8.4

plankton 7
WC 8.8
Little attempt to correlate W.C + Plankton. But otherwise pretty good.

7.9

A Limnological Survey of Hummingbird and Bay Lakes

Joseph Bosco

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Introduction

This report is being written in compliance with the requirements of BIO 569, in order to study and better understand the relationships between the many aspects of aquatic biology. Hummingbird and Bay lake will be discussed here.

Methods

All chemical tests followed the Hach Kit methods and were done in at least duplicate, the phosphate in triplicate. Dissolved oxygen and temperature were measured with a field meter. and pH was measured with a field kit in the boat immediatly after the water was collected. Water samples were taken with a Kemmerer sampler, and the phytoplankton sample was one Kemmerer sample passed through a phytoplankton funnel. The zooplankton sample was collected using a 5 min. standard tow with a bolting cloth zooplankton funnel at a constant speed so that the rim of the funnel would stay about 5 cm below the water surface. The plankton was sampled in Sedgwick-Rafter cells at 100X using at least 3 rows lengthwise.

The Hummingbird samples were taken between 9 and 10 AM on June 2, 1977. The Bay lake samples were collected between 10:30 and 11:30 AM on June 3, 1977. Both night zooplankton tows were run between 9:30 and 10 PM. The weather was sunny and warm both days but followed two days of miserable cold rain. Wind was moderatly strong both days and caused some drifting during the tests.

The depth recordings were taken using sonar depth recorder. The advance mechanism did not operate during the Bay lake trials so the paper had to be pulled by hand and was not regularly and proportionally spaced. Maps were traced from aerial photographs, and the Hummingbird map was further enlarged.

Results

Hummingbird

The dissolved oxygen and temperature graphs show that this lake is very sharply divided because the decrease in temperature and oxygen is very sharp. Another indication the lake is stratafied is the sulfide test which was positive, and the characteistic odor was also clearly present in the four meter water. The sulfate test showed no sulfate at 4 m because the lack of oxygen at this depth causes sulfur to be in the form of H_2S.

The large difference in pH between .5 m and 4 m also indicates that the lake is sharply divided. Phenolphthalein acidity was higher at 4 m(70 to 45 mg/l). The causes? for this higher acidity are partly minerals, as shown by the higher total hardness(20 to 15mg/l) and slightly higher specific conductance(38 to 37μmhos/cm) at 4 meters. But more important is the presence of hydrogen sulfide and humic acid. The difference between the color of the two depths is one of the larger differences between the two levels. Since humic acid is a cause of color, and the two depths had such different color, humic acid could be important in both the low pH and the high acidity. The hydrogen sulfide also must be important, but the relative importance of H_2S and humic acid is difficult to determine since the H_2S test is more qualitative than quantitative.

Alkalinity was negligible.

The phosphate test showed that the phosphate concentration, both ortho- and total, was much higher at the 4 m level, presumably because there are few, if any, organisms who can live, and thus use nutrients, at that depth because of the low O_2 concentration. There is therefore nothing to lower the concentration at 4 m, while at .5 m, organisms are using it. The same holds true for nitrate(.35 at .5 m, and .85 mg/l at 4 m). The difference between the total and ortho tests gives the concentration of polyphosphates(Standard Methods, 1965, p.236). It is interesting to note that the polyphosphate concentration is only .005 mg/l higher at 4 m than at .5 m, or considering the accuracy of the test, they are equal.

The sonar depth recorder was used on one pass the length of the lake south to north as indicated on the map. The southernmost half was about 3 meters deeper, and the bottom of the entire lake seemed to be covered by a thick layer of mud, probably of partially decomposed organic matter.

The trees lining the edge of the water were very mixed with many bushes and a fair number of conifers, much less than at Tender bog, but more than at Bay. There was very little Sphagnum moss, and what there was was isolated and certainly not a mat.

In the table of plankton counts, the columns labeled "counted" represent the number of organisms actually counted under the microscope in 3 rows(5 in the case of Bay phytoplankton) the length of a Sedgwick-Rafter cell. The column "/ml sample"(per milliliter of sample) is the number of organisms counted in 3(or 5) rows multiplied by the number of rows in a Sedgwick-Rafter cell, 26, and divided by the number of rows counted. This represents the number of organisms in the cell, or in one ml of the sample. Multiplying by the volume of the sample will give the number of organisms in the 2 liters of lake water collected, in the case of the phytoplankton sample, or the total number of organisms collected during the tow, in the case of the zooplankton sample. By multiplying the number of organisms in 2 liters by 500, the number of organisms per cubic meter of lake water can be determined.

The equation written out is as follows:

$$\text{no. counted} \times \frac{\text{26 rows on cell}}{\text{no. of rows counted}} \times \text{vol. in sample} \times \frac{\text{phyto. only}}{500}$$

(counted) (/ml sample) phyto.(in sample) zoo. (in tow) ($/m^3$)

Hummingbird's algae was mainly Mougetia, Protococcus, and Scenedesmus. Desmids were few, but there were Staurastrum and Micrasterias. Protozoans were mostly Ceratium, Dinobryon, Euglena, Eudorina, Peridinium, and Uroglena. The major rotifers were Keritella, Polyarthra, and Trichocera. Crustaceans included Bosmina, Daphnia, Cyclops, and many nauplii.

The major difference between the day and night zooplankton tows were that the protozoans were all different, and that Keritella and Trichocera were the only rotifers at night but were much more concentrated than they were during the day, about 9 and 50 times more concentrated respectively. The crustaceans were also all more concentrated at night. Chaoborus were only present at night.

Hummingbird is the only body of water at U.N.D.E.R.C. known to have three types of Chaoborus living together. At least two species were collected in the night zooplankton tow, differentiable by size. The giant of the aquatic Hemiptera, Lethocerus, was also caught here, as were mudminnows, Umbra limi. Perch, Perca flavescens, is said to live here also, but it cannot reproduce under these conditions. It is said that the perch swim into Hummingbird from Bay through a small stream which is supposed to connect the two, however the water was standing still when the tests were performed. Water levels in all the lakes were low, so it is possible that during times of higher water the lakes are connected.

