Pauly, D., m.Small, R.Vore and M.L. Palomares. 1990. Fisheries yields and morphoedaphic index of Lake Mainit, Philippines, p.835-838. In: R. Hirano and I. Hanyu (eds.) The Second Asian Fisheries Forum, Asian Fisheries Society, Manila, Philippines.

FISHERIES YIELDS AND MORPHOEDAPHIC INDEX OF LAKE MAINIT, PHILIPPINES

D. Pauly(*1), M. Small(*2), R Vore(*2) and M.L. Palomares(*1)

(*1) International Center for Living Aquatic Resources Management (ICLARM), MC P.O. Box 1501, Makati, Metro Manila, Philippines. (*2) Former U.S. Peace Corps volunteer, based in Mindanao Island, Philippines. ICLARM Contribution No. 533.

Abstract

An assessment of the fishery of Lake Mainit, Mindanao Island, Philippines is presented, based on catch and effort data by gear, location and species group collected in 1980/81. The morphoedaphic index (MEI) of Lake Mainit was computed, and its value related to yield via an empirical regression of fish yield vs. MEI for tropical lakes. Observed differences are discussed with reference to the peculiar fauna of Lake Mainit, consisting, to a large part, of visiting marine and introduced freshwater species.

Introduction

Lake Mainit, located in the northeastern part of the southern island of Mindanao, with a surface area of 73.4 km^2, is the fourth largest lake as well as the deepest of the Philippine lakes (Baluyut 1983). A number of reports, published and unpublished, exist which discuss various aspects of the lake (Manacop 1937; Gracia et al. 1962; Pambid 1970; Lewis 1973; Reyes et al. 1975; Gracia and Magsumbol 1981; Gracia 1985). However, it was the comprehensive limnological study of Lewis (1973) which put Lake Mainit "on the map" (Fig. 1).

The present contribution aims to complement this study by providing a more detailed account of the fishes and fisheries of Lake Mainit than presented in Lewis (1973). Three lines of investigation have been followed:

i) collection and analysis of catch data by gear and location,
ii) estimation of total dissolved solids, as needed - along with mean depth - to compute the morphoedaphic index of Lake Mainit, and
iii) consolidation and analysis of secondary published and unpublished data, particularly on the fish fauna.

Materials and Methods

Fisheries

Fisheries catch data by landing site, number of gears and their characteristics and other data on various aspects of the Lake Mainit fisheries were collected over a period of 12 months spanning the years 1980/81. Each village bordering the lake was visited for information gathering and at least one fisherman was interviewed for each gear type. To smooth out seasonal fluctuations, the collected catch records were used to compute the mean annual daily catch, by gear, for each landing center (except for Alipao and Puntud, which were pooled because their border could not be identified). All gears deployed at each site were recorded, along with the length of coastline pertaining to each site.

Morphoedaphic Index

Estimation of the morphoedaphic index (MEI), of a given water body requires that water body's mean depth (Z) and total dissolved solids (TDS), because MEI =

