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J. A. Lasater
Professor of Oceanography, Florida Institute of Technology, Melbourne, Florida

T. A. Nevin
Professor of Microbiology

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Dr. J. A. Lasater
Professor of Oceanography
Florida Institute of Technology
Melbourne, Florida

Dr. T. A. Nevin
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ABSTRACT

Detailed examination of the water quality parameters of the lagoons of East Central Florida were begun in 1969. This investigation was subsequently expanded to include other aspects of these waters. General trends and a statistical model are beginning to emerge for the water quality parameters. Man-made and natural effects have resulted in substantial alteration of water parameters since the study was initiated.

INTRODUCTION

A major geophysical feature of Florida's Central East Coast is the classical lagoonal system which extends along the Atlantic Coast. The natural divisions of this lagoonal system are the Indian River Lagoon (or Mosquito Lagoon), the Indian River, and the Banana River. New Found Harbor and Sykes Creek form a poorly connected arm of the Banana River and are often considered as two additional divisions. All of these waters are saline.

GEOPHYSICAL ASPECTS

The lagoonal system of the Indian/Banana River and the Indian River Lagoon involves portions of five counties: Volusia, Brevard, Indian River, St. Lucie, and Martin counties. Indian River Lagoon extends along the southeastern edge of Volusia County from Ponce de Leon Inlet into the northeastern section of Brevard County. The northern terminus of the Banana River is within the Kennedy Space Center - Cape Canaveral complex and it joins the Indian River just north of State Road 518. The northern reaches of the Indian River are near the Volusia Brevard County line and it extends southward along Brevard, Indian River, and St. Lucie Counties, terminating at the St. Lucie Inlet at the northeastern corner of Martin County.

There is only one direct connection between the Indian River Lagoon and the Atlantic Ocean, Ponce de Leon Inlet. However, there are several instances where the barrier beach is very narrow and ocean water breaks over the barrier beach during rough weather. The Banana River has no direct connection with the ocean except the possibility of a small amount of water exchange via the lock system at Port Canaveral. The Indian River, on the other hand, has three direct connections to the ocean: Sebastian Inlet, Fort Pierce Inlet and St. Lucie Inlet.

There are no significant fresh water streams entering the Indian River Lagoon south of the Ponce de Leon Inlet; however, the Halifax River estuary is just north of the Inlet. The principal sources of fresh water entering the Indian River Lagoon appear to be direct land runoff and a number of small man-made canals. The only source of fresh water entering the Banana River is direct land runoff and numerous small man-made canals. In contrast, there are a number of fresh water sources, both natural and man-made, for the Indian River. At the northern end of the Indian River there is a small source, Turnbull Creek; however, with the exception of the St. Lucie River, the most significant natural influx of fresh water occurs in the southern part of Brevard County. The principal natural fresh water streams entering the Indian River in the southern part of Brevard County are the Eau Gallie River, Crane Creek, Turkey Creek and Sebastian Creek. The fresh water influx has been significantly modified by man-made structures in all of these streams except the Eau Gallie River. A man-made canal empties into Crane Creek. This canal extends in a generally westerly direction some 5.3 miles. Similarly there is a six mile drainage canal that empties into Turkey Creek. More recently, a canal (C-54) emptying into Sebastian Creek was completed by the East Central Florida Flood Control District. An older canal, Fellsmere Canal, also empties into Sebastian Creek.

In the case of Crane and Turkey Creek, the preponderance of water entering the Indian River is a consequence of the drainage canals. The same is true of Sebastian Creek outflow, the bulk of which appears to enter from the Fellsmere Canal.

Between Sebastian Creek and the St. Lucie River, there are no significant natural sources of fresh water, but there are major man-made canals entering the Indian River at both Vero Beach and Stuart. Since these canals extend beyond the natural watershed dividing line, they are sources of fresh water which would not naturally enter the Indian River. Man-made sources of fresh water influx are numerous. Essentially all of the urbanized centers along the lagoon system utilized these waters to dump storm and sanitary sewer effluents. In some instances, there are storm sewers which drain land that is primarily utilized for agricultural purposes. In the less urbanized portions of the land adjacent to the lagoons; it is the usual practice for the residential sections to employ septic tanks for sewage disposal.

