五、Water Quality Improvement of Aquaculture Pond by A New Type Aerator

T. Yoshida*, D. F. Hwang*, T. Maruyama**,
Y. Masuda*** and K. Sato***

* *National Taiwan Ocean University, Keelung 20224, Taiwan, ROC*
** *Tokyo University of Fisheries, Minato-ku, Tokyo 108, Japan*
*** *M. T. Engineering Co. Ltd., Chiyoda-ku, Tokyo 139, Japan*

INTRODUCTION

In order to maintain organisms healthy. A favorable environmental condition for aquatic organisms is essentially required in aquaculture. Dissolved oxygen concentration (DO) may be the most important water quality parameter among others. Shortage of oxygen in a water mass may commit a various kind of undesirable responses in organisms not only by direct effect such as suffocation but also by indirect effects which being secondary introduced from deoxidized condition. There could be at the same time considered that unhealthy organisms under low DO might have a lower resistibility to bacterial or virus infection. And also their immune responsibility may somewhat be affected.

Shrimp culture in Taiwan has been suffered an almost catastrophic damage last two years. A series of research work by the project of council of agriculture was made from various points of view. It was considered to be a kind of disease caused by virus. However, only evidences to be obtained from intact organisms can tell its possibility. From the results of survey on water quality as well as bottom deposits condition of shrimp farming ponds in Tuchian, Iran Prefecture, a shortage of oxygen in water mass or bottom deposits was generally observed. This facts lead us to make an