SOME ASPECTS OF FISHERIES AND THEIR DEVELOPMENT IN MAN-MADE LAKES IN INDONESIA WITH SPECIAL REFERENCE TO LAKE JATILUHUR, WEST JAVA

by

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Abstract

In general, the fish production of man-made lakes in Indonesia increases during the first years of inundation and thereafter decreases to a constant level. Stocking, restocking and the introduction of fish species have been undertaken to improve productivity.

The cladoceran, *Daphnia carinata* King, from Japan, has been successfully introduced into Lake Jatiluhur. Experiments on culturing common carp in a floating cage system show that Lake Jatiluhur and some others are suitable for that purpose.

CONTENTS

1. INTRODUCTION

Fishing in Indonesian inland waters has been practised for a long time, but until now there has been little management of the fishery.

Among thousands of natural and man-made lakes there are several lakes which have been managed rationally; for example, Lake Tempe (South Sulawesi), reservoirs of Darma, Selorejo, Karangkates and Jatiluhur (Java). They cover an area of only about 3 percent of the total lake surface.

Most of the well managed lakes are constructed mainly for irrigation and hydro-electrical power and freshwater fisheries are usually a secondary use.

2. MORPHOLOGY

The total area of natural and man-made lakes in Indonesia is more than 1.8 million hm^2, while the total area of open waters (including swamps and rivers) is 13 751 000 hm^2 (1972). In the island of Java there are about 23 780 hm^2 of lake surface. Sumatra has the largest area of natural lakes (see Table 1).

The total area of man-made lakes in Indonesia is around 27 000 hm^2. Since the main purpose of man-made lakes is for irrigation and power production, most of the reservoirs are situated in Java where agriculture and population are more important (see Table 2).

In Java most man-made lakes have an area of less than 400 hm^2 and their maximum depth is less than 10m. The larger artificial lakes, for example, reservoirs of Jatiluhur, Karangkates and Riam Kanan, have been built during the last 20 years. Their area, volume and depth vary according to the season and degree of utilization. Water level fluctuation of Lake Jatiluhur, for example, can be 25 m in any year (Dubouchet, 1973).

Several man-made lakes, such as Jatiluhur and Karangkates Reservoirs, have a steep slope. The others, such as Rawa Pening, Rawa Jombor and Darma Reservoirs, have a gentle incline to their bottom. The shoreline forms of reservoirs as well as those of natural lakes, vary greatly. An elongated form is exemplified by Karangkates Reservoir, a pipe form by Lake Jatiluhur, a circular form by Bunder Dam and an elliptical form by Darma and Selorejo Reservoirs.

The altitudes of man-made lakes also vary. Selorejo Reservoir has an altitude of 620 m, Prijetan Reservoir of 46.4 m and Lake Jatiluhur of 107 m above sea level. Most Indonesian reservoirs are at an altitude of less than 300 m.

3. GENERAL, PHYSICAL AND CHEMICAL PROPERTIES OF THE WATERS

Generally Indonesian reservoirs have a brownish-yellow to bluish-green colour. In some man-made lakes it changes with the season.

During the three year filling period of Jatiluhur Reservoir, ending in 1967, the colour of the water was light yellow, except in some places which were bluish-green in colour. Now the water is greenish-blue in the dry season and is greenish-yellow in the rainy season. The upstream part of the reservoir has a brownish-yellow colour in the dry season and brown colour in the rainy season.

The transparency of some man-made lakes varies from 17 to 450 cm. In the rainy season the transparency is low at the mouths of rivers flowing into reservoirs, such as the Brantas River (Karangkates Reservoir), Citarum and cilalawi (Jatiluhur Reservoir). The highest transparency may be observed near the main dam and where there are many submerged aquatic weeds such as in Lake Prijetan and Rawa Pening. The lower transparency at the inlets is mainly caused by an abundance of mud and organic matter. In other lakes, such as Lake Pacal and Lake Cigombong, the same transparency is constant over the whole reservoir area.

The surface temperatures of Indonesian man-made lakes vary between 27.0 and 33.8°C, which is a little below recorded air temperatures. The surface temperature of the Jatiluhur Reservoir is about 26 to 28°C, while the bottom temperature of the littoral area varies from 26 to 28°C. In the middle part of the lake the temperature of a layer 40-50 m under the surface has been found to range from 23 to 26°C (S. Achmad, 1970, Dubouchet, 1973). There is little temperature stratification in this reservoir.

Most Indonesian man-make lakes have a surface water pH of between 7.3 and 9.2. The high value of pH is mainly due to alkaline bottom soil and to the high concentration of buffer substances in the inlet stream and its tributaries. Some small artificial lakes in the northern part of Bogor such as Situ Cibinong, Gedang, Lebakwangi, Malang Nengah and Situ Kemang are slightly acid due to their acid bottom soil (laterite).

In shallow lakes there is little stratification of pH but, as shown in Fig. 3, in deep lakes there is a decrease of pH with depth.

In general, the total alkalinity of Indonesian man-made lakes is relatively high. In the surface layer it ranges between 40 and 120 mg CaCO per litre. According to Ohle's classification (1937) almost all Indonesian artificial lakes belong to medium-hard or hard water lakes. This high alkalinity may limit the fluctuation of pH (Hutchinson, 1957).

The distribution of alkalinity in Lake Jatiluhur and Karangkates, shows that in general the lower the layer the higher the alkalinity, although it may sometimes decrease in the layer of water a few metres below the surface (see Fig. 4). This phenomenon has been observed also in some natural lakes (Ruttner, 1931; Welch, 1952; Hutchinson, 1957).

The amount of carbon dioxide in artificial lakes varies considerably. It ranges between 0 to 24 ppm in the surface layer and from 8 to 40 ppm on the bottom.

In Lakes Jatiluhur and Karangkates we sometimes find no soluble CO_2 in the surface layer in daytime. This is caused by the strong photosynthetic activity of the phytoplankton. In Rawa Pening, in the zone of submerged higher aquatic plants, the same phenomenon is observed.

As shown in Fig. 5, the CO_2 content in man-made lakes generally increases in the lower layers.

Due to high photosynthetic activity, supersaturation of oxygen can occur in the upper layers during the day. Oxygen concentrations range from 4 to 16 ppm at the surface to 0.4 to 1 ppm at the bottom of deep lakes (Karangkates and Jatiluhur). In the deep artificial lakes the highest oxygen concentration may occur several metres below the surface (see Fig. 6).

In some shallow acid lakes (Situ Malangnengah, Situ Gedong and Situ Kemang) the O_2 content is low at 2 to 4 ppm. This situation is related to the high content of organic matter and the low number of phytoplankton organisms. However, this concentration is still slightly higher than the minimum requirements of some fish species, i.e. *Puntius*, carp, tilapia, etc.