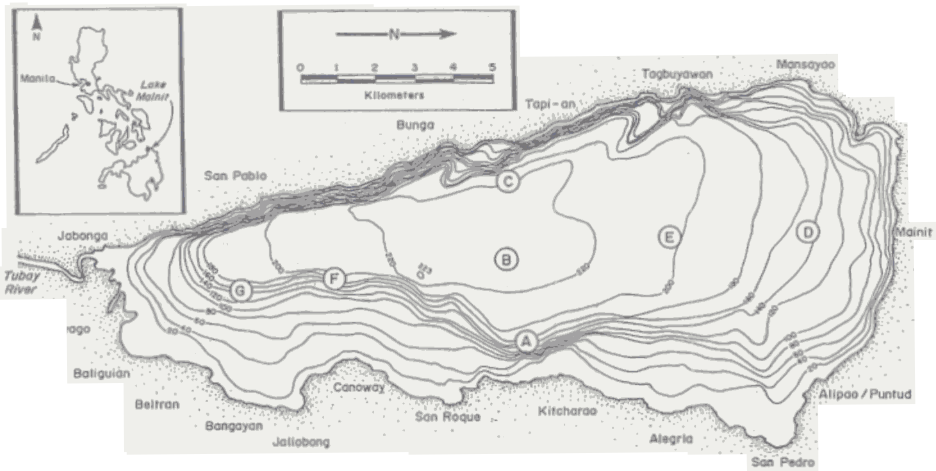

Fig. 1. Map of Lake Mainit, Philippines, showing depths in m (from Lewis 1973), location of fisheries catch and effort sampling Table 1) and stations (A-G) for estimation of total dissolved solids and related statistics (see Table 2).

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TDS/Z (Ryder 1965, 1982). The method used to estimate TDS followed Greenberg et al. (1981):

i) filter water sample through a 12.5 cm piece of Whatman No. 42 ashless filter paper, to remove seston,
ii) evaporate a 100 ml sample of filtered water from a previously pre-weighted porcelain evaporating dish (over 1 hour at 103-105°C),
iii) cool and dry dish in desiccator (approximately 2 hours),
iv) weigh dish with remaining solids with a precision digital balance and convert weight of solids to ppm TDS.

All water samples were analyzed twice, and the mean of the two TDS values was taken. The water samples were taken at stations A-G in Fig. 1, from September 1982 to May 1983.

Consolidation and Analysis of Catch, Effort and Other Data

A commented list of all fish species reported from Lake Mainit was compiled from various sources. Also, an attempt was made to analyze the fishery catch and effort data using the spatially-structured surplus production model of Munro (1979), as extended to a multigear setting by Marten (1979a, 1979b). Specifically, we estimated the parameters of a number of multiple regressions linking the catch per effort of a given gear at different sites, to the number of gears of different types of those sites.

Results and Discussion

The fisheries of Lake Mainit are exclusively small-scale, and conducted either from shore, or from small non-motorized "bancas". One large weir operates near Jabonga and traps migrating fishes.

Table 1 presents the key characteristics of the various landing sites around Lake Mainit. As might be seen, total landings at Jabonga at the mouth of Tubay River contribute 86% of the total catch from Lake Mainit, a fact to which we shall return further below.

Table 2 presents the fishery catch of Lake Mainit, by landing site and gear, while Table 3 gives an idea of the number of fishing gears at each site. These two tables re-emphasize the importance of Jabonga as key landing site for Lake Mainit.

We were unable to derive a significant multiple regression model - whether Jabonga was excluded or not - such as to be able to explain the catch per effort of any gear at given sites in terms of the number of gears deployed at those sites. We conclude that Lake Mainit is too small for local differences in gear deployment to result in significant local difference in catch per effort (Marten's above cited successful analyses pertained to Lake Victoria, Africa, a lake with a surface area almost a thousand times larger than that of Lake Mainit).

Table 2 presents our values of TDS, as well as some ancillary data collected along with the water samples. As no clear-cut trend of TDS with location or depth emerged, we have derived the mean TDS for Lake Mainit as a whole by first computing the mean for each station, across all depths and months; then, we took the mean of the station means. This led to an overall mean TDS = 68.3 ppm, which, combined with the mean depth of 128 m, gives MEI = 0.534 for Lake Mainit.

The total annual fish catch (see Table 1) is plotted against MEI on Fig. 2. As might be seen, the data point for Lake Mainit is well above the line estimated for 17 African lakes by Henderson and Welcomme (1974), and also higher than the single other point available from elsewhere in the Philippines, i.e. Lake Sampaloc (Manrique 1988). We explain this in terms of the peculiar ichthyofauna of

Table 1. Summary statistics on Lake Mainit, Philippines, per landing site, for the years 1980/81. The number under each gear type are the annual catche (in t) and the number of units in use (in brackets).

