Acc#2093

JOB REPORT

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Project No. M-2-R-2 Date 15 January 1961.

Project Name: Biological Survey of Area M-2.

Period Covered: November 1959 to November 1960. Job No. E-2

Hydrographic and Climatological Data for Area M-2

Objectives: To make a hydrographic and climatological study in Area M-2 and determine the effects on marine fauna and flora (Figure I). A chemical and physical analysis was run on water samples collected at stations in the area.

Procedures: Surface water samples were collected by submerging a collecting bottle in water by hand over side of the boat. Subsurface water samples were collected by means of the Nansen reversing water bottle. Surface temperatures were recorded at the time the surface water samples were collected. Bottom temperatures were taken with a reversing thermometer attached to the Nansen bottle at the time the bottom water samples were collected. All the water samples were subjected to chemical and physical tests to determine the conditions that exist in the bay during this time. Turbidity was determined by the Lumetron Colorimeter and the pH was checked with the Beckman pH meter. The dissolved oxygen concentration of the bay water was determined by the Unmodified Winkler Method. All water samples were titrated with silver nitrate to determine the salinity. Data were collected in conjunction with Job No. A-2, B-2, and C-2. Hydrographic and climatological data collected at the Seabrook Field Laboratory were also used in conjunction with this report.

Findings: Climatological Data

Climate: Precipitation: The total rainfall, observed at the Seabrook Field Laboratory, for the period of one year of this project was 31.4 inches. This was an average of 2.6 inches per month. A graph of the monthly precipitation record for Area M-2 is presented in Figure II. August 1960 was the month of greatest precipitation with 10.4 inches and April 1960 had less than one inch of rain according to the rain guage at the Seabrook Field Laboratory. Precipitation records per month for the ten principle cities on the Galveston Bay-Trinity Bay watershed are presented in Table 1. This information was taken from the Climatological Data of Texas.

Air Temperatures: This was the important factor in determining the water temperatures in Area M-2; therefore both subjects will be covered in the following discussion. Figure III shows the close correlation between the average air and average water temperatures per month. The air and water temperature show a rise in November and then a slow decline during December, a fairly constant low through January and February, then the temperature starts upward and continues to climb until attaining a peak in July. The temperature begins to decline in August and continues a constant drop through October.

Wind: Wind speed and direction were the important factors in determining the tides and tubulence in Area M-2. The gravitational pull of the sun and the moon affect the tides very little, but the wind, on the other hand, change the tide as much as two to three feet in several hours. If the wind blows from a northerly direction, the water level drops due to the water being pushed out of the bays into the Gulf, but when the wind switches to a southerly direction the tides begin to rise rapidly. The wind not only influences the tide levels in the bay, but it also aids in flushing and forcing high salinity water back into the bay. Wind speed and direction were recorded at the Seabrook Field Laboratory twice a day. At the end of each month the average monthly wind speed and prevailing wind direction were determined. This data is presented in Table 2.

Hydrographic Data

Tides: The normal tide amplitude in Area M-2 was found to be very small, but a "norther" or a strong wind from a southerly direction could cause the tides to vary several feet above or below the normal. As a rule, the tide level was recorded morning and evening at the Seabrook Field Laboratory. All tide level readings were based on the mean sea level and are presented in Table 3 which gives maximum and minimum tides for each month.

Salinity: Upper Galveston and Trinity Bays show two characteristics common to most Texas bays; a horizontal salinity gradient and a vertical salinity gradient in the deep channel in the bay. The horizontal gradient is directly influenced by the rivers, creeks and bayous that constantly pour varying amounts of fresh water into the bay and the vertical salinity gradient is due to the intrusion of the heavy high salinity water moving along the bottom of the ship channel from the Gulf and the lighter fresher bay water flowing over the high salinity water.

By dividing the area into two separate bay systems, Trinity and Upper Galveston Bay, the horizontal salinity gradient is easily followed. Trinity Bay is separated from Upper Galveston Bay by a line from Smith Point to Houston Point. The salinity in this bay is influenced by the Trinity River, Cross Bayou, Double Bayou and Lone Oak Bayou. The Trinity River generally controls the salinity more than the three bayous in the area. Only in December, 1959, did Lone Oak and Double Bayou lower the salinity in the bay more than the Trinity River. The salinity, Table 4, shows that Cross Bayou has the least effect on the salinity conditions in Area M-2. The salinities in this bay were generally low at the mouth of the Trinity River and increase as you move southeast toward Red Fish Island.

The salinity pattern in Upper Galveston Bay is influenced by the Houston Ship Channel, Cedar Bayou and Clear Creek. This bay generally shows a horizontal salinity gradient as you move from Morgan Point southeast toward Red Fish Island. Table 4 shows the salinity patterns in both bays for each month of this project.

The vertical salinity stratification was observed in the Houston Ship Channel all months of this study. Frequently the bottom salinity would more than double the surface salinity. This was due to the intrusion of the heavy high salinity gulf water along the bottom of the channel and a surface flow of the lighter fresh water out of the area.

Salinity samples were collected every week of the year either at hydrographic or trawl stations in Area M-2. An average surface and bottom salinity per month were calculated for the entire area and graphed in Figure V. The highest average monthly salinity for Area M-2 occurred in June 1960 and the lowest average monthly salinity occurred in January 1960. Check the effects of precipitation on the salinity by referring to Figure II and Table 1.

Dissolved Oxygen: Tests were run to determine the dissolved oxygen concentration in Area M-2 twice a month. This was done in conjunction with the trawl sampling to check pollution and the plankton blooms that were common occurrences in the area this year. Periods of lowest dissolved oxygen concentration occurred from June to September 1960. This was during a period of high water temperatures that lowers the capacity of the water to dissolve oxygen and also during a flooding of the ship channel into the area bringing water with a high bio-chemical oxygen demand. The area of lowest dissolved oxygen concentration during this study was the Houston Ship Channel and the area adjacent to the channel at Morgan Point. This was also the area of the majority of the fish kills in Area M-2 this year. Figure VI shows the average monthly dissolved oxygen concentration in Area M-2 during this project year.

pH: The pH was recorded bimonthly at all stations in Area M-2. This was done to determine the effects of the channel water and various plankton blooms in the bay. All water samples were brought to the laboratory at Seabrook for analysis. A deviation would be expected in the pH over this time lapse, but any drastic changes were considered to be abnormal. It was found that during periods of ship channel water in the bay, the pH usually dropped below 7 indicating the foreign material was acidic. If a plankton bloom was in the bay the pH usually jumped to 8 or 9.

Turbidity: Water samples collected for trawl and hydrographic data were checked with the Lumitron Colorimeter to determine the percentage of transmittance of light. Averages per month were calculated and presented in Figure VII. November 1959, May 1960 and September 1960 were periods of clearest water in the bay. Winter months were the most tubid due to the strong north winds that were prevalent at this time. The highly turbid condition of the bay water is the main limitation on marine growth in Area M-2. Wind and siltation from the watershed areas were found to be the main factors causing the highly turbid conditions in the bay.

Sediment: All sedimentation data presented here is taken from the "Report on Galveston Bay" by the Corps of Engineers in 1942.

"The volume of Trinity River sediment entering Galveston Bay in suspension in an average year has been determined at 11,750,000 cubic yards."

"The volume of the San Jacinto River sediment entering Galveston Bay in an average year has been determined at 1,300,000 cubic yards."

"For the remaining tributary area of 1,275 miles square, the amount of sediment entering the bay has been determined on the basis of the San Jacinto River record and in the ratio of the respective areas; the volume of sediment entering the bay from these secondary sources has been determined at 200,000 tons or 420,000 cubic yards."

"The total volume of river sediment carried in suspension into Galveston Bay in an average year is 6,354,800 tons or 13,470,000 cubic yards."

"More than 98% of this amount enters the upper bay and less than 2% enters the lower bay."

