THE MARINE LABORATORY
University of Miami

57-8

Progress Report

February, 1957

POLLUTION STUDIES IN BISCAYNE BAY DURING 1956

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTES OF HEALTH
Under Grant RG-4062(C3)

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SUMMARY

1. A method for the Warburg BOD analysis of sediments is described. Eighteen sets of 5-day data representing the full range of values for Biscayne Bay were obtained. From this work, a relationship between 3-hour and 5-day results was found by semi-log graphical analysis that applied to the data with reasonable accuracy. This indicated that a synoptic picture of the entire study area might be produced from 3-hour data alone. This was done for 67 stations.

2. Preliminary analysis of the 3-hour BOD data shows:

a. maxima in areas of highest pollution

b. minima in areas isolated by hydrography from pollution centers, with the important exceptions that low values occurred an shallow bars in highly polluted areas where current velocities are high

c. intermediate values indicating that substantial organic deposition has occurred in central parts of the bay where currents are weakest.

3. Data on specific gravity, moisture content, appearance and particle size distributions were obtained at the above 67 stations. A figure is presented showing the distribution by specific gravity of sediments at these stations. Values below 1.30 occurred under two conditions: (a) at scattered points, usually in natural settings adjacent to the Miami shoreline; and (b) in a midbay area between and adjacent to the MacArthur and Venetian Causeways. The data show that these areas constitute zones of degradation due to the combined effects of dredging, island building and pollution. The remaining isolines indicate gradations in general conformity with the hydrography and bottom topography of the area.

4. A method for adaptation of the millipore field kit (H-D Endo medium) to studies of the coliforms in sediments is outlined. Representative data on results are presented. Indications from this and other experiments are that the coliform densities in both sediments and waters are substantially less since activation of Miami's new sewage treatment plant.

5. Figures on the abundance of bottom plants and Macroinvertebrates indicate: (a) sharply limited abundance of algae within formerly heavily polluted areas adjacent to the Miami shoreline and in the midbay degradation area, plus comparatively great abundance of phanerogams in a north midbay area which received comparatively large amounts of organic materials; and (b) minimal abundance of macroinvertebrates in degradation zones adjacent to the Miami shoreline and in a midbay degradation area, plus maximal abundance adjacent to the most polluted parts of the bay where water movement is rapid.

6. A new method for synoptic study of fouling organisms is described whereby plastic coated stakes are exposed and the plastic later removed for microscopic examination. A summary of results at 43 stations is presented indicating: (a) association of tube-building amphipods with the most highly polluted parts of the bay; (b) association of green and blue-green algae with cleaner waters of the bay; and (c) association of barnacles with neither polluted nor clean waters selectively. Continuing studies on exposed glass panels are described.

INTRODUCTION

Activation of the Miami Sewage Treatment Plant took place between approximately September 18 to December 15, 1956. During the period covered by this report (March, 1956 to February, 1957), emphasis has been on obtaining all possible data defining conditions in the bay before complete activation of the plant.

Under terms of the grant supporting this works there are two immediate objectives:

1. Continued development of the Warburg BOD method for muds, the aim being to achieve greater accuracy, greater simplicity, and additional data bearing directly on development of an accurate, rapid standard method applicable to all non-toxic organic wastes.

2. Continued development of semiquantitative bottom and fouling methods, the aim being to demonstrate specific biological criteria for measuring degree of pollution.

Manometric methods were proposed because:

1. Results should help to define the pollutional status of the sediments for correlation with hydrographic, chemical, bacteriological and biological data;

2. Information would be provided on the mechanism and effects of organic deposition throughout the area;

3. The Warburg method is well adapted for studying the dynamics of the BOD reaction;

4. Adaptation of B0D to sediments has not been attempted previously.

The Warburg apparatus was made available for this work by Dr. C. E. Lane of The Marine Laboratory staff.

Progress toward development of semi-quantitative bottom and fouling biological methods will be covered in the final section of this report.

I. BOTTOM STUDIES

A. General

Sixty-seven stations have been studied, located as shown in Figure 1. Their number and location should permit direct comparison with all past studies of the area.

The preliminary analyses presented below emphasize zonation of the sediments in the study area by: (1) pollutional status (Warburg BOD); (2) Physical characteristics (specific gravity, moisture content and gross appearance); and, (3) abundance of plants and animals. These three points will receive separate treatment,

Figure 1. Station Locations and 1 fathom contour line.

B. Warburg BOD of Sediments

The BOD test has long been used to establish the pollutional status of waters and industrial wastes. Its application to sediments seems to be limited to studies on: (1) benthal decomposition, by Fair, E. W. Moore and Thomas (1941); (2) methods, by Ruchhoft and W. A. Moore (1940); and, (3) oxygen consuming capacity of benthal microorganisms, cited by Zobell (1946).

In recent years, manometric BOD methods have been developed and proposed, tentatively, as standard methods for water analysis (A.P.H.A., 1955). Application of these methods to sludges and muds is mentioned as a possibility.

In this work, past experience indicated probable locations of maximum and minimum BOD values. Eighteen gets of 5-day data were obtained throughout this range. From this work, the relationship between 3-hour and 5-day results was studied. A relationship between the two was found that applied to the data with reasonable accuracy. This indicated that a synoptic picture of the entire study area might be produced from 3-hour data alone. This was done for 67 stations.

1. Field Methods. A coring device developed for this work is shown on the left in Figure 2. it consists of a standard plastic coring tube (length 10.5 in., O.D. 2 in., thickness 1/16 in.) secured to a cylindrical length of wood by three brass supports. Wing nuts through the wooden cylinder permit detachment of the tube and from a length of calcutta bamboo. The device has been used to a depth of 30 ft. Resting on top of the plastic coring tube is a sponge rubber ball. A precise fit between ball and tube was obtained by gentle grinding with fine sandpaper between the ball and the tube. A wire through the ball was attached to a piece of light line at the top (to prevent loss in the field) and to a small lead weight at the bottom (to give the ball weight). Not shown in the figure but essential to the use of the device is a plunger made by fitting a rubber stopper to the end of a dowel about 1 ft. long. Mud samples were extruded upward by use of the plunger for removal from the top end of the tube. Samples representing approximately the topmost 1 in. of sediment were used in all cases. Refrigeration of samples in transit was not attempted although care was taken to keep samples in the shade. The time from sampling to first reading of the Warburg averaged about 2.5 hours.

2. Laboratory Methods. Since the displacement volume of mud can be determined accurately, the immediate objective was delivery of a precise volume of mud to the reaction vessels. This was done by transferring small quantities of the vigorously mixed mud into a pipette containing a known quantity of sterile sea water (millipore). The pipette was made from a 2-mL automatic micropipette graduated at 0.1-mL intervals. The lower end was cut 1.6 mm above the tip to make a tip diameter large enough to allow passage of sand and small shell fragments. The upper and was cut so as to leave an effective internal volume of 1.3 mL. A stand was made for the pipette from a small rubber stopper and surgical tubing so that the pipette could be placed upright on the work table with the tip end sealed against loss of water. Routinely, 0.5 mL of sterile sea water was delivered to the pipette using a syringe. An equal quantity of mud was then transferred from the sample bottle using a small spatula, maximum width 2 mm. It was found that large sand and shell particles simply dropped off this small spatula, and that the presence of small polychaetes and other macroinvertebrates could be detected and eliminated from the samples.