As shown in Fig. 7, the conductivity of Jatiluhur Reservoir does not change greatly with depth.

The concentration of phosphate and nitrate in Indonesian artificial lakes is generally relatively high (see Fig. 8). In the surface water of Lake Jatiluhur the quantity of phosphate was 28 to 51 mg m^{-3} (August-September 1975).

The total phosphorus concentration in the surface waters of Lakes Karangkates and Selorejo was 480 and 56 mg m^{-3}, respectively (May 1973). Hutchinson (1957) states that there is a tendency for oligotrophic lakes to show little variation in the phosphorus concentration with depth, but eutrophic lakes show a considerable increase in the phosphorus in the lower hypolimnion in the later phases of stagnation. This phenomenon was found in Lake Jatiluhur (oligotrophic) and Rawa Pening (eutrophic) (Fig. 8).

The nitrate concentration in the surface layer of Lake Jatiluhur was 220 to 750 mg m^{-3} (August-September 1975) and in Rawa Pening it was 260 mg m^{-3} (May 1973). In the surface water of Karangkates and Selorejo reservoirs (May 1973) the total nitrogen concentration was 535 and 600 mg m^{-3}, respectively. By way of comparison, the nitrate content in the surface water of Lake Mendota (Wisconsin) was 100 to 400 mg m^{-3} (Welch, 1952).

4. PLANKTONIC COMMUNITY

107 genera and 157 species of planktonic organisms have been found in Indonesian man-made lakes (see Table 4).

Generally in acid artificial lakes, such as in some of the lakes situated in the northern part of Bogor, the dominant phytoplankton are Desmidiaceae, Chlorocococcacae and Scenedesmaceae, while in alkaline reservoirs, for example, Situ Cigombong, Jatiluhur and Riam Kanan Dams, we find many Bacillariophyceae, Nostocaceae, Oscillatoriaceae and Chroocaceaceae.

Xanthophyta and Euglenophyta are scarcely found in deep man-made lakes.

Generally we find more zooplankton in shallow man-made lakes than in the deep ones with planktonic Protozoa, Rotifera, Copepoda and Cladocera represented. Protozoa and Rotifera are found in great quantities in man-made lakes which are covered with aquatic plants or in which there is much organic matter, such as Lake Malagnengah and Rawa Jombor.

In Lake Jatiluhur we found four species of Cladocera; one of them, *Daphnia carinata* King, is a species introduced from Japan in 1969. It was introduced into Lake Jatiluhur in 1970 and has become established (see Fig. 9). Before the introduction of *D. carinata*, *Daphnia* was only found in Lakes Ranau (Brehm, 1933) and Lindu.

Copepoda found in Lake Jatiluhur are *Diaptomus* sp., *Mesocyclops* sp. and *Eucyclops* sp. at a density of only about 1 to 7 individuals l^{-1}.

Ostracods are scarcely found in the deep man-made lakes. In Riam Kanan Dam we found very small numbers of one genus: *Cypris*. In shallow man-made lakes which have plenty of aquatic weeds, Ostracod are often found in great quantities. Vavra (1906) found *Cypris subglobosa* and *Stenocypris derupta* in Situ Bagendit, West Java (*In* Klie, 1933) and Klie (1933) found *Cadona fabaeformis* in Situ Cigombong.

Species of Vermes which have been found in Indonesian reservoirs are *Chaetonotus* sp. and *Anguillula* sp. *Mesostoma productum* had been observed in the plankton of Lakes Toba, Diatus, Ranau, and Telaga Ngebel (Reinsinger, 1934).

In general, insect larvae, mostly Diptera and Trichoptera, are found in man-made lakes with a covering of higher aquatic plants, or if many plants grow on its banks, such as in lakes of Bureng, East Java and Rawa Pening, Central Java.

5. HIGHER AQUATIC PLANTS

An inventory of higher aquatic plants found in Indonesian inland waters has been published by van Steenis and Ruttner (1923) and Vaas *et al.* (1949, 1951 and 1956). Achmad (1971) stated that more than 100 species of higher aquatic plants have been found in Indonesian inland waters, important among which are: *Eichhornia crassipes*, *Salvinia* spp., *Hydrilla verticillata*, *Ceratophylum demersum*, *Pistia stratiotes*, *Nymphaea* spp., *Nolumbium* spp., *Najas* spp., *Panicum* spp., *Phragmites* spp., and *Lemna* spp.

Shallow man-made lakes are usually a good habitat for the development of higher aquatic plants. *Eichhornia crassipes*, and to a lesser extent *Salvinia* spp., are plants that frequently create problems either for fisheries or for irrigation and hydro-electric power plants.

In reservoirs of Curug (Parwakarta), Malangnengah (Bogor), Bureng (Malang) and Jampang Dam (Bogor), the higher aquatic plants may cover more than 50-70 percent of the surface area. In 1931 about 60 percent of the surface area of Rawa Pening (Central Java) was observed to be covered with either floating masses of grass or with water hyacinth (Vaas and Schuurmann, 1949) and in the years before 1960, Rawa Jombor (Klaten), which has an area of 190 hm^2, had a dense cover of higher aquatic plants (Achmad, 1971).

The larger and deeper artificial lakes, Karangkates, Riam Kanan, Selorejo and Jatiluhur, are still free from invasion by higher aquatic plants. Although in the basin of the River Citarum, the affluent of Lake Jatiluhur are found plenty of floating aquatic weeds, e.g. water hyacinth, *Salvinia* and *Pistia*, it seems that the reservoir, because of its steep shore and wave action, will remain free of macrophytes.

Much effort has been made by the Indonesian people and Government to solve the problems of aquatic weeds but, in general, without success. For nearly 50 years attempts have been made to control the aquatic weeds in Rawa Pening but the major part of the lake surface still remains covered.

Because the reservoirs are used for irrigation and electric power production, higher aquatic plants are not desirable, since they may accelerate the process of sedimentation and cause damage to the turbines. For fisheries, a small quantity of higher aquatic plants is required to increase the fish production (Achmad, 1971).

6. FISH AND FISHERIES

A total of 800 fish species are known from Indonesian open waters. The two orders of fishes: Ostariophysi and Labrinthici, which dominate the fish population of open waters in Kalimantan and Sumatra, have more than 368 species, mostly of unknown biology. By comparison, according to Smith (1945) in Thailand there are 206 species of Cyprinidae and 100 species of catfish. Dussart (1974) stated that in Singapore 70 species of fish are found in fresh waters, while in Sri Lanka there are 73 species and in Cambodia we know about 171 species of fresh water fishes.