Houston Ship Channel Survey

A station was established at Mk. 122 on the Houston Ship Channel to check the effects of the channel water, with the industrial waste, on the marine life of the area. This station was sampled bi-monthly and hydrographic data recorded. Hydrographic data pertaining to the ship channel is presented in Figure VIII.

Out of twenty-four trawl collections made on the channel this year, five collections made in April, July and August show the ship channel to be barren. During these particular months the dissolved oxygen concentration was never over 2.3 o/ooo.

Twenty-seven vertebrate species were collected at Mk 122 during the year. This was a total of 210 vertebrate animals or less than 1% of the vertebrates collected in Area M-2.

Only six invertebrate species were collected at Mk 122 this year. From the few invertebrates compared to the number of vertebrates collected, it is evident that the vertebrate animals were better able to adjust themselves to the hydrographic conditions of the ship channel water. Following is a list of the vertebrate and invertebrate animals collected at Mk 122 during this project year.

Vertebrate	No. Collected
Galeichthys felis	2
Stellifer lanceolatus	24
Micropogon undulatus	100
Cynoscion arenarius	17
Spheroides nephelus	2
Brevoortia patronus	9
Cyprinidon variegatus	13
Anchoa mitchelli	16
Gobius hastatus	5
Menticirrhus americanus	1
Synodus foetens	3
Symphurus plagiusa	4
Citharichthys spilopterus	4
Galeichthys felis	2
Centropristes philadelphicus	1
Mollienesia latipinna	1
Mugil cephalus	1
Menidia beryllina	1
Dorosoma cepedianum	2
Dorosoma petenensis	1
Leiostomus xanthurus	1

Invertebrate	No. Collected
Callinectes sapidus	28
Penaeus setiferus	18
Penaeus aztecus	1
Palaemonetes sp.	14
Mnemiopsis mccradyi	abundant
Squilla empusa	16

Fish Kills in Area M-2

June to October 1960 were months of mass fish mortalities in Area M-2 this year. The majority of the mortalities occurred in the vicinity of Morgan Point. During all fish kills a trip was made up the ship channel to determine the conditions of the channel at the time.

Hydrographic data pertaining to each kill is presented in the following discussion.

June 19, 1960 - This was the first report of a fish kill in Area M-2 this year. An estimated 8 to 10 tons of Brevoortia patronus were trapped in the Houston Yacht Club Basin and died due to lack of sufficient oxygen. The menhaden moved into the yacht basin, which has restricted circulation, and depleted the oxygen in the water. Instead of swimming out of the basin, the fish merely swam around until they suffocated.

June 28, 1960 - The second and by far the most destructive fish kill of the year accounted for mortalities of ten species of fish. Flounder, drum and speckled trout were the game fish found in this kill. Dead fish were found at 9 a.m. in the vicinity of Morgan Point and Scott's Reef. From all indications the fish had died several hours before they were found. A chemical analysis was run to determine the cause for the mortalities and the oxygen concentration in the kill area was found to range from 3.5 to 4 o/ooo. A trip was made up the ship channel at this time to determine the condition of the channel. Pictures of this fish kill are shown in Figures IX and X.

August 23, 1960 - This was the third major fish kill occurring in Area M-2 this year. The dead fish were found about 10 a.m. from Morgan Point to Scott Reef. A survey was made of the ship channel above Morgan Point to check on the condition of the ship channel. The dissolved oxygen concentration in the channel water was very low and dead fish were seen floating toward the bay. A chemical analysis of the water collected in the bay within the vicinity of the fish kill showed the dissolved oxygen concentration to be around 2.4 parts per million. The chemical smell of ship channel water was noticed in the fish kill area. Menhaden, mullet, croaker, hardhead catfish, and shad made up the majority of the fish in this kill.

September 23, 1960 - Shad, drum, mullet and croaker were found floating from Morgan Point to Scott Reef. From the condition of the fish, it looked like they died several days before they were found. A routine chemical test was run, and the hydrographic conditions were found to be normal by this time. These fish probably died in the ship channel above Morgan Point and floated into the bay due to the current of the channel.

September 29, 1960 - Speckled trout and drum were found dead near the mouth of Cross bayou. These fish had been dead several days when found. A chemical analysis of the water was run but as expected the hydrographic conditions were normal. The cause for this fish kill remains a mystery.

October 21, 1960 - This was the last major fish kill reported in Area M-2 this year. Sand trout, drum and speckled trout were found dead from Morgan Point to the Trinity River. The majority of the fish found had been dead several days before being reported. A chemical analysis was run at various locations in the bay. At this time the dissolved oxygen concentration was 4.0 parts per million in the vicinity of Morgan Point and the chemical smell common to the Houston Ship Channel was observed in the area of the kill.

Although there were fewer menhaden mortalities this year, the fish kills were more detrimental to the sports species of fish. Most of the kills were probably caused by industrial waste from the Houston Ship Channel.

Effects of Plankton Blooms on the Hydrographic Conditions in Area M-2

This year there were numerous plankton blooms in the bay, but three blooms occurring in November 1959, January 1960 and September 1960 caused much speculation among the sport and commercial fishermen. These blooms were not the "red tide" organism, although they could be detrimental to the marine life if they lower the oxygen concentration of the water to a lethal point or if their toxic waste products become too concentrated.. No evidence was found to indicate that the blooms were the cause of the fish kill in the bay this year.

To better understand the effects of the "blooms" studies were made from the bulkhead at the Seabrook Field Laboratory over a twenty-four hour period for the three major blooms of the year. The data collected is presented in Tables 5 through 7.

Conclusion: The author feels that the above discussion is not thorough enough to give a picture of the overall hydrographic conditions month by month. Therefore, Table 8 gives the maximum, minimum and average for the hydrographic data collected in Area M-2 this project year.

Prepared by E.J. Pullen Accepted by Howard T. Lee

Howard T. Lee

Marine Biologist Date 10 February 1961

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Table 1

Precipitation Records of Cities on the Galveston Bay - Trinity Bay Watershed

City	County	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Bowie	Motague	.42	3.49	3.35	2.09	2.29	1.90	3.22	2.13	4.28	1.49	2.24
Gainsville	Cook	.73	3.02	3.63	1.29	1.89	1.27	2.89	1.82	4.22	3.15	3.09
Waxahachie	Ellis	.66	5.74	3.81	2.30	1.28	1.87	2.82	3.56	.82	5.92	1.82
Corsicana	Navarro	1.37	3.60	4.36	2.17	.77	1.69	2.69	6.90	.45	3.77	1.06
Palastine	Anderson	3.68	5.00	5.10	4.02	2.30	3.45	1.52	9.10	.29	2.63	3.91
Crockett	Houston	3.86	3.72	3.98	4.56	1.68	3.19	.88	8.20	2.37	6.61	1.99
Huntsville	Walker	2.67	4.49	3.52	4.61	1.19	3.26	1.17	10.75	3.67	5.52	4.80
Conroe	Montgomery	2.14	4.56	4.42	4.86	.74	5.57	.48	11.88	7.73	8.90	1.16
Houston	Harris	1.90	5.34	2.05	3.93	.38	1.42	.90	14.66	5.84	2.78	1.86

Table 2

Prevailing Wind Direction and Speed (mph)

	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.
Area M-2	N-10	E-10	N-13	E-12	E-14	SE-10	SE-12	S-10	S-8	S-8	N-6	N-8

Table 3

Maximum and Minimum Tides
Area M-2

Month		Maximum Tide	Minimum Tide
November	1959	2.8	-0.4
December	1959	2.0	-0.6
January	1960	1.9	-1.1
February	1960	2.3	-0.1
March	1960	2.5	-0.3
April	1960	2.9	0.1
May	1960	2.5	0.4
June	1960	3.0	0.7
July	1960	2.1	0.8
August	1960	2.5	1.0
September	1960	2.6	1.2
October	1960	2.4	-0.2

