis ( $k$  in units  $\text{mg}/\text{l}/\text{hr}/100\%$  deficit) plotted as a function of average wind velocity during nighttime hours.

Figure C-3. Reaeration Constants as a Function of (a) Bottom depth, and (b) Average Wind Velocity. Odum and Wilson, 1962.

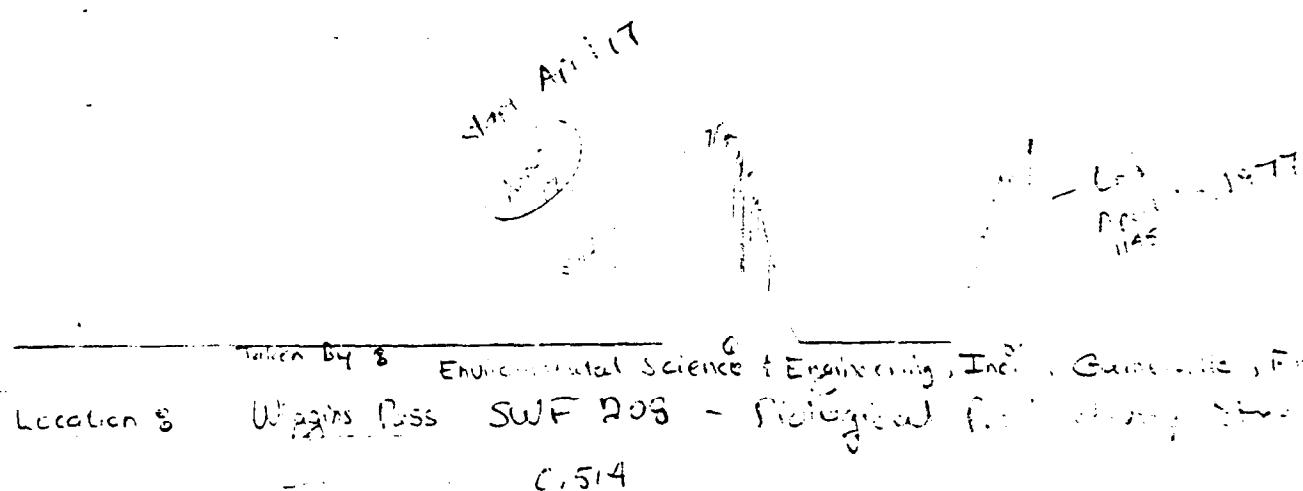
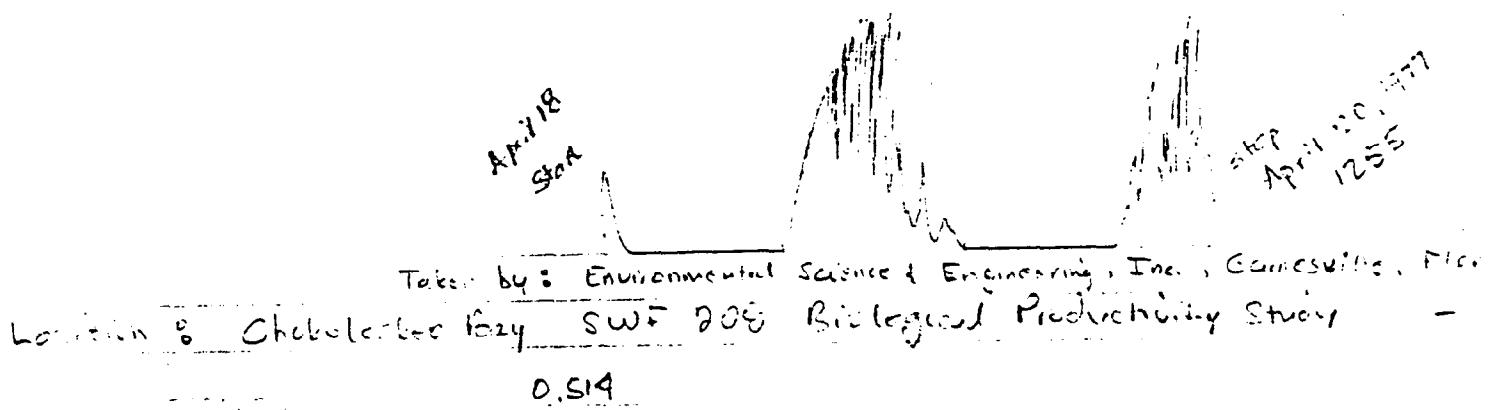
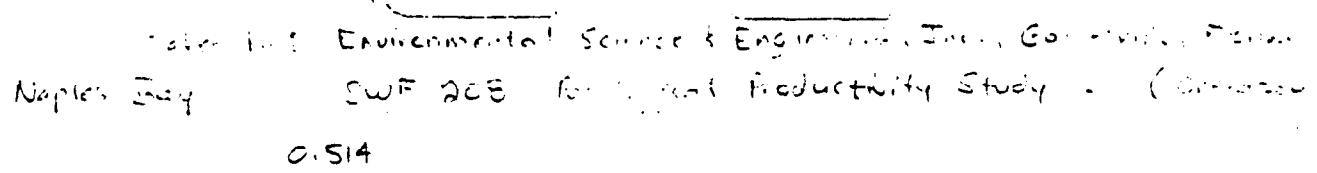


Figure C-4. Solar Insolation for Big Cypress Basin Area, April 17-22, 1977.

**APPENDIX D**  
**PLANKTON METABOLISM DATA**

Table D-1. Plankton Metabolism as Determined from Oxygen Changes in Light and Dark Bottles, Big Cypress Basin,  
April 1977

Date	Location	Average Diurnal Water Temperature, °C	Average Diurnal Salinity, 0/00	Average Diurnal Depth, Meters	Location in Water Column	Metabolism (g O <sub>2</sub> /m <sup>2</sup> /day)*		
						P <sub>net</sub> 24	R <sub>24</sub>	P <sub>gross</sub> 24 (P <sub>net</sub> 24 + R <sub>24</sub> )
<b>April 17 &amp; 18 Wiggins Pass Area</b>								
Station 2	22.8	33.8	2.3	Surface †	0.83	0.06	0.89	
				1.0 meter †	1.20	0.06	1.26	
				‡ (surface to 1.0 meter)	1.02	0.06	1.08	
				‡ (1.0 meter to bottom)	1.62	0.08	1.70	
				Summation for water column	2.64	0.14	2.78	
<b>April 18 &amp; 19 Chokoloskee Bay</b>								
Station 2	23.5	32.6	1.0	Surface †	1.27	1.06	2.33	
				0.75 meter †	1.06	0.93	1.99	
				‡ (surface to 0.75 meter)	0.87	0.75	1.62	
				‡ (0.75 meter to bottom)	0.36	0.32	0.68	
				Summation for water column	1.23	1.06	2.30	

Table D-1. Plankton Metabolism as Determined from Oxygen Changes in Light and Dark Bottles, Big Cypress Basin,  
April 1977 (Continued, page 2 of 2)