Bay

Dissolved oxygen and temperature profiles were taken at two different points marked 1 and 2 on the map. All the chemical tests were performed on water from site 1.

pH was lower at 8 meters than at 2 m(5.25 to 6.5), but phenolphthalein acidity was slightly higher at 2 m (30 to 25 mg/l). Other indicators of the water's buffering capacity were equal, such as alkylinity (5 mg/l), specific conductance (22 μmhos/cm), and calcium hardness (7 mg/l). Total hardness was higher at the deeper depth(15 to 10mg/l), as was color (40 to 20 units). The increase in color often means more humic acid and therefore can be an explanation for the pH, but the greater total hardness at 8 m seems to contradict the lower acidity, because a higher hardness usually means more salts which can act to buffer the water. Apparently, the salts in Bay at 8 m are not very good buffers, possibly because their equation of

$$H(salt) + H_2O \rightleftharpoons H_3O^+ + (salt)^-$$

has gone too far to the right by buffering very much already. In this way the salt concentration can be high and the acidity low, and the low pH fits in well with this possibility.

Sulfate was lower at 8 meters(4.9 to 5.8 mg/l), possibly because the lower oxygen content of the water changed some of sulfate to H_2S, although no H_2S test was performed to make sure.

Phosphate values seem high for the 2 m sample(ortho 1.21, total 1.3 mg/l; 0.44 and 0.55 mg/l at 8 m), but the results were consistent in all the trials. The polyphosphate concentration is 0.09 mg/l and 0.11 mg/l for the 2 m and 8 m levels respectively. Nitrate concentration was only slightly higher at the 8 m depth(0.76 to 0.70 mg/l), presumably because it isn't being used at that depth.

Three passes were made using the depth recorder. Since the paper feeder mechanism didn't work, the depths are not proportional with the length. In other words, the strip of paper from the machine is not a scale profile of the bottom of the lake. Numbers have been inserted on the paper and on the map to show about where the depth recorder paper corresponds to the lake. The deepest points were 5a and 8, 43ft (14m) and 49ft (16m) respectively. Notice the long stretch of fairly flat and shallow (13 ft) bottom past number 13, and the basin with a steep incline at 14, the eastern shore near the public access.

The vegetation lining the shores was varied with few bushes and conifers but many birches. The lake bottom was very rocky in the shallow points, such as between 4 and 5, and at points 7, 12, 16. Many of the rocks were 0.5 and 1.5 meters in diameter and made using a motor on the boat impossible at 5 and 16.

Plankton samples showed that the common algae included Anabena, Protococcus, Scenedesmus, and Gloetrichia. The desmid Staurastrum was very common, as were the diatoms Astrionella and Diatoma. The most common protozoans were Dinobryon and Eudorina, but there were also a few Peridinium, Ceratium, and Volvox counted. There were many rotifers, mostly Asplanchna, Episcura, Kellicottia, Keratella, Ploesoma, and Polyarthra. Bosmina, Holopedium, various cyclopoid and calonoid copepods, and very many nauplii were also present.

The major differences between the day and night zooplankton tows were the greater concentration of Anabena at night, the presence of Gloetrichia only at night. and the absence of protozoans at night. The rotifers were also much more abundant at night, with Episcura absent during the day but rather common at night. Crustaceans were somewhat more abundant at night, particularly Cyclops. Canthocamptus, Limnocalanus, and Senecella were found only during the day tow, while Diaptomus was found only at night.

Largemouth Bass(Micropterus salmoides) and Smallmouth Bass(Micropterus dolomieu) live in Bay lake, as well as Perch (Perca flavescens), Rock Bass(Ambloplites repestris), Northern Pike(Esox lucius). Walleye(Stizostedion vitreum) is also said to live there. There was a large Ephemorella emergence in Bay the week after the tests were performed.

Test		Hummingbird		Bay	
		.5m	4m	2m	8m
Acidity- (mg/l)	Methyl Orange	5	0	0	0
	Phenolphthalein	45	70	30	25
Alkylinity (mg/l)		0	5	5	5
Color- (units)	Apparent	155	175	20	45
	True	145	170	20	40
Hardness- (mg/l)	Calcium	12	12	7	7
	Total	15	20	10	15
Hydrogen Sulfide (ppm)		--	1	--	--
pH		6.5	3.85	6.5	5.25
Phosphate- (mg/l)	Ortho	.05	.9	1.21	.44
	Total	.145	1	1.3	.55
Nitrate (mg/l)		.35	.85	.70	.76
Specific Conductance (μmhos/cm)		37	38	22	22
Sulfate (mg/l)		8.2	0	5.8	4.9

Hummingbird

Phytoplankton Sample

Algae	counted	*/ml sample	* in sample	*/m³ lake water
Mougeotia	14	117	1872	9.36×10^{5}
Protococcus	12	104	1664	8.32×10^{5}
Scenedesmus	33	286	4576	2.29×10^{6}
Desmids				
Closterium	1	9	139	69333
Staurastrum	4	34	544	2.72×10^{5}
Protozoans				
Ceratium	1	9	139	69333
Dinobryon	69	598	9568	4.78×10^{6}
Eudorina	21	182	2912	1.46×10^{6}
Peridinium	18	156	2496	1.25×10^{6}
Uroglena volvox	9	78	1248	6.24×10^{5}
Rotifers				
Keritella	48	416	6656	3.33×10^{6}
Mytillina	1	9	139	69333
Polyarthra	114	988	15808	7.9×10^{6}
Trichocera	42	364	5824	2.91×10^{6}
Unknown Rotifer	42	364	5824	2.91×10^{6}
Crustaceans				
Copepod	3	26	416	208000
Cyclops	1	9	139	69333
Nauplii	13	113	1803	9.01×10^{5}

Day Zooplankton Sample

	counted	* /ml sample	* in 5 min tow
Diatom			
Asterionella	159	1378	322452
Desmid			
Micrasterias	1	9	2028
Protozoans			
Ceratium	5	43	10140
Dinobryon	17	147	34476
Euglena	16	139	32448
Monas	6	52	12168
Unknown Mastigophoran	1	9	2028
Rotifers			
Keritella	34	295	68952
Lecane	2	17	4056
Polyarthra	4	35	8112
Trichocera	3	26	6084
Possible Ploesoma	19	165	38532

	counted	* /ml sample	* in 5 min tow
Crustaceans			
Cyclops	4	35	8112
Bosmina	4	35	8112
Ospranicum	1	9	2028
Nauplius	5	43	10140

Night Zooplankton Sample

Diatom			
Asterionella	232	2011	939000
Protozoans			
Unident. Protozoan	49	425	198000
Uroglena	5	43	20200
Rotifers			
Keritella	138	1196	559000
Trichocera	56	485	227000
Crustaceans			
Bosmina	3	26	12100
Cyclops	10	87	40500
(Cerio-?)Daphnia	32	277	129500
Nauplius	1	7	4047
Insect Larvae			
Chaoboris	4	35	16190