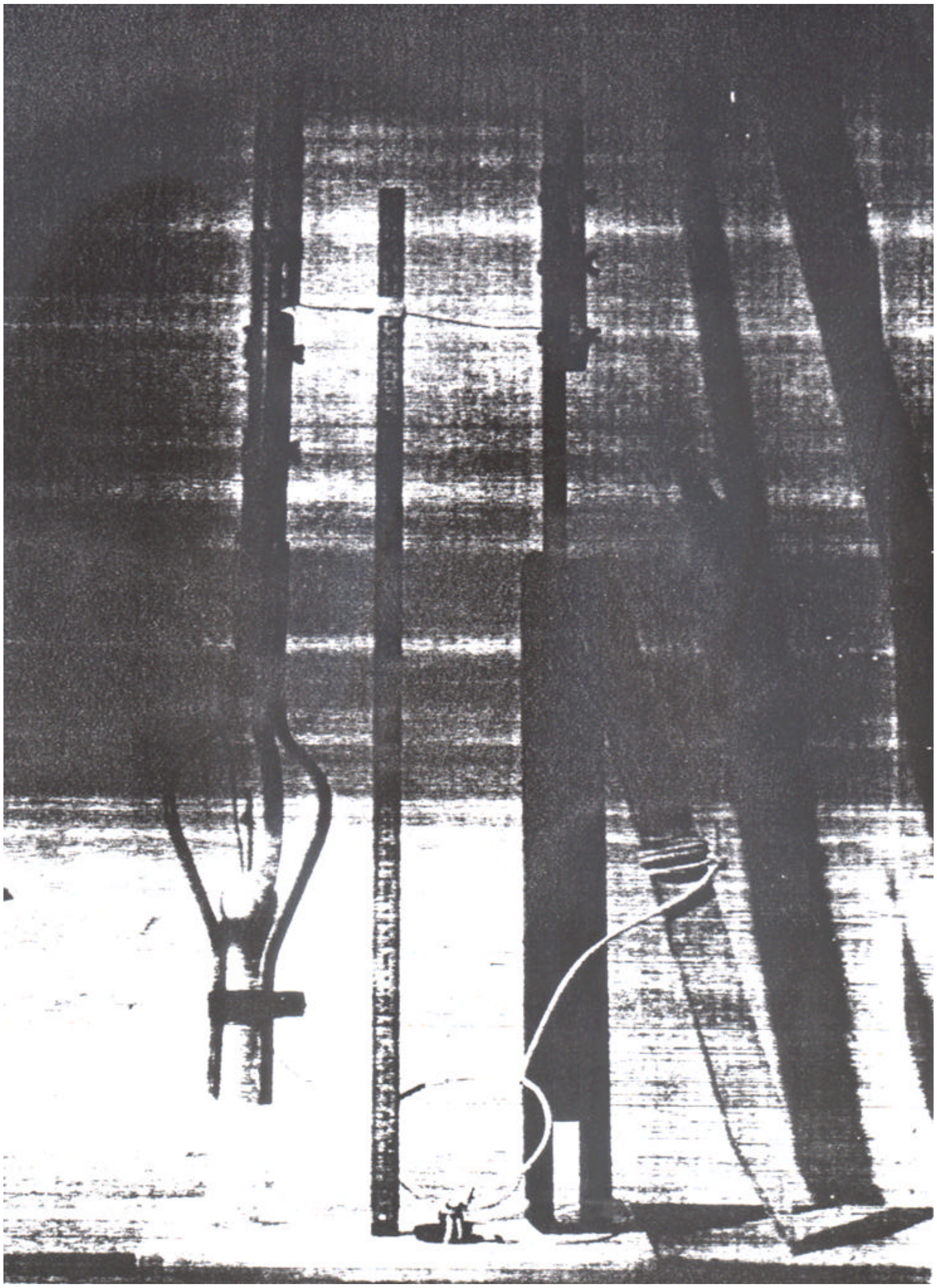

Figure 2. Core sampler (left) and stake driver with stake (right). [SCAN OF FIGURE IN ARCHIVE COPY.]

By placing the index finger over the top of the pipette, removing it from its base and inserting the tip Inside the reaction vessel, simply lifting the finger and prodding contents of the pipette with a piece of wire delivered the mud sample to the reaction vessel. The pipette was than refilled with sea water to rinse the pipette and bring contents of the reaction vessel up to the calibrated sample volume of 2.0 mL.

The size of the reaction vessels was approximately 7 mL capacity. After addition of 0.2 mL of 10% KOH and small pieces of fluted filter paper into the KOH wells, the vessels were attached to the manometers and the test was ready to begin. A 2.0 mL sample of the same water was used in the thermobarometer. All tests were run at 25 °C (the approximate temperature in nature); shaking rate was adjusted to 100 per minute. Only 10 to 20 minutes were allowed for equilibration before taking the first reading.

Readings were taken at 1, 2 and 3 hours on all samples; additional readings were taken as convenient for the 5-day samples. None have been run past 5 days to date. Calculations were made using the basic formula proposed in Standard Methods except with "h" in mm, "k" in µL per mm, and "V" in mL, the formula becomes:

$$\frac{mg}{L}\ BOD = 1.430\ \frac{k}{V}\ h.$$

3. Results, 3-Hour BOD. The 3-hour BOD data are summarized in Figure 3. Approximate linear isolines drawn in the geometric series 125, 250, and 500 ppm permit dividing the area into 4 zones, as shown. Full discussion must await publication of hydrographic results. At this time it is possible only to point out the most obvious relationships with pollution. Maxima occurred in areas of highest pollution. Minima occurred in areas isolated by hydrographic from pollution centers, with these important exceptions: values of only 37 and 53 ppm occurred an shallow bars in highly polluted areas at stations 704 and 16, respectively, where current velocities are high. Intermediate values, notably the high values in midway between Venetian and 79th Street Causeways, indicate organic deposition in central parts of the bay where currents are weakest.

4. Results, 5-Day BOD. The data were graphed on semi-log paper using the method of Orford and Ingram (1953). Two distinct phases were observed at the beginning and at the end of the 5-day reaction; these plotted as essentially straight lines. Between them, the points described a curve which seems to represent components of both "straight-line" phases. Following the interpretation of Hoover, Jasewicz and Porgos (1953), the initial and final stages seem to represent "growth" and "endogonous respiration" phases, respectively.

A method of estimating the 5-day from the 3-hour BOD is illustrated in Figures 4 and 5. This involved:

(a) determination of the average starting time from available 5-day data, found to be 0.0158 days (this was used as the base point for subsequent semi-log constructions since deviations from this point followed no pattern consistent with other data);

(b) extrapolation of the initial growth phase curve determined by the straight line of best fit through point (a) above, and the observed two- and three-hour BOD values;

(c) extrapolation of the "endogenous respiration" curve back to its intersection with (b) above;