Table 4

Average Surface and Bottom Salinities in Trinity Bay
(parts per thousand)

Stations		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
TL	Surf.	----	----	----	----	----	-----	11.00	13.00	2.00	5.00	4.00	8.50
	Bot.												
ML	Surf.	----	----	----	----	----	-----	11.00	12.00	1.50	3.50	3.00	5.00
	Bot.												
CL	Surf.	10.20	12.70	2.86	8.00	8.84	11.04	14.03	13.47	1.87	4.29	4.92	9.60
	Bot.	11.40	12.70	3.82	7.70	8.84	11.04	13.83	13.47	2.50	3.41	4.92	9.60
MK122	Surf.	12.60	8.90	4.80	1.20	6.68	8.20	4.96	9.95	3.87	10.70	9.43	9.10
	Bot.	15.20	13.20	8.40	22.50	15.10	10.18	9.17	11.45	3.77	14.93	14.73	12.45
MP	Surf.	14.90	15.20	9.00	11.50	7.77	14.02	12.23	9.72	5.85	9.33	11.95	13.77
	Bot.	16.40	15.20	10.70	11.50	7.77	14.02	13.43	9.72	5.85	9.33	12.45	13.77
5MP	Surf.	13.70	15.50	11.90	12.80	8.67	14.83	12.12	16.64	7.53	12.06	13.73	16.62
	Bot.	19.80	19.50	19.80	24.10	20.70	18.34	21.43	24.40	21.11	13.22	22.86	19.16
SB	Surf.	12.30	13.90	9.80	11.50	9.79	12.72	14.33	9.93	6.17	10.95	10.89	12.02
	Bot.	14.80	14.50	9.80	11.50	9.42	12.72	14.03	9.93	6.27	11.30	10.89	17.15
HC	Surf.	12.30	14.50	10.20	12.90	9.42	14.38	14.78	10.99	5.91	13.27	13.37	17.37
	Bot.	12.80	14.50	10.30	12.90	9.42	14.38	15.23	10.99	6.01	13.27	13.37	17.37
CB	Surf.	10.20	8.20	6.20	1.50	9.28	12.07	12.11	15.23	4.34	7.80	10.18	8.75
	Bot.	11.40	16.74	6.20	1.50	9.43	13.07	11.30	15.38	4.39	7.80	10.18	9.75
MK	Surf.	11.50	13.30	4.90	9.10	7.85	13.27	12.37	15.18	7.15.	10.94	11.45	16.72
	Bot.	11.70	13.60	5.20	9.40	7.85	13.27	13.02	15.43	7.45	10.94	11.45	16.72
B60	Surf.	13.70	15.40	10.90	10.58	15.63	17.79	16.38	20.19	11.60	17.84	16.04	17.99
	Bot.	19.80	19.50	19.60	30.52	23.28	24.44	24.50	27.46	23.35	27.75	24.01	22.40
SP	Surf.	9.70	13.40	5.70	6.60	8.21	8.92	13.93	16.88	8.22	12.91	12.42	16.04
	Bot.	11.00	14.20	6.30	7.90	12.75	9.27	13.93	16.88	8.72	13.51	12.42	16.09

Table 4 - Continued

Stations		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
FS	Surf.	11.20	11.20	0.30	1.60	2.90	7.60	7.94	11.11	5.72	8.60	8.82	9.78
	Bot.	11.40	11.50	0.30	2.60	2.90	8.85	10.30	11.11	5.72	8.60	8.82	9.93
DB	Surf.	3.40	4.80	0.20	0.80	15.63	2.65	6.39	9.33	2.27	5.04	9.97	11.71
	Bot.	4.30	5.80	0.30	0.90	23.28	2.65	6.39	9.33	3.35	4.99	7.97	11.71
AC	Surf.	3.90	6.90	0.20	0.40	8.21	1.77	3.78	7.65	1.37	3.57	5.68	9.17
	Bot.	4.90	7.40	0.20	0.40	12.75	1.77	3.94	7.65	1.37	3.57	6.20	9.17

Table 5

Diurnal Oxygen Curve
Laboratory Bulkhead - November 1959 during *Gymnodinium* and *Exuviella* bloom

Date	Time	Water Temperature C°	pH	DO	Turb.	Air Temperature C°
1959 20 November	1200	13.4	8.7	18.7	86	15.2
	1300	14.3	9.1	19.3	69	15.2
	1400	14.2	9.2	19.5	37	14.9
	1500	14.1	8.9	18.9	77	14.5
	1600	14.0	9.0	18.0	65	14.5
	1700	13.9	8.9	17.8	72	14.0
	1800	13.8	8.9	17.0	80	14.0
	1900	13.8	8.9	16.9	78	14.0
	2000	13.7	8.9	16.7	91	14.0
	2100	13.7	8.7	12.4	77	13.5
	2200	13.7	8.6	11.6	84	13.0
	2300	13.9	8.5	11.7	89	13.0
	2400	13.5	8.4	9.8	43	12.5
1959 21 November	0100	13.2	8.5	9.8	48	12.0
	0200	13.2	8.5	11.3	55	12.0
	0300	13.0	8.4	10.0	61	11.5
	0400	12.9	8.4	9.6	63	12.0
	0500	13.0	8.4	10.0	82	12.0
	0600	13.0	8.4	9.3	82	11.3
	0700	12.8	8.4	10.4	87	10.6
	0800	12.9	8.4	10.7	86	12.8
	0900	13.3	8.8	13.0	80	15.5
	1000	13.7	8.8	14.7	75	16.5
	1100	14.7	8.8	17.1	83	17.6
	1200	18.0	9.2	17.9	52	18.5

Table 6

Diurnal Oxygen Curve - Laboratory Bulkhead During *Eutreptia* and *Gymnodinium* Bloom

Date	Time	Temp. C° Air	Temp. C° H_2O	DO	pH	Turb.	Sal.	Cloud	Wind	
1960										
28 January	0800	12.0	---	10.7	7.9	95	----	H. Fog	0-5	S
	0900	----	13.7	11.9	8.1	--	----	H. Fog	---	-
	1000	----	13.8	12.8	8.1	97	----	H. Fog	---	-
	1100	----	14.1	14.0	8.2	97	8.7	H. Fog	---	-
	1200	14.2	15.0	14.9	8.25	96	8.7	H. Fog	---	-
	1300	15.6	16.8	16.3	8.5	94	8.6	Fog Lifting	5-10	S
	1400	15.0	16.7	15.5	8.6	92	8.6	Sun Spotty	5-17	S
	1500	16.8	16.8	15.5	8.6	93	8.6	100% Cloud	15	S
	1600	20.0	16.9	14.2	8.65	94	8.3	Sun Spotty	15-17	S
	1700	19.3	16.8	14.3	8.6	94	8.2	Sun Spotty	15	S
	1800	19.0	17.5	13.3	8.4	96	8.3	100% Cloud	0-5	-
	1900	18.0	16.5	14.4	8.3	95	7.7	Rain	0-5	-
	2000	18.0	16.4	13.7	8.3	92	8.0	Rain	5-10	S
	2100	18.0	16.7	11.1	8.3	95	7.7	Rain	5-10	N
	2200	18.0	16.4	11.9	8.3	97	7.7	Clear	5-10	N
	2300	16.0	15.8	11.9	8.3	97	7.6	Clear	10-15	N
	2400	13.0	14.9	12.2	8.3	96	8.0	Clear	13-17	N
1960										
29 January	0100	11.0	14.8	11.5	8.3	96.5	8.3	Clear	12-17	N
	0200	9.0	14.2	11.2	8.4	98	8.0	Clear	17-25	N
	0300	8.0	13.7	12.3	8.4	98	8.9	Clear	12-17	N
	0400	7.0	13.6	12.2	8.5	96	9.0	Clear	14-16	N
	0500	6.0	13.4	11.9	8.4	97	9.2	Clear	15-18	N
	0600	6.0	13.2	11.9	8.4	98	8.9	Clear	12-18	N
	0700	6.0	12.9	11.5	8.5	97	9.6	Pt. Cloudy	12-15	N-NW
	0800	6.0	12.3	11.7	8.5	97	9.3	Pt. Cloudy	15	N
	0900	8.0	13.0	12.4	8.4	97	8.9	Pt. Cloudy	16	N
	1000	8.5	13.0	12.0	8.6	97	8.4	Pt. Cloudy	15-20	N
	1100	10.0	14.3	12.7	8.5	95	8.5	Sl. Cloudy	15	N
	1200	12.5	15.2	12.5	8.6	93	8.0	Clear	20-25	N