Man-made features which have modified the lagoonal system also include roadways, canals, and channels.

One of the dominant man-made features is the Intracoastal Waterway. Prior to the construction of the Intracoastal Waterway there was a (low-lying) land bridge that separated the southern end of Indian River Lagoon from the northern end of the Indian River. The Haulover Canal now connects these two lagoons and permits a significant interchange of their waters. In contrast, the construction of the Crawlerway form the Vehicle Assembly Building (VAB), Kennedy Space Center, to the Saturn V launch pad has completely severed a tenuous connection between the southern end of the Indian River Lagoon and the northern reaches of the Banana River. A connection between the northern part of the Indian River and the Banana River was established by the construction of the Canaveral Barge Canal across Merritt Island.

There are 16 vehicular roadways crossing the Indian River Lagoon/Indian River. There are five existing crossings of the Banana River. There are two roadway crossings in Volusia County, two in Indian River County and four in St. Lucie County. Although each of the roadways is distinctive in character, there are certain features which are similar in 14 of the crossings. As a general rule, there is a central span (which traverses the navigable waterway) of one-quarter to one-half mile in length, and small relief bridges are usually located near one or both original shorelines. The greater portion, one to three miles, of the crossing is a dredged landfill. The A1A crossing in Volusia County and State Road 3 (Mathers Bridge) crossing of the Banana River are built essentially the entire distance on pilings since the lagoons are relatively narrow at these two locations.

As a consequence of natural and man-made connections, the Indian/Banana River and Indian River Lagoon constitute an interacting water system. However, the various roadways and natural land areas tend to cause the lagoons to consist of series of basins.

All segments of the lagoons are relatively shallow and the deepest portions are generally a result of dredging operations. Volumetric studies of the Indian River Lagoon shows that over one-half of this waterbody has a depth of two feet or less. For the most part, the Intracoastal Waterway represents the deepest portion of the lagoon. The Intracoastal Waterway, when initially constructed, was 100 feet wide and 12 feet deep. The material removed to form the channel was deposited as a series of spoil islands. Many of these spoil islands extend well above the water surface; however, some of the smaller spoil islands in the Banana River are located within the contiguous waters of the Space Center Complex and at the eastern end of the Canaveral Barge Canal.

Natural but low-lying islands dot the northern half of the Indian River Lagoon. Most of these islands are associated with mangrove growths. The natural islands in the Banana River are primarily located in the Cocoa Beach area with a few scattered along the shore in the southern portion of these waters. There are relatively few natural islands in the Indian River from Haulover Canal to Sebastian Inlet; however, numerous natural islands dot the River south of State Road 512 to the Vero Beach area. The southern portion of the Indian River is virtually free of natural islands.

GENERAL CLIMATOLOGY

The climate of East Central Florida is subtropical with hot humid summers and short mild winters. During the warmer portions of the year there is little or no change in the general weather pattern; however, sharp temperature gradients often develop along the 150 mile length of the Indian River Lagoon/Indian River, but these gradients are usually of short duration. In these instances where a strong cold front engulfs all or most of the state of Florida, the temperature gradient is less distinct.

As a general rule, the weather pattern of East Central Florida, from April to October, is dominated by east to southeast winds traveling around the Bermuda Anticyclone. In October the prevailing winds shift abruptly to the north or northwest, and in winter months the movement of polar air masses through the region giving a distinct continental flavor to the climate. Wind effects are among the most important factors influencing the lagoonal behavior since almost all water motion is wind induced.

The rainy season is usually from June through October. Initially the rains are due to the beginning of the thunderstorm season, but later in the season the rains are usually connected with tropical storm activity. Winter rains are commonly associated with frontal activity and occur, on the average, once every three to five days. These rains are generally light and reasonably uniform. Summer rains (thunderstorms) on the other hand, can be heavy, of short duration, and very localized. Rainfall for the lagoonal area averages almost 50 inches per year.

LAGOONAL CHARACTERIZATION STUDIES

Detailed examination of the character of the lagoonal complex were initiated by the Florida Institute of Technology (FIT) faculty in the summer of 1969 with a limited number of studies being performed prior to that time. Initial studies were concentrated in the general area of water quality parameters but have been expanded to include biological, microbiological, physical and sedimentary studies. However, this presentation is restricted to the water quality parameters.