Bay Lake

Phytoplankton Sample

	counted	*** /ml sample	*** in sample	*** /m³ lake water
Algae				
Anabena	10	52	2132	$1.07x10^6$
Protococcus	102	530	21750	$1.087x10^7$
Richterella	1	5	213	106600
Scenedesmus	178	926	37950	$1.897x10^7$
Desmid				
Staurastrum	94	489	20081	$1.002x10^7$
Diatom				
Astrionella	68	354	14500	$7.25x10^6$
Diatoma	477	2480	101700	$5.085x10^7$
Navicula	1	5	213	106600
Protozoans				
Dinobryon	89	463	18975	$9.49x10^6$
Eudorina	88	458	18762	$9.38x10^6$
Peridinium	2	10	426	213200
Unknown Protozoan	10	52	2132	$1.07x10^6$

Rotifers				
Kelicotia	2	10	426	213200
Keritella	3	15	640	319800
Ploesoma	6	31	1279	639600
Polyarthra	35	182	7462	3.73×10^6
Trichocera	1	5	213	106600
Unknown Rotifer	1	5	213	106600
Crustaceans				
Limnocalanus	1	5	213	106600
Nauplius	3	16	640	319800
Hydra	1	5	213	106600

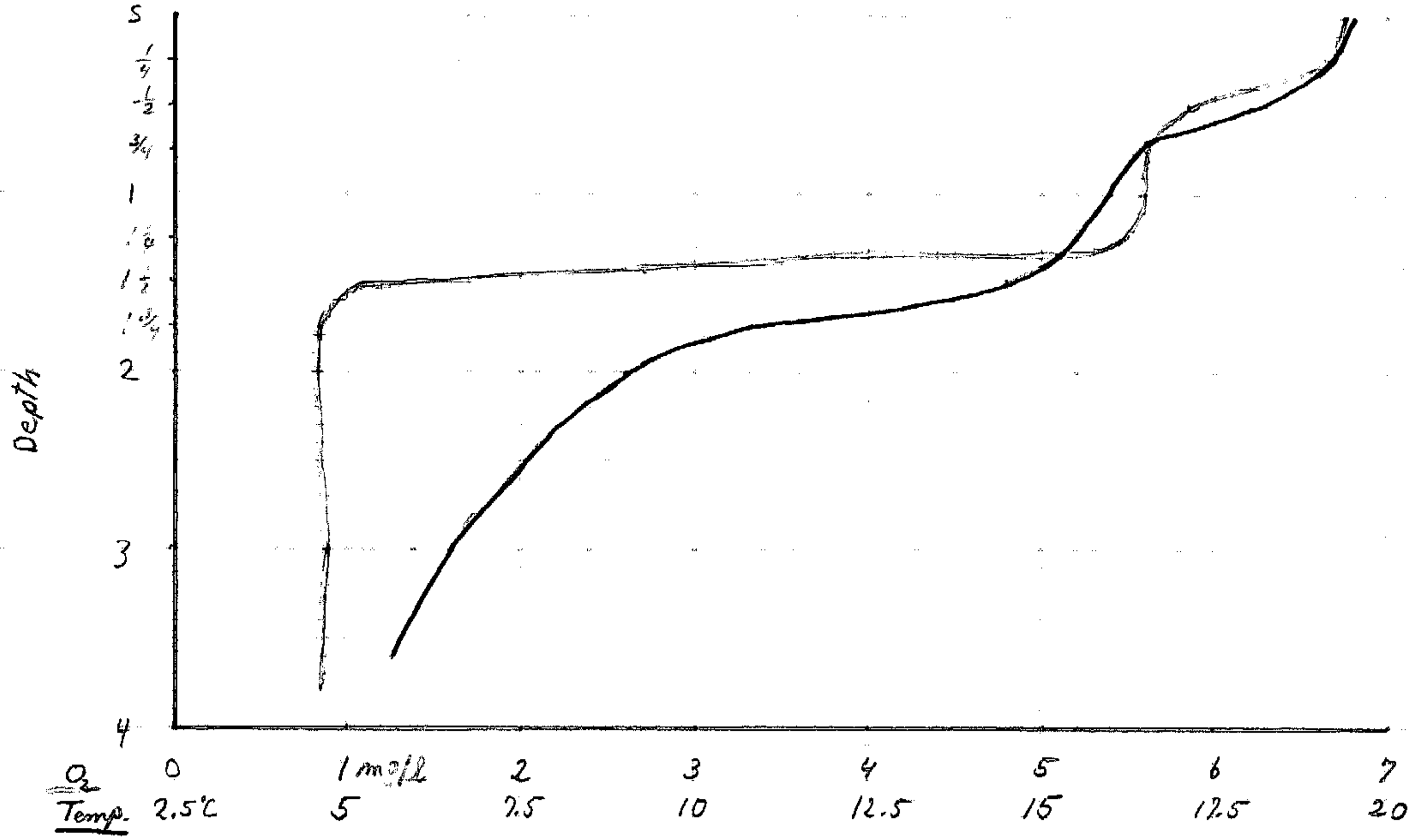
Day Zooplankton Sample

	counted *	/ml sample *	in 5 min tow
Algae			
Anabena	398	3458	172900
Scenedesmus	45	390	19500
Ulothrix	4	35	1733
Desmid			
Staurastrum	107	927	46367
Diatoms			
Diatoma	227	1967	98367
Navicula	1	9	433
Protozoans			
Ceratium	1	9	433
Dinobryon	68	589	29467
Volvox	7	61	3033
Rotifers			
Asplanchna	480	4160	208000
Kellicotia	16	139	6933
Keratella	232	2010	100533
Ploesoma	71	615	30767
Polyarthra	5	43	2167
Unknown Rotifer	4	35	1733
Crustaceans			
Bosmina	17	147	7367
Holopedium	6	52	2600
Canthocamptus	2	17	867
Cyclops	25	217	10833
Limnocalanus	1	9	433
Nauplii	54	468	23400
Senecella	3	26	1300