Date	Location	Average Diurnal Water Temperature, °C	Average Diurnal Salinity, 0/00	Average Depth, Meters	Location in Water Column	Pnet 24	R24	P gross 24 (Pnet 24 + R24)	Metabolism (g O <sub>2</sub> /m <sup>2</sup> /day)*
April 21 & 22	Naples Bay Station 2	24.6	31.0	1.5	Surface †	6.09	0.52	6.61	
				1.0 meter †	1.54	0.41	1.95		
				̄ (surface to 1.0 meter)	3.82	0.46	4.28		
				̄ (1.0 meter to bottom)	0.71	0.19	0.90		
				Summation for water column	4.52	0.65	5.18		
April 21 & 22	Naples Bay Station 1-S	24.9	28.3	2.0	Surface †	7.46	4.87	12.33	
				1.5 meters †	0.19	2.30	2.49		
				̄ (surface to 1.5 meters)	5.74	5.38	11.12		
				̄ (1.5 meters to bottom)	0.09	1.13	1.22		
				Summation for water column	5.83	6.51	12.34		

\* Means and sums of data in g O<sub>2</sub>/m<sup>2</sup>/day.

† Surface and 0.75, 1.0, or 1.5 meter values in g O<sub>2</sub>/m<sup>3</sup>/day.

**APPENDIX E**  
**PHYTOPLANKTON COMPOSITION**

Table E-1. Relative Abundance of Phytoplankton Divisions Encountered in Samples Taken at Wiggins Pass, April 17, 1977

Division	Station				
	1	2	3	4	Avg.
Bacillariophyceae	97.5	52.4	79.3	75.8	76.3
Dinophyceae		0.6	0.5		0.3
Chlorophyceae				1.4	0.4
Cryptomonadaceae	0.7	27.4	12.2	15.6	14.0
Xanthophyceae				0.5	0.1
Coccolithophoridae		0.6			0.2
Euglenophyceae	0.1	1.8			0.5
Microflagellates,	1.8	17.3	8.1	6.6	8.5

All values rounded to nearest 0.1 percent.

Blank indicates that members of taxa were not encountered.

Table E-2. Relative Abundance of Phytoplankton Divisions Encountered in Samples Taken in Chokoloskee Bay, April 19, 1977

Division	Station				
	1	2	3	4	Avg.
Bacillariophyceae	42.5	99.6	50.0	86.3	69.6
Dinophyceae	0.9	0.3	0.3	1.3	0.7
Chlorophyceae				0.4	0.1
Cryptomonadaceae	26.4		12.3	2.7	10.4
Euglenophyceae		0.1	0.7		0.2
Microflagellates	30.2		36.8	9.2	19.1

All values rounded to nearest 0.1 percent.

Blank indicates that members of taxa were not encountered.

Table E-3. Relative Abundance of Phytoplankton Divisions Encountered in Samples Taken in Naples Bay, April 22, 1977

Division	Station					
	1	2	3	4	5	Avg.
Bacillariophyceae	99.9	99.9	97.8	98.9	99.9	99.3
Dinophyceae	0	0	0.3		0	0.1
Chlorophyceae	0	0	0.1	0.1		0
Cryptomonadaceae		0	0.5	0.9	0	0.3
Xanthophyceae			0.4	0.1	0	0.1
Cyanophyceae			0.9			0.2
Euglenophyceae	0	0.1	0	0.1		0

All values rounded to nearest 0.1 percent.

0 indicates presence but with relative abundance of less than 0.1 percent.

Blank indicates that members of taxa were not encountered.

Table E-4. Wiggins Pass Area Phytoplankton Concentrations, April 17, 1977

Species	Station/Concentration (avg #/ml)			
	1	2	3	4
<b>Bacillariophyceae</b>				
<u>Amphiprora alata</u>			1	
<u>Biddulphia aurita</u>	1			
<u>Chaetoceros danicus</u>			2	
<u>Cosinodiscus lineatus</u>	1			
<u>Cylindrotheca closterium</u>	8	14	17	23
<u>Gyrosigma spp.</u>		1		
<u>Leptocylindrus minimus</u>		1		4
<u>Melosira sulcata</u>			3	
<u>Nitzschia delicatula</u>	7			5
<u>Rhizosolenia setigera</u>			2	2
<u>Skeletonema costatum</u>	4495	46	140	87
<u>Thalassionema nitzschioides</u>	110	20	14	36
<u>Thalassiosira pseudonana</u>	3		3	3
<b>Dinophyceae</b>				
<u>Peridinium spp.</u>		1	1	
<b>Chlorophyceae</b>				
<u>Pyramimonas sp.</u>				3
<b>Cryptomonadaceae</b>				
<u>Rhodomonas amphioxiaeia</u>	4	9	9	21
<u>Rhodomonas minuta</u>	27	37	18	12
<b>Xanthophyceae</b>				
<u>Olisthodiscus sp.</u>				1
<b>Coccolithophoridae</b>				
<u>Acanthoica aculeata</u>			1	
<b>Euglenophyceae</b>				
<u>Eutreptia sp.</u>	3	3		
Microflagellates, unidentified	83	29	18	14

Table E-5. Chokoloskee Bay Phytoplankton Concentrations, April 19,  
1977

Species	Station/Concentration (avg #/ml)			
	1	2	3	4
<b>Bacillariophyceae</b>				
<u>Amphiprora alata</u>	1			
<u>Ceratulina bergenii</u>		36		5
<u>Chaetoceros affinis</u>			3	
<u>Chaetoceros wighamii</u>	3	3238	13	362
<u>Cylindrotheca closterium</u>	4		5	8
<u>Guinardia flaccida</u>		16	1	
<u>Leptocylindrus minimus</u>		17		
<u>Licmophora</u> sp.	2			
<u>Mastogloia</u> sp.		2		
<u>Melosira moniliformis</u>				2
<u>Melosira sulcata</u>	6		8	6
<u>Nitzschia delicatula</u>			2	
<u>Rhizosolenia imbricata</u>				
var. <u>shrubholei</u>	4			
<u>Rhizosolenia setigera</u>	7	11		5
<u>Skeletonema costatum</u>	8	187	103	17
<u>Striatella unipunctata</u>	3			3
<u>Thalassiosira nitzschiodes</u>	2		16	
<u>Thalassiosira pseudonana</u>	5			3
<b>Dinophyceae</b>				
<u>Peridinium trochoideum</u>		10		
<u>Peridinium</u> spp.	1		1	6
<b>Chlorophyceae</b>				
<u>Pyramimonas</u> sp.				2
<b>Cryptomonadaceae</b>				
<u>Rhodomonas amphioxiaeia</u>			10	1
<u>Rhodomonas minuta</u>	28		27	12
<b>Euglenophyceae</b>				
<u>Eutreptia</u> sp.		5	2	
<b>Microflagellida, unidentified</b>	32		111	44

