LIMNOLOGICAL AND FISHERIES SURVEY OF NAUJAN LAKE

By

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ABSTRACT

Limnological investigations of Naujan Lake were conducted for a period of one year and five months to evalute its productivity. Studies were made on the lake's physico-chemical and biological characteristics including the lake's fisheries, using the monthly landings in the three existing landing points including catches from the only fish corral operating in the area.

Results of the chemical analysis of the water showed a considerable amount of dissolved oxygen ranging from 4.9 to 8.5 parts per million; pH ranges from 6.0 to 9.8; carbon dioxide ranges from 0.8 to 2.0 and alkalinity had an annual mean reading of 145.4 to 162 as calcium carbonate, from surface to bottom. Visibility test ranged from 1 to 2.5 meters. Phytoplankton identified consisted of Cyanophyta, Cholorophyta and Chrysophyta while Zooplankton was represented by rotifers, copepods and cyclop. These indicate that the lake is highly productive as evidenced by a chemically active substrate and the presence of rich dissolved substances. The lake was found to be biologically active and showed signs of seasonal and spatial variations. The fish stock reflected a varying fair to large amounts of indigenous and migratory fish species present in the lake.

A continuing program of research is indispensable for the lake's development.

INTRODUCTION

There is a pressing need to establish sound limnological data on Naujan Lake because of its high economic potential. The lake is the only inland water in Luzon where migratory species of marine fishes are still abundant in commercial scale. It is considered to be a sanctuary area and potential reservoir of fish breed stock like milkfish (sabalo), eel, red snapper, mullet, etc. Early researches on the lake started as early as 1916 by Pratt, Woltereck, et al (1932), Blanco, et al (1955), Delmendo and Angeles (1967) provided some information on the lake's characteristics. The present research which covered the period from April 1977 to August 1978, is an attempt to study the physico-chemical and biological conditions, including the lake's fisheries. The information is necessary for proper management and conservation purposes and to realize maximum fish production.

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Lake Naujan is located in the northeastern coast of Mindoro, an island in the southern part of Luzon. The lake has an area of about 6,912 hectares. It is elongated from north to south with a surface dimension of 7 by 14 kilometers. Elevation is estimated to be 20 meters above sea level and its greatest depth, at 45 meters. The outlet is towards the north through Lumangbayan river. No large streams flow into the lake.

The lake is probably volcanic in origin as evidenced by some indicators, although it does not appear to be a crater lake. The eastern shore is precipitous but to the west, the land gradually rises through vegetation which covers the shallow water and swamps. The outlet has cut a fairly deep valley around the base of a hill. Several hot springs emanate along the edges of the shore and show signs of solfatara on its eastern margin.

MATERIALS AND METHODS

Four sampling stations for physico-chemical and biological parameters were established in the lake. The collection of samples was made twice each month throughout the research period. The same procedure of sampling was also maintained throughout the period.

Water samples were taken at three levels: the surface, middle and bottom using 3 BOD bottles connected in series through rubber stopper. Analysis of water sample was done to determine its chemical composition such as $CaCO_3$, using modified winkler method, alkalinity by titration method with .05/N. HCl against methyl orange and phynolpthalein indicators, and pH by Hydrion litmus paper indicators. Temperature measurement from water surface to bottom was done using an ordinary laboratory thermometer to determine if it stratifies.

Light penetration was determined through Secchi dish reading from water surface down to a level where the instrument is no longer visible. No conductivity reading was undertaken due to lack of instrument for this purpose.

Benthic organisms were obtained by the use of Ekman Dredge and plankton samples, through horizontal towing using plankton net. Samples were preserved in 10% formaldehyde for laboratory analysis.

Fish catch data were collected through survey of three landing points with four dealers in Naujan Lake. The majority of the fishermen in the lake bring their catches to these landing points. Daily catches on migratory fishes were recorded and taken from fish corral operators at Butas River. These data were to be used for correlation purposes with physico-chemical and biological productivity.

RESULTS AND DISCUSSION

Temperature

The mean annual temperature is 29°C in 1977 and 28°C in 1978. The temperature readings reflected a relatively even increase with 31.5°C as the highest in 1977 and 32°C in 1978. The monthly record was fairly constant, hence, the lake may be considered as having mild climate and indicates a favorable productive capability. Based on climate map of the Philippines, the area belongs to type 4 where rainfall is more or less evenly distributed throughout the year.