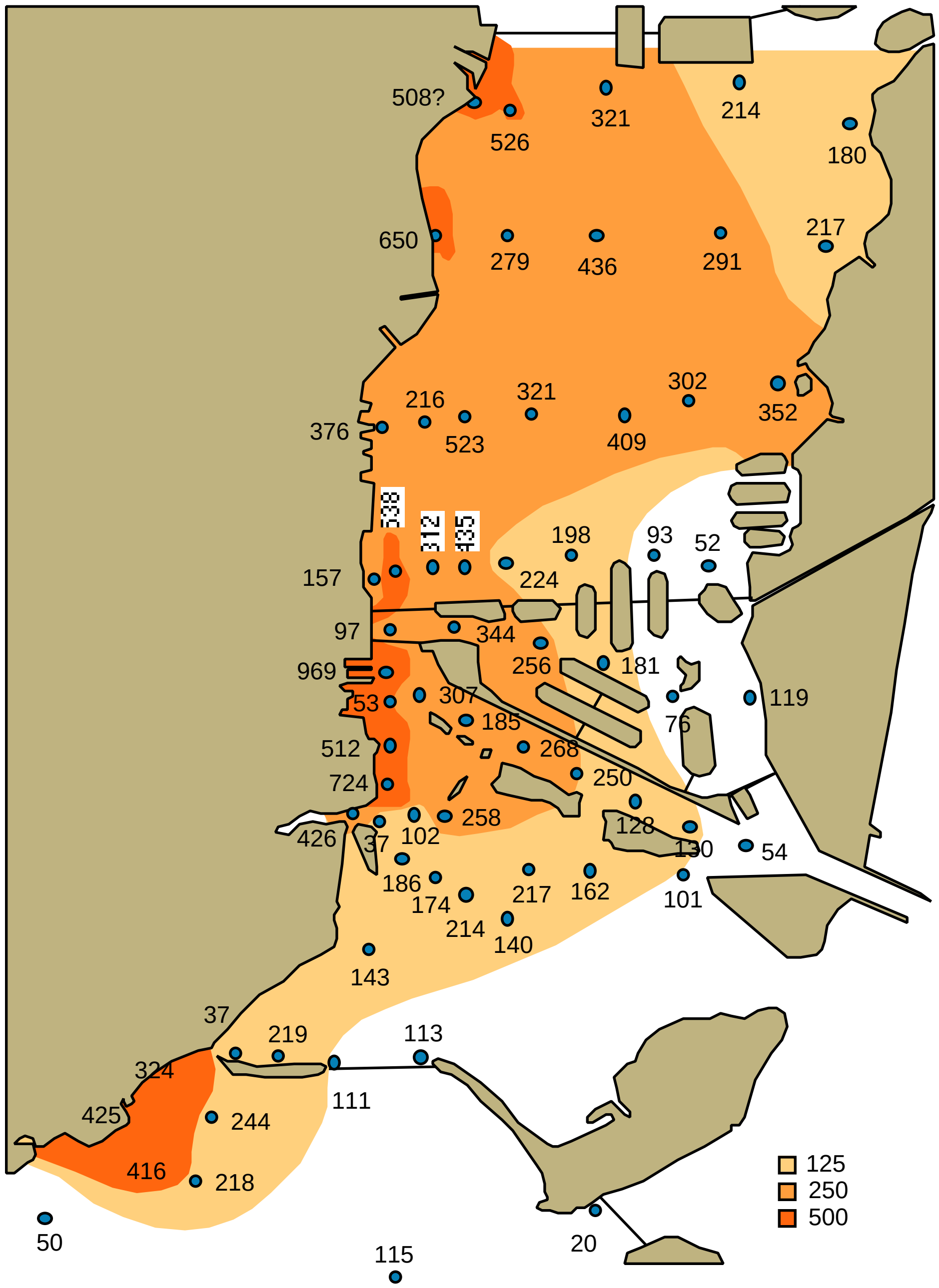

Figure 3. 3-Hour BOD of sediments (mg/L).

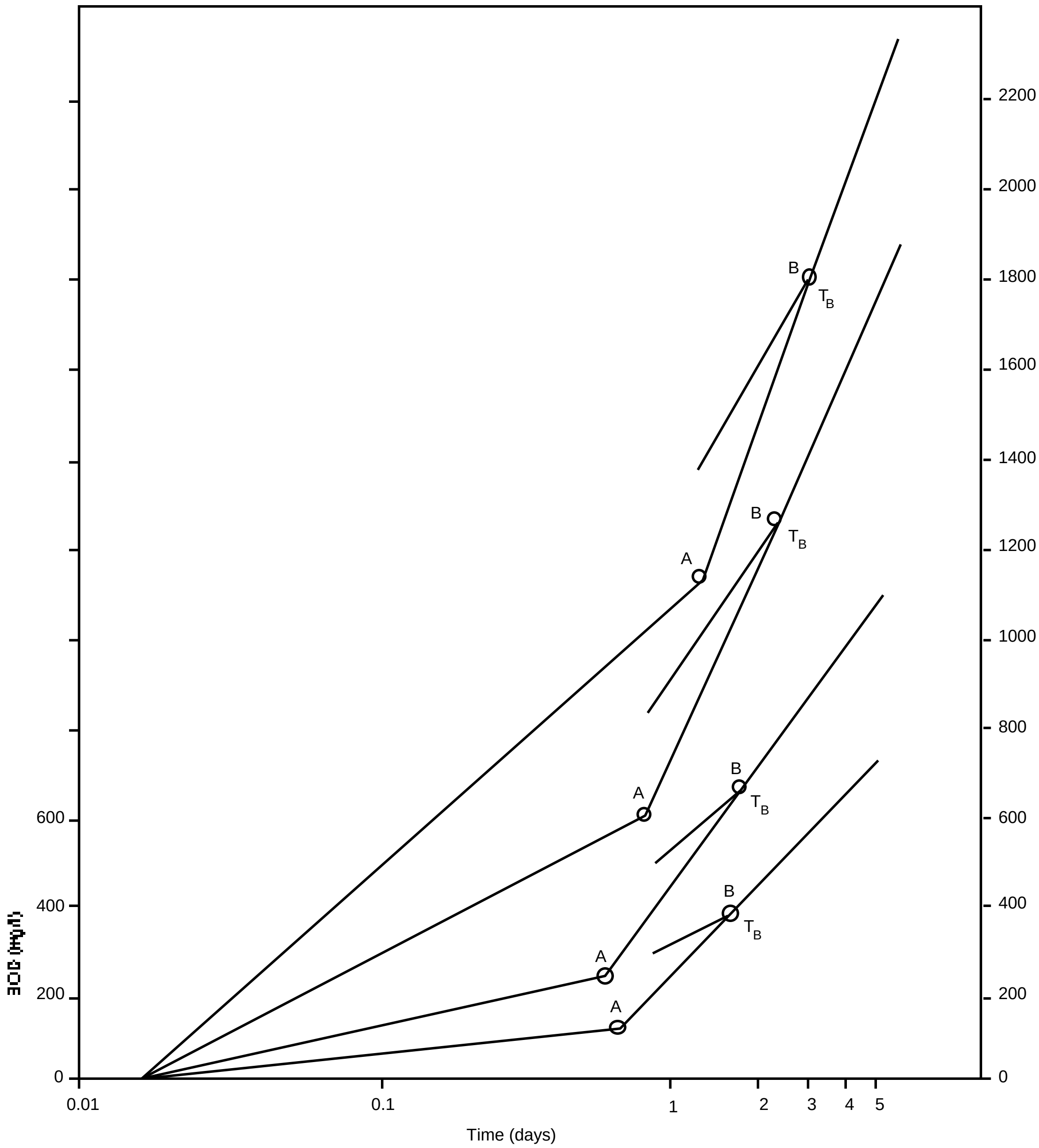

Figure 4. Semi-log plot of representative data to illustrate construction and points used to estimate 5-day BOD from 3-hour BOD.

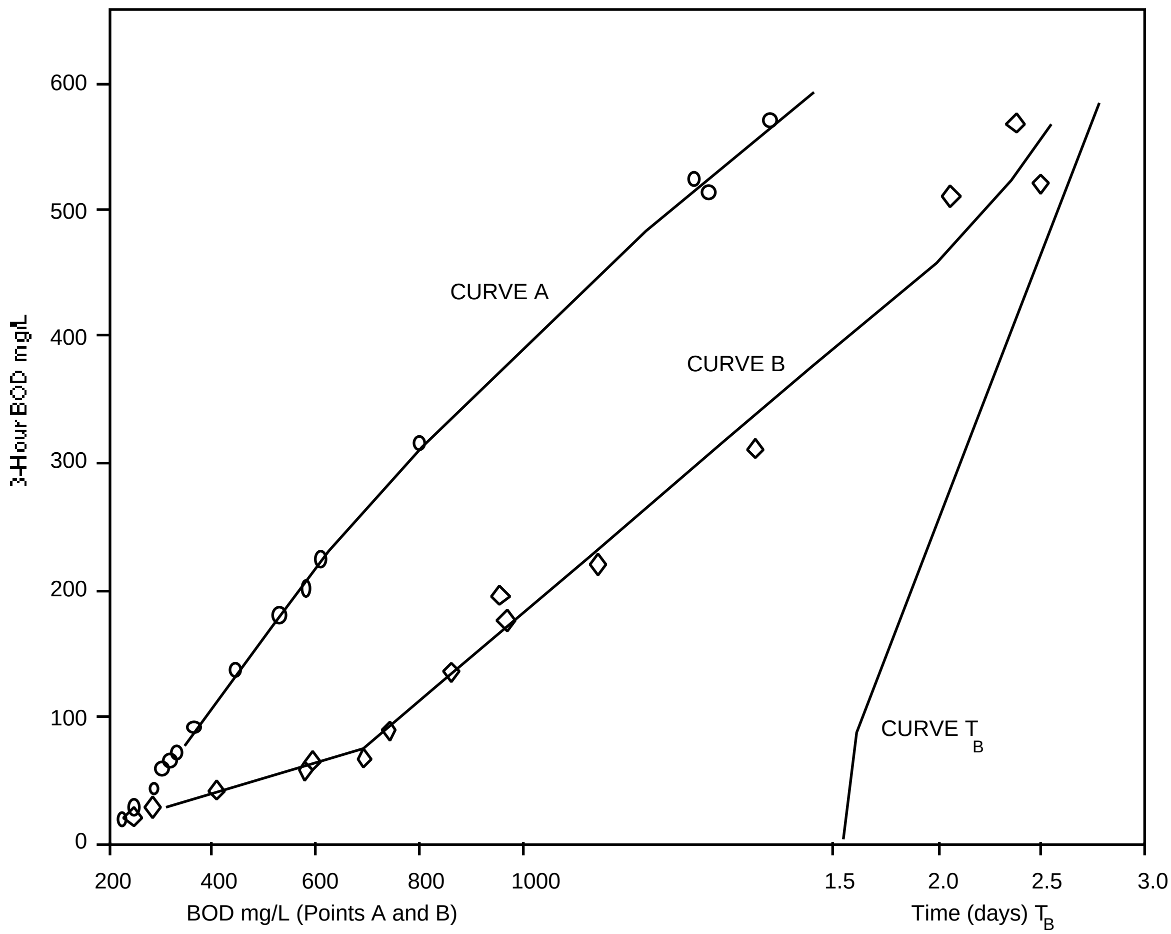

Figure 5. "Calibration" curves for estimating 5-day from 3-hour BOD.