Area	Shoreline length (km)	Total annual catch	Longline small hooks	Longline large hooks	Gillnet small	Gillnet medium	Gillnet large	Beach seine
Mainit	8.1	270	20 (4)	71 (15)	0 (0)	9.3 (2)	0 (0)	170 (20)
Alipao/Puntud	6.5	23	10 (2)	13 (22)	0 (0)	0 (0)	0 (0)	0 (0)
San Pedro	3.1	6	0 (0)	0.7 (7)	3.1 (2)	2 (1)	0 (0)	0 (0)
Alegria	1.9	18	4.2 (1)	0 (0)	8.3 (2)	5.9 (3)	0 (0)	0 (0)
Kitcharao	4.4	88	28 (3)	19 (5)	28 (16)	0 (0)	0 (0)	13 (1)
San Roque	4.4	566	28 (6)	59 (8)	52 (12)	84 (11)	13 (2)	330 (10)
Canoway	2.2	79	0 (0)	56 (12)	14 (2)	0 (0)	0 (0)	9.3 (1)
Jaliobong	2.0	75	3.1 (1)	46 (10)	5 (3)	1.4 (1)	0 (0)	19 (2)
Bangayan	1.5	38	5.6 (1)	31 (5)	1.2 (1)	0 (0)	0 (0)	0 (0)
Beltran	2.0	440	0 (0)	24 (4)	16 (2)	0 (0)	0 (0)	400 (20)
Baliguian	2.5	73	47 (20)	25 (20)	0 (0)	0.7 (1)	0 (0)	0 (0)
Cuyago	4.0	144	0 (0)	110 (12)	9.3 (1)	25 (3)	0 (0)	0 (0)
Jabonga	13.9	12900	350 (50)	2900 (1000)	1200 (190)	4900 (440)	3400 (200)	150 (7)
San Pablo	3.3	42	0 (0)	1.1 (1)	0 (0)	0.8 (1)	0 (0)	40 (5)
Bunga	6.1	160	7.8 (4)	6.2 (10)	0 (0)	130 (10)	0 (0)	16 (1)
Tapi-an	5.6	32	9.3 (2)	8.5 (3)	4.5 (3)	9.6 (3)	0 (0)	0 (0)
Tagbuyawan	3.0	15	0 (0)	1.9 (3)	1.2 (1)	0 (0)	0 (0)	12 (1)
Mansayao	6.0	139	64 (40)	28 (30)	12 (5)	0 (0)	0 (0)	35 (3)
Sums	81.0	15108	577 (134)	3400 (1167)	1355 (240)	5169 (476)	3413 (202)	1194 (71)

Table 2. Estimates of total dissolved solids (TDS, in parts per million) and ancillary parameters at 7 stations in Lake Mainit, September 1982 to May 1983.

Date	Time (see Fig. 1)	Station	Total depth (m)	Cloud cover (%)	Wind direct. and speed (kph)	Air temp. (°C)	Surface water temp. (°C)	Secchi depth (m)	Sample depth (m)	Sample temp. (°C)	TDS (ppm)
26-09-82			-		-	-		-	5		61.5
28-10-82	1600		20	10	N,20	-		3.0	5		36.5
29-11-82	0930		15	50	0	29.0	28.7	4.0	5	-	44.5
18-12-82	1300		-	50	N,10-20	-	-	4.4	5	-	61.0
30-01-83	0730		19	0	S,5	25.5	27.0	5.5	5	27.5	55.5
28-01-83	1330		29	30	NE,20	29.8	28.0	5.7	5	27.8	45.5
28-03-83	1500		26	5	N,20-25	29.8	28.7	5.3	5	28.7	15.0
27-04-83	1130		21	40	N,15-20	29.5	28.5	5.9	5	28.5	140.0
29-05-83	1100		22	20	0	31.4	32.0	3.4	5	29.7	80.0
26-09-82	1530		219	10	0		-	3.0	0		134.0
									10		160.0
									20		79.0
									30		48.0
									40		34.0
18-12-82	1230		-			-		4.7	5		17.0
30-01-83	0830		228			26.5		5.9	0	27.9	21.0
									10	27.9	104.5
									20	27.8	101.0
									30	27.5	53.0
									40	27.1	139.5
									50	26.6	85.0
	1230		222	20			30.2	3.5	0	29.7	30.0
									10	29.5	8.0
									20	29.0	4.0
									30	28.8	6.0
									40	27.8	32.0
									50	27.4	46.0
									60	27.0	
18-12-82	1200				N,10-20				5		70.5
18-12-82	1130				N,10-20			5.5	5		86.5
18-12-82	1100				N,10-20			4.6	5		39.0
18-12-82	1030				N,10-20			5.1	5		81.5
18-1-2-82	1000				N,10-20			4.8	5		81.0