Table E-6. Naples Bay Phytoplankton Concentrations, April 22, 1977

Species	Station/Concentration (avg #/ml)				
	1	2	3	4	S
<b>Bacillariophyceae</b>					
<u>Ceratulina bergonii</u>			1		1
<u>Chaetoceros affinis</u>				3	
<u>Chaetoceros danicus</u>		4	4	2	
<u>Chaetoceros wighamii</u>				4	
<u>Cylindrotheca closterium</u>	45	6	14	26	12
<u>Leptocylindrus danicus</u>				6	
<u>Leptocylindrus minimus</u>	265	72	18	19	29
<u>Nitzschia delicatula</u>	5	14		15	
<u>Rhizosolenia delicatula</u>		3	5		
<u>Rhizosolenia setigera</u>	21	2		10	
<u>Skeletonema costatum</u>	30,361	11,189	2,514	1,114	27,470
<u>Skeletonema tropicum</u>	2,789	223	100	64	46
<u>Striatella unipunctata</u>		3			
<u>Thalassionema nitzschioides</u>	16	22	21	32	52
<u>Thalassiosira pseudonana</u>	297	187	77	56	1,453
<b>Dinophyceae</b>					
<u>Katodinium rotundatum</u>					6
<u>Peridinium trochoideum</u>			1	1	
<u>Peridinium spp.</u>	16			7	
<b>Chlorophyceae</b>					
<u>Pyramimonas sp.</u>	16	5	2	1	
<b>Cryptomonadaceae</b>					
<u>Rhodomonas amphioxenia</u>			1		6
<u>Rhodomonas minuta</u>		1	14	12	
<b>Xanthophyceae</b>					
<u>Olisthodiscus sp.</u>			12	1	6
<b>Cyanophyceae</b>					
<u>Oscillatoria sp.</u>			26		
<b>Euglenophyceae</b>					
<u>Eutreptia sp.</u>	5	6	1	1	

APPENDIX F  
ZOOPLANKTON COLLECTION AND ANALYSIS DATA  
FOR WIGGINS PASS, CHOKOLOSKEE BAY, AND  
NAPLES BAY, APRIL, 1977

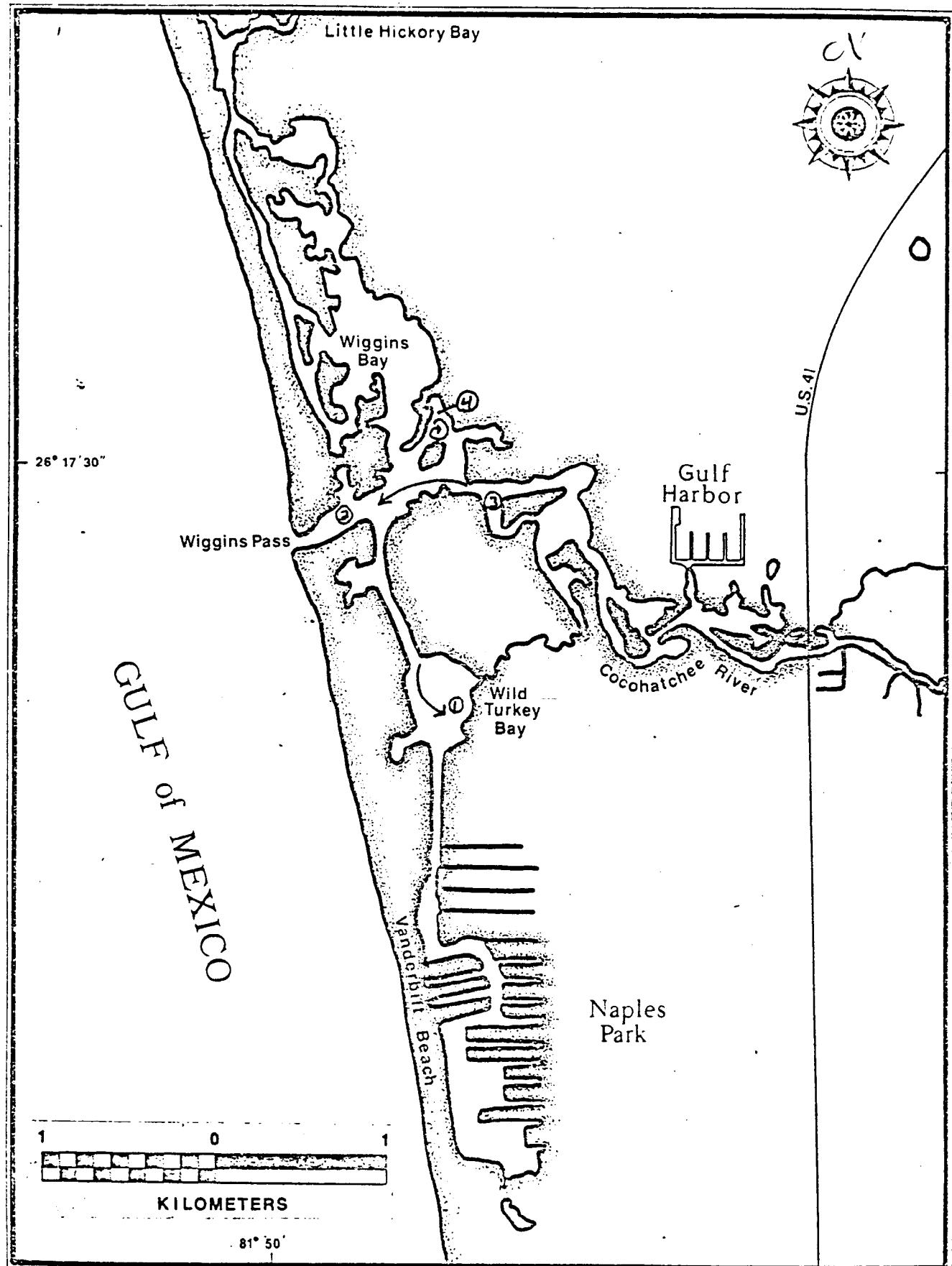


Figure F-1. Vicinity and Direction of Zooplankton Tows Made at Wiggins Pass, April 1977.