TABLE I. SUMMARY OF OBSERVED AND ESTIMATED 5-DAY BOD OF SEDIMENTS FROM BISCAYNE BAY, FLORIDA

Station	Observed 5-Day BOD mg/L	Estimated 5-Day BOD mg/L	Percent Deviation
16	551	480	12.9
704	833	720	13.6
1001_1	734	780	6.3
$1001_{1/2}$	857	915	6.8
66_1	1090	1020	6.4
$66_{1/2}$	1120	1110	0.9
704E	1150	1225	6.5
20	1150	1280	11.3
77	1420	1340	5.6
605	1810	1700	6.1
603	2140	2250	5.1
502	2320	2250	3.0
401	2220	2300	3.6

(d) estimation of the time at which the "endogenous respiration" phase begins, influenced by the preceding part of the reaction (this point was estimated graphically by plotting the time at which the "endogenous respiration" phase first plots as an essentially straight line).

The numerals in Figure 4 illustrate the above discussion. Also shown in the figure are points "A", "B" and "T_B". These three points taken from 15 sets of 5-day data are plotted in Figure 5. The resulting three curves constitute rough "calibration" curves for estimating of 5-day from 3-hour data in four steps as follows:

(a) enter Figure 5 with the 3-hour values; determine the equivalent BOD from Curve A;

(b) repeat for Curve B;

(c) repeat for Curve T_B, time equivalent of Curve B;

(d) on semi-log paper, construct the line of best fit through base time (0.0158 days) between the 2- and 3-hour observed data; extrapolate this line to BOD "A"; plot point B, T_B; connect points A and B., continuing the line to its 5-day intercept and record.

Table I gives the observed and estimated 5-day values for 23 sets of data (the same data used in Figure 5).

Since the standard deviation of sewage BOD data ranges from 3 to 10 per cent (cited by Orford and Ingram, 1953) and other large undetermined errors are present (field sampling, procedural), the practical question arises: For purposes of classifying the muds of a bay as to pollutional status by the BOD method, is there sufficient increase in accuracy of the 5-day Warburg BOD compared to a 3-hour BOD to warrant the additional weeks of the required to do job? To date, practical necessity and some experimental evidence have indicated a negative answer. Such fundamental topics as procedural standardization, ultimate oxygen demand, and benthal decomposition have been deferred, although preliminary work has been done. These subjects have been discussed with other members of The Marine Laboratory staff and with Walter R. Lynn, Assistant Professor of Civil Engineering, University of Miami.

C. Specific, gravity, Moisture Content and Appearance of Sediments

All Warburg BOD samples were also examined for specific gravity, moisture content, appearance and particle size distribution. [RESULTS ARE LISTED IN TABLE II.] The objective was to produce usable synoptic data from small samples, sample size being limited by the time spent on field work.

The method used for specific gravity and moisture content tests was to deliver precisely 2 mL of freshly mixed mud to dry vials calibrated for that volume, then weigh, dry, and weigh again. Wet sievings for particle size determinations were done for all stations using Tyler standard screens having mesh openings of 2.0, 1.0, 0.500, 0.246, 0.125 and 0.062 mm. Analyses are incomplete. Tests for volatile material have not been made although samples are available for this determination.

Figure 6 shows the distribution by specific gravity of sediments throughout the area. Values below 1.30 occurred under two conditions: (1) at scattered points, usually in natural settling basins, adjacent to the Miami shoreline; and, (2) in a midbay area between and adjacent to the MacArthur and Venetian Causeways. These areas constitute zones of degradation due to the combined effects of dredging, island building and pollution. The remaining isolines indicate gradations between these extremes in general conformity with the hydrography of the area.

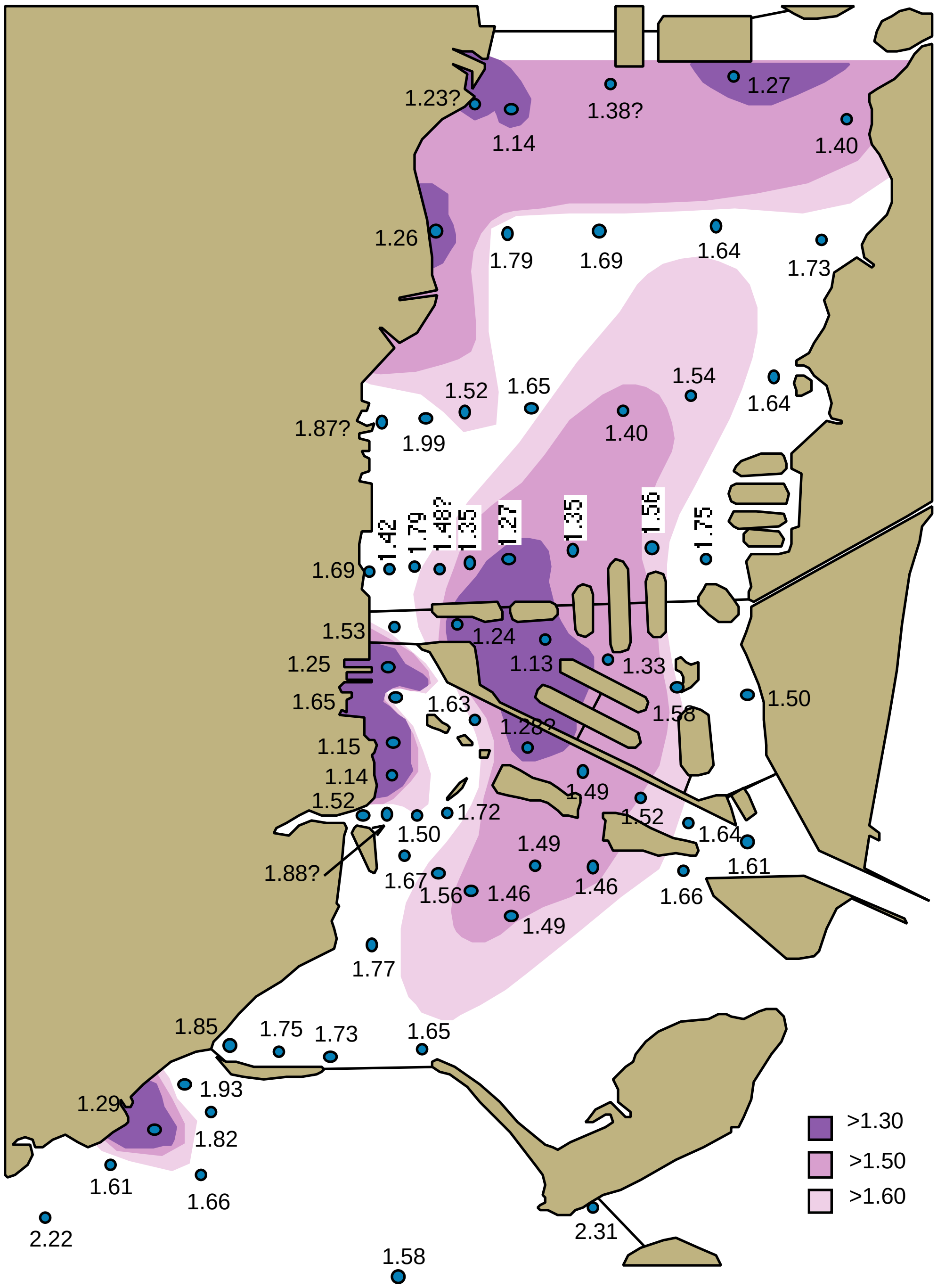

Figure 6. Specific gravity of sediments. [SOME CONTOUR LINES MISSING IN ORIGINAL FIGURE.]