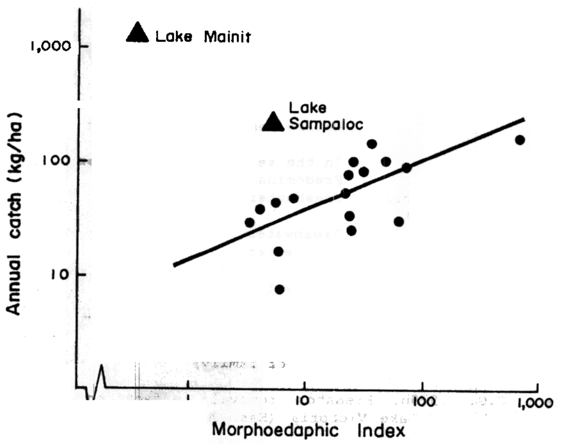

Fig. 2. Relationship between recorded annual catch (Y) in morphoedaphic index (X) and 19 African (•) and Philippine (▲) lakes. African data (from Henderson and Welcomme 1974) pertain to lakes with more than one fisherman/km^2 and lead to the regression $Y = 14.3\ X^{0.468}$, which is well below observed catch levels for Lake Sampaloc and especially Lake Mainit (see text).

Lake Mainit, which consists to a large extent of marine species that have immigrated upstream through the Tubay River (see Table 3).

Lewis (1973) wrote that "the composition of the catch in 1971 and reports of local fishermen are at variance with the observation of Manacop (1937), who lists several marine species among the fishes he found". We see, however, no reason to doubt Manacop's suggestion that marine fishes significantly contribute to the fisheries of Lake Mainit - especially in view of the fact that, of all sites around Lake Mainit, it is Jabonga where fishes migrating up and/or down the Tubay River are caught which has the highest landings. Furthermore, the data presented in Table 3 are in agreement with the general tendency for Philippine lakes to support large numbers of marine species, often more than true freshwater species (Herre 1959; Pauly 1982).

We expect to see, in the next years, more estimates of MEI for Philippine lakes. These and matching estimates of annual fishery catches will clarify the question whether or not the "stocking" of Philippine lakes by marine fishes generally increases fisheries yield, such that a regression of yield per area vs. MEI for Philippine lakes would have a higher intercept than that for African lakes.

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Table 3. Species listing of fishes recorded from Lake Mainit both seasonally (with respect to migratory species) or throughout the year (indigenous or introduced).

