

POLLUTION STUDIES IN BISCAYNE BAY

by

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I. LETTER OF TRANSMITTAL

Mr. G. F. Catlett
Chief Engineer
State Board of Health
Jacksonville, Florida

Dear Mr. Catlett:

Enclosed herewith you will find the report of an investigation of pollution in Biscayne Bay in connection with two bathing areas. This survey was conducted at the request of local health authorities in Miami, Florida, and Mr. S. D. Macready, District Sanitary Officer, State Board of Health. Mr. Macready assisted and undersigned in making the survey.

Respectfully submitted,

J. W. Wakefield
Assistant Engineer

II. GENERAL CONSIDERATIONS

Biscayne Bay is a large shallow body of water in Dade County. It is approximately 24 miles long by three miles wide. The depth in general varies from 1 to 10 feet except in relatively narrow channels which have been dredged out for ships. Much of the Bay is very shallow being only two or three feet deep at low tide.

The Bay has five general openings into the ocean:

(1) Bakers Haulover in the extreme north end of the Bay is an artificial opening maintained by constant dredging. It is about 100 yards wide and 14 feet deep at the entrance.

(2) The main channel directly opposite the down town area of the City of Miami is about 300 yards wide and 30 feet deep throughout its length from the ocean to the docks in Miami. This also is an artificial opening.

(3) Norris Cut which is about a mile south of the main channel is about a half mile wide and very shallow (about 2 feet at low tide).

(4) Bear Cut lies between Virginia Key and Biscayne Key about the middle of the Bay longitudinally. This cut is about one mile wide and terminates in quite shallow water on both the ocean and the Bay sides.

(5) South of Biscayne Key for a distance of about nine miles the Bay is separated from the ocean by a large series of shoals out by numerous narrow and relatively deep channels.

The City of Miami occupies the northern half of the west shore of the Bay while the City of Miami Beach occupies nearly as large an area on the eastern shore.

The layout of the Bay is shown on an accompanying map. It will be noted that it is divided roughly into three sections by the earthen causeways and bridges connecting Miami and Miami Beach. The northern section is north of the 79th Street Causeway, near Little River. The second section is defined on the north by the 79th Street Causeway and on the south by the Venetian and the County Causeway. The third section constitutes the entire south half of the Bay being that portion south of the County Causeway.

III. TIDES, WINDS AND WEATHER CONDITIONS

The tides in Biscayne Bay have a mean range of 2.0 feet and a spring range of 2.4 feet. In most of the Bay the height of the water and deflection of currents are primarily due to the direction and force of the wind rather than the tide.

The prevailing wind during most of the year is east except November and February when it is northwest; then June and July when it is southwest. During the time of this survey there was only one day when the wind was from the west. The rest of the time the wind varied from northeast to southeast.

The average annual rainfall in Miami is 59.78 inches, of this only 15.38 inches falls during the six month period between November and April, while 44.40 inches fall during the summer months. During the time of sampling there was a light rainfall on March 15th.

The average winter temperature in Miami is 68°F. The average summer temperature is 81°F. This it will be seen that the temperature is excellent for biological action throughout the year.

IV. CURRENT OBSERVATIONS

Brief observations of currents in the Bay gave the following conclusions:

(1) By far the majority of the water in the section north of 79th Street Causeway enters the Bay through Bakers Haulover and the Inland Waterway Canal.

(2) Little or no current was found at 79th Street Causeway at any time.

(3) The currents through the openings in the County Causeway were high. It is very probable that most of the diluting water in Area No. 8 comes into the Bay through the Main Ship Channel just south of the County Causeway.

(4) With the prevailing wind from the east, it is reasonable to expect that most of the water in Area No. 3 (south of County Causeway) comes into the Bay south of Cape Florida. The northern end of this area is undoubtedly affected by the main channel and by Norris and Bear Cuts. Currents along the west shore which would be expected from the direction of the prevailing wind failed to materialize largely because of the extremely shallow water. This shallow area extends out nearly a mile off shore and is cut in numerous places by dredging and natural channels running at right angles to the shore. This causes such currents as would ordinarily be set up along the shore to be moved out approximately a mile off shore along the edge of the shallow water.