TABLE II. SPECIFIC GRAVITY, MOISTURE AND APPEARANCE OF SEDIMENTS IN BISCAYNE BAY, FLORIDA.

Sta.	Specific gravity	Moisture Content (per cent)	Appearance	
			Type	Color
6	1.28	71.1	sft M & S	bk
47	1.14	72.2	sft M & S	bk
47E	1.38	61.6	sft M & S	lt gy
87E	1.27	59.8	sft M & S	lt gy
87	1.40	53.4	sft M & S	lt gy
7	1.26	71.4	sft M & S	bk
48	1.79	40.1	hrd S, brk Sh, M	gy
48E	1.69	46.0	hrd S, brk Sh, M	gy
88W	1.64	45.4	hrd S, brk Sh, M	lt gy
88	1.73	35.7	hrd S, brk Sh, M	lt gy
10	1.87	31.1	S, M & brk Sh	dk gy
10E	1.99	29.7	S, M & brk Sh	dk gy
51	1.52	46.4	hrd M, S & brk Sh	dk gy
51E	1.65	41.0	hrd M, S & brk Sh	gy
304	1.40	54.1	hrd S, M & brk Sh	lt gy
305	1.54	44.2	hrd S, M & brk Sh	gy
306	1.64	39.8	hrd S, M & brk Sh	gy
401W	1.69	32.6	hrd S, M & brk sh	gy
401	1.42	45.8	sft M & S	bk
402	1.79	26.8	hrd M & S	gy
402E	1.48	41.7	hrd M & S	dk gy
403W	1.35	50.0	sft M & S	gy
403	1.27	62.2	sft stk M	lt gy
404	1.38	57.8	sft stk M	lt gy
405	1.58	34.9	hrd S & Brk Sh	yl-gy
406	1.75	32.1	hrd brk Sh & S	yl-gy
501	1.53	41.0	hrd S & M	gy
502	1.24	57.5	sft M & S	gy
503	1.13	67.2	sft stk M	lt gy
504	1.33	52.6	sft M & S	gy
505	1.58	44.3	hrd M & S	gy
506	1.50	45.7	hrd S & M	ly gy
15	1.25	69.9	sft stk Oz	bk
16	1.65	32.0	hrd S & M	gy
17	1.15	75.0	sft stk M	dk gy
18	1.14	60.1	sft stk Oz	dk gy

TABLE II. SPECIFIC GRAVITY, MOISTURE AND APPEARANCE OF SEDIMENTS IN BISCAYNE BAY, FLORIDA (CONT.).

Sta.	Specific gravity	Moisture Content (per cent)	Appearance	
			Type	Color
603	1.26	57.0	sft stk M	gy
604	1.63	37.0	hrd S, M & brk Sh	gy
605	1.28	54.0	hrd S, M & brk Sh	gy
606	1.49	48.0	hrd S, M & brk Sh	gy
607	1.52	40.9	hrd S, brk Sh & M	lt gy
608	1.64	37.2	hrd S, brk Sh & M	gy
609	1.61	30.7	hrd S, M & brk Sh	gy
703	1.52	36.2	hrd S & M	bk
704	1.88	24.0	hrd S	yl-gy
704E	1.50	38.3	hrd S M & brk Sh	gy
706	1.72	27.9	hrd S M & brk Sh	dk gy
708	1.49	39.7	hrd S M & brk Sh	lt gy
709	1.46	41.4	hrd brk Sh, S & M	gy
710	1.68	35.8	hrd brk Sh, S & M	gy
20	1.67	38.7	hrd S & M	gy
21	1.77	36.7	S & M	gy
20E	1.58	39.0	S & M	gy
73W	1.46	39.4	hrd S & M	lt gy
73	1.49	40.6	hrd S & M	lt gy
801	1.85	30.0	hrd S & M	gy
802	1.75	28.6	S & M	dk gy
803E	1.73	27.2	S & M	gy
77	1.65	36.7	brk Sh & M	lt gy
901NE	1.82	31.4	hrd S & M	bk
901NNE	1.93	27.3	hrd S & M	bk
901	1.29	73.6	sft stk Oz	bk
902	1.88	35.5	hrd S, M & brk Sh	gy
901S	1.81	38.4	sft M & fne S	bk
1001	2.22	25.5	hrd S	gy-yl

Abbreviations:

M	Mud	sft	soft
Oz	Ooze	hrd	hard
S	Sand	dk	dark
Sh	Shells	lt	light
brk	broken	bk	black
stk	sticky	gy	grey
fne	fine	yl	yellow

D. Coliform organisms in Sediments and Waters

The writer assisted with a short study of the survival of coliform organisms during the early period of treatment plant activation. This was Grant E-1347, Dr. Ernest S. Reynolds, senior investigator. The writer's assistance included: (1) participation in and direct responsibility for all field work; (2) joint attempts with Dr. Reynolds to adapt the millipore field kit to coliform determinations on mud samples; and, (3) direct cooperation with State and county public health officers in assessing the improvement to bay waters during activation of the new treatment plant.

Since a complete report on the coliform survival project is still being written, the following information is included with permission of Dr. Reynolds as an indication only of what is occurring in the bay.

Using MF kit, H-D Endo and sterile distilled water, the field procedure was as follows: (1) place 1 mL (by displacement) of freshly collected mud in a 15-mL centrifuge tube and dilute to 10 mL; (2) shake vigorously; (3) centrifuge for 1 min with portable hand centrifuge at 1500-2000 rpm; (3) decant supernatant; (4) repeat steps 1-3 twice, combining the supernatant from the three washings; (5) run 10, 1 and 0.1 mL portions of the supernatant through the millipore, add the medium, incubate and in 18-24 make the counts.

Table III gives results obtained at four stations. The October and November experiments were done near the middle of the period that the treatment plant was being put into operation. Raw sewage and septic tank wastes were still being discharged in the vicinity of the four stations. The January experiment was done about a month after the plant went into full operation.

Following conferences which included Dr. T. E. Cato, Dade County health commissioner, Mr. Robert L. Quick, resident sanitary engineer of the Florida State Board of Health, Dr. Reynolds and the writer, a number of water samples for the Dade County Health Department were collected while making regularly scheduled field trips. In all, 48 samples from 6 stations were collected during the period November 1-14, 1956 through November 28, 1956. Reports received from the Health Department indicated a considerable decrease in water coliforms compared with counts at the same or similar stations in past years.

Thus, there is evidence that coliform counts in both the sediments and the waters of the bay have decreased markedly due to activation of the new sewage treatment plant.

E. Macroorganisms

Sixty-four stations were sampled for microorganisms between May and August, 1556. A Petersen grab, which samples about 0.074 sq. m., was used, three samples per station. Two high school students volunteered for field assistance. They are Jonathan Baskin and Scott McCowen, both of Coral Gables, Florida. Their help plus generous assistance of Robert F. Burrows of The Marine Laboratory with day-to-day logistics problems greatly facilitated the program.

Mud samples were washed in a box containing monel screens with aperture size about 0,7 mm. Organisms were sorted, preserved and later catalogued and numbered. A sizable reference collection has developed, the full value of which is to be evaluated as the next step. It contains at least one example of virtually every common benthal macroorganism in the study area.

TABLE III. TEN MILLIPORE FIELD KIT COUNTS OF COLIFORM ORGANISMS IN SEDIMENTS BEFORE AND AFTER FULL ACTIVATION OF MIAMI SEWAGE TREATMENT PLANT.

Station	Date	Tide*	Number of Colonies per mL of mud (H-D Endo)	Per Cent Difference
401	10/24/56	F2	486	
	1/11/57	E1	138	-71.6
16	10/22/56	F4	356	
	11/1/56	E2	432	
	1/11/57	E1	178	-50.0 to -58.8
18	10/23/56	F3	243	
	1/11/57	E1	65	-73.3
703	10/23/56	F3	4100	
	11/1/56	E2	1080	
	1/11/57	E1	300	-72.2 to -92.7

*Tide Designators: F, Flood tide
E, Ebb tide
F2, Sampled during 2nd hour of flood tide
E1, Sampled during 1st hour of ebb tide, etc. Based on U. S. Coast and Geodetic Survey Tide Table times, Miami Harbor Entrance corrected for tidal difference at Miami City Yacht Basin (plus 1 hr. 40 min.).