METHODS AND PROCEDURES

Due to the shallow water depths, samples were acquired using shallow draft power boats. Samples were collected in one-half gallon plastic jugs and transported to the F.I.T. laboratory or laboratory boat for analysis. Analyses were performed according to procedures (usually spectrophotometric) described in Standard Methods for the Examination of Water and Wastewater (American Public Health Association). Salinities were determined using either an induction salinometer or an optical salinometer. The usually measured parameters were temperature, salinity, dissolved oxygen, pH, nitrate, nitrite, orthophosphate & turbidity. However, the studies included chlorinity, sulfate, sodium, potassium, calcium, magnesium, ammonia and selected trace metals in some instances.

Throughout these studies, it has been necessary to either modify standard oceanographic devices or develop alternate sampling methods. Water samples are routinely taken using a water sampler schematically illustrated in Figure 1.

LOCATIONS AND DATA HANDLING

Sample site locations were generally referenced to marker identified on NOAA Nautical Charts 843SC and 845SC. Although sampling has been accomplished from Ponce de Leon Inlet to St. Lucie Inlet the bulk of the effort has been concentrated in selected areas. These areas are vicinity of Kennedy Space Center, Orlando Power and Light Plant (Delespine), Melbourne area and Vero Beach Power Plant. It is estimated the faculty and students have collected and examined over 10,000 water samples from the complex and adjoining areas.

A major effort is currently in progress to subject the individual parameters to statistical analysis. In addition efforts are being made to develop a systematic rational for interpretation of the data required.

DATA AND RESULTS

Profound alteration in the water quality parameters have occurred since the studies were begun due to both man-made and natural causes. The most far reaching influence was an extended drought extending from about September 1970 to June 1971. An increased influx of saline water occurred during the early part of 1970 which substantially altered the saline distribution.

SALINITY VARIATIONS

Most of the salinity variations shown in Figure 2 and 3 can be attributed to either influx of fresh water or evaporation. In this respect, the southern end of the Indian River Lagoon and the northern end of the Banana River appear to be basins where the fresh water influx is essentially balanced by the evaporation over a yearly cycle. However, the marked change in the salinity distribution curve for 7/70 of Figure 2 & 3 is a consequence of invasion of saline water from the south as seen in Figure 4. Station 6S is approximately 10 miles south of Station 1N (SR 518). Salinity values have declined in recent months but have not attained the 1969 levels.

Careful evaluations have demonstrated conventional methods of measuring the salinity but are not reliable for these lagoonal waters beyond $\pm$ 0.1 °/oo even though salinities are greater than 30 °/oo. Apparently, this is a consequence of non-oceanic ionic ratios.

NUTRIENTS

Prior to the occurrence of the extended dry period, the nutrient levels were often above typical oceanic values as seen in Figures 5 and 6 but their ratios were close to the desired nitrogen to phosphorus ratio. During the dry period, the nutrients became depleted with the nitrogen disappearing first. Since the return of the rains, the nutrient values have returned to measurable levels but far below the predrought values. Average values range around 0.05 - 0.08 ppm for nitrate and 0.08 - 0.18 ppm for orthophosphate.

OTHER PARAMETERS

Observed values for the chlorinity and sulfate are close to those expected for waters with the measured salinity value. The pH usually falls within the typical oceanic range of 7.8 - 8.3. Dissolved oxygen values vary with the temperature and an average value is about 5 ppm; however, the DO's fall to low values near sediments which are rich in organic materials.

CONCLUSIONS

Natural and man-made causes result in wide variations in the water quality parameters of the lagoonal complex. Although substantial portions of these lagoons are healthy and productive, the presence in some areas of sediments rich in organic materials (muck) is a matter of concern. Continued monitoring of these waters is a necessary procedure to establish the impact of man's activities.