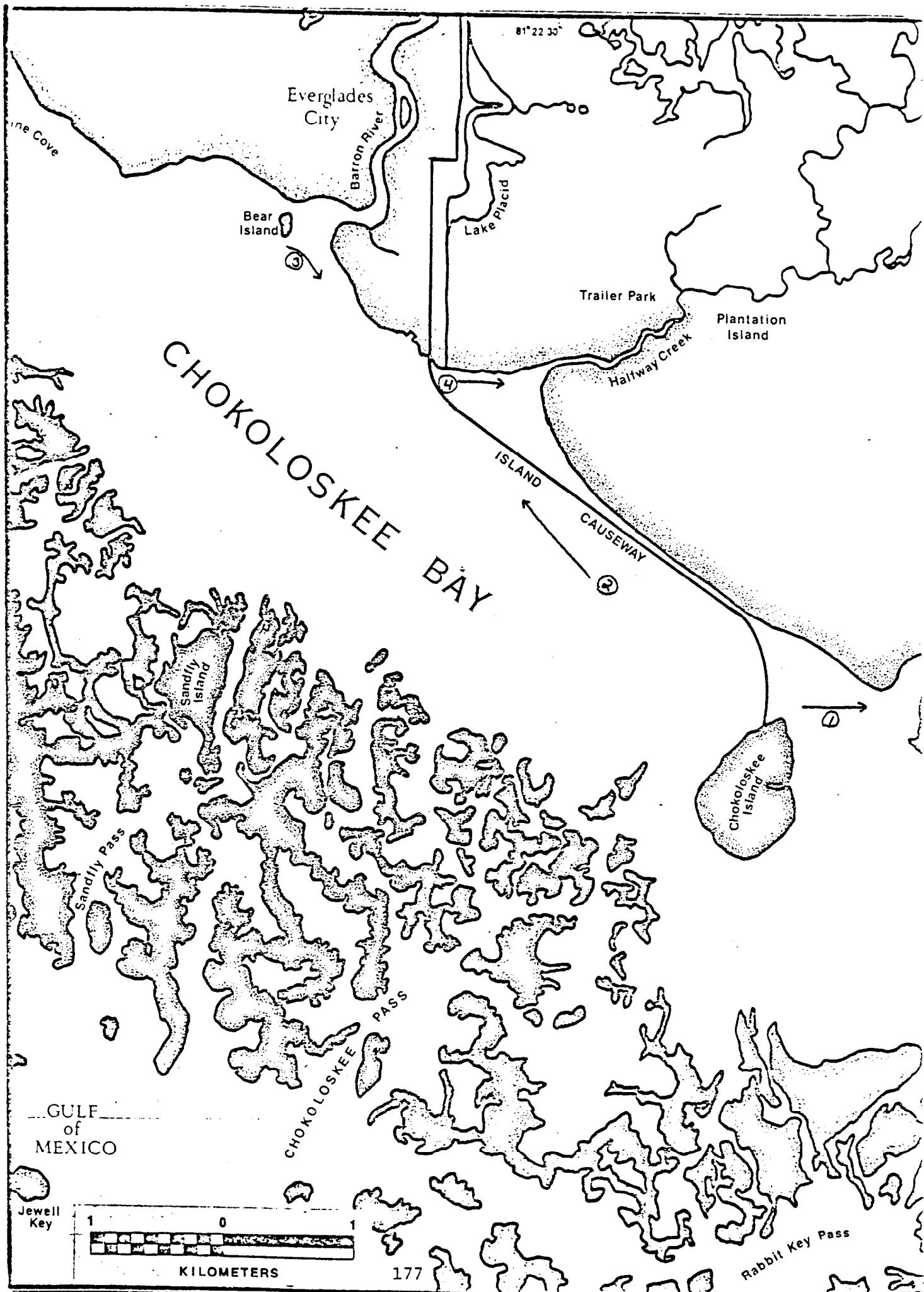


Figure F-2. Vicinity and Direction of Zooplankton Tows Made at Chokoloskee Bay April 1977

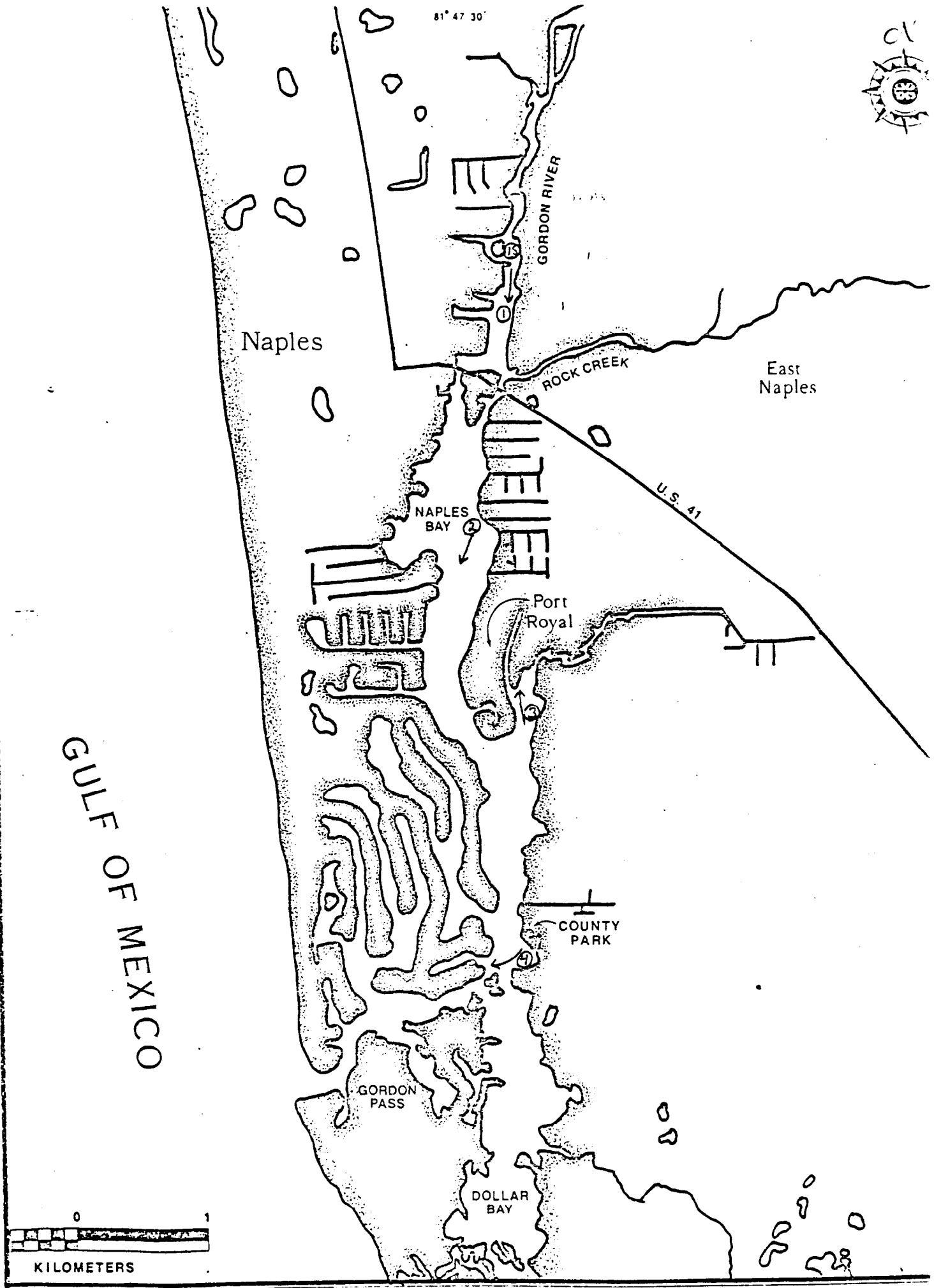


Figure F-3. Vicinity and Direction of Zooplankton Tows Made at Naples Bay, April, 1977.