Tide	1-29-60	0600	+0.7
		0800	+0.4
		1200	0

Table 7

Diurnal Oxygen Curve - Laboratory Bulkhead During *Gymnodinium splendens* Bloom. September 1960

Date	Time	Temp. C° Air	Temp. C° H_2O	DO	pH	Turb.	Sal.	Cloud	Wind Rate	Wind Dir.	Bar Pressure	Tide	Comments
9-21-60	0800	26.0	29.0	2.2	7.6	95	11.5	20%	0-5	E-NE	29.95	1.8	Foggy
	0900	29.0	29.5	2.9	7.6	95	11.7	30%	5-10	NE	29.96	1.9	
	1000	29.0	29.5	4.1	7.7	95	11.7	30%	0-5	E-NE	29.97	1.8	
	1100	29.0	30.0	5.7	7.8	94	11.7	20%	5-10	E-NE	29.98	1.7	
	1200	29.5	30.2	9.8	8.3	90	11.8	20%	10-12	E	29.97	1.7	pH meter erratic
	1300	29.2	30.8	12.5	8.3	88	11.8	20%	12-14	E	29.96	1.6	water getting rougher
	1400	29.0	30.5	12.8	8.4	88	11.8	20%	8-16	E-NE	29.94	1.6	
	1500	29.5	30.0	11.3	8.4	87	11.7	15%	10-20	E-SE	29.94	1.6	
	1600	29.5	31.0	11.3	8.3	87	11.7	10%	10-20	E-SE	29.90	1.5	
	1700	29.5	31.0	10.0	8.3	87	11.8	0	14	SE	29.90	1.7	
	1800	29.5	30.6	9.9	8.3	89	11.9	0	13	SE	29.90	1.8	Sunset 1815
	1900	28.8	30.8	8.6	8.2	89	11.8	0	6	SE	29.91	1.8	or 1.9
	2000	27.5	30.8	6.1	8.1	91	12.1	0	5	SE	29.91	1.9	
	2100	27.0	30.0	4.9	8.0	92	12.0	0	0- 5	SE	29.92	1.9	
	2200	27.0	29.5	3.4	7.9	95	11.9	0	0- 5	SE	29.92	1.9	
	2300	27.0	29.5	2.9	7.75	93	11.7	0	0- 5	SE	29.92	1.8	
	2400	25.0	29.0	2.1	7.7	95	11.7	0	0- 5	SE	29.92	1.8	Calm
9-22-60	0100	24.5	29.0	1.7	7.7	95	11.8	0	0- 5	SE	29.92	1.7	Calm
	0200	24.0	29.0	1.3	7.55	95	11.7	0	0- 5	SE	29.92	1.6	Calm, Mist over water
	0300	23.8	29.0	1.2	7.4	95	11.6	0	0- 5	SE	29.91	1.6	Calm
	0400	23.5	29.0	1.4	7.4	95	11.5	0	0- 5	SE	29.91	1.6	
	0500	20.2	29.0	1.3	7.5	93	11.7	0	0- 5	SE	29.91	1.7	
	0600	22.0	29.0	1.2	7.5	93	11.6	5%	0- 5	NW	29.91	1.8	
	0700	23.0	29.0	1.4	7.6	93	11.7	5%	0- 5	NW	29.91	1.9	
	0800	27.0	28.5	1.3	7.7	95	11.6	5%	0- 5	N	29.94	2.0	

Table 8 - Hydrographic Data - Area M-2.

		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Air Temp. °C													
	Max.	24.4	20.8	17.2	17.0	24.8	26.2	30.0	31.6	33.8	33.0	31.4	29.0
	Min.	1.1	8.0	0.2	7.8	5.0	17.2	22.0	25.5	25.2	26.4	21.6	13.0
	Avg.	13.2	15.0	9.3	13.0	14.0	21.6	25.6	28.4	29.6	29.6	27.2	23.0
Water Temp. °C													
Surface:	Max.	16.7	16.4	16.2	14.3	22.5	26.0	30.8	31.9	35.0	33.5	32.5	29.0
	Min.	7.9	9.8	6.5	8.8	7.5	16.3	31.2	27.1	28.8	29.0	24.5	16.0
	Avg.	13.2	13.4	10.5	12.0	13.5	21.4	25.0	29.6	31.0	30.4	28.4	24.4
Bottom:	Max.	16.2	16.2	12.2	12.6	22.2	25.2	30.8	31.8	34.2	32.6	30.6	28.2
	Min.	7.4	8.9	5.0	8.5	7.4	16.0	20.8	26.2	28.3	28.6	23.8	23.0
	Avg.	12.5	12.5	9.4	10.0	12.8	21.0	25.4	28.9	30.0	30.0	27.2	26.0
Salinity °/oo													
Surface:	Max.	16.74	23.21	12.72	12.90	17.44	19.84	18.24	21.24	14.03	19.91	17.14	19.04
	Min.	2.90	0.40	0.20	0.20	0.20	0.30	1.05	5.64	0.30	1.15	3.60	1.50
	Avg.	10.90	12.50	4.80	5.50	6.90	10.50	10.93	13.15	7.86	9.35	10.30	11.54
Bottom:	Max.	21.73	25.49	22.12	30.52	24.90	28.15	24.80	26.58	24.90	31.60	26.38	23.08
	Min.	2.90	1.50	0.20	0.20	0.20	0.30	2.55	5.64	0.90	1.15	3.60	1.50
	Avg.	13.10	13.20	6.80	7.60	8.90	11.00	12.30	14.70	8.30	11.50	12.35	12.50
pH													
Surface:	Max.	8.0	7.7	8.6	8.5	8.7	8.6	8.0	8.2	8.6	8.4	8.7	8.3
	Min.	6.8	7.3	7.1	7.0	7.1	6.9	7.1	7.1	7.3	7.3	7.4	6.9
	Avg.	7.1	7.4	7.6	7.8	7.9	7.7	7.6	7.8	7.9	7.8	7.9	7.8
Bottom:	Max.	8.3	7.9	8.5	8.4	8.6	8.6	8.2	8.2	8.5	8.4	8.7	8.3
	Min.	6.6	7.2	7.0	7.2	7.3	7.1	7.1	7.1	7.1	7.3	7.4	7.0
	Avg.	7.7	7.5	7.7	7.8	7.9	7.7	7.8	7.8	7.9	7.8	8.0	7.7
Turbidity %													
Surface:	Max.	98	98	99	99	99	99	100	98	97	99	99	99
	Min.	83	15	43	63	66	80	88	91	62	89	89	50
	Avg.	97	90	87	90	91	94	96	95	90	95	96	94
Bottom:	Max.	96	98	99	99	100	98	100	98	97	99	99	99
	Min.	96	68	40	39	66	84	70	77	64	0	64	54
	Avg.	96	89	83	85	91	94	95	93	88	95	93	92
DO °/ooo													
Surface:	Max.	15.3	9.3	18.9	10.8	11.0	10.6	11.5	8.7	11.9	9.7	9.8	10.3
	Min.	1.5	5.0	4.6	6.0	2.3	1.5	5.9	1.0	1.2	1.0	0.5	0
	Avg.	10.5	7.9	9.5	9.0	9.4	7.7	8.0	6.7	6.4	6.5	7.2	7.6