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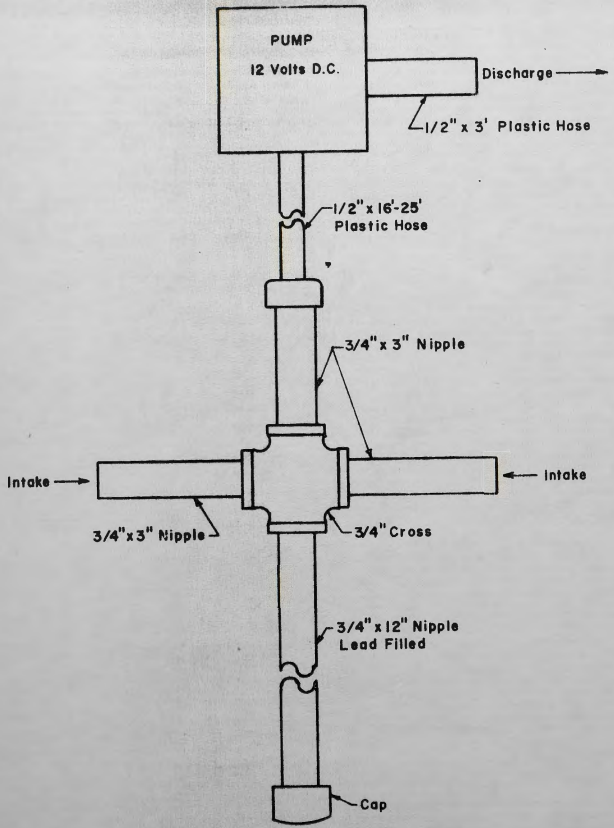

Figure I. Schematic of Depth Sampler.

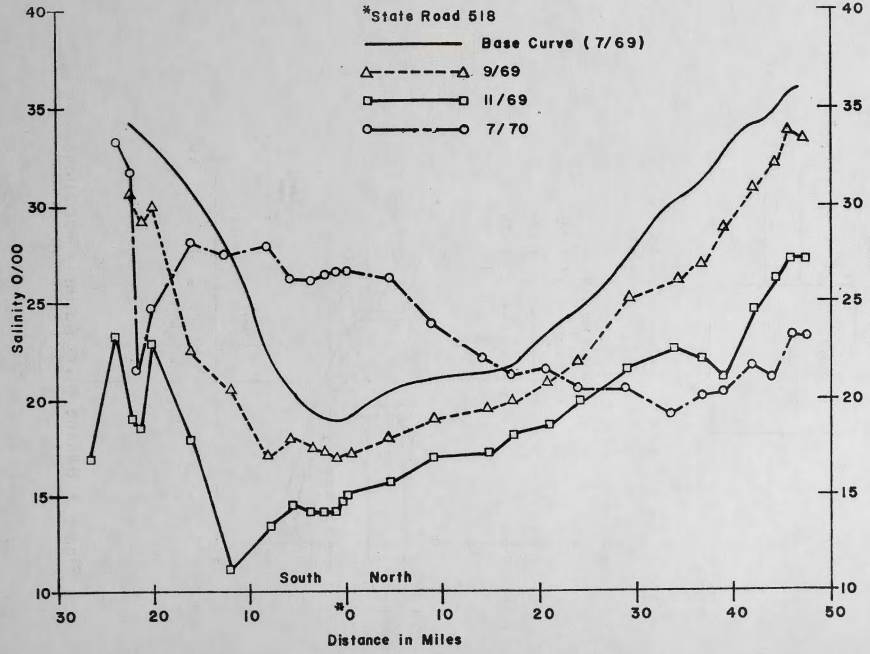

Figure 2. Indian River Salinity Variations.

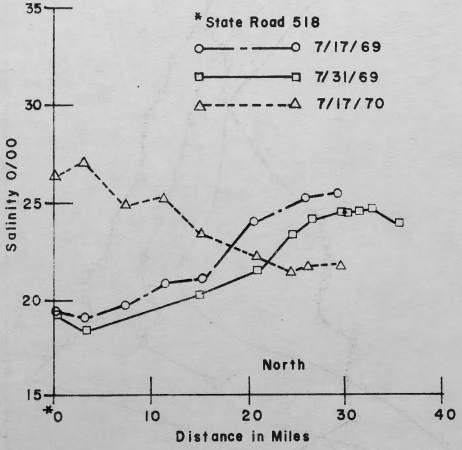

Figure 3. Banana River Salinity Variations.