In the deep and vast natural lakes of Indonesia we do not find many fish species. In Lake Toba (Sumatra) there are about 25 species, of which eight or nine species are economically important (Therezien, 1970). In Lake Lindu (Central Sulawesi) we have observed eight fish species, in Lake Towuti (South Sulawesi) and Lake Poso (Central Sulawesi) there are seven species. In comparison, about 440 fish species are found in the tidal and swampy area of Kalimantan, and Vaas *et al.* (1953) found 60 species in the inland waters along the Rivers Ogan and Komering (South Sumatra).

In Indonesian reservoirs we have found about 40 indigenous and introduced species (see Table 5). In Lake Jatiluhur, 33 fish species belonging to 14 families and nine orders, and a species of freshwater shrimp (*Caridina* sp.) have been observed.

About 20 to 30 percent of the fishes inhabiting artificial lakes in Indonesia are predators. Among them, the most important species are snakeheads (*Ophiocephalus* spp.), catfishes (*Macrones* spp.) and hampal (Hampala macrolepidota). The population of predators may reach about 10 to 60 percent of the total fish population in the lake.

In Table 5 we can see that although all artificial lakes are stocked with new species in order to increase production, the effort may be unsuccessful. None of the nine species introduced into Lake Jatiluhur has established a good population.

Cyprinus carpio and *Puntius javanicus* have been introduced into Lake Selorejo and grow well although apparently do not breed successfully. The dominant species in Selorejo Reservoir is *Tilapia mossambica*. Fernando (1971) stated that *Tilapia mossambica*, introduced into Sri Lanka's fresh waters, have successfully occupied the lake habitats with an immense increase in fish production.

Fish production of artificial lakes in Indonesia varies greatly (between 12 to 770 kg hm^{-2} year^{-1}). The lowest production (12 kg hm^{-2} year^{-1}) is produced by Lake Jatiluhur and the highest yield (770 kg hm^{-2} year^{-1}) is produced by Lake Darma (West Java).

Fish production in shallow and small reservoirs, such as Situ Kemang, Rawa Jombor, Sentir and Bunder, depends greatly on stocking and restocking (see Fig. 10). These water bodies are usually managed by the local inhabitants.

The vast and deep reservoirs are generally managed by government bodies. Production, as shown in Fig. 11, increases during the first years of inundation and thereafter decreases to a more or less constant level. This phenomenon can easily be understood if we consider the change of habitat from that of a lotic environment into that of standing waters. In such conditions endemic and introduced species have to adapt to the new ecosystem. During the process of adaptation, fish production of the lake will increase gradually as some fishes, especially non-predatory species, become well adapted to the new environment. In the presence of enough food for predacious species, the population of predators will increase and the total fish production of the lake will consequently decrease until the occurrence of a natural balance between the population of predatory and non-predatory species.

The number of full and part-time fishermen on artificial lakes varies from one lake to another (Table 6). In some reservoirs, for example in Lake Jatiluhur, the number of fishermen may vary from year to year (Table 7). This is caused by many factors, especially by the yield of the fishery.

The fishing gear used by fishermen in artificial lakes is limited. In Rawa Pening we find 16 types of fishing gear, while in Lake Jatiluhur there are ten types, and in Pacal Dam we find only six types of fishing gear. Hook and line, gillnet, longline, castnet and traps are the fishing gear most commonly used by fishermen.

The efficiency of the gear varies in different reservoirs. In Lake Jatiluhur the efficiency of gillnets is 5-8 g m^{-2} day^{-1}, while in Rawa Pening it is 20 to 50 g m^{-2} day^{-1}, and in the Selorejo Dam we have observed an efficiency of 10 to 15 g m^{-2} day^{-1}. The efficiency of longline is 1 to 2 percent in Lake Jatiluhur, 3 to 5 percent in Rawa Jombor and 2 to 4 percent in the Pacal Dam.

7. FISHERIES DEVELOPMENT

7.1 General

Relatively little has been done to develop the fisheries of Indonesian reservoirs, in fact in many dams fisheries have been completely overlooked.

The development of fish populations in unmanaged reservoirs will, of course, depend on the nature and catching activities of local fishermen. Their fish production varies greatly from year to year.

The fisheries of artificial lakes are commonly developed by stocking and restocking with domestic fishes; sometimes followed by fishing regulations based on technical and biological estimations and on classical fisheries management methods. It is evident that we have few research results on the biology of wild fishes or on the lakes themselves. We realize that such knowledge is very important in developing the lake fisheries. Of the more than 500 species of economically important fishes living in Indonesian open waters, we know a little about the biology of only some ten species.

In some lakes, fishing regulations have been observed by the fishermen, while in others the fishermen are not cooperative.

In artificial lakes constructed during the last 20 years, e.g., Lake Jatiluhur, Darma Reservoir, Lake Karangkates, Lake Selorejo and Riam Kanan Dam, and some older lakes, such as Rawa Pening and Rawa Jombor, we have put much effort into developing their fisheries, but the results of these efforts are not yet satisfactory.

7.2 Lake Jatiluhur

The Jatiluhur Dam, completed in 1967, was to provide electrical power and water for irrigation. The reservoir can irrigate about 240 000 hm^2 of paddy-fields and produces about 720 million kw $year^{-1}$. Other uses of the reservoir are for flood control, water supply for industry and the local population, fisheries and recreation.

Since 1964 efforts have been made to develop the fisheries of Jatiluhur Reservoir. At that time there were already many part-time fishermen operating. Limnological and fisheries biology observations have been conducted since the end of 1964.

Since 1965 we have stocked and restocked the reservoir with several kinds of fishes (see Table 8). Each stocking, except the stocking of Nile tilapia (*Tilapia nilotica*), has more or less influenced the fish production in the following year (Fig. 11). With the exception of *Puntius javanicus*, an indigenous species, it appears that most of the species stocked cannot reproduce well.

The introduction of Nile tilapia, during 1972-74, has not yet succeeded, probably because of the small quantity stocked (Table 8). The growth of the fish is good and four months after the fingerlings were released into the reservoir, the average weight was 100 to 200 g. Near the shore Nile tilapia fry are occasionally observed. The fish may have difficulty in finding a good spawning ground, since 90 percent of Jatiluhur Reservoir has a depth of more than 5 m.

To help the breeding of non-predatory species, a spawning bed with an area of 3 300 m^2 was constructed on the shore of the reservoir at the beginning of 1973. At low water level it will be a pond of about 1 m depth and, therefore, it will become a suitable place for spawning. At high water level the spawning bed will be inundated, so that the fishes can enter freely into the reservoir. The results of observations made in the following years show that the spawning bed cannot supply enough seed for the dam. It is estimated that the reservoir needs a further three to four spawning beds to supply the demand for fish fry.