Figure I

Hydrographic System Area M-2

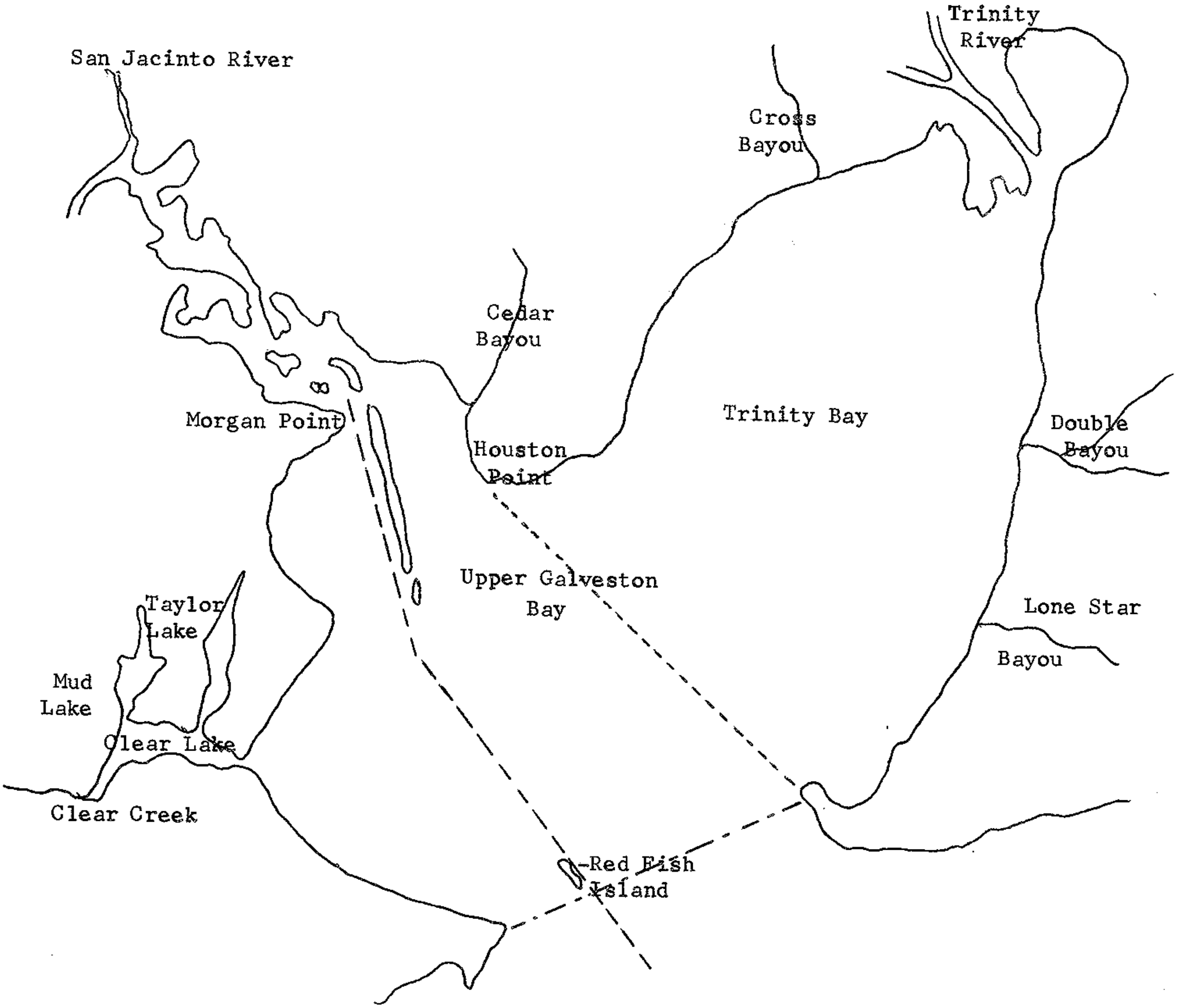

Figure II

Precipitation Average Per Month

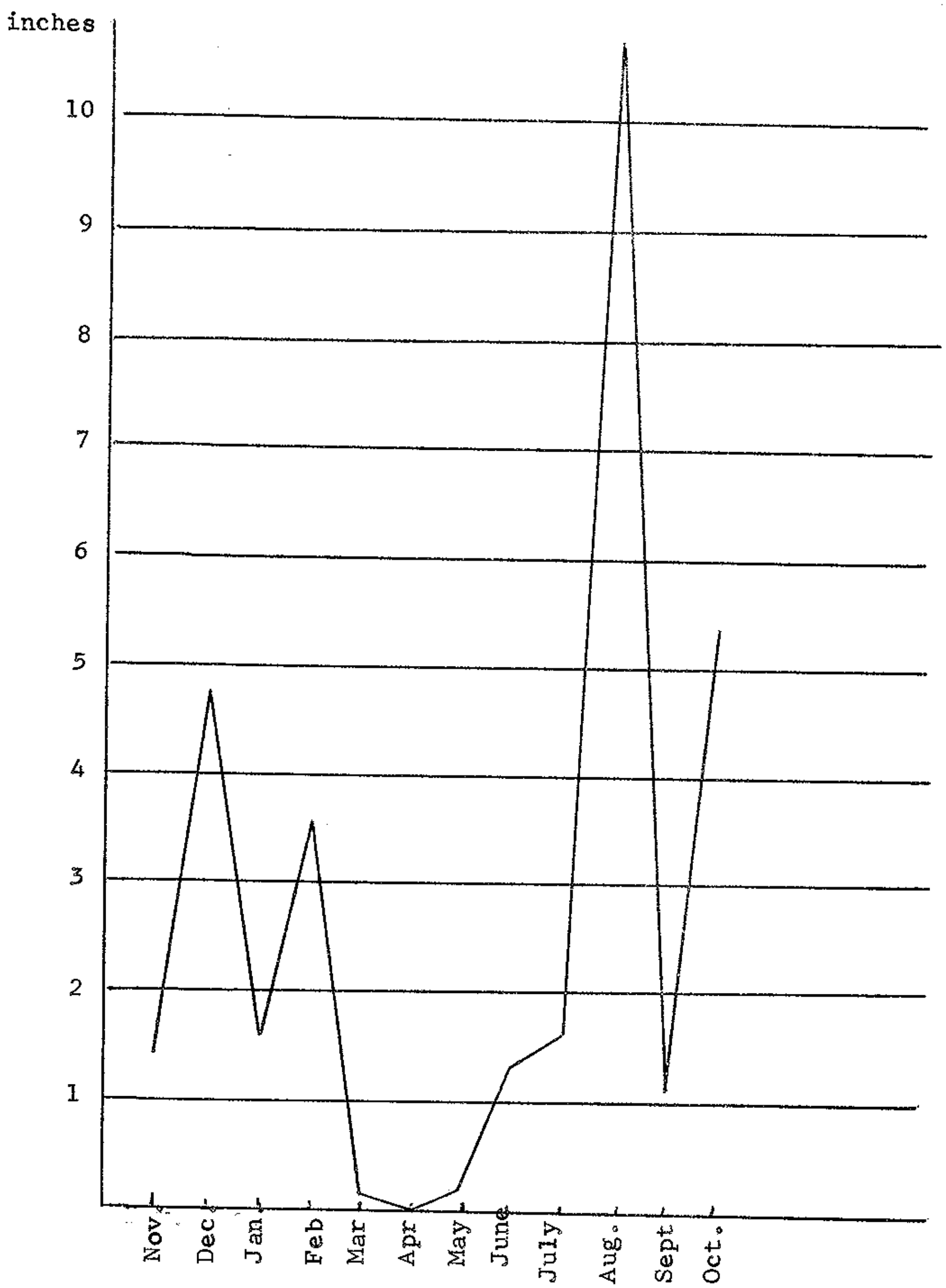

Figure III

Air and Water Temperature Average Per Month

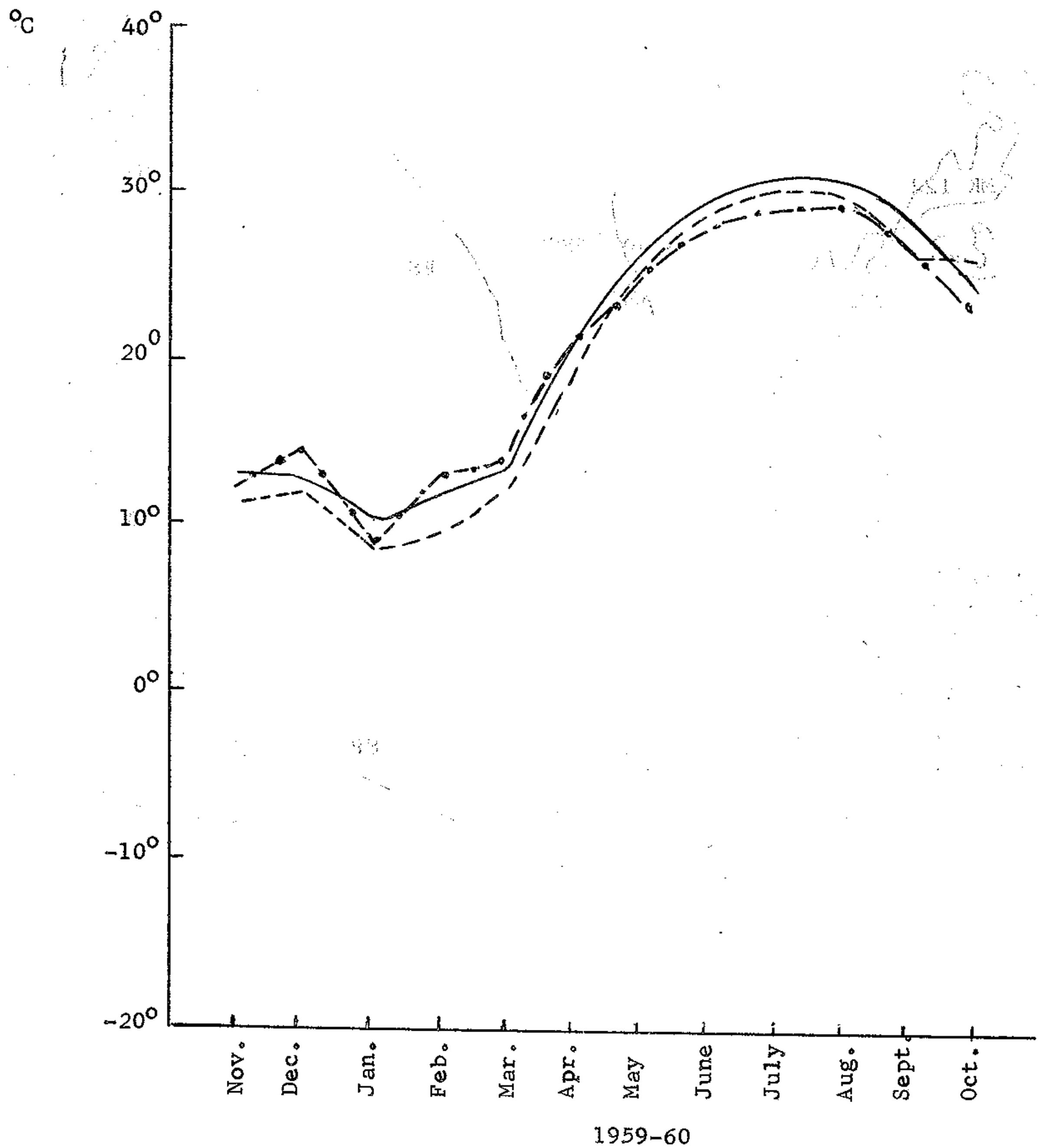