Figure 7 shows the abundance in mL displacement per 3 Petersen grabs of algae and phanerogams taken in this survey. Representative genera are indicated. A beginning toward elaboration of the floral communities has been made with the generous assistance of Dr. Robert E. Williams of the University of Miami Botany Department.

The figure shows only the most general relationships, most outstanding of which are: (1) the limited abundance found within formerly heavily polluted areas adjacent to the Miami shoreline and in the midbay degradation area; and, (2) the great abundance of phanerogams in the north midbay area. Since the bottom BOD data indicate that this area has received abundant organic materials (other factors being favorable as well), it seems likely that pollution has had a beneficial effect on the productivity of this north midbay area.

Figure 8 shows abundance in number of individuals per 3 Petersen grabs of the macroinvertebrates. Three trends are shown: (1) minimum abundance in the degradation zones adjacent to the Miami shoreline and in the midbay degradation zone adjacent to causeways and islands; (2) maximum abundance adjacent to the most polluted parts of the bay (near the Miami shoreline from the Miami River, Stations 703 and 704, northward to about NE 20th Street, near Station 402B, where water movement is rapid; (3) areas of intermediate abundance

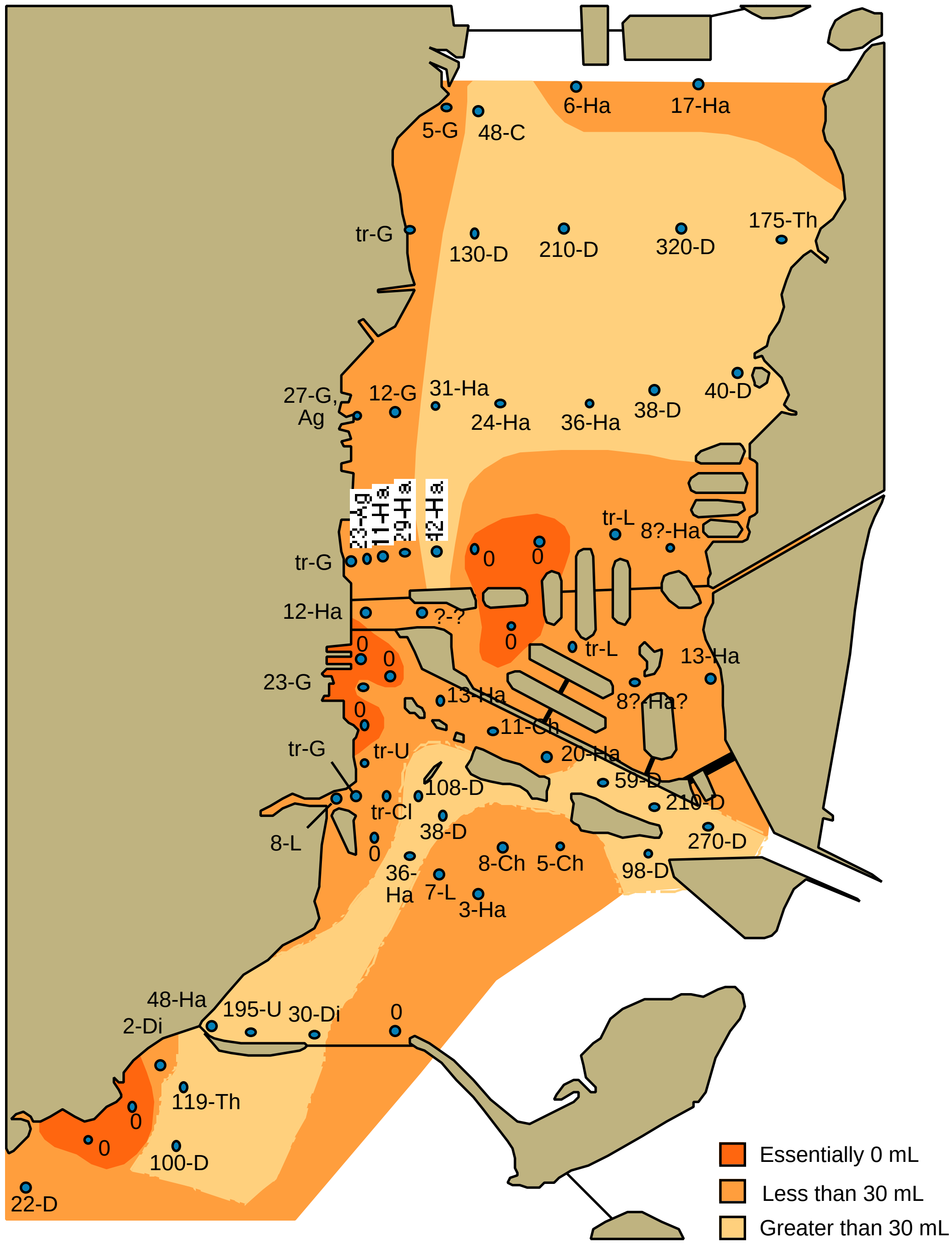

Figure 7. Abundance of bottom macroflora (in mL displacement volume per 3 Peterson grab samples). [AREA OF VALUES GREATER THEN 30 ML NORTH OF FISHER ISLAND NOT CONTOURED IN ORIGINAL DOCUMMENT.]

Representativ genera:

Ag	*Agardhiella*	D	*Diplanthera*	L	*Laurencia*
C	*Cymodocea*	Di	*Dictyota*	Th	*Thalassia*
Ch	*Chaetomorpha*	G	*Gracilaria*	U	*Ulva*
Cl	*Cladophora*	Ha	*Halophila*		