(5) It seems probable that the division line between the effects of the tide from the openings in the northern part of Area No. 3, and the openings south of Cape Florida will fall about opposite the subdivision of Coconut Grove.

V. CENTERS OF POPULATION

The incorporated centers of population with their location in respect to the Bay and their 1935 census population are listed in the following table:

City	Location	Population
Miami	Central and northern section of west shore	127,600
Miami Beach	Central and northern section of east shore	13,330
Coral Gables	About one mile west of Miami	6,747
North Miami	Extreme northern end of the Bay	1,354
South Miami	About one mile south of Miami	1,690
Hialeah	About two miles north of Coral Gables	3,168
Opa Locka	About two miles north of Hialeah	522
Total		154,411

While all of the foregoing towns are not immediately adjacent to the Bay, they are all drained by rivers, creeks and canals which eventually reach the Bay.

In addition to the above mentioned municipalities, the rural sections of Dade County near Miami are heavily populated. The 1935 census gives Dade County a total population of 180,998 people and fully 80 per cent or about 170,000 people live close enough to Biscayne Bay to be considered as adjacent population.

All of the foregoing figures are based on permanent population. All of the cities mentioned are subject to enormous increases during the winter tourist season. There are no figures available giving the number of visitors present during the height of the tourist season but it is probably not less than 350,000 giving a maximum population in the area of 500,000 people.

VI. SANITARY SURVEY

There is no doubt that a rural population of the size present in this area contributes considerable pollution to waterways by means of surface run-off. However, the principle centers of population are of such greater importance as pollution sources that all of the available time for a sanitary survey was spent in studying the kinds and effects of the various municipal sewage systems.

The chief source of pollution in the entire area is the City of Miami. The greater part of the City is sewered by sanitary sewers with disposal by dilution only. Twenty-eight of these sewers empty into the Miami River which enters the Bay about opposite Norris Cut and has a direct channel connecting with the Main Ship Channel near its entrance to the ocean. Thirty-six sewers empty directly into the Bay. By far the greater number and the larger sewers are in the central part of the City. The last large sewer to enter the Bay on the north is at Northeast 55th Terrace approximately one and a half miles south of the 79th Street Causeway. North of this point there are quite widely separated. The last sewer to enter the Bay on the North enters the Little River Canal about one mile above its mouth, serves only a small area and is supposed to carry nothing but septic tank effluent. The last large sewer on the south empties into the Bay approximately 3 miles south of the County Causeway at the foot of 25th Road. Beyond this point there are two small systems about one mile apart. The last sewer to enter the Bay on the south is at No. Farlan Street and serves only the business section of Coconut Grove. Between 25th Road and Northeast 55th Terrace, a distance of approximately five and one-half miles, the sewage from about 7,900 acres of densely built city enters Biscayne Bay and Miami River through 59 separate outfalls.

The City of Miami Beach collects its sewage into a central pumping station and disposes of it by dilution in the deep waters of the Ocean. There are no known sanitary sewers, either private or public, entering Biscayne Bay from Miami Beach.

The City of Coral Gables is drained by the Coral Gables Canal which enters Biscayne Bay about opposite Cape Florida. In addition to the permanent residents listed above, there is a large hotel located directly on the bank of the Canal. Coral Gables has no public sewer system depending on private septic tanks and drainfields exclusively. It has been rumored that sewage from the hotel entered the canal but both hotel and city authorities deny this and the writer could find no connection with the canal.

None of the other cities listed above have public sewer systems and all claim to prevent the discharge of sewage into streams. That there is some occasional pollution from these areas there can be no doubt, but no definite sources were found.

In addition of the above mentioned sources of pollution one must add pollution due to ships. Biscayne Bay is an important port and is a regular port of call for a number of large steamship lines. Also in the winter months there are a large number of private yachts in the harbor, many of which are used for sleeping quarters. This item undoubtedly adds a considerable quantity of pollution.

VII. CLASSIFICATION OF AREAS BY SANITARY SURVEY

Based on sanitary survey the following classifications of areas in Biscayne Bay seems reasonable.