Figure IV

Salinity Stations - Area M-2

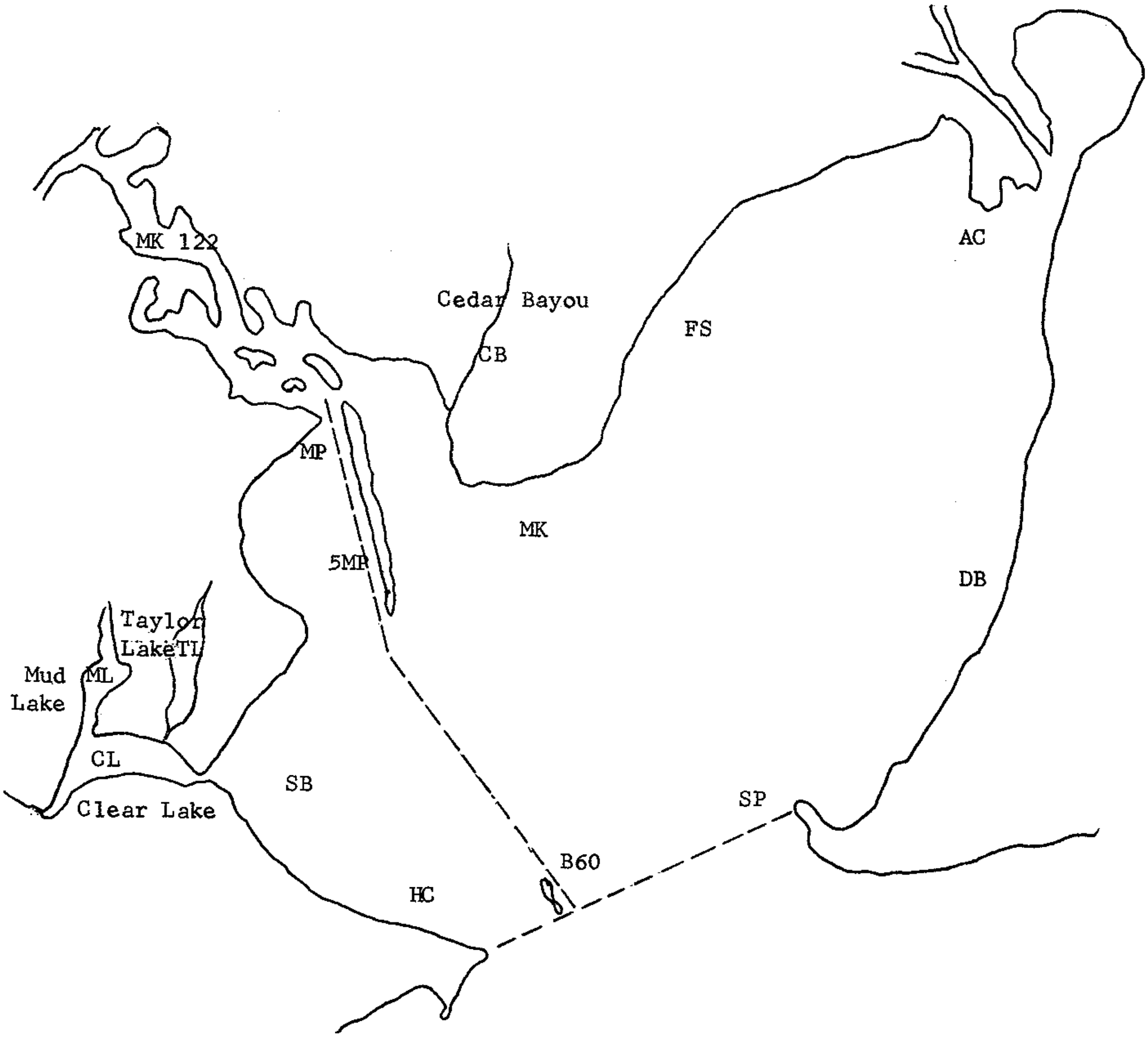

Figure V

Surf. and Bottom Salinity Averages Per Month

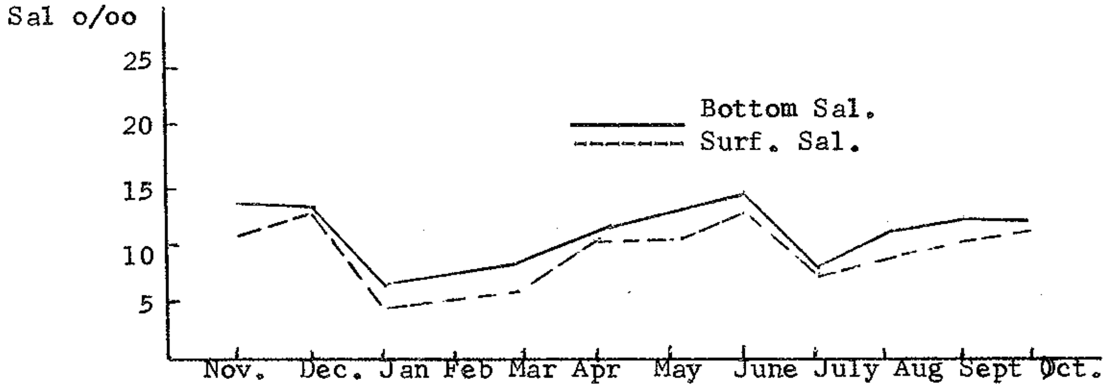

Figure VI

Average Dissolved Oxygen Concentration Per Month

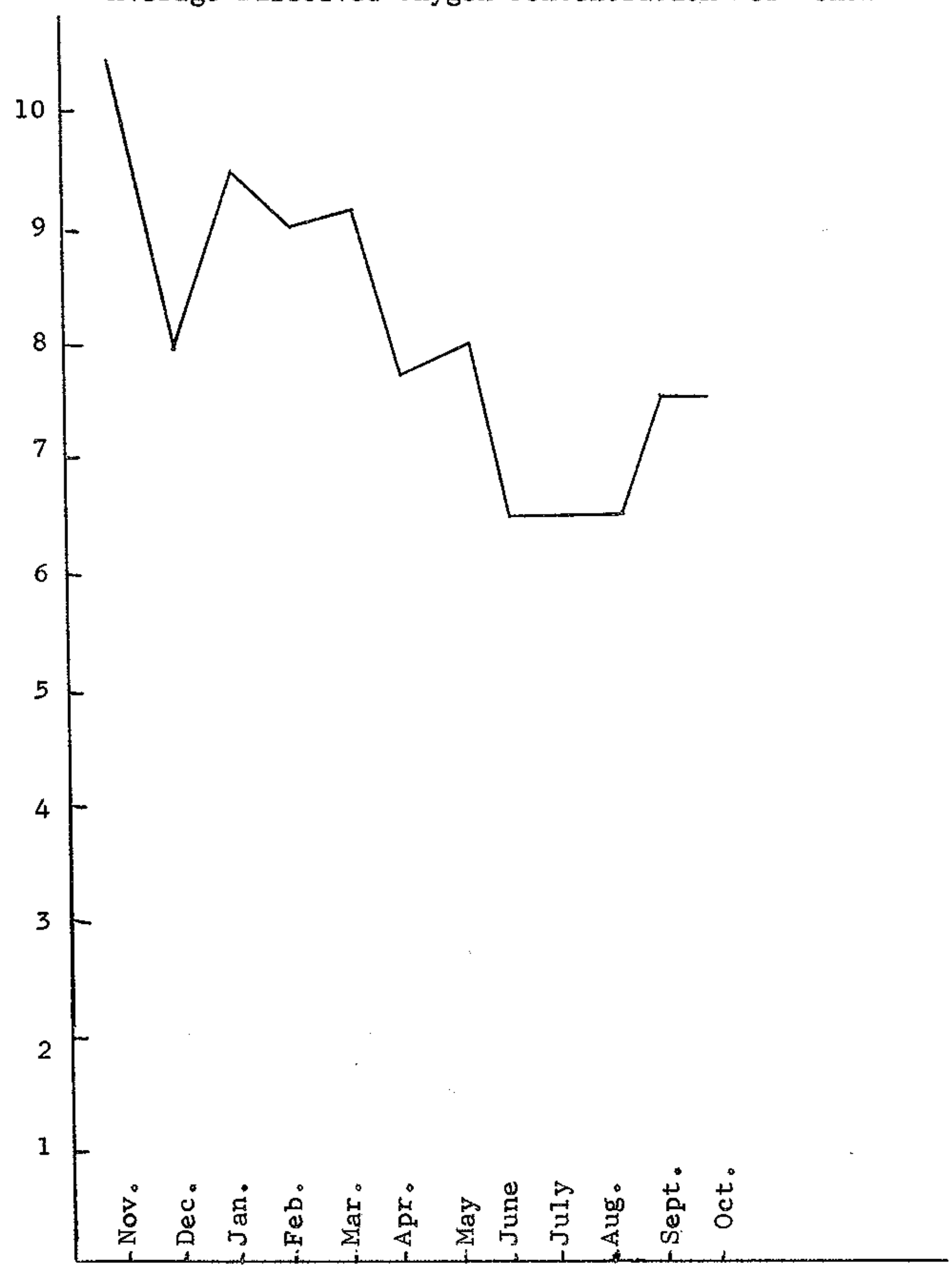