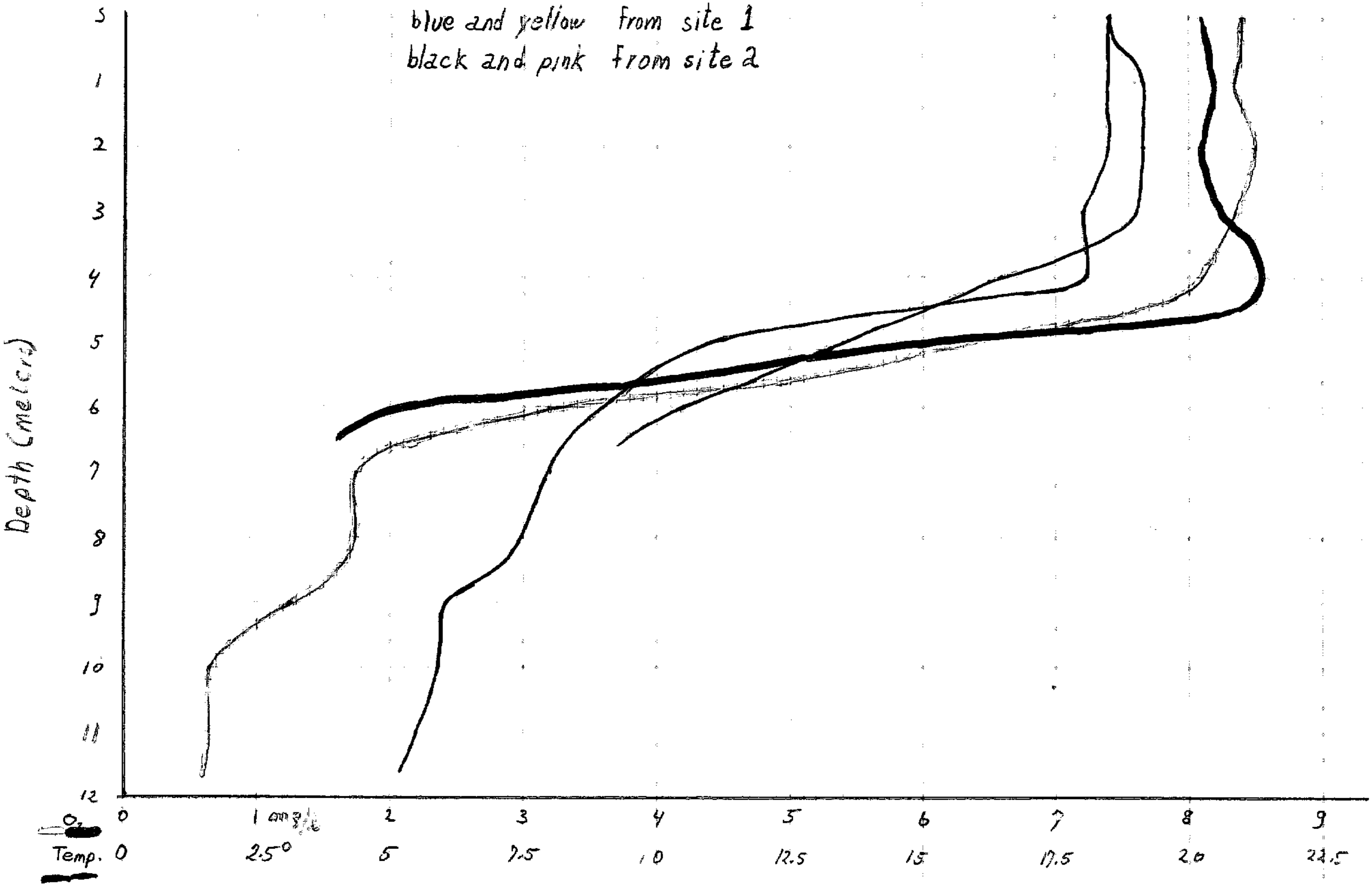
Night Zooplankton Sample

	counted	* /ml sample	* in 5 min tow
Algae			
Anabema	810	7020	652860
Gloeotrichia	40	347	32240
Scenedesmus	23	199	18538
Ulothrix	1	9	806
Desmid			
Staurastrum	93	806	74958
Diatom			
Diatoma	54	468	23400
Rotifers			
Asplanchna	565	4897	455390
Epischura	28	243	22568
Kellicottia	8	69	6448
Keratella	112	971	90272
Ploesoma	4	35	3224
Polyarthra	1	9	806
Crustaceans			
Bosmina	12	104	9672
Cyclops	61	529	49166
Diaptomus	3	26	2418
Holopedium	6	52	4836
Nauplii	37	321	29822
Unknown Copepod	5	43	4030

HUMMINGBIRD

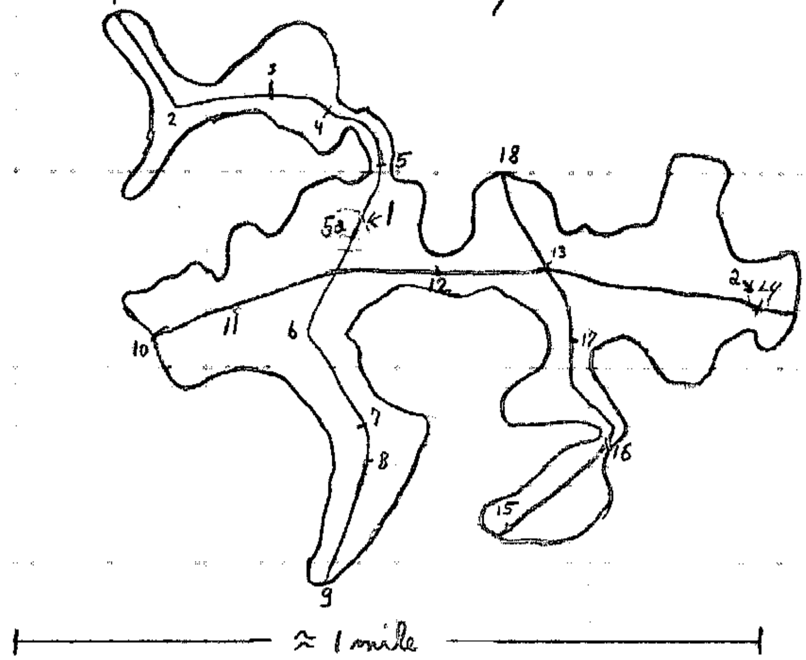


BAY LAKE



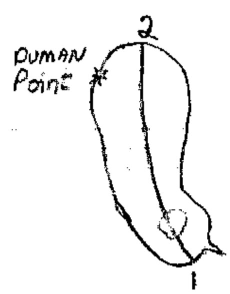
blue and yellow from site 1
black and pink from site 2
Depth (meters)
5
1
2
3
4
5
6
7
8
9
10
11
12
0
1 mg/l
2
3
4
5
6
7
8
9
O_2
Temp. 0
2.5°
5
7.5
10
12.5
15
17.5
20
22.5