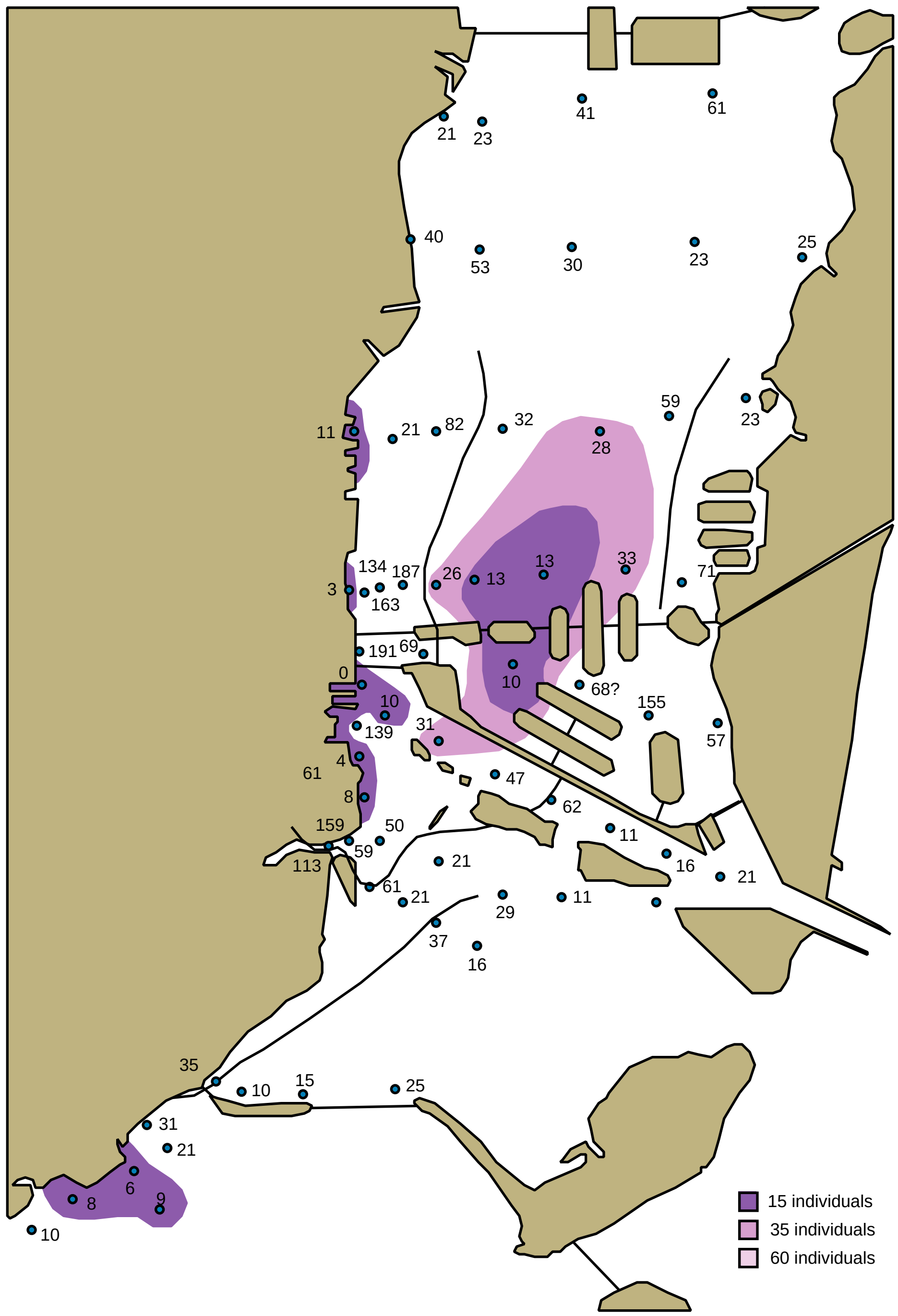

Figure 8. Abundance of bottom macroinvertebrates. [SOME CONTOURS WERE MISSING.]

between these extremes related to the hydrography, topography and bottom characteristics of the area. Here again, description of community structures is a continuing objective. The helpful assistance of Dr. Hilary B. Moore, Assistant Director of The Marine Laboratory, and Dr. Gilbert L. Voss, Curator of the Invertebrate Museum, The Marine Laboratory, is gratefully acknowledged for the preliminary work done.

II. FOULING STUDIES

Progress toward obtaining a synoptic picture of fouling throughout the study area has been made using two methods: (1) monthly change of glass panels at 14 stations; and, (2) planting of stakes at 57 stations throughout the bay.

Analyses and evaluation of the glass panels has been delayed by bottom work. The preserved samples represent a series that is essentially complete for 14 months covering the period before, during, and after activation of the treatment plant. There are qualitative and quantitative data extending back to March, 1954, plus the results of preliminary experiments from several months previous to the above date. Direct comparison of panels exposed during the next few months can be made with panels exposed at the same stations last year. This has been done, gross comparisons only, and the evidence is that only in the Miami River mouth has there been a significant change since last year. This change is mainly an increase in the abundance of barnacles at a station (703) where barnacle settling was previously light during comparable months.

The stake experiment was devised for these reasons: (1) to provide comparative data at precisely the same stations used in bacteriological, chemical and bottom work; (2) to try a new method which, due to concealment, would not suffer from the depredations of vandals.

On the right of Figure 2 is the stake driver and a stake. The bottom end consists of a wooden housing which supports the stake loosely. Removable lengths of 2" x 2" lumber permitted adjustment of total length to required depth. It was used successfully to 20 ft. The stake is a standard surveyor's stake attached to a length of plastic line. This line is sold at hardware stores under the trade name "Cordite" and is manufactured for use as a plastic clothesline. At least 20 ft. per stake was used. A weight (2 to 5 large iron washers) attached to the bitter end of the plastic line kept the line submerged and facilitated snagging of the line for later recovery. Attached at the top of the stakes were strips of calendeted (roughened) Vinylite, 1/10,000 in. thickness for subsequent removal and examination under a microscope.

In the field, a fix was carefully taken on convenient objects before planting the stake. Fifty-seven stations were covered in two days. Recovery was made using a length of iron pipe to which 4 or 5 three-pronged gaff hooks were attached. This object, fitted with a bridles was towed over the bottom in the vicinity of the stake and in 13 passes (average) snagged the plastic line permitting recovery of the stake. The recovery rate was 84%.

The experiment ran for two weeks only in September in order to show initial attachment of dominant fouling organisms before activation of the treatment plant. Figure 9 shows abundance of tube building amphipods, predominantly of the genera *Erichthonius* and *Corophium* at 43 stations. Their association with the most highly polluted parts of the bay, suggested by panel experiments, was thus confirmed. Figure 10 shows the reduced abundance of green and blue-green algae within the heavily-polluted areas. Typical genera are *Entoromorpha*, *Ulva*, *Cladophora*, *Chaetomorphas* and *Lyngbia*. A community of these organisms is clearly associated with cleaner water in Biscayne Bay. Barnacle attachment showed no clear relationship with pollution, as indicated in Figure 11. The areas of greatest abundance occurred along both the

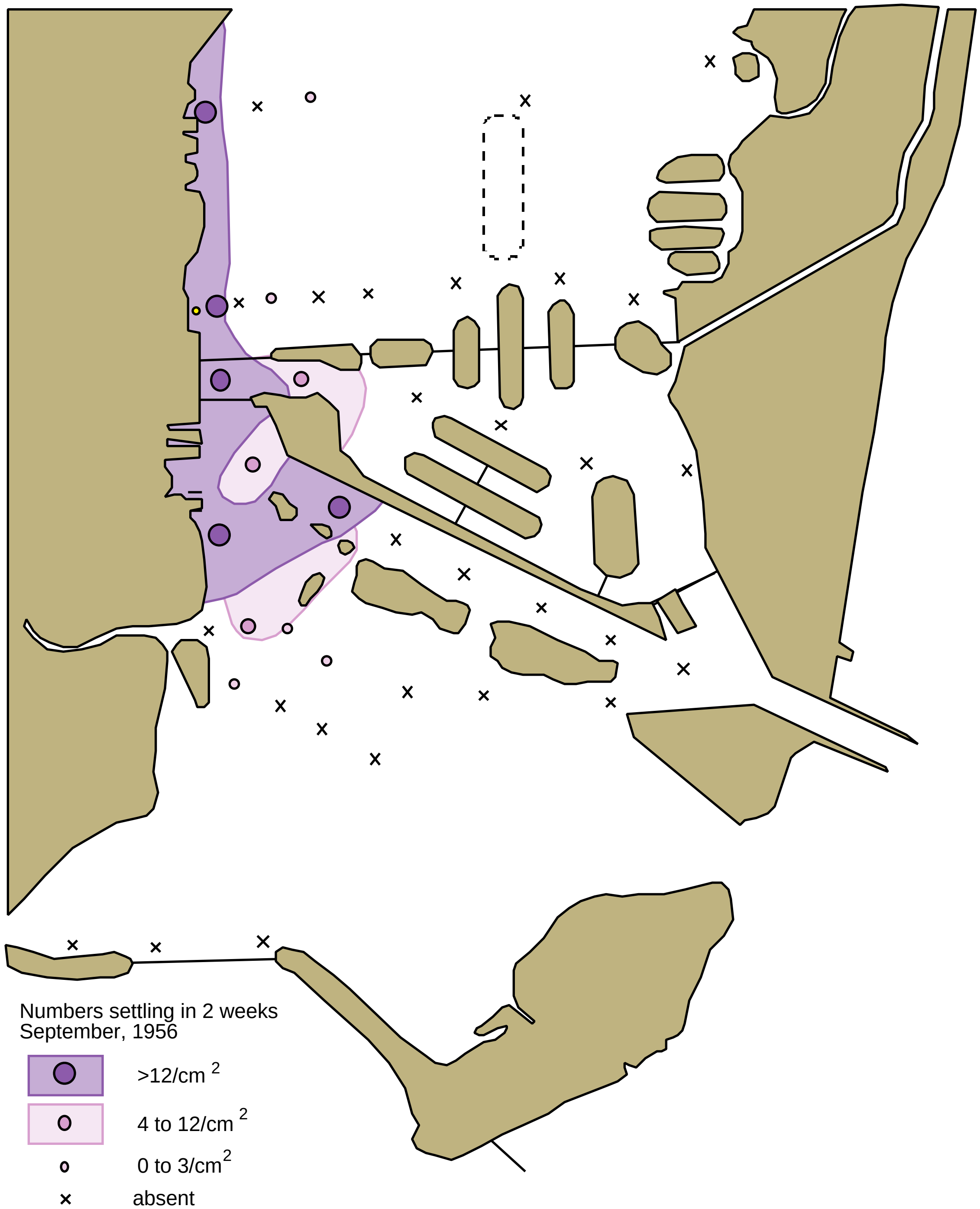

Figure 9. Amphipod abundance, stake exp't.