(1) The area north of 79th Street Causeway seems to receive only occasional pollution from sources immediately adjacent to it. In times of a high wind from the south or southeast, it is possible that pollution is pushed up through the narrow opening of the 79th Street Causeway into the area.

(2) The area between 79th Street Causeway and County Causeway seems to receive constant pollution. It will be apparent that most of this pollution is along the west shore due both to the locality of sources of pollution and to the practically constant east wind. However, it is possible under certain weather conditions for this polluted water to be disposed throughout the area and hence the entire area should be so classified.

(3) The area south of the County Causeway can be considered receiving constant pollution in high concentrations as far south as a line between Dinner Key and the north end of Key Biscayne.

(4) The area south of the above mentioned line to a line from Tahiti Beach to Cape Florida can be considered receiving constant pollution in small amounts and with a strong wind from the northeast might receive higher concentrations from the north.

(5) The area south of the Tahiti Beach - Cape Florida line is probably free from any but very casual pollution and such pollution as reaches this area is subject to extremely high dilution.

VIII. PREVIOUS SURVEY IN AREA

In 1927 the cities of Miami and Miami Beach had a detailed study made of Biscayne Bay and the adjacent Atlantic Ocean to determine the extent of pollution from these cities. This study was made by Frank P. Theroux under the direction J. E. Cotton who was at that time Director of public service in Miami. Most of the work on this survey was concentrated in the areas which in the above classification were considered highly polluted. No work was done as far north as the 79th Street Causeway and very little was done south of the Miami River. A copy of the conclusions reached in the report of this investigation is included herewith.

CONCLUSIONS

This investigation of Biscayne Bay is by no means complete. Many points might well bear further study. It is realized that conclusions now drawn may be modified by further study. It would seem that the following conclusions are supported by results obtained:

1. That the waters of Biscayne Bay are polluted by the Miami River discharge and the discharge of numerous sewer outfalls along the Bay front.
2. That the pollution exists only close to shore and the degree of pollution decreases rapidly as the distance from the Miami River and sewer outfalls increases.
3. That purification of the sewage is affected within the Bay itself and that unpurified sewage or other contaminating material does not pass out of the Bay.

It would seem that Bay waters, except possibly close to sewer outfalls, are not appreciably depleted in dissolved oxygen by the sewage from the City of Miami. Because of the complicated movement of the waters of the Bay due to tide, channel and wind effects, it is difficult to determine with any degree of security just how much sewage the Bay waters can care for without creating a nuisance in the Bay and vicinity. At least several times the present values of sewage can be cared for readily by the Bay waters without nuisance if well distributed and the coarser and floating solids removed by screening or sedimentation.

An investigation was made of the off-shore condition from Miami River south to Tahiti Beach. Bacteriological samples were taken at points near the shore on three trips during October 1927. Another trip was also made in January 1927. The results of these four trips show gross pollution as far south as 17th Road and slight pollution from that station to Tahiti beach. This report recommends further sampling studied in the Tahiti area.

IX. DISCUSSION

Attention must be called to the fact that this survey was conducted in 1928. At that time the population was considerably less than it is at the present time and the portion of the city in which sewers were available was considerably smaller. It is therefore reasonable to assume that conditions are worse at the present time than at the time of this survey,

X. SCOPE OF PRESENT SURVEY

In addition to physical factors, and a sanitary survey effecting the whole Bay, a number of bacteriological samples were obtained from the two areas which were of particularly importance in this survey. These areas were defined by the location of two bathing places. One of these areas hereinafter referred to as the northern area was located due to the presence of a bathing lagoon at the Miami Military Academy. This bathing place is a small land-locked lagoon approximately 1.7 miles north of the 79th Street Causeway. In order to determine the extent of pollution in this area sampling stations were established in the intercoastal waterway channel beginning at the 79th Street Causeway and running north to west shore of the Bay as shown on the accompanying map. Six sets of samples were taken in this area under varying tidal and wind conditions as given in the attached table. Bacteriological results are shown on the attached sheet.