Dissolved Oxygen

The dissolved oxygen (D.O.) data (Table 1) shows ranges of 5.6 to 7.4 ppm at the surface and 5 to 6.9 ppm in bottom layer as obtained in 1977.

Table 1. Dissolved oxygen at 3 depths, Naujan Lake.

	DATE	SURFACE	MIDDLE (15 feet)	BOTTOM
1977	April	7.4	7.1	6.9
	May	6.7	6.4	6.1
	June	6.0	5.8	5.2
	July	5.6	5.2	5.0
	August	7:1	6.9	6.4
	September	6.8	6.6	6.4
	October	6.6	6.4	6.1
	November	5.6	5.4	5.1
	December	5.6	5.4	5.0
	MEAN	6.3	6.13	5.83
1978	January	5.8	5.6	5.4
	February	7.1	7.0	6.8
	March	8.5	8.2	8.2
	April	5.3	5.0	4.9
	May	6.7	6.5	6.2
	June	6.6	6.4	6.1
	July	5.9	5.6	5.4
	August	5.5	5.2	5.0
	MEAN	6.42	6.18	5.47

Surface water was found to be well oxygenated throughout the year and gradually decreased as the water temperature increased. As the water cooled, oxygen content increased until December 1977. Oxygen at all depths was almost the same (5.0-5.66 ppm) while in 1978, oxygen at all levels ranged from 4.9-8.5 ppm.

In contrast, the summer period recorded the oxygen levels as gradually decreasing with a slight increase in the upper level. Ruttner's (1953) explanation of the phenomenon of the dissolved oxygen process involves either the effect of greater hydrostatic pressure allowing greater solubility and/or sufficient light penetration to the lower area to allow photosynthetic activity at that depth, followed by a lateral diffusion of dissolved oxygen in the upper portion of the hypolimnion.

Carbon Dioxide

Free carbon dioxide ranged from 0 to 1.16 ppm at surface water and 1.0 to 2.0 ppm (Table 2) at bottom which is too small to affect fish. In deeper

Table 2. Carbon Dioxide at 3 depths, Naujan Lake.

	DATE	SURFACE	MIDDLE (15 feet)	BOTTOM
1977	April	1.02	1.04	1.06
	May	0.8	1.0	1.03
	June	0.8	1.0	1.08
	July	0.8	1.0	1.04
	August	0	0.8	1.0
	September	1.16	1.20	1.16
	October	1.0	1.12	1.16
	November	0	1.08	2.0
	December	0	1.08	1.09
	MEAN	0.62	0.924	1.186
1978	January	1.2	1.07	2.0
	February	1.0	1.05	1.06
	March	0.8	1.0	1.03
	April	0	1.02	1.05
	May	0.8	1.01	1.03
	June	1.12	1.15	1.18
	July	1.0	1.06	1.10
	August	0.8	1.0	1.05
	MEAN	0.84	1.045	1.187

waters of Naujan Lake, carbon dioxide concentrations were found to increase and fluctuate widely from 1 to 2 ppm in one season, probably due to plant and animal activity. Furthermore, CO_2 concentration increases with depth, with high value accumulating at the bottom and maybe considered to vary inversely with D.O.

pH

The hydrogen-ion concentration (pH), a result of many chemical conditions was relatively constant in 1977 and 1978. The annual mean for both years was 8.0 and reflected that the lake water was alkaline. Alkaline reaction for water and soil is necessary as it affects the productivity of the lake. A pH range of 6.5 to 8.5 is favorable for fish production. Table 3 has recorded the pH range for two years. The lake's biological productivity was evident as substantiated by the abundance of phytoplankton and zooplankton (Table 5) and benthic organisms.

Table 3. pH readings at 3 depths, Naujan Lake.

	DATE	SURFACE	MIDDLE (15 feet)	BOTTOM
1977	April	7.9	7.6	7.4
	May	7.8	7.7	7.3
	June	7.2	7.1	7.0
	July	7.6	7.4	7.2
	August	8.0	7.0	6.0
	September	8.1	8.0	7.0
	October	8.0	7.4	7.1
	November	8.2	8.1	8.0
	December	8.0	7.6	7.4
	MEAN	7.8	7.5	7.1
1978	January	7.9	7.6	7.2
	February	8.0	7.9	7.5
	March	8.2	8.0	7.8
	April	8.1	8.9	8.6
	May	8.1	8.0	7.9
	June	9.0	9.1	9.3
	July	9.10	9.6	9.5
	August	9.8	9.7	9.5
	MEAN	8.5	8.6	8.7

Total Alkalinity

As shown in Table 4, the total alkalinity ranged from 109 to 208 ppm with annual mean from surface, middle and bottom of 145 ppm (surface 158.6 ppm (middle) and 162 ppm (bottom) as calcium carbonates in 197 In 1978 it ranged from 73 to 132 ppm with annual mean of 120.2 ppm (su face), 123.5 ppm (middle) and 138 ppm (bottom). The values may be co sidered as relatively stable with slight variation in each month. However, th readings gradually increased with depth as recorded highest at the botto

Table 4. Total alkalinity at 3 depths, Naujan Lake. (mg/liter C_0C_0).

	DATE	SURFACE	MIDDLE (15 feet)	BOTTOM
1977	April	124	127	129
	May	152	155	154
	June	182	186	200
	July	162	165	169
	August	171	174	176
	September	156	158	160
	October	142	146	150
	November	109	202	208
	December	111	115	116
	MEAN	145.4	158.6	162
1978	January	110	113	115
	February	183	186	190
	March	105	109	202
	April	121	125	128
	May	120	124	130
	June	127	129	132
	July	73	77	80
	August	123	125	129
	MEAN	120.2	123.5	138.2

BIOLOGICAL CHARACTERISTICS

The nature of bottom organisms and aquatic plants were, to a large extent, determinants of the level nutrients in the body of water and aquatic productivity. Each environment differs in the amount of living matter it is able to support. Productive differences among waters are characterized by many factors which include phytoplankton, the basic producers, the zooplankton, the middle consumers, and the fish as final consumer.

Phytoplankton

Seasonal variation in abundance of net phytoplankton was obtained and consisted of three types of algae: Cyanophyta, Chlorophyta and Chrysophyta. Algae is found to be abundant in the western and coastal shallow portion of Naujan Lake.

Blue green algae predominated in the amount ranging from 2,278 to 2,689 cells per milliliter. Diatoms ranked second ranging from 1,522 to 2,089 cells per milliliter. This was represented monthly by *Navicula, Anaebaena, Melosira* and *Cycletella.* The green algae ranged from 689 to 803 cells per milliliter, represented by 3 genera: Chlorella, Pediastrum and Cosmarium.

Table 5. Number (cells/ml) and percentage of phyto- and zooplankton counts, Naujan, Lake.

ORGANISMS	1977		1978	
	NUMBER	%	NUMBER	%
A. Phytoplankton				
– Diatoms	1,522	31	2,089	41
– Blue-Green	2,689	54	2,278	44
– Green	689	14	803	15
B. Zooplankton				
– Rotifers	1,609	42	2,028	44
– Copepod	1,606	45	1,892	40
– Cyclop	533	14	701	15

Zooplankton

The lake showed an increasing production of zooplankton (Table 5) co posed of rotifers ranging from 1,609 to 2,028 cells per milliliter, copepo ranged from 1,606 to 1,829 cells per milliliter and cyclops were present negligible amounts at 533 to 701 cells per milliliter.

The zooplankton population showed little variation in abundance at su face and mid-depth (10 feet) levels. Apparently, difference in depth was n sufficient to cause any change in species composition and abundance.

Samples were taken occassionally, thus, total of plankton in Table 5 a not precise portrayal of the average plankton production in Naujan Lake, b are representative of trends in plankton abundance. Production may va seasonally by area which have not been fully explored during the period study. At this juncture, further studies along this field is needed in order determine the magnitude of its economic importance to the fishery resourc of Naujan Lake.

Bottom Fauna

Just like the plankton group, samples were taken occassionally and th collections showed that the shallowest portion of the lake was most produ tive.

Table 6 shows the volumes of bottom fauna obtained in the lake. An nelid were observed abundant in May and October 1977 and became scarc in 1978. Crustaceans were present in fair amount in May 1977 and Januar 1978. Whereas, in May, June and August 1978 no crustaceans were obtaine from the samples. Insects were found abundant in July and October 1977 an became fairly available in January, May and June 1978.

Bottom organisms include annelids, snails and chaoboridae.

LAKE FISHERIES

The kind of fish caught in the lake can be classified into migratory an non-migratory species. The migratory species are listed according to ran of production based on the landed fish caught (Table 7-10) in 1977 t 1978.

Mullet (*Mugil dussumieri*) predominated with annual production o 39,550 kg in 1977 and 36,070 kg in 1978. *Caranx* (maliputo) ranke second with an annual yield of 12,835 kg in 1977, but declined to 3,14 kg in the succeeding year. Gray snapper (*Lutianus argentimaculatus*) a tained an annual yield of 4,674 kg in 1977 and abruptly increased to 13,52 kg in the following year. Red snapper (*Lutianus malabaricus*) recorded

Table 6. Number per square foot and volume millimeters of bottom fauna as per collection of sample in Naujan Lake.

ORGANISMS (15 feet)	MAY 1977	JULY 1977	OCTOBER 1977	DECEMBER 1977	JANUARY 1978	MARCH 1978	MAY 1978	JUNE 1978	AUGUST 1978
Mollusca	5/.007	5/.004	9/.017	0/0	9/.033	1/.007	0/0	5/.467	0/0
Crustacea	48/.013	0/0	16/5	1/5	29/.013	1/5	0/0	0/0	0/0
Annelida	565/.0173	77/.040	659/.231	23/5	24/.013	3/5	1/5	0/0	5/5
Insecta	11/5	277/.197	121/.152	0/0	51/.080	13/.040	1/5	19/0.020	0/0
TOTAL	629/.193	359/.241	805/.400	24/5	113/.139	18/.047	2/5	24/.487	5/5

Table 7. Landed fish catch by species fr... at Butas River, Naujan ... fish corral ... Lake.
1977
(K... g)

Month	Total	Mullet	Caranx	Eel	Milkfish pc (4-6/kg)	Red Snapper	Grey Snapper
January	2,400	2,400	None	None	–	None	None
February	3,258 (41 pc)	100	–	–	41 pc (166.8)	59	–
March	435	–	435	–	–	–	–
April	980	–	–	–	–	–	980
May	1,968.9 (10 pc)	–	–	–	19 pc (84.4 kg)	800	1,084.5
June	9,680	–	9,478	–	–	2	200
July	2,599.8 (5 pc)	–	1,819	–	5 (22.5 kg)	371.8	386.5
August	2,177	–	89	–	–	82	2,006
September	666	–	649	–	–	–	17
October	1,604	–	204	–	–	1,400	–
November	14,042.4 (300 pc)	12,500	140	–	300 (1,402.4 kg)	–	–
December	25,626 (184 pc)	24,550	20	104 kg (12 pc)	172 (895 kg)	57	–
TOTAL	62,504.9 (594 pc)	39,550	12,835	104 (12 pc)	537 pc (2,571.1 kg)	2,771.8	4,674

Table 8. Landed fish catch by species from fish corral at Butas River, Naujan Lake.
1978
(Kg)

Month	Total	Mullet	Caranx	Eel	Milkfish pc (4-6/kg)	Red Snapper	Grey Snapper	Spadefish
January	538 (31 pc)	320	None	218 (31 pc)		None	None	None
February	578	None	–	–		43	535	–
March	498	–	–	–		–	498	–
April	6,038 (24 pc)	–	–	–	24 (156 kg)	344	5,518	20
May	1,974	–	–	–	–	–	1,974	–
June	4,095	–	310	–	–	502	3,283	–
July	1,559	–	442	–	–	–	1,117	–
August	1,037.5 (70 pc)	–	411	–	70 (462.5 kg)	160	–	4
September	1,863.5 (87 pc)	–	467	–	87 (353.5 kg)	726	210	107
October	994.4 (41 pc)	–	668	21 (3 pc)	38 (154.4 kg)	110	–	41
November	31,728.5 (48 pc)	28,500	340	100 (6 pc)	42 (178.5 kg)	2,450	130	30
December	10,266.1 (104 pc)	7,250	508	230 (30 pc)	74 (320.1 kg)	1,620	260	78
TOTAL	61,170 (405 pc)	36,070	3,146	569 (70 pc)	335 (1625 kg)	5,955	13,525	280