Table F-1. Zooplankton Taxa Observed in Samples Collected at Wiggins Pass. April 17, 1977

	Concentration (individuals/m <sup>3</sup> )		
	Station 1-3	2	4
PROTISTA			
Ciliophora			
Tintinnoidea			
miscellaneous unidentified			
COELENTERATA-CNIDARIA			
Hydrozoa			
<u>Obelia</u> sp.	14		
miscellaneous Medusae			
ASCHELMINTHES			
Rotifera			
<u>Synchaeta</u> sp.			
<u>Trichocecea marina</u>			
miscellaneous unidentified			
ANNEDLIDA			
Polychaeta			
miscellaneous unidentified			
ARTHROPODA			
Crustacea			
Copepoda			
Calanoida			
<u>Acartia tonsa</u>	3656	5633	6454
<u>Labidocera aestiva</u>			
<u>Paracalanus</u> spp.	954	1238	1318
<u>Phyllopus</u> sp.	14		
<u>Pseudodiaptomus coronatus</u>			
<u>Temora turbinata</u>			
<u>Tortanus setacaudatus</u>			
Caligoida			
miscellaneous unidentified			
Cyclopoida			
<u>Corycaeus</u> spp.			
<u>Oithona</u> spp.	477	48	99
<u>Oncaea</u> sp.			
miscellaneous unidentified		16	
Notodelphoid			
miscellaneous unidentified	68		

Table F-1. Zooplankton Taxa Observed in Samples Collected at Wiggins Pass, April 17, 1977 (Continued, Page 2 of 3)

	Concentration (individuals/m <sup>3</sup> )		
	Station 1-3	2	4
Harpacticoid			
<u>Clytemnestra nostrata</u>			
<u>Euterpina acutifrons</u>	508	2808	581
miscellaneous unidentified	41	20	19
Lernaeopodoida			
Monstrilloida		3	
Copepod nauplii	1159	1728	387
Cladocera			
<u>Evadne tergestina</u>			
<u>Penilia avirostris</u>			
<u>Podon polyphemoides</u>	27	192	58
miscellaneous unidentified		26	
Ostracoda			
Mysidacea			
Amphipoda			
Isopoda	27		
Decopoda			
Other Crustacea		3	
Arachnida			
Hydracarina			
CHAETOGNATHA			
<u>Sagitta</u> sp.	14	13	4
MOLLUSCA			
CHORDATA			
Urochordata			
Appendicularia			
<u>Oikopleura</u> sp.	54	71	19
Cephalochordata			
<u>Amphioxus</u> sp.		16	
LARVAL FORMS			
Polychaete	68	162	58
Cirriped nauplii	109	344	58
Cirriped cyprids		33	
Decapod zoea	109	120	
Decapod megalops			4
Decapod mysids	14	18	19
Gastropod	136	178	58
Pelecypod	1200	2687	291

Table F-1. Zooplankton Taxa Observed in Samples Collected at Wiggins Pass, April 17, 1977 (Continued, Page 3 of 3)

	Concentration (individuals/m <sup>3</sup> )		
	1-3	2	4
Echinoderm			
Cephalochordata			
Vertebrata fish eggs		13	4
Vertebrata fish larvae			
Miscellaneous Unidentified	14	51	
TOTAL	8690	15368	9871

Table F-2. Zooplankton Taxa Observed in Samples Collected at Chokoloskee Bay. April 19, 1977.

	Concentration (individuals/m <sup>3</sup> )			
	Station 1	2	3	4
PROTISTA				
Ciliophora				
Tintinnoidea				
miscellaneous unidentified				
COELENTERATA-CNIDARIA				
Hydrozoa				
<u>Obelia</u> sp.				
miscellaneous Medusae				
ASCHELMINTHES				
Rotifera				
<u>Synchaeta</u> sp.				
<u>Trichocecea marina</u>				
miscellaneous unidentified				
ANNEDLIDA				
Polychaeta				
miscellaneous unidentified				2
ARTHROPODA				
Crustacea				
Copepoda				
Calanoida				
<u>Acartia tonsa</u>	100	507	809	147
<u>Labidocera aestiva</u>		6		2
<u>Paracalanus</u> spp.	28	36	237	108
<u>Phyllopus</u> sp.				5
<u>Pseudodiaptomus coronatus</u>				
<u>Temora turbinata</u>				3
<u>Tortanus setacaudatus</u>				
Caligoida				
miscellaneous unidentified				
Cyclopoida				
<u>Corycaeus</u> spp.			26	
<u>Oithona</u> spp.	61		243	56
<u>Oncaea</u> sp.			6	
miscellaneous unidentified				
Notodelphoid				
miscellaneous unidentified	6		35	33

Table F-2. Zooplankton Taxa Observed in Samples Collected at Chokoloskee Bay, April 19, 1977 (Continued, Page 2 of 3)

	Concentration (individuals/m <sup>3</sup> )			
	1	2	3	4
Harpacticoid				
<u>Clytemnestra nostrata</u>				
<u>Euterpina acutifrons</u>	398		153	49
miscellaneous unidentified	50	79	18	7
Lernaeopodoida				2
Monstrilloida				
Copepod nauplii	166	30	442	96
Cladocera				
<u>Evadne tergestina</u>				
<u>Penilia avirostris</u>				
<u>Podon polyphemoides</u>				
miscellaneous unidentified				
Ostracoda			3	
Mysidacea				
Amphipoda		36		2
Isopoda			3	
Decopoda				
Other Crustacea				
Arachnida				
Hydracarina				2
CHAETOGNATHA				
<u>Sagitta</u> sp.			3	7
MOLLUSCA				
CHORDATA				
Urochordata				
Appendicularia				
<u>Oikopleura</u> sp.			9	
Cephalochordata				
<u>Amphioxus</u> sp.				
LARVAL FORMS				
Polychaete	6	6	21	5
Cirriped nauplii	841	127	97	91
Cirriped cyprids				5
Decapod zoea	6	54	35	2
Decapod megalops				
Decapod mysids				
Gastropod		79	78	37
Pelecypod	17	24	56	16

Table F-2. Zooplankton Taxa Observed in Samples Collected at  
Chokoloskee Bay, April 19, 1977 (Continued. Page 3 of 3)

	Concentration (individuals/m <sup>3</sup> )			
	Station 1	2	3	4
Echinoderm				
Cephalochordata				
Vertebrata fish eggs			3	2
Vertebrata fish larvae				
Miscellaneous Unidentified			3	
TOTAL	1679	984	2278	676

Table F-3. Zooplankton Taxa Observed in Samples Collected at Naples Bay, April 22, 1977