Area No. 2 or the southern was fixed by the presence of a large bathing lagoon and beach at Tahiti Beach about two and one-half miles south of Dinner Key and about opposite Cape Florida. This is a public bathing places and has quite a large number of bathers during warm weather. Sampling stations in this area were located to show (1) the concentration of pollution in the bathing waters. (2) The source of pollution affecting the area, if any. (3) The path pollution from the highly polluted waters of the northern part of the area. Thus Station 101 is in the pool. Station 103 is at the Bay entrance to the pool. Station 102 is in the Coral Gables Canal just north of the pool. Station 104 is close to shore, about opposite the southern most sewer in Coconut Grove. Station 105 is at the shore end of a dredged channel running at right angles to shore. Station 106 is at the sea end of this channel. Station 107 is at the sea end of another channel, south of the first one. Station 108 is approximately half way between Station 107 and the Coral Gables Canal. Tide, weather conditions, and bacteriological results are included herewith.

XI. LABORATORY METHODS

Bacteriological analyses were made in the Miami Branch of the State Board of Health Laboratory. They were made by plating out suitable portions of the samples on nutrient agar and incubating for twenty-four hours at 37 °C and by inoculating a series of lactose broth fermentation tubes with portions of the samples and incubating 48 hours at 37 °C. The smallest portion showing positive fermentation was then streaked on Eosine Methylene Blue Agar and incubated at 37 °C for 24 hours for confirmation of colon-aerogenes group. the lactose broth series used consisted of 5 - 10 mL portions, 1 - 1 mL, and 1 - 0.1 mL portion. The results of these tests are summarized on the attached data sheets. The count on nutrient agar is given as the total count per milliliter. The results obtained by fermentation tubes are given as the most probable number of colon-aerogenes organism per 100 mL as listed in the American Public Health Association publication "Standard Methods for Water Analysis". All laboratory report sheets are on file with the Chief Engineer, State Board of Health.

DATA SHEET
NORTHERN AREA BISCAY BAY
Miami Military Academy
(1938 - 1939)

Date	Dec. 20 _____	Mar. 15 _____	Mar. 20 _____	Mar. 22 _____
Tide	High	High and slack	Low and falling	High and rising
Wind	SE	West - 8 mph	NE - 15 mph	East - 10 mph
Weather	Clear	Clear	Clear	Clear

Station Most probable number coli-aerogenes per 100 mL and average

	Most probable number	Total count per mL	Most probable number	Total count per mL	Most probable number	Total count per mL	Most probable number	Total count per mL
1	-	-	5.0	12	5.0	14	38	19
2	-	-	2.2	7	2.2	26	2.2	10
3	-	-	0	11	0	15	5.0	15
4	-	-	0	13	4.4	18	5.0	9
5	0	8	0	3	2.2	14	0	4
6	2.2	5	0	9	0	7	0	14
7	0	11	0	18	0	15	0	27
8	0	7	0	16	0	10	0	10
9	0	14	5.0	22	240	48	0	15
10	0	7	0	74	240	68	0	8
11	240	71	0	13	5.0	14	0	12
12	-	-	0	11	2.2	8	0	38

Date	Mar 28 _____	Mar. 29 _____	Average _____
Tide	Medium low and rising	High and rising	
Wind	SE - 10 mph	SE - 5 mph	
Weather	Clear	Clear	

Station Most probable number coli-aerogenes per 100 mL and average

	Most probable number	Total count per mL	Most probable number	Total count per mL	Most probable number	Total count per mL
1	8.8	12	-	-	14.2	14
2	240	17	2.2	Unc.	49.7	15
3	8.8	22	0	13	2.5	15
4	2.2	13	0	Unc.	2.3	13
5	0	7	0	-	0.4	9
6	0	53	0	-	0.4	17
7	0	9	0	-	0	16
8	0	134*	0	-	0	11
9	8.8	33	0	17	42.3	25
10	0	24	0	12	40.0	32
11	2.2	81	0	83	41.2	61
12	-	-	0	50	0.51	26

* Not used to compute average.