An experiment with an artificial shelter was also conducted. The two floating artificial shelters used had areas of 25 and 50 m^2. The experiment showed that the number of plankton and periphyton in the shelters was greater than outside them. It was also evident that in the shelter there were a lot of small fishes (*Chela oxygastroides*, *Rasbora argyrotaenia*, fingerlings of *Tilapia mossambica*, etc.) and small shrimps (Caridina sp). This shelter, made of bamboos, branches and polyethylene film tapes, can only last 3-4 months. In some lakes and rivers in the U.S.A. artificial shelters of brush and other material have been installed in the hope of bettering the conditions for fish life (Tarzwell, 1936; Hubbs and Eschmeyer, 1938; Rodeheffer, 1939, 1940 and 1945). And in Sagami Reservoir artificial weeds of plastic tapes were set for fish nesting during the spawning season of Crucian carps (Yokote, 1969).

To increase the fish food available in the Jatiluhur Reservoir, in 1970, a Japanese species of Cladocera, Daphnia carinata, has been introduced. In Fig. 9 it can be seen that the introduction has succeeded (Soepriyono and Achmad, 1975). This kind of fish food is not only used by the plankton feeder but also by jambal (*Pangasius pangasius*).

Fishing regulations in Lake Jatiluhur have been in force since 1967, and in the following years they have been improved. Since 1972 the fishing regulations in Lake Jatiluhur are as follows:

Prohibition of fishing during the months of September and October

Obligation for fishermen to obtain a fishing licence

Prohibition of the use of explosives, toxicants and certain fishing tools

Year-round prohibition of fishing in the protected area

These regulations are often neglected by fishermen, particularly by the part-time ones.

Development trials are also being made with common carp in floating net cages made of synthetic fibre, with an area of 80 m and 1½ m deep. The fish grew at the rate of 3 to 6 g per day with food conversions of about 1.2 to 1.5. Similar experiments conducted in other man-made lakes, such as Ciburuy, Batu Karut, Waduk Darma, Karangkates and Rawa Pening, showed that these waters were also fit for rearing fish in floating net cages. Kuronuma (1966) stated that the growth rate of the carp cultured in floating net cages in Japan was about 2 to 8 g per day, while the food conversion was 1.1 to 2.5.

In the scheme of fisheries development of Lake Jatiluhur, in addition to the efforts in fisheries biology and management, a three months' training course has been conducted to upgrade the practical fisheries knowledge of local fishermen. The training course was conducted in 1970 in three villages around the reservoir. The effort is important, since without the support of local fishermen it would be very difficult to manage the fisheries efficiently.

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TABLE 1

AREA OF OPEN WATERS IN INDONESIA IN 1971

Island	*Natural and artificial lakes (hm²)*	*Rivers, swamps and others (hm²)*
Java	23 780	72 590
Sumatra	919 800	3 134 040
Bali	2 450	460
Nusatenggara ...	2 680	11 860
Kalimantan ...	637 410	8 391 530
Sulawesi	154 660	337 520
Maluku and West Irian	63 220[a]	—
Total	1 804 000	11 947 000

a To be revised

TABLE 2

AREA OF ARTIFICIAL LAKES IN INDONESIA

Island	*Area (hm²)*
Java	115 900
Sumatra	
Kalimantan	9 200
Sulawesi	
Lesser Sunda Island	1 900
Maluku and West Irian	—
Total	27 000

TABLE 3

AREA AND DEPTH OF TYPICAL LAKES

Lake		*Area* (hm^2)	*Depth* (m)
Artificial lakes:			
Cigombong	...	30	17
Jatiluhur	...	8 300	90
Jombor	...	190	4
Rawa Pening	...	2 200	10
Darma	...	400	19
Karangkates	...	1 500	75
Selorejo	...	400	46
Pacal	...	387	32
Riam Kanan	...	9 200	50
Natural lakes:			
Toba	...	112 970	450
Kanau	...	12 590	229
Telaga warna	...	24	20
Klakah	...	34	29
Batur	...	1 590	88
Towuti	...	56 108	203
Mahalona	...	2 440	73

TABLE 4

PLANKTONIC ORGANISMS IN INDONESIAN MAN-MADE LAKES

Phylum		*Genera*	*Species*
Cyanophyta	...	15	20
Chlorophyta	...	24	45
Chrysophyta	...	22	32
Xanthophyta	...	1	1
Euglenophyta	...	2	5
Pyrrophyta	...	4	6
Protozoa	...	7	7
Rotifera	...	15	20
Cladocera	...	5	6
Copepoda	...	4	5
Ostracoda	...	4	6
Vermes	...	2	2
Insecta	...	2	2
Total ...	...	107	157

TABLE 5

NUMBER OF FISH SPECIES KNOWN IN SOME ARTIFICIAL LAKES IN INDONESIA

	Number of fish species		
	Indigenous	*Stocked*	*Total*
West Java:			
Cigombong	8	5	13
Jatiluhur	24	9	33
Darma	11	4	15
Patok	9	3	12
Central Java:			
Rawa Pening ...	12	6	18
Rawa Jombor ...	11	3	14
East Java:			
Selorejo	10	2	12
Karangkates	8	3	11
Pacal	10	4	14
Prijetan	10	5	15
South Kalimantan:			
Riam Kanan ...	20	4	24

TABLE 6

AREA, FISH PRODUCTION AND NUMBER OF FISHERMEN IN SOME MAN-MADE LAKES IN INDONESIA IN 1971

Water area	*Area (hm^2)*	*Number of fishermen*	*Fish Production*	
			Total (t)	*Average/ fishermen (kg)*
Jatiluhur ...	8 300	545	180.39	331.3
Darma	400	550	111.00	201.8
Pening	2 200	970	709.50	731.4
Rawa Jombor ...	190	356	38.40	107.9
Pacal	387	1 100	138.03	125.5
Prijetan	229	145	11.24	77.5
Sentir ...	67	42	3.29	78.3
Kalen ...	45	25	1.76	70.4

TABLE 7

NUMBER OF FISHERMEN IN LAKE JATILUHUR DURING 1969-75

Year	Fishermen	
	Full-time	*Part-time*
1969	139	373
1970	244	437
1971	260	285
1972	304	281
1973	322	438
1974	198	253
1975	249	264

TABLE 8

STOCKING OF FISH IN LAKE JATILUHUR

Year	*Species stocked*	*Total*	
		Weight (kg)	*Number*
1965	*Osphronemus goramy* *Puntius javanicus* *Tilapia mossambica*	250	10 000
1966	*Cyprinus carpio* *Puntius javanicus* *Helostoma temmincki*	1 500	130 000
1967	*Cyprinus carpio* *Puntius javanicus* *Tilapia mossambica* *Helostoma temmincki* *Trichogaster pectoralis* *Trichogaster trichopterus*	2 500	263 000
1968			
1969	*Osteochilus hasselti* *Puntius javanicus*	600	150 000
1970			
1971			
1972	*Tilapia nilotica*	25	5 000
1973	*Tilapia nilotica*	150	26 000
1974	*Tilapia milotica*	100	20 000