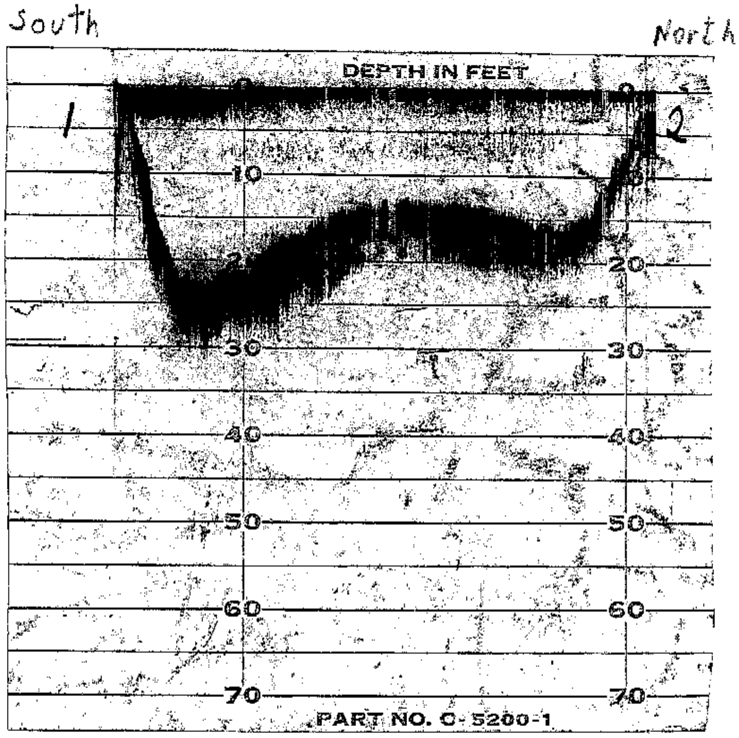
Bay



N

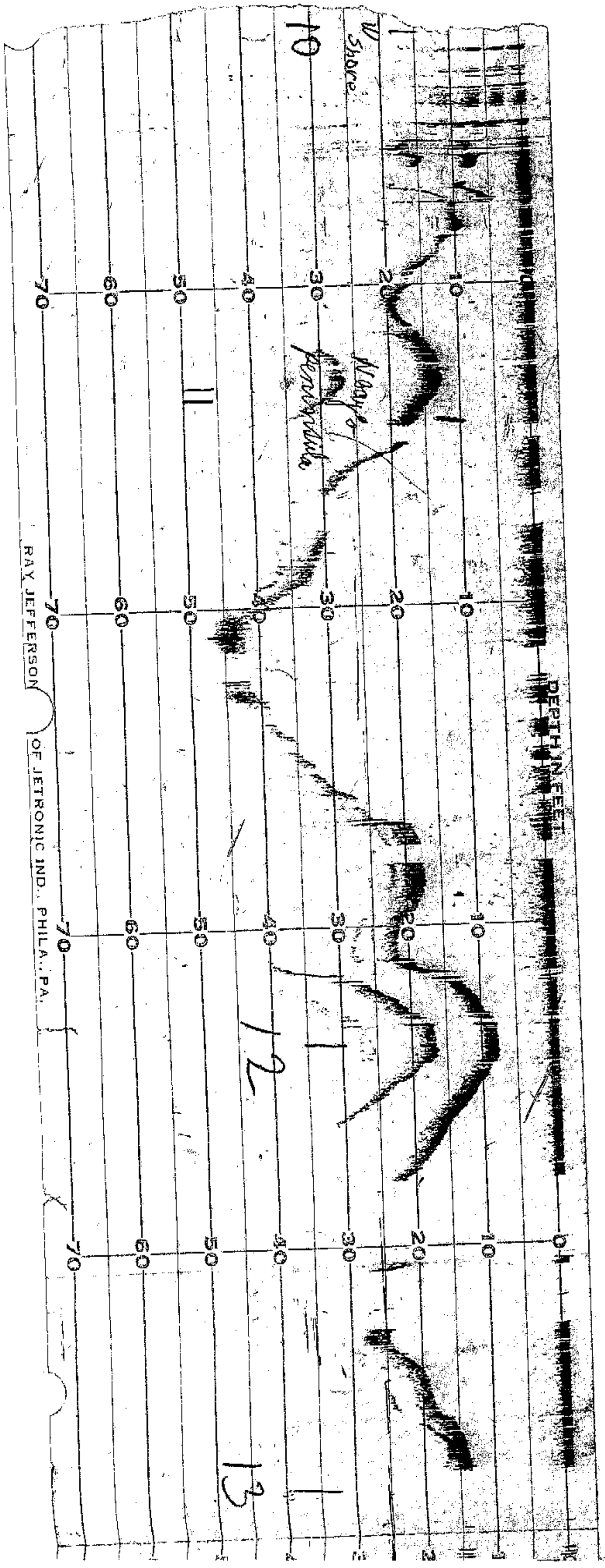
HUMMINGBIRD

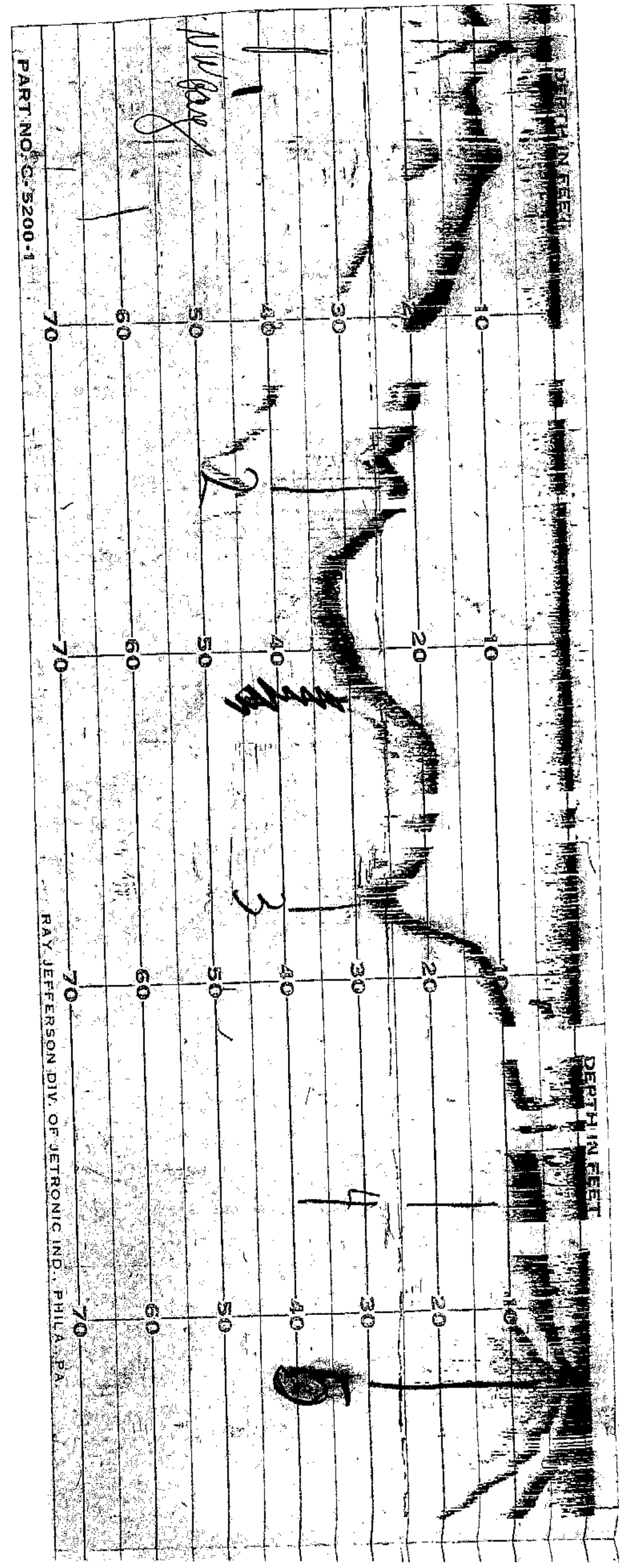




Hummingbird

Bay lake


DEPTH IN FEET