Figure VII

Average Turbidity Per Month

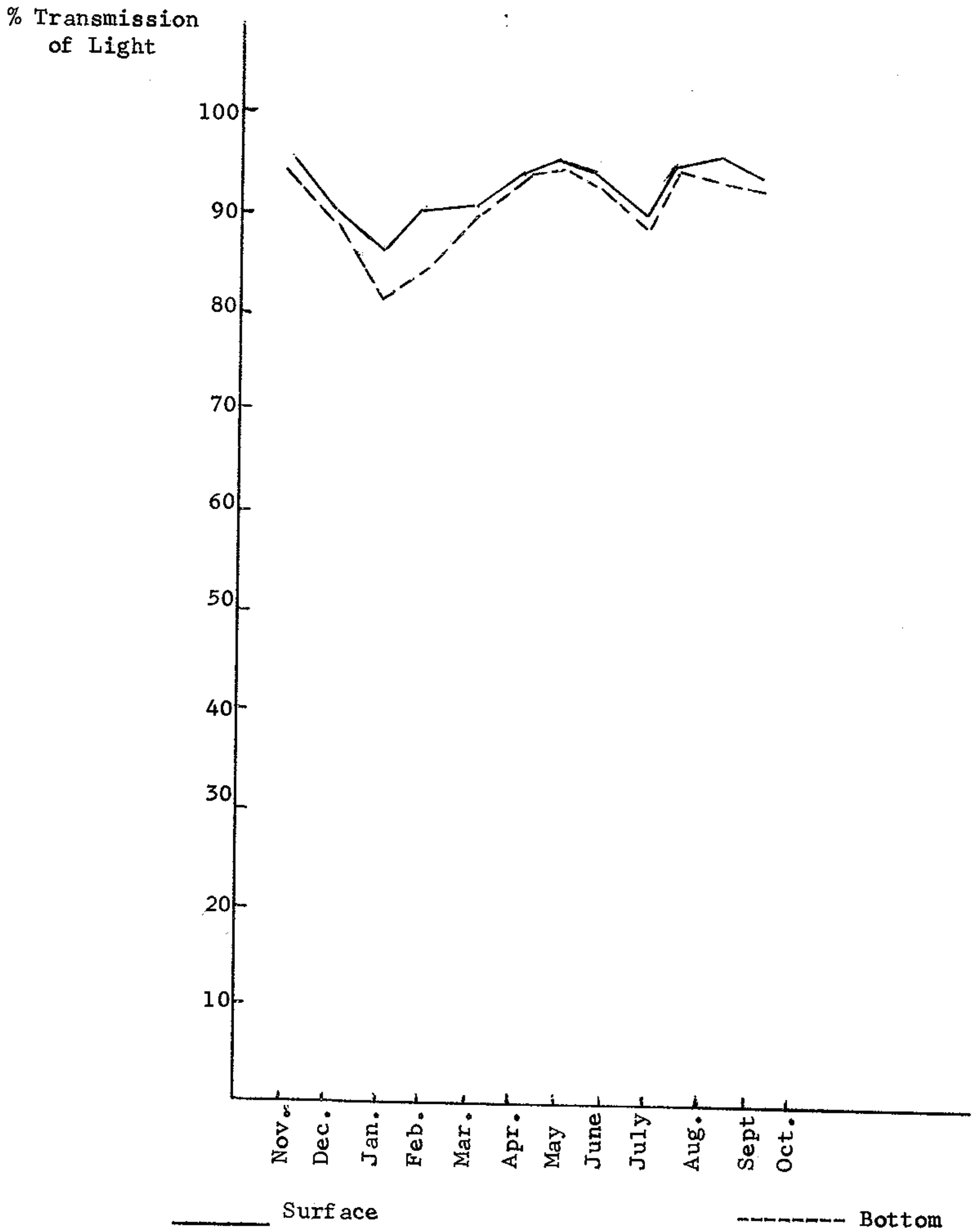

Figure VIII

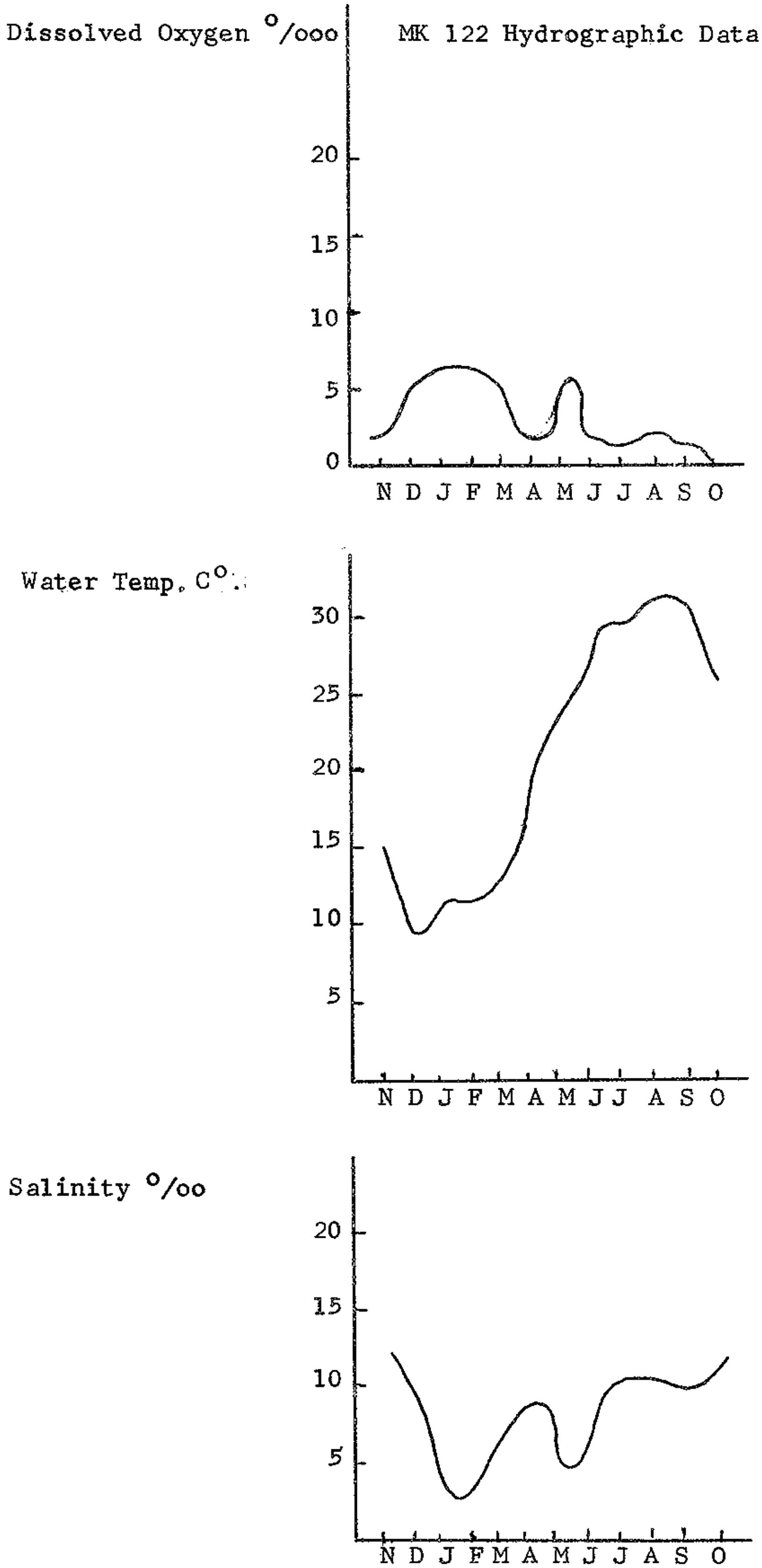
Dissolved Oxygen °/ooo
MK 122 Hydrographic Data
20
15
10
5
0
N D J F M A M J J A S O
Water Temp. C°.
30
25
20
15
10
5