	Concentration (individuals/m <sup>3</sup> )			
	Station IS-1*	2	3	4
<b>PROTISTA</b>				
Ciliophora				
Tintinnoidea				
miscellaneous unidentified				
<b>COELENTERATA-CNIDARIA</b>				
Hydrozoa				
<u>Obelia</u> sp.				
miscellaneous Medusae	0.4	1	7	
<b>ASCHELMINTHES</b>				
Rotifera				
<u>Synchaeta</u> sp.				
<u>Trichocecea marina</u>				
miscellaneous unidentified				
<b>ANNEDLIDA</b>				
Polychaeta				
miscellaneous unidentified				
<b>ARTHROPODA</b>				
Crustacea				
Copepoda				
Calanoida				
<u>Acartia tonsa</u>	1.6	43	86	4887
<u>Labidocera aestiva</u>				42
<u>Paracalanus</u> spp.	1.2	28	93	1336
<u>Phyllopus</u> sp.				
<u>Pseudodiaptomus coronatus</u>				
<u>Temora turbinata</u>				
<u>Tortanus setacaudatus</u>				
Caligoida				
miscellaneous unidentified		1		
Cyclopoida				
<u>Corycaeus</u> spp.				
<u>Oithona</u> spp.	0.8	85	193	793
<u>Oncaeae</u> sp.				
miscellaneous unidentified				84
Notodelphoid				
miscellaneous unidentified	13.5	14	7	42

Table F-3. Zooplankton Taxa Observed in Samples Collected at Naples Bay, April 22, 1977 (Continued, Page 2 of 3)

	Concentration (individuals/m <sup>3</sup> )			
	IS-1*	2	3	4
Harpacticoid				
<u>Clytemnestra nostrata</u>				
<u>Euterpina acutifrons</u>	1.2	6	7	1420
miscellaneous unidentified	0.4	2		42
Lernaeopodoida				
Monstrilloida				
Copepod nauplii	3.6	112	114	459
Cladocera				
<u>Evadne tergestina</u>				
<u>Penilia avirostris</u>				
<u>Podon polyphemoides</u>				
miscellaneous unidentified				
Ostracoda				
Mysidacea				
Amphipoda				
Isopoda				
Decopoda				
Other Crustacea				
Arachnida				
Hydracarina				
CHAETOGNATHA				
<u>Sagitta</u> sp.			43	1002
MOLLUSCA				
CHORDATA				
Urochordata				
Appendicularia				
<u>Oikopleura</u> sp.			7	167
Cephalochordata				
<u>Amphioxus</u> sp.				
LARVAL FORMS				
Polychaete	2.8	14	21	125
Cirriped nauplii	5.2	157	193	2256
Cirriped cyprids		1		
Decapod zoea	0.4	1	21	2130
Decapod megalops				42
Decapod mysids				
Gastropod		4	29	2381
Pelecypod	3.2	25	307	13743

Table F-3. Zooplankton Taxa Observed in Samples Collected at Naples Bay, April 22, 1977 (Continued, Page 3 of 3)

	Concentration (individuals/m <sup>3</sup> )			
	1S-1*	2	3	4
Echinoderm				
Cephalochordata				
Vertebrata fish eggs				125
Vertebrata fish larvae	0.4			
Miscellaneous Unidentified		2	14	
TOTAL	35.1	492	1,142	31,034

\* Samples taken between Stations 1S and 1.

**APPENDIX G**  
**BENTHIC MACROINVERTEBRATE DATA**

Table C-1. Phylogenetic Listing by Estuarine Bay of Benthic Macroinvertebrate Abundance, Big Cypress Basin,  
April 16-23, 1977

Taxon	Wiggins Pass Area		Location	
	Individuals/m <sup>2</sup>	(mean of all stations)*	Chokoloskee Bay Individuals/m <sup>2</sup>	Naples Bay Individuals/m <sup>2</sup>
<b>Phylum Mollusca</b>				
Class Gastropoda				
<i>Anachis avara</i>	44		44	
<i>Bulla occidentalis</i>	22		378	
<i>Cerithium muscasum</i>			67	
<i>Crepidula maculosa</i>	22			
<i>Strombina</i> sp.	34		56	
Juvenile Olividae				
Class Pelecypoda				
<i>Anomiaocardia cuneimeris</i>	111		111	
<i>Chione paphia</i>	22		56	
<i>Dosinia elegans</i>	167			11
<i>Macoma baithica</i>	244			
<i>Macoma constricta</i>			22	
<i>Macoma tenta</i>	89			
<i>Nacra fragilis</i>	78		22	
<i>Mercenaria campechiensis</i>	22			
<i>Periploma inaequale</i>				
<i>Phacoides nassula</i>	44			
<i>Tellina alternata</i>	378			
<b>Phylum Annelida</b>				
Class Polychaeta				
<i>Ammotripane aulogaster</i>	44			
<i>Autolytus</i> sp.	96		237	
<i>Cirratulus grandis</i>	44		178	
<i>Glymenella torquata</i>	44		22	
<i>Cossura longocirrata</i>			533	
<i>Glyceria dibranchiata</i>	67		11	
<i>Goniada maculata</i>			22	
<i>Resianura</i> sp.				22

Table G-1. Phylogenetic Listing by Estuarine Bay of Benthic Macroinvertebrate Abundance, Big Cypress Basin,  
 April 16-23, 1977 (Continued, page 2 of 3)

Taxon	Wiggins Pass Area		Location		Naples Bay Individuals/m <sup>2</sup> (mean of all stations)*	Naples Bay Individuals/m <sup>2</sup> (mean of all stations)*		
	Individuals/m <sup>2</sup>	(mean of all stations)*	Chokoloskee Bay Individuals/m <sup>2</sup>	(mean of all stations)*				
<b>Phylum Annelida</b>								
Class Polychaeta (continued)								
<i>Lugia</i> sp.	22		122		356			
<i>Lumbrineris</i> sp.	30							
<i>Maldane sarsi</i>	22							
<i>Marpissa sanguinea</i>								
<i>Nereis succinea</i>								
<i>Nichonache lumbiricalis</i>								
<i>Notocirrus spiniferus</i>								
<i>Notomastus</i> sp.								
<i>Parapionosyllis</i> sp.								
<i>Pectinaria guidii</i>	22							
<i>Protomystides</i> sp.								
<i>Sabellina microphthalma</i>								
<i>Sabellina eliasoni</i>								
<i>Scoloplos fragilis</i>								
<i>Travisia</i> sp.								
<i>Travisiopsis levinseni</i>	22							
Juvenile Capitellidae								
Juvenile Nericidae								
Juvenile Glyceridae								
Juvenile Onuphidae								
Class Sipuncula								
<i>Phascolion strombi</i>	89							
<b>Phylum Arthropoda</b>								
Class Crustacea								
Order Cumacea								
<i>Campylaspis</i> sp.					22			
<i>Cyclaspis</i> sp.					67			
<i>Oxyurostyliis smithi</i>	44				67	22		