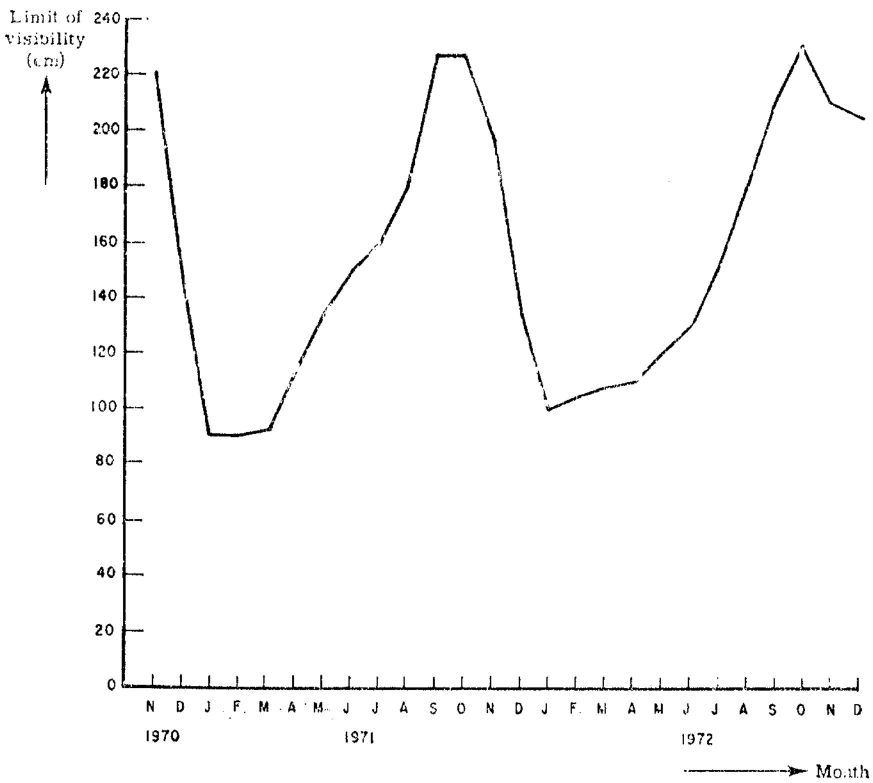

Figure 1: Limit of visibility of lake Jatiluhur

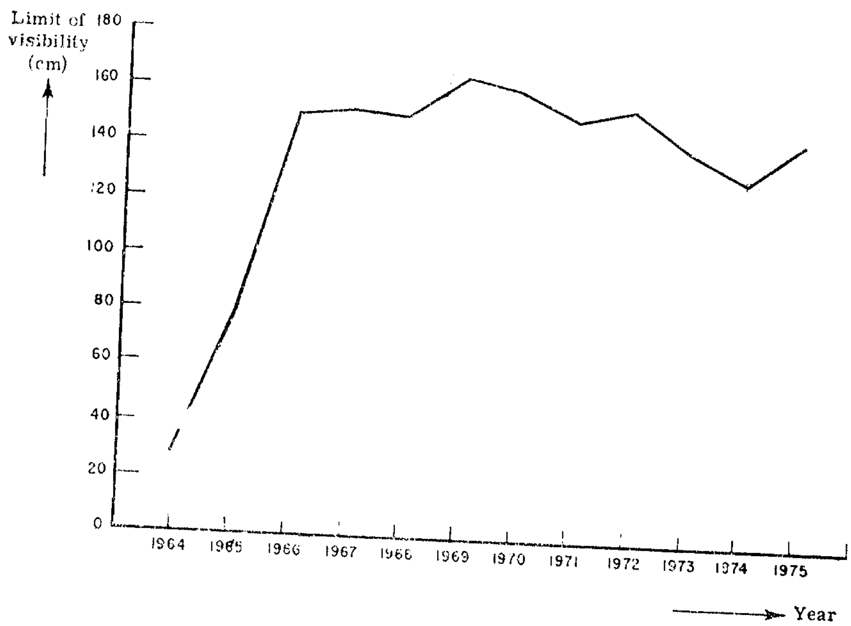

Figure 2: Limit of visibility of lake Jatiluhur

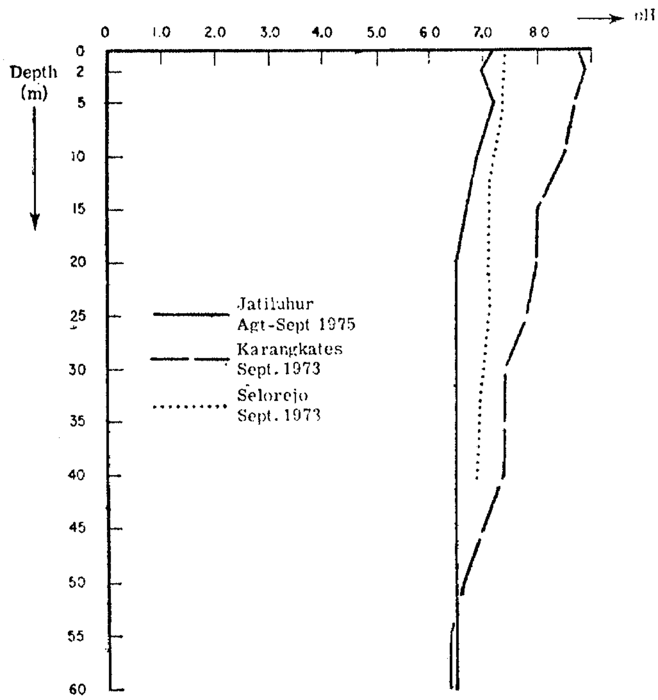

Figure 3: pH of some artificial lakes

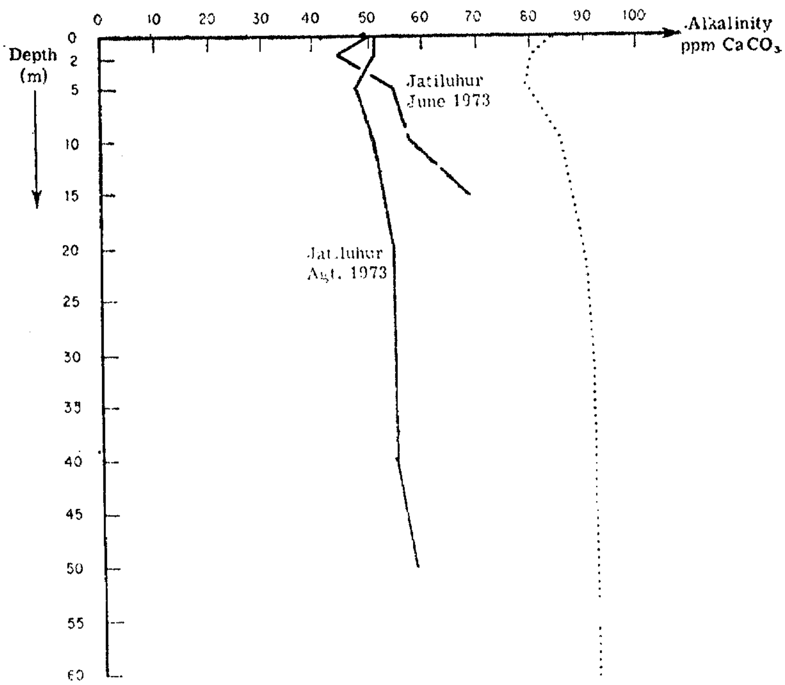

Figure 4: Total alkalinity of Karangkates and Jatiluhur reservoirs