DATA SHEET
SOUTHERN AREA BISCAY BAY
Tahiti Beach
(1938 - 1939)

Date (1938)	Dec. 20 _____	Mar. 14 _____	Mar. 21 _____	Mar. 23 _____
Tide	Falling	Low and falling	High and falling	Medium high falling
Wind	SE	Slight	E - 10 mph	East - 10 mph
Weather	Clear	Clear	Clear	Clear

Station Most probable number coli-aerogenes per 100 mL and average

	Most probable number	Total count per mL	Most probable number	Total count per mL	Most probable number	Total count per mL	Most probable number	Total count per mL
101	240	22	15	Unc.	0	85	0	10
102	240	58	15	25	240	175	5.0	5
103	38	11	12	22	38	106	0	36
103	15	45	0	19	38	14	0	12
104	7.6	5	0	37	0	11	0	10
106	0	6	0	20	0	12	0	8
107	38	13	240	30	0	5	0	9
108	15	47	0	21	0	20	-	-

Date (1938)	Mar 28 _____	Mar. 29 _____	Average _____
Tide	Very high and falling	Very low and rising	
Wind	SE - 10 mph	SE - 5 mph	
Weather	Clear	Clear	

Station Most probable number coli-aerogenes per 100 mL and average

	Most probable number	Total count per mL	Most probable number	Total count per mL	Most probable number	Total count per mL
101	0	53	2.2	Unc.	42.8	42
102	0	11	5.0	28	84.2	50
103	0	45	0	14	14.7	39
104	0	9	8.8	39	10.3	23
105	0	Unc.	0	Unc.	1.3	15
106	0	33	0	22	0	13
107	0	17	2.2	16	46.7	15
108	0	Unc.	2.2	9	3.4	24

XII. DISCUSSION BACTERIOLOGICAL RESULTS

It will be seen from the attached data sheets that bacteriological results substantiate the conclusion reached from the sanitary survey that little pollution is reaching the area north of the 79th Street Causeway and that pollution around Tahiti Beach is quite spasmodic and casual. It seems from these tests that there is more pollution reaching both areas from adjacent drainage canals than from sewage polluted waters.

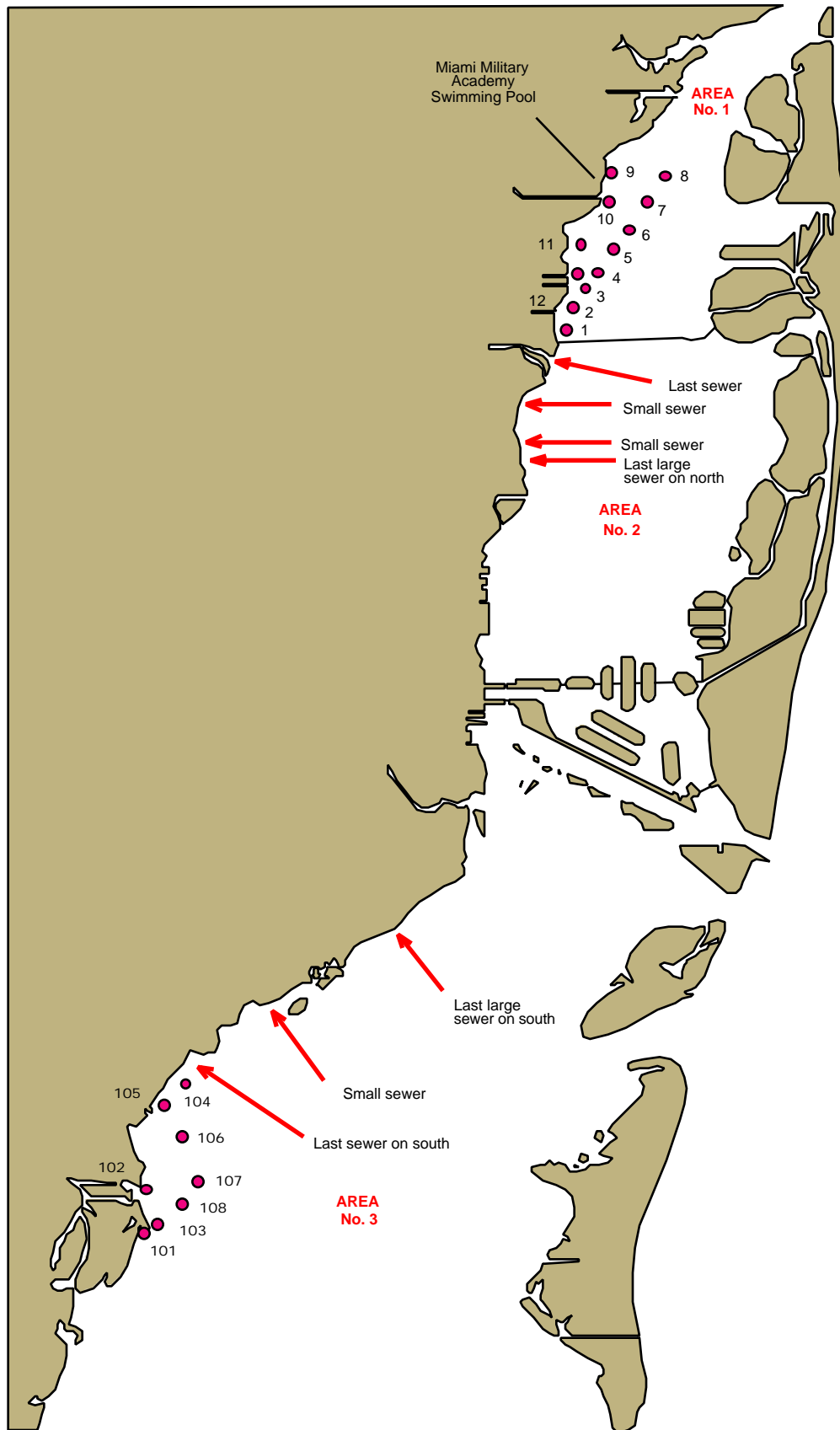
The waters in the northern area seem to be fairly free from pollution under all tidal and wind conditions experienced during sampling. It is believed that the 79th Street Causeway will prevent serious contamination of this area even under extreme adverse weather conditions.