Table G-1. Phylogenetic Listing by Estuarine Bay of Benthic Macroinvertebrate Abundance, Big Cypress Basin,  
April 16-23, 1977 (Continued, page 3 of 3)

Taxon	Wiggins Pass Area		Location	
	Individuals/m <sup>2</sup>	(mean of all stations)*	Individuals/m <sup>2</sup>	Individuals/m <sup>2</sup>
Order Tanaidacea				
Family Paratananidae	22		3,333	83
Order Isopoda				
Family Anthuridae	22		89	22
Family Cynothoidae			22	22
Family Idoteidae			22	
Order Amphipoda				
Family Ampeliscidae	296			272
Family Aoridae	430			108
Family Atylidae			267	111
Family Corophiidae				22
Family Haustoriidae	156			
Family Pontogeneiidae			644	
Order Mysidacea		33		
<u>Mysidopsis bigelowi</u>				
<u>Mysis mixta</u>				
Order Decapoda				
Infraorder Caridea				
<u>Ogyrides limicola</u>				22
Infraorder Anomura				
<u>Pagurus arcuatus</u>		44		
Juvenile Brachyura				22
Phylum Echinodermata				
Class Stellerioidea				
Order Ophiuroidea				
<u>Amphilima olivacea</u>			22	
<u>Hemipholis elongata</u>				
<u>Ophioderma brevispinum</u>		22		
<u>Ophiomusium lymani</u>		244	44	22

\* Mean of those stations where found, see Table G-2 for exact distribution.

Table C-2. Relative Biomass ( $\text{g/m}^2$ ; dry weight) of Major Benthic Macroinvertebrate Groups, Big Cypress Basin, April 16-23, 1977.

\* Declassified using 20 percent NCI

Dry weight includes meat plus protein matrix of shell  
decarinellized using 20 percent ac.

**APPENDIX H**  
**PHOTOSYNTHETIC PIGMENT DATA**

Table I-1.

Photosynthetic Parameter Data for Wiggins Pass Area, Choctawhatchee Bay, and Naples Bay,  
May 24-27, 1977.

LOCATION	WATER TIDE DEPTH	-750	-665	-645	-630	A665	EXTVOL_L	SAMVCL_M	-480
WP	1	H	0.5	0.012	0.054	0.035	0.029	0.01	0.140
WP	1	H	0.5	0.015	0.060	0.039	0.033	0.01	0.004
WP	1	L	0.5	0.027	0.101	0.069	0.065	0.01	0.136
WP	1	L	0.5	0.009	0.070	0.045	0.048	0.01	0.274
WP	2	H	0.5	0.016	0.048	0.038	0.045	0.01	0.176
WP	2	H	0.5	0.031	0.065	0.052	0.022	0.01	0.004
WP	2	L	0.5	0.018	0.040	0.037	0.039	0.015	0.162
WP	2	L	0.5	0.014	0.034	0.029	0.020	0.014	0.094
WP	3	H	0.5	0.008	0.056	0.028	0.026	0.015	0.217
WP	3	H	0.5	0.070	0.062	0.044	0.042	0.030	0.131
WP	3	L	0.5	0.010	0.089	0.048	0.041	0.055	0.169
WP	3	L	0.5	0.017	0.101	0.058	0.051	0.057	0.01
WP	4	H	0.5	0.016	0.047	0.039	0.039	0.022	0.111
WP	4	H	0.5	0.025	0.062	0.046	0.046	0.026	0.127
WP	4	L	0.5	0.014	0.071	0.043	0.037	0.037	0.155
WP	4	L	0.5	0.016	0.075	0.047	0.042	0.046	0.01
WP	5	H	0.5	0.007	0.029	0.020	0.019	0.017	0.160
WP	5	H	0.5	0.050	0.081	0.074	0.077	0.016	0.004
WP	5	L	0.5	0.022	0.078	0.055	0.055	0.038	0.167
WP	5	L	0.5	0.024	0.086	0.060	0.055	0.043	0.004
WP	5	L	0.5	0.024	0.086	0.060	0.055	0.043	0.183

PHAEGRAL ACHLOR BCXLGR CCHLGR PCHLGR PHCOPHYA MSPU

1. 44824	2. 8566	1. 20100	4. 3451	2. 16937	1. 21819	7. 0000
1. 36364	3. 0468	1. 27663	3. 8125	2. 00250	1. 85231	5. 6875
1. 5n167	4. 9879	2. 37675	6. 6377	4. 33875	1. 26825	12. 0625
1. 35556	4. 1024	2. 20175	4. 5323	2. 67000	2. 58656	9. 3125
1. 45445	2. 1750	0. 76000	2. 9420	1. 66875	0. 90112	
1. 5n545	2. 2747	1. 21450	4. 0934	2. 00250	0. 56738	
1. 46667	1. 4211	1. 28125	4. 6451	1. 16813	0. 58406	6. 7500
1. 42857	1. 3149	1. 01157	2. 7044	1. 00125	0. 63412	3. 2500
1. 37143	3. 305	0. 78825	2. 7580	2. 16938	1. 91906	
1. 40000	2. 8293	1. 35800	3. 8995	2. 00250	1. 50187	4. 4375
1. 43636	5. 3692	1. 91700	4. 4980	4. 00500	2. 41969	9. 9375
1. 47368	5. 7246	2. 08663	5. 0746	4. 50563	2. 15269	10. 3750
1. 40909	2. 0391	1. 49937	4. 6641	1. 50187	1. 06800	3. 9375
1. 42308	2. 4922	1. 13312	4. 0064	1. 83562	1. 20150	3. 2500
1. 50054	3. 8749	1. 57038	3. 2989	3. 33750	0. 98456	7. 0625
1. 47500	4. 009	1. 69200	4. 0684	3. 17062	1. 50187	7. 0000
1. 29412	1. 4781	0. 75363	2. 1626	0. 83438	1. 15144	
1. 93750	2. 0110	1. 77700	5. 7335	2. 50312	1. 0625	
1. 47368	3. 7653	1. 97687	4. 6391	3. 0375	1. 43512	
1. 44186	4. 1731	2. 11938	5. 1907	3. 17062	1. 05231	