RAY JEFFERSON OF JETRONIC IND., PHILA., PA.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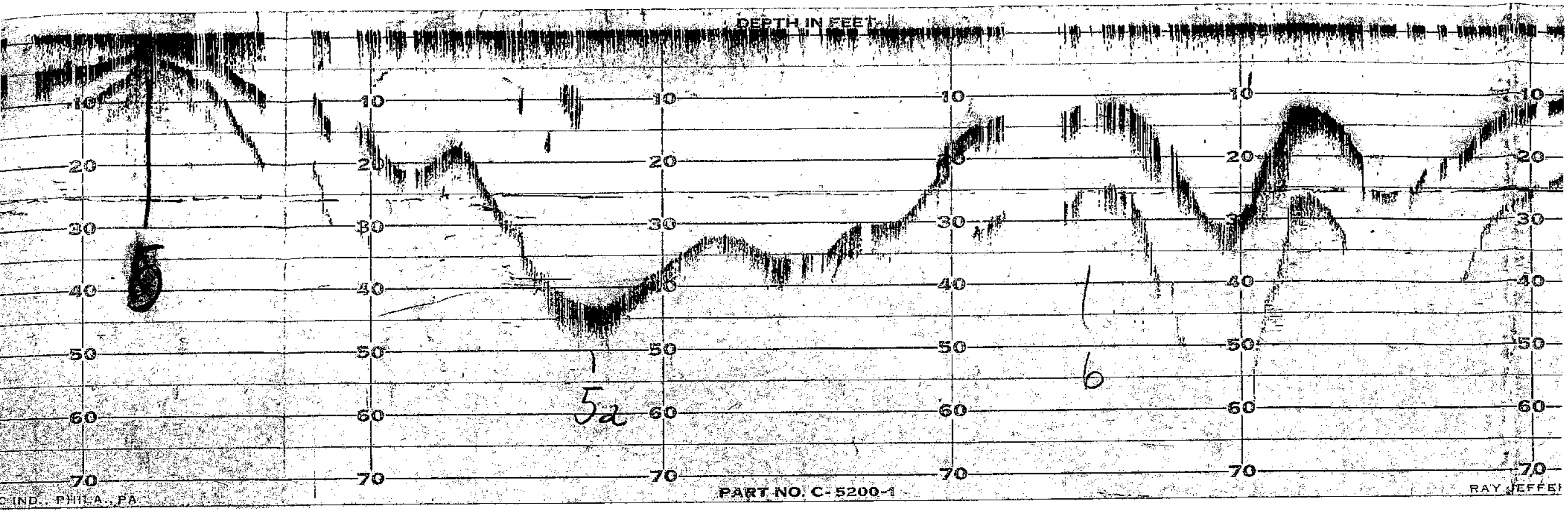
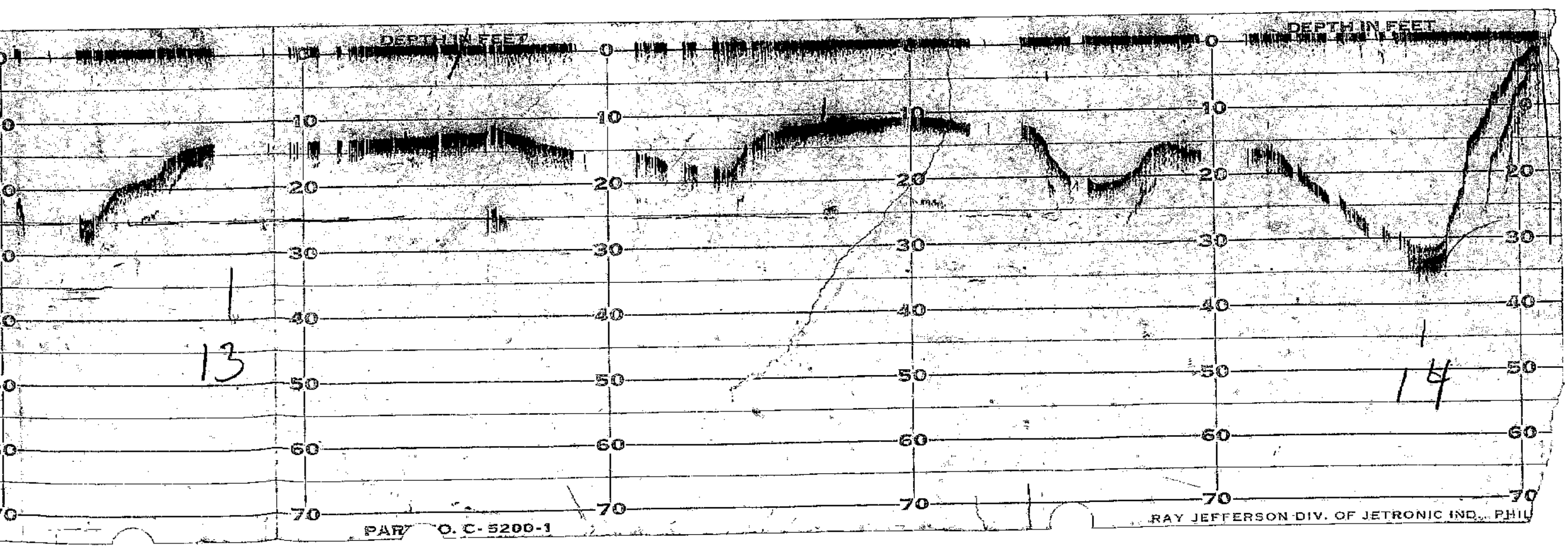
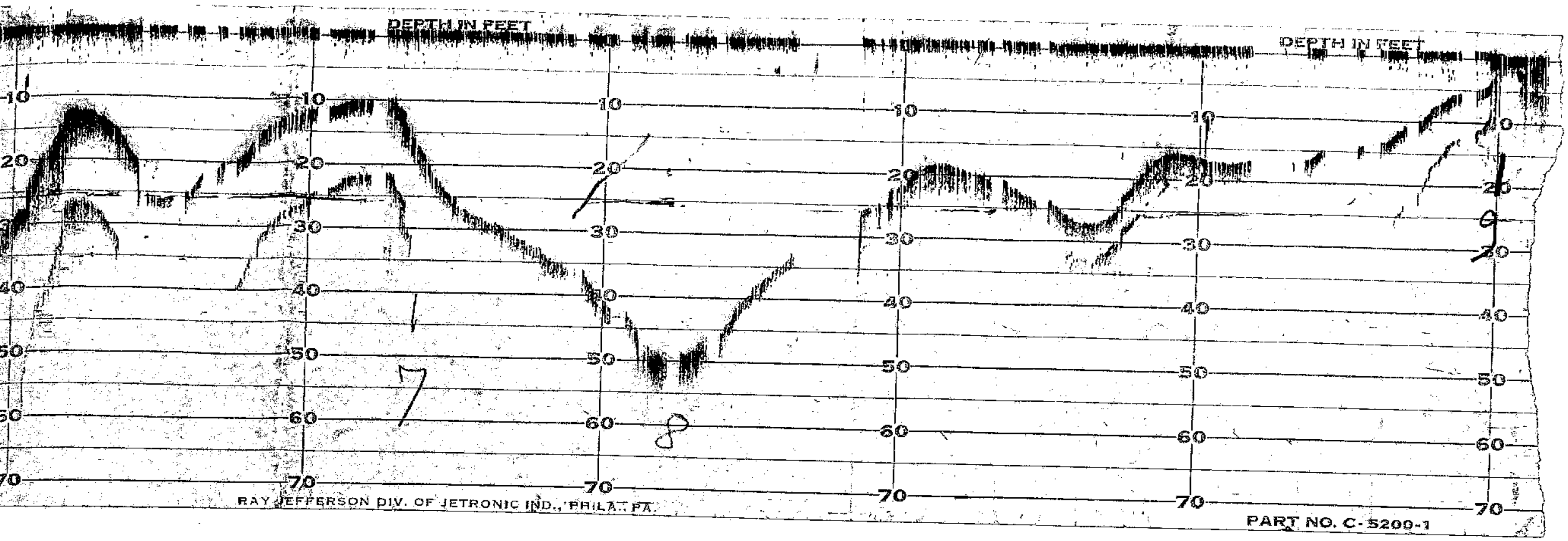