The southern area seems rather doubtful. While at present most of the pollution found is believed to be coming from the Coral Gables drainage canal, it is possible under extreme weather conditions that the highly polluted waters in the northern part of the Bay may be swept down on the area under examination. Since the waters in the Tahiti Beach Pool not only carry the pollution present in outside waters but also pollution added by the considerable number of swimmers which use this pool, the writer believes this pool to be of questionable quality.

Tahiti Beach is owned by the City of Coral Gables and leased to private operators [THIS WAS MARKED "Error" IN PENCIL IN THE ORIGINAL.]. It represents considerable investment and there is no doubt that considerable opposition will be encountered if it is found necessary to close the Beach either at present or at a later date. However, there are a number of places somewhat similar in nature where large scale disaffection has been resorted to for protection of swimmers. It is believed that such an arrangement would be practical in the case of Tahiti Beach. For example chlorine could be added to the water at the mouth of the lagoon on rising tides or a low lift pump could be installed to pump sufficient chlorinated waters into the land end of the pool to cause a flow out of the mouth of the lagoon at all times. Some bathing beaches have been chlorinated by the use of a boat running back and forth along the beach distributing chlorine. Regardless of the final decision on this survey, it is recommended that some such method of purification be devised to protect this bathing area.

XIII. CONCLUSIONS AND RECOMMENDATIONS

1. It is believed that the waters north of 79th Street Causeway are sufficiently free from pollution at the present time to permit establishment of properly constructed and operated bathing places.
2. It is believed that small lagoons with narrow openings in areas of small tidal fluctuation do not provide sufficient dilution water to care for any considerable number of bathers.
3. It is believed that the waters adjacent to Tahiti Beach are of doubtful sanitary quality and it is recommended that some method of protection for the waters in the bathing pool be resorted to if Tahiti Beach or any other large public bathing pool of this nature is to continue to operate, it be sampled at frequent intervals for analysis by the State Board of Health.
4. The area between 79th Street Causeway and a line between Dinner Key and Cape Florida is receiving constant pollution which in many places reach high concentrations. It is therefore recommended that this area be closed to swimming and the citizens warned not to use the Bay in this area.
5. It is evident that pollution problems in Biscayne Bay will continue to grow worse until some definite steps are taken to properly dispose of Miami's sewage.



Pollution studies in Biscayne Bay