Table H-1. Continued, page 2 of 3

LOCATION NUMBER	TIDE DEPTH	-750	-665	-645	-630	A665	EXTVOL_LC	SAMVCL_H	-400
CP	H	0.5	0.007	0.050	0.030	0.026	0.030	0.01	0.0004
CR	H	0.5	0.019	0.065	0.045	0.044	0.032	0.01	0.0004
CR	L	0.5	0.005	0.036	0.014	0.014	0.029	0.01	0.0004
CR	L	0.5	0.021	0.064	0.043	0.043	0.028	0.01	0.0004
CA	H	0.5	0.021	0.153	0.076	0.077	0.085	0.01	0.0004
CH	H	0.5	0.021	0.085	0.040	0.040	0.050	0.01	0.0004
CR	H	0.5	0.005	0.110	0.034	0.035	0.076	0.01	0.0004
CB	L	0.5	0.008	0.061	0.026	0.027	0.036	0.01	0.0004
CH	L	0.5	0.011	0.044	0.030	0.028	0.075	0.01	0.0004
CR	H	0.5	0.016	0.042	0.034	0.034	0.018	0.01	0.0004
CR	L	0.5	0.030	0.074	0.052	0.050	0.031	0.01	0.0004
CH	L	0.5	0.034	0.086	0.065	0.065	0.035	0.01	0.0004
CB	L	0.5	0.023	0.090	0.051	0.047	0.047	0.01	0.0004
CA	H	0.5	0.025	0.100	0.059	0.057	0.050	0.01	0.0004
CR	H	0.5	0.028	0.081	0.055	0.054	0.039	0.01	0.0004
CR	L	0.5	0.035	0.096	0.073	0.072	0.042	0.01	0.0004
CR	L	0.5	0.035	0.096	0.073	0.072	0.042	0.01	0.0004

PHAEOPHYT	ACIULOR	ACIULOR	CCHLOR	PCHLOR	PHAEOPHYA	MSPU
1.43333	2.9126	1.28438	2.9411	2.16937	1.33500	5.2500
1.43750	3.1002	1.42538	4.6110	2.3625	1.40175	4.8750
1.41379	2.8029	0.90400	2.3754	2.00250	1.38506	6.1250
1.53571	2.9207	1.15500	3.0430	2.56312	0.76763	3.7500
1.55294	9.0707	1.98812	9.8189	7.84313	2.08594	17.5000
1.48000	5.1022	0.94350	4.8684	4.00500	1.83563	5.3750
1.51316	7.9832	0.82125	6.4419	6.50812	2.36963	13.1250
1.47222	3.6785	0.36625	3.1605	2.83688	1.36837	3.1250
1.32000	2.2221	1.09337	2.9511	1.33500	1.58531	4.0000
1.44444	1.7219	1.12625	3.5998	1.33500	0.76763	3.8125
1.41935	2.9924	1.10025	3.3577	2.16937	1.45181	3.1875
1.48571	3.4891	1.74375	5.9901	2.83687	1.25156	6.2500
1.42553	4.6072	1.14213	3.4545	3.33750	2.15269	5.6875
1.50000	5.1311	1.48038	5.3612	4.17187	1.66875	6.2500
1.35897	3.5987	1.33725	4.6499	2.33625	2.21944	5.8750
1.45238	4.0790	2.23950	7.0765	3.17062	1.73350	7.3750

\* Number 81 stands for

### Station 1-SA.

Number 91 stands  
Station 1-S.

PHAFORW	ACHLOR	BCHLOR	PCHLOR	PHENYL	MSPPU
1. 32409	8. 3135	3. 18250	6. 1620	1. 5625	1. 5625
1. 28283	8. 6859	2. 97275	5. 06625	5. 74050	5. 06625
1. 36150	1. 9744	5. 73162	4. 4314	4. 67250	6. 89194
1. 36719	1. 8177	5. 80475	1. 1. 1. 1.	7. 84313	12. 9375
1. 11791	6. 4177	3. 14737	5. 9394	7. 84313	7. 34250
1. 00244	7. 9060	1. 87513	6. 9000	4. 67250	2. 3. 8125
1. 32885	10. 6823	5. 85062	12. 1796	5. 50687	14. 2500
1. 01509	10. 1049	1. 36362	9. 4744	4. 07175	11. 7500
1. 42222	4. 3798	1. 29763	4. 1271	2. 08594	7. 3750
1. 50000	3. 9919	2. 658062	6. 2162	1. 33500	8. 7500
1. 00816	4. 6289	2. 62288	5. 4078	3. 33750	9. 5000
1. 458035	4. 7195	2. 39225	4. 8950	3. 67125	9. 5625
1. 38065	1. 9230	1. 30363	3. 3090	1. 33500	3. 9375
1. 45833	2. 3390	1. 31675	5. 9625	1. 83562	0. 96787
1. 53068	4. 4196	2. 57488	5. 5966	3. 83812	1. 18481
1. 45238	4. 1015	2. 17413	4. 8760	3. 17062	1. 73550
1. 36885	1. 3961	4. 13500	7. 9758	7. 50937	6. 74175
1. 35200	1. 5433	4. 05312	8. 2615	7. 34250	7. 25906
1. 38614	9. 4524	4. 02087	7. 8294	6. 50813	5. 28994
1. 35091	10. 4631	3. 51612	7. 2361	7. 17562	5. 67375
1. 37500	12. 8111	3. 90425	9. 0508	8. 51062	7. 37587
1. 29268	10. 8191	4. 36200	8. 2078	6. 00750	8. 36044
1. 28000	12. 7768	6. 65700	9. 0674	8. 07600	7. 0477

LEGEND TO TABLE H-1

LOCATION--WP = Wiggins Pass; CB = Chokoloskee Bay; NB = Naples Bay.

NUMBER--Station number.

TIDE--H = High; L = Low.

DEPTH--Approximate depth at which samples were taken.

750--Absorbance reading of acetone extract at a wavelength of 750 nanometers.

665--Absorbance reading of acetone extract at a wavelength of 665 nanometers.

645--Absorbance reading of acetone extract at a wavelength of 645 nanometers.

630--Absorbance reading of acetone extract at a wavelength of 630 nanometers.

A665--Absorbance reading of acetone extract at a wavelength of 665 nanometers following acidification and corrected for 750 mm turbidity reading.

480--Absorbance reading of acetone extract at a wavelength of 480 nanometers.

EXTVOL\_L--Extract volume expressed in liters.

SAMVOL\_M--Volume of original sample expressed in cubic meters.

PHAEORAT--Ratio of corrected 665 reading before acidification to corrected 665 reading after acidification.

ACHLOR--Concentration of chlorophyll a in mg/m<sup>3</sup> as calculated from the trichromatic equation of Strickland and Parsons (1972). See text.

BCHLOR--Concentration of chlorophyll b in mg/m<sup>3</sup> as calculated from the trichromatic equation of Strickland and Parsons (1972). See text.

CCHLOR--Concentration of chlorophyll c in mg/m<sup>3</sup> as calculated from the trichromatic equation of Strickland and Parsons (1972). See text.

PCHLORA--Concentration of chlorophyll a in mg/m<sup>3</sup>. corrected for phaeopigments as calculated by the monochromatic equation of Strickland and Parsons (1972). See text.

Legend (continued)

PHAEOPHYA--Concentration of phaeopigments in mg/m<sup>3</sup>, corrected for phaeopigments as calculated by the monochromatic equation of Strickland and Parsons (1972). See text.

MSPU--Concentration of total carotenoids in millispecific plant units as calculated by the equation of Strickland and Parsons (1972) for a crop primarily composed of Chrysophyta and Pyrrrophyta. See text.

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