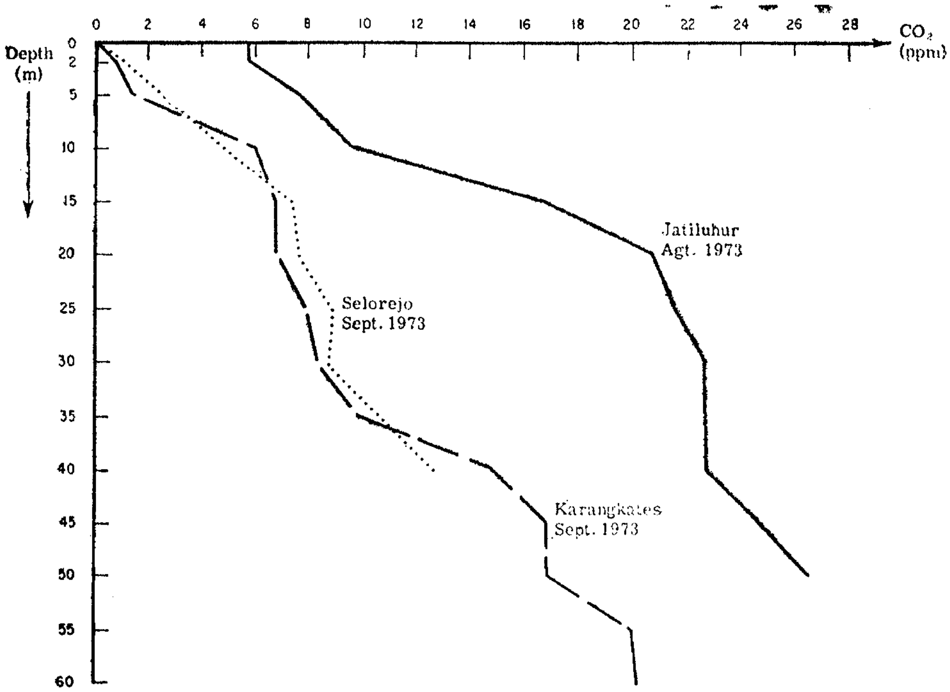

Figure 5: Carbondioxide content of lakes Jatiluhur, Karangkates and Selorejo

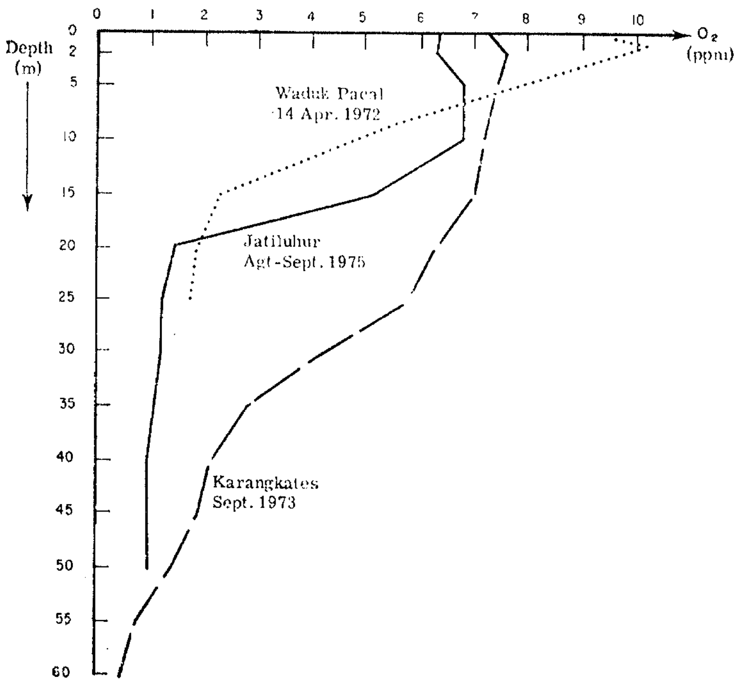

Figure 6: Dissolved oxygen content of some lakes

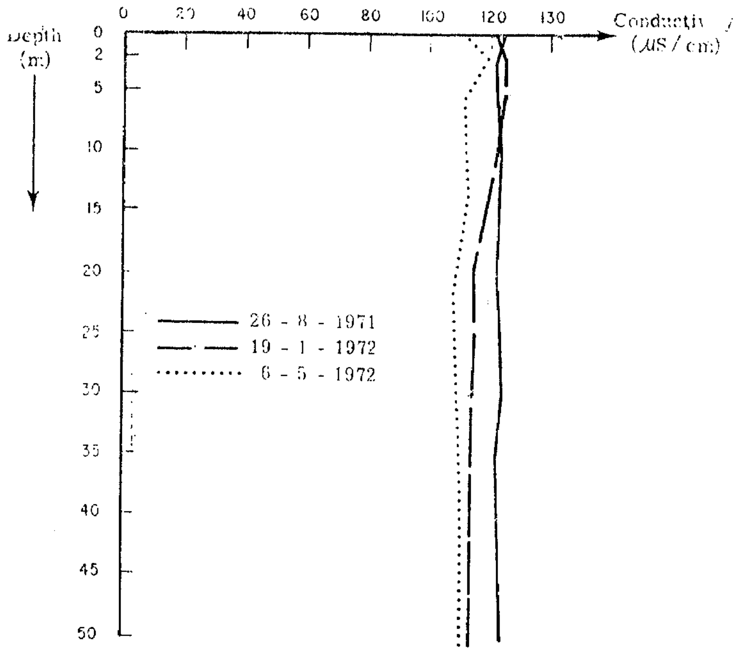

Figure 7: Conductivity of Lake Jatiluhur (after Dubeuchet, 1973)