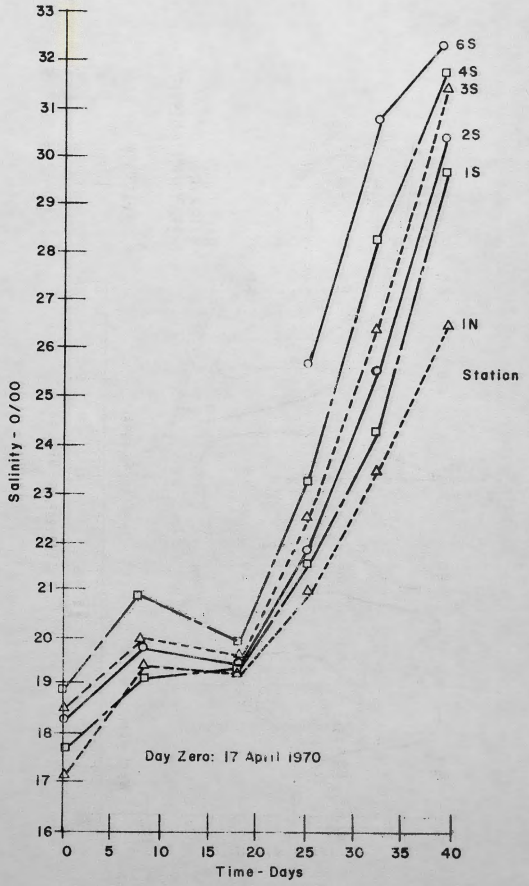

Figure 4. Salinity-Time Studies

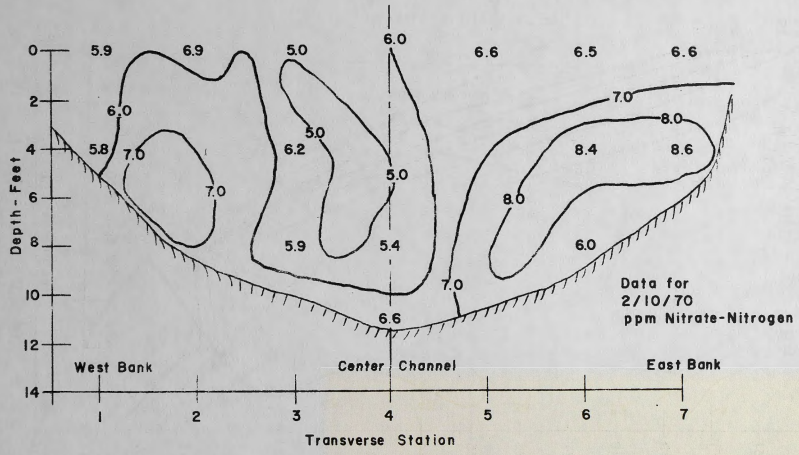

Figure 5. Nitrate-Nitrogen Values at Station 1N.

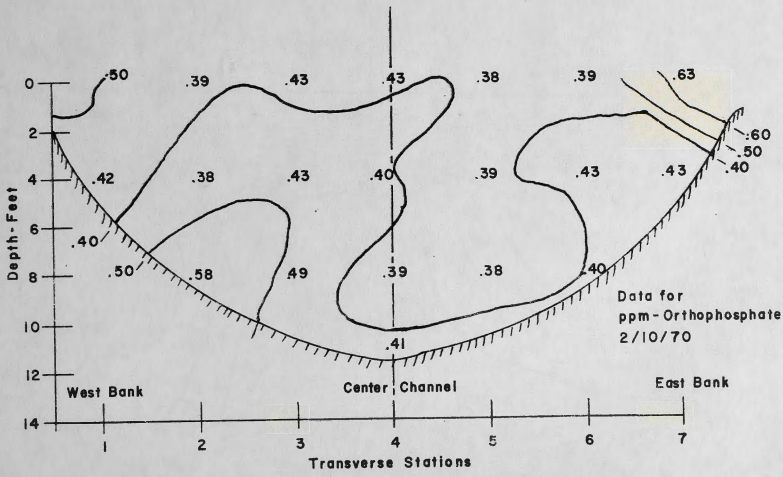

Figure 6. Orthophosphate Values at Station IN.