DEPTH IN FEET
PART NO. C-5200-1
RAY JEFFE
C IND., PHILA., PA.
5
5a
6


DEPTH IN FEET
DEPTH IN FEET
PAR O. C-5200-1
RAY JEFFERSON DIV. OF JETRONIC IND., PHIL
13
14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DEPTH IN FEET
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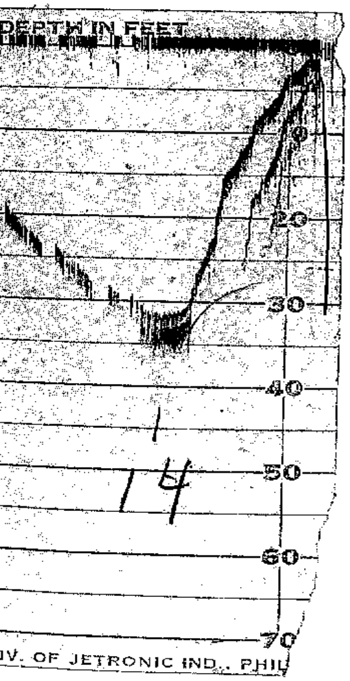
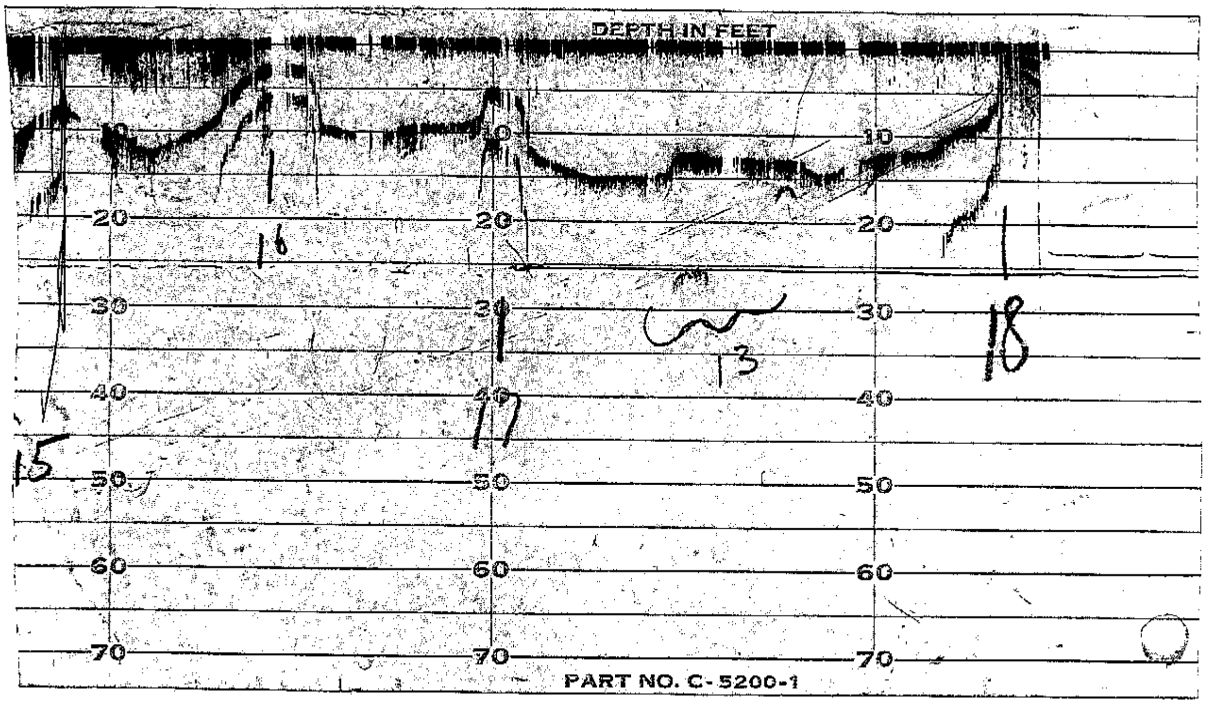
PART NO. C-5200-1
7
8
9