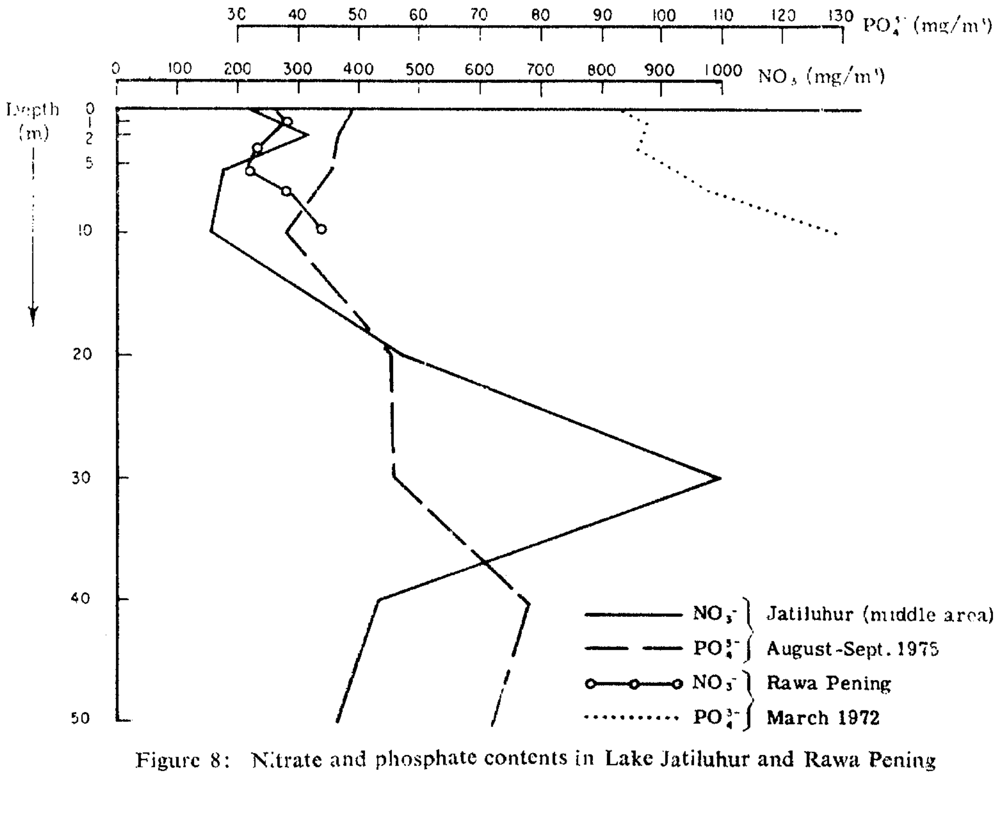

Figure 8: Nitrate and phosphate contents in Lake Jatiluhur and Rawa Pening

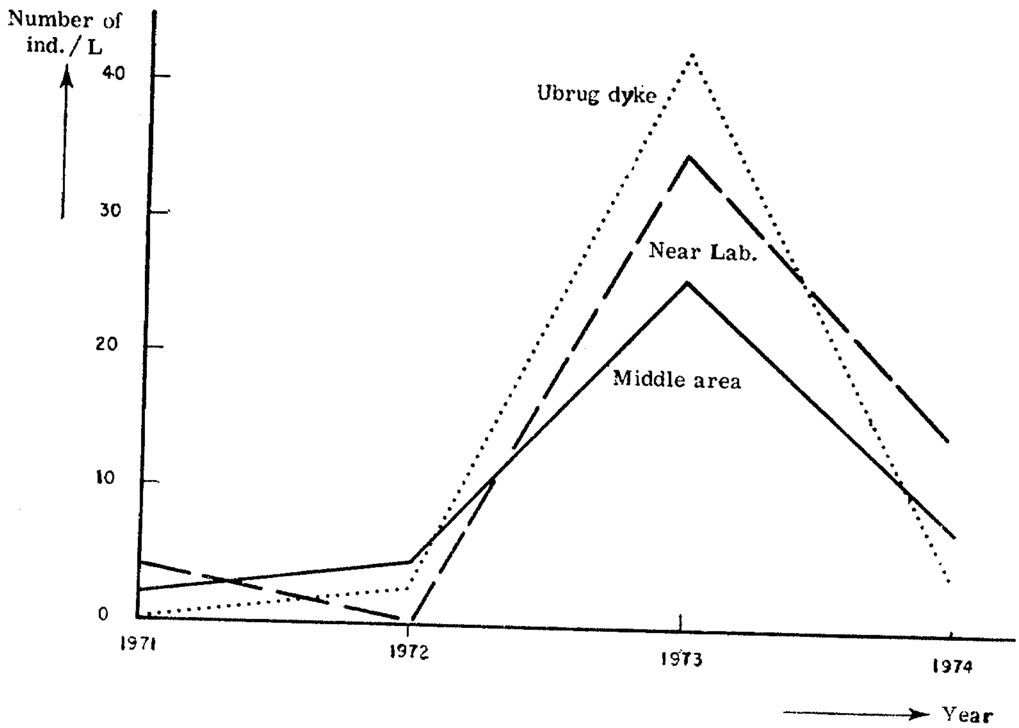

Figure 9: Population of *Daphnia carinata* King in lake Jatiluhur during 1971—1974 (after Soepriyono and Achmad, 1975)