N D J F M A M J J A S O
Salinity °/oo
20
15
10
5
N D J F M A M J J A S O

Figure IX

Fish kill in vicinity of Morgan Point and Scotts Reef, June 28, 1960.

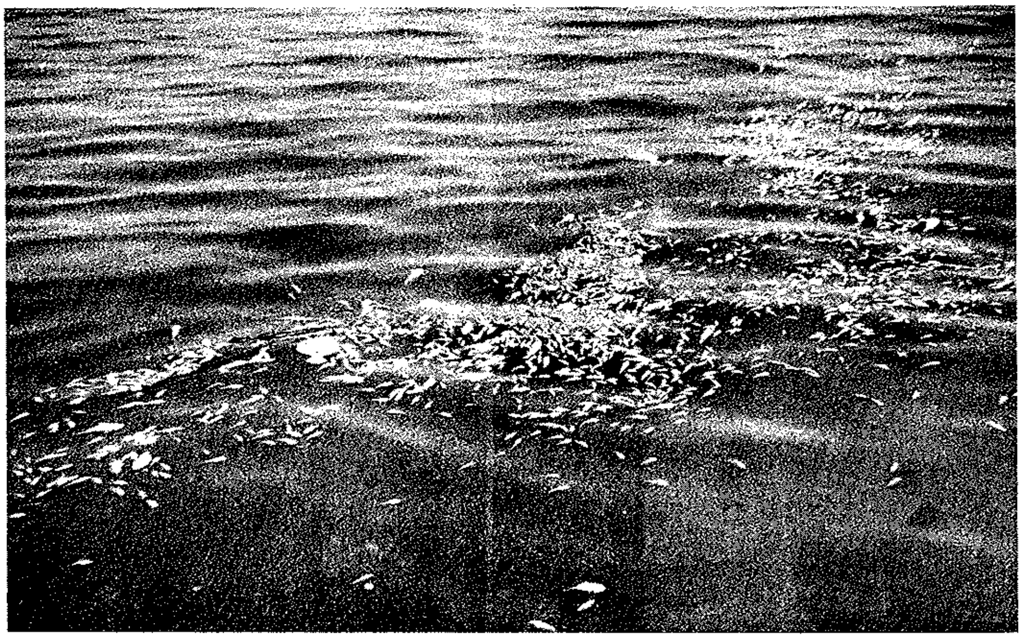

Figure X

Closer view of the same kill shows some of the 10 different species.