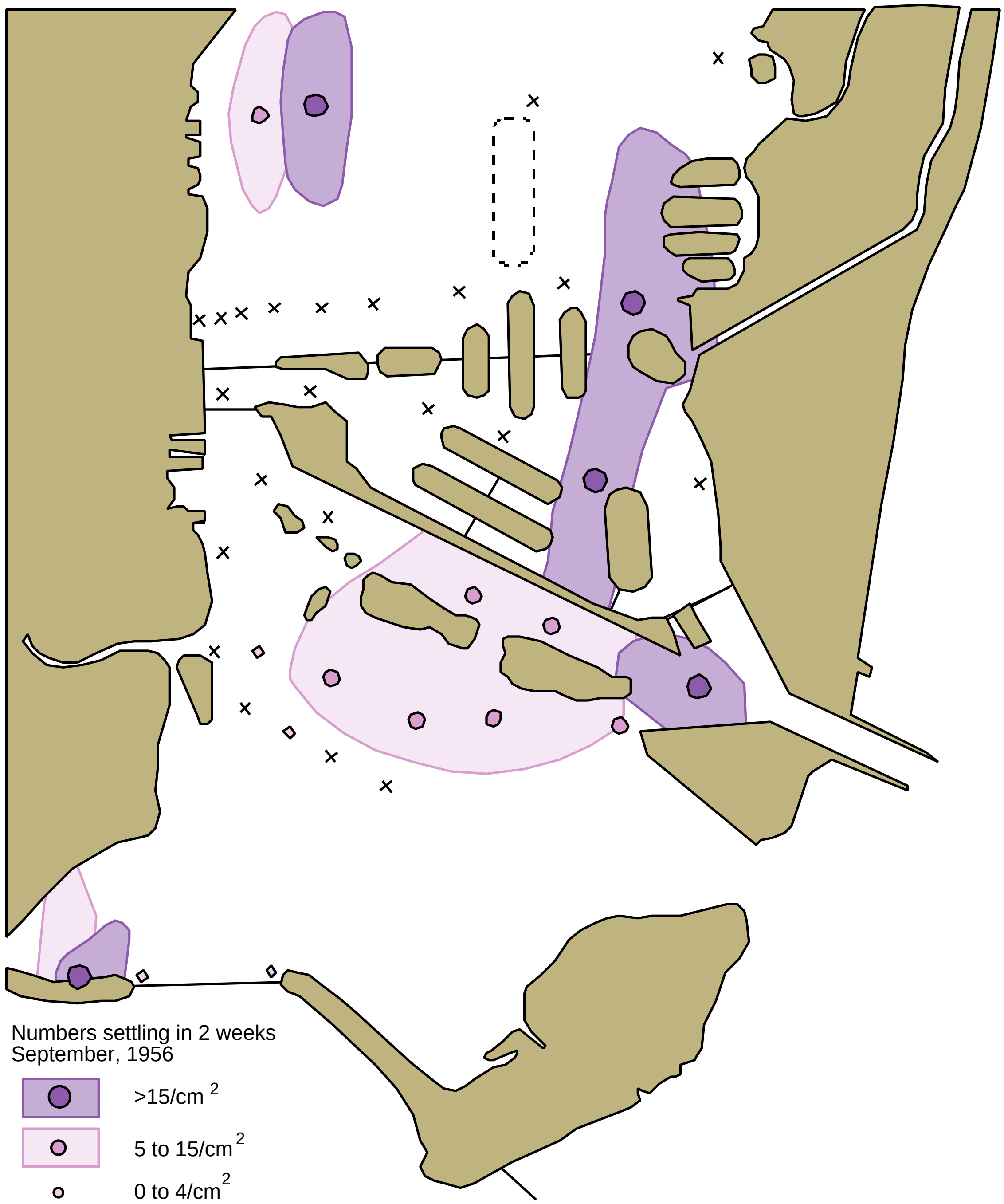

Figure 10. Abundance of green and blue-green algae - stakes.

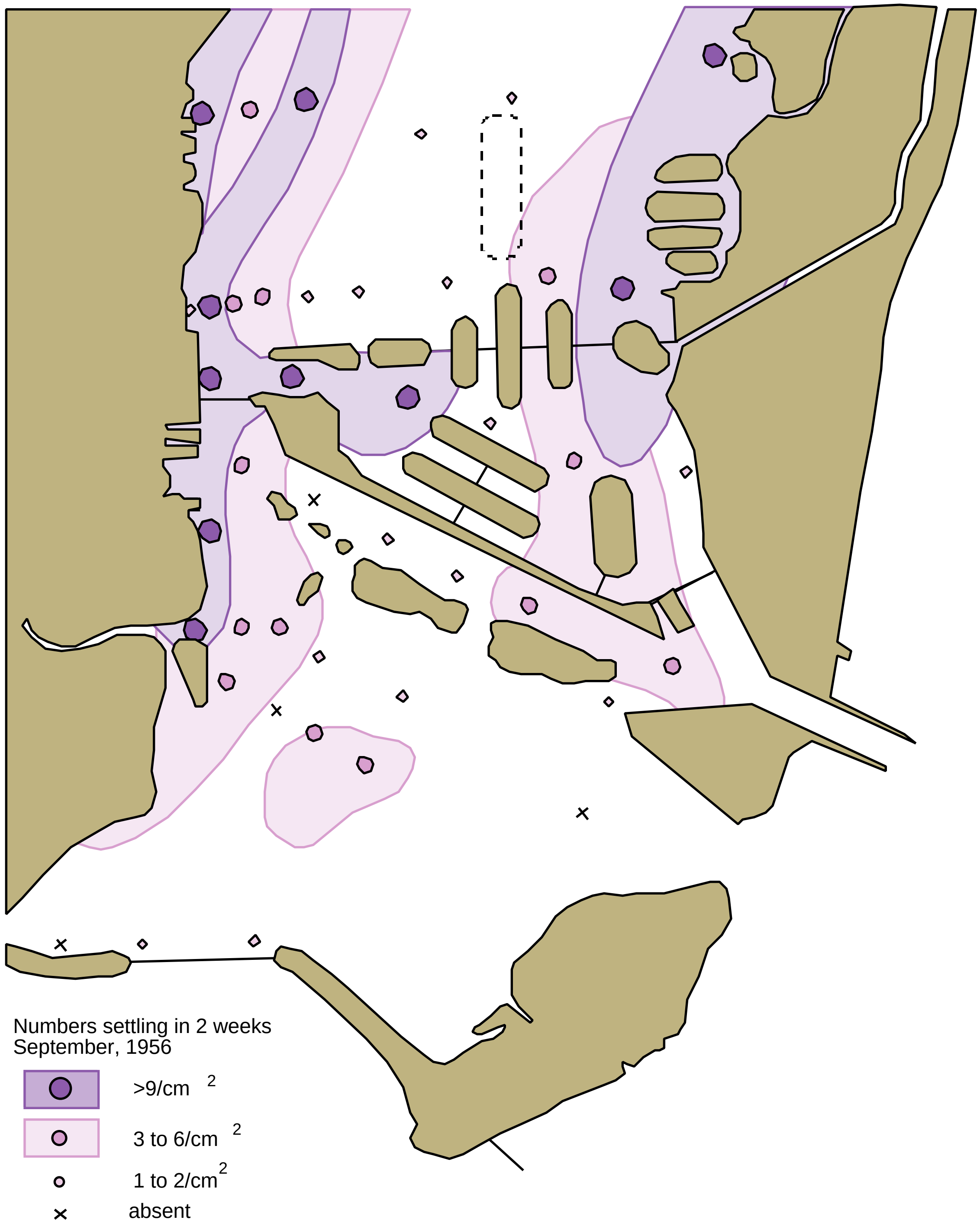

Figure 11. Barnacle abundance, stake exp't.

Miami and Miami Beach shorelines, and seemed to reflect primarily available surface areas provided by docks, boats and sea walls. The species are *Balanus improvisus* Darwin, *B. eburneus* Gould, and *B. amphitrite niveus* Darwin.

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