DEPTH IN FEET
IV. OF JETRONIC IND., PHIL
14



DEPTH IN FEET
10
20
30
40
50
60
70
15
16
17
13
18
PART NO. C-5200-1

Discussion

The sulfate test has one form of interference which affected the results for Hummingbird. The spectophotometer was set to emit violet light to measure how much light is absorbed by the $BaSO_4$ crystals. If the water is yellow, it will also absorb violet light, and it will interfere with the results. Using a sample of water without adding $BaCl_2$ in order to zero in the spectrophotometer did not solve the problem because the readings for Hummingbird at 4 m were slightly below zero every time on six trials and two different blanks. The $BaCl_2$ and acid must decrease the color of the water. Filtering or centrifuging would have been pointless because most of the color was true color(170 to 175 units) and would not have been removed.

The Hach sulfide test is mostly qualitative and not very sensitive, and was therefore not used except to confirm the odor at Hummingbird at 4 meters.

Hummingbird's alkalinity seems out of line when compared to its acidity. While it could be possible that high buffering capacity of a water would allow it to have both a higher acidity and alkylinity than another body of water, the case isn't likely here because the differences in hardness and specific conductivity between the two levels aren't large enough to allow this. Most likely there is an error. Standard Methods suggests that water samples between 50 and 100 ml be titrated, while we used 10 and 11.4 ml samples. This would decrease errors due to contamination of containers since the volume would be increased by cubes of the dimensions while the surface area of the containers only by the square. Sensitivity would also be increased since the endpoint could now be found more accurately. Using this case as an example, an alkalinity of 5 mg/l represents only one drop of acid in titration. If

50 ml of sample had been used, any point between 0 and 5 could have been located. If the point had been at one drop again, the alkalinity would have been 1 mg/l and would have fit in better with the slightly higher hardess and conductivity since it would represent such a small difference from the other level.

Similarly, it is difficult to say exactly how much lower the phenolphthalein acidity of Bay at 8 m is compared to 2 m, since the difference is only 5mg/l. It is also difficult to interpret the alkalinity results of Bay because they both only took one drop to reach the endpoint, and are listed as 5 mg/l. Knowing more exactly which level had higher alkalinity would allow a more confident statement on whether (1) both depths have the same buffering salts with one level's water balanced more in one direction of the equilibrium equation than the other, which would be indicated by identical specific conductance and hardness for both levels but with one level having a higher acidity and lower alkylinity than the other, or (2) one level had more salt than the other and thus had a better buffering ability, which would be indicated possibly by higher acidity, alkalinity, hardess, and specific conductance. The problem with Bay is that it fits the characteristics of case 1 and some of case 2, and acidity and alkalinity aren't sensitive enough to tell what exactly the case is. Specific conductivity is equal, as is calcium hardness, but total hardness is 5 mg/l higher at 8 m(The hardness test could also use an increase in water sample volume for more sensitivity). Acidity is lower at 8 m. This doesn't correspond very well with a conventionally expected system, and although a possible explanation is presented under results, greater sensitivity could have made the situation clearer. Sensitivity is needed more in these two lakes because both have very soft water.

The 2 m Bay phosphate tests are totally out of line with what one would expect. There was no algal bloom in the water, and there is little likelyhood of the lake's contamination so concentrated that far from shore. All the tests gave very consistent results(±0.02mg/l), so if there was contamination, it must have been in the sample. The 8 m level does not have a high phosphate concentration(0.55mg/l), and usually the lower levels have a higher concentration of nutrients, so contamination seems very likely.

The general trends in the day and night zooplakton samples were a decrease in protozoans and an increase in rotifers and crustaceans at night. This was probably due to upward migration for feeding in the case of the rotifers and crustaceans, and a downward migration of the protozoans, with possibly the feeding on the protozoans lowering their number a little also.

Hummingbird has a very sharply divided oxygen and temperature profile. The epilimnion goes until 1 1/4 meters, and the thermocline really only lasts 1/4 meter, down to 1 1/2 meter. Everyting below is hypolimnion. The "bump" in the O_2 curve at 1/2 to 3/4 m is probably due to a higher rate of respiration there than further up, where there was probably a higher rate of photosynthesis. Oxygen probably decreased to zero between 2 m and 3 m, but the curve goes straight down at an aproximately constant concentration of 0.85 mg/l because H_2S interferes with the reading by passing through the membrane and being indistinguishable from oxygen to the meter. The shift to the right of the curve of the temperature above 3/4 m was probably due to the sun's heating the water for the first time after two days of cold rain. The slope isn't as sharp as the O_2 curve, probably because heat diffuses more freely than actual molecules.

Hummingbird has been called both a lake and a bog, and which it is is a matter of semantics. Although it doesn't have a mat, the water's qualities are very similar to those of bogs, and probably a mat will begin to develop in the futur. Hummingbird is a little larger than most bogs, and this may allow wind to cause small waves which make it difficult for a mat to begin to grow.

The oxygen and temperature profiles for both sites at Bay are very similar. The O_2 curve for site 2 suggests an algal bloom at 4 meters because it increases by 0.5 mg/l from the 2 m reading. The temperature drops off suddenly at 4 m at site 1 and after 3 m for site 2. This probably shows the deepest point the wind and sun can directly affect the temperature. The epilimnion is above 4 m, the thermocline is between 4 m and 7 m, and rest is hypolimnion.

Bay lake is one of the more productive lakes at U.N.D.-E.R.C., although it wouldn't be considered very productive compared to many lakes elsewhere. It has a greater number and variety of organisms than Hummingbird, as can be seen on the tables of plankton samples.