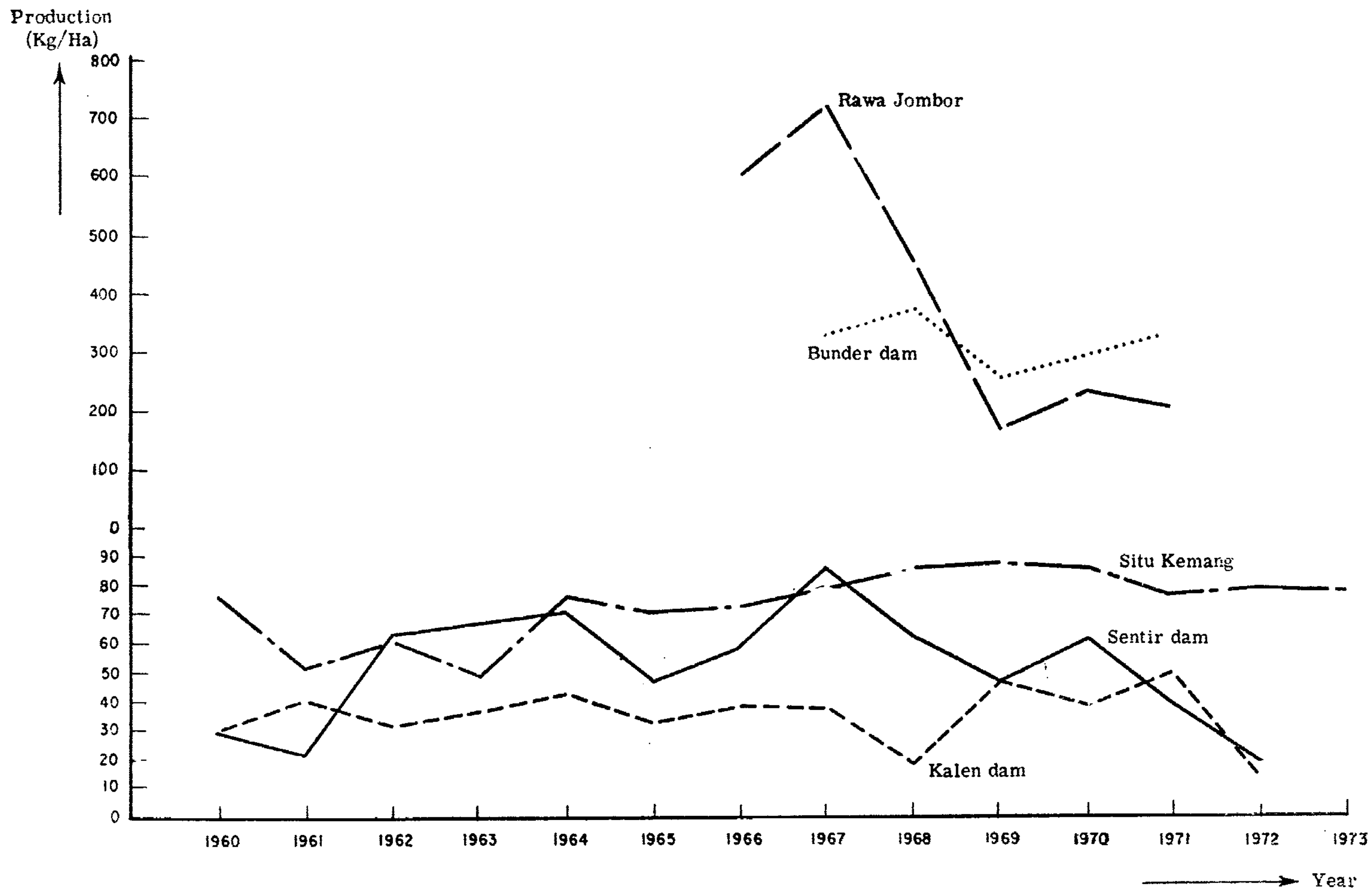

Figure 10: Fish production of some shallow and small reservoirs in Indonesia

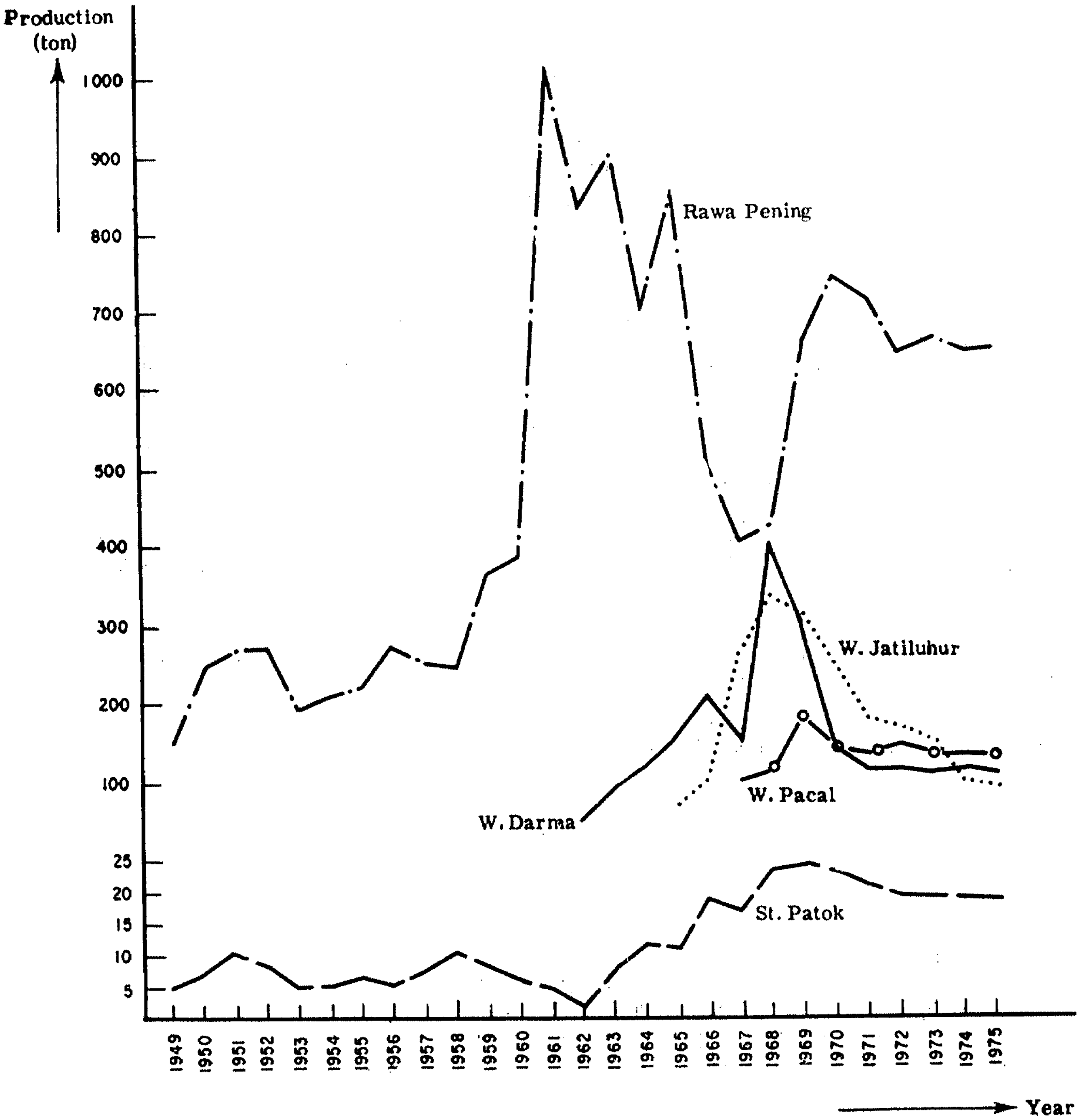

Figure 11: Fish production of vast and deep Indonesian artificial lakes