Table 9. Landed fish catch by species in Naujan Lake.
1977
(Kg)

MONTH	TOTAL	Mudfish	Goby	Catfish	Gourami
January	33,722	15,394	17,685.5	642.5	
February	18,160	4,950.5	13,032.0	177.5	
March	25,173	6,205.0	18,776.0	192.0	
April	30,059.5	10,391.5	19,200.0	448.0	
May	13,597.5	5,545.0	7,528.0	524.5	
June	13,150	6,354.0	5,684.0	137.0	975.0
July	25,607.5	0,056.5	13,123.0	194.0	1,234.0
August	24,165.5	8,908.5	15,257.0		
September	19,835.6	8,723.1	11,112.5		
October	14,427.6	5,840.1	8,444.0	39.5	
November	17,893	5,142.0	12,625.0	112.0	14.0
December	16,393	5,461.0	10,880.0	52.0	
TOTAL	251,184.2	92,971.2	15,336.7	2,519.0	2,327.0
VALUE		₱372,461.00	408,846.00	11,880.00	9,308.00
			TOTAL AMOUNT.....		₱797,495.00

production of 1,982.3 kg in 1977 and increased to 4,955 kg in 1978. Milkfish ranging from 4-8 pieces per kg yielded an annual production of 2,571 kg in 1977 and declined to 1,622 kg in 1978. While eels weighing from 4-14 pieces per kg recorded a minimal production of 334 kg to 548 kg from 1977 to 1978. The last species was spadefish which was included in 1978.

Seasonal downward migration of mullet and eel occurs every November to February, while other species such as milkfish, red snapper, gray snapper, caranx and spadefish migrate from Naujan Lake to the sea all year round but are most abundant during inclement weather. However, occasional migration occurs in fair sunny days. Factors which affect their migration were consistently observed due to changes in temperature from high to low. This is attributed to inclement weather; turbidity of water due to flooding or siltation from tributaries of the lake; wind direction from the southwest that affects wave action of water and exit towards Naujan Lake. Monsoon also triggers migration of fish (three days before and after new moon and three days before and after full moon).

Table 10. Landed fish catch by species in Naujan Lake.
1978
(Kg)

MONTH	TOTAL	Mudfish	Goby	Catfish	Gourami
January	26,543	8,081.5	17,519.0	942.5	–
February	19,733.5	4,028.5	15,231.0	474.0	–
March	27,696.5	7,537.5	19,793.0	366.0	–
April	34,266.0	13,423.0	19,908.5	934.0	–
May	29,078.5	15,205.5	13,338.5	534.5	–
June	28,772.5	14,037.0	14,613.0	122.5	–
July	29,909.5	14,467.0	14,725.5	109.0	608.0
August	30,621.5	13,601.5	12,978.0	164.0	3,878.0
September	21,643.5	9,290.5	10,900.0	41.5	1,411.5
October	16,469	5,806.5	10,616.5	46.0	–
November	13,183.5	5,685.0	7,129.5	189.0	–
December	18,202	8,526.5	8,968.0	707.5	–
TOTAL	296,119	119,870.0	165,720.5	4,631.0	5,897.5
VALUE.....		₱. 599,355.00	497,461.50	23,155.00	23,990.00
			TOTAL AMOUNT		₱1,143,956.50

SUMMARY AND CONCLUSION

1. Certain environmental factors need to be studied and analyzed for such factors are essential in the sound planning of lake management especially in the fisheries of the lake.

2. Chemical considerations concern the presence and reactions of nutrient elements or compounds. The various readings of dissolved oxygen, carbon dioxide, the pH range and total alkalinity of the lake, signify a chemically active substrate. The lake's water may be considered highly productive as evidenced by the presence of generally rich dissolved substances and an alkaline pH range (7.0 to 8.5).

3. Abundance and/or fluctuations of phytoplankton, zooplankton and bottom organisms showed seasonal and geographical variation, although the fairly large amount of fish taken in the lake seems to indicate a biologically active water.

4. A continuing program of study and management measures may achieve production of fish in commercial proportion both for migratory and indigenous fish species.

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