Family[a]	Species	Source	Occurrence[b]
	Elops hawaiiensis	Gracia et al. (1962)	Marine, entering freshwater
	Megalops cyprinoides	Gracia et al. (1962)	Marine, entering freshwater
	Anguilla mauritana	Manacop (1937); Lewis (1973)	Marine, entering freshwater
	Anguilla sp.	Gracia (1985)	Marine, entering freshwater
	species not identified	Gracia et al. (1962)	Predominantly marine
	Chanos chanos	Manacop (1937); Herre (1953); Gracia et al. (1962); Pambid (1970); Gracia and Magsumbol (1981); Gracia (1985)	Marine, entering freshwater
Cyprinidae	*Cyprinus carpio*	Pambid (1970); Gracia and Magsumbol (1981)	Freshwater (introduced)
	Puntius binotatus	Manacop (1937); Lewis (1973)	Freshwater
	Rasbora philippina	Woltereck (1941)	Freshwater
Clariidae	*Clarias batrachus*	Manacop (1937); Pambid (1970); Lewis (1973)	Freshwater
Exocoetidae	unidentified hemirhamphid	Manacop (1937); Lewis (1973)	Predominantly marine
Atherinidae	*Atherina* sp.	Gracia and Magsumbol (1981)	Predominantly marine
Phallostethidae	*Solenophallus thessa*	Herre (1953); Lewis (1973)	Marine, entering freshwater
Syngnathidae	species not identified	Lewis (1973)	Predominantly marine
Channidae	*Ophiocephalus striatus*	Manacop (1937); Pambid (1970); Lewis (1973); Gracia and Magsumbol (1981); Gracia (1985)	Freshwater
Ambassidae	species not identified	Gracia et al. (1962)	Predominantly marine
Theraponidae	*Therapon cancellatus*	Manacop (1937); Gracia et al. (1962)	Marine, entering freshwater
Carangidae	species not identified	Manacop (1937); Gracia et al. (1962); Gracia and Magsumbol (1981)	Predominantly marine
Leiognathidae	*Leiognathus equulus*	Gracia et al. (1962)	Marine, entering freshwater
	Leiognathus sp.	Gracia et al. (1962)	Predominantly marine
Lutjanidae	*Lutjanus argentimaculatus* ("red snapper")	Manacop (1937); Herre (1959); Gracia et al. (1962); Gracia and Magsumbol (1981)	Marine, entering freshwater Marine, entering freshwater
	Lutjanus sp. ("gray snapper")	Gracia et al (1962); Gracia and Magsumbol (1981)	Predominantly marine
Pomadasyidae	*Pomadasys hasta*	Manacop (1937)	Marine, entering freshwater
Scatophagidae	*Scatophagus argus*	Manacop (1937); Gracia et al. (1962); Gracia and Magsumbol (1981)	Marine, entering freshwater
Cichlidae	*Oreochromis mossambicus* (≈"*Tilapia mossambicus*")	Pambid (1970); Gracia and Magsumbol (1981); Gracia (1985)	Freshwater (introduced)
	O. niloticus (≈"*T. niloticus*")	Gracia and Magsumbol (1981); Gracia (1985)	Freshwater (introduced)
Mugilidae	*Mugil* sp.	Manacop (1937); Gracia et al. (1962); Gracia and Magsumbol (1981)	Predominantly marine
Gobiidae	*Glossogobius giurus*	Manacop (1937); Herre (1953); Gracia et al. (1962); Pambid (1970); Lewis (1973); Gracia and Magsumbol (1981); Gracia (1985)	Marine, entering freshwater
	Ophioeleotris agilis (≈*Hypseleotris agilis*)	Lewis (1973)	Marine, entering freshwater
	Ophiocara aporos	Gracia and Magsumbol (1981)	In the sea and in freshwater
Siganidae	*Siganus* sp. (≈*Teuthis* sp.)	Gracia and Magsumbol (1981)	Predominantly marine
Anabantidae	*Anabas testudineus* (≈*Osphronemus gouramy*)	Manacop (1937); Pambid (1970); Gracia and Magsumbol (1981); Gracia (1985)	Freshwater (introduced)
	Trichogaster ireri	Gracia and Magsumbol (1981)	Freshwater
	T. pectoralis	Pambid (1970); Gracia and Magsumbol (1981)	Freshwater
	T. trichopterus	Lewis (1973)	Freshwater
	Trichogaster sp.	Gracia (1985)	Freshwater

[a]As defined and arranged by Greenwood et al (1966)
[b]Adapted from Herre (1953, 1959); "predominantly marine" refers to taxon as a whole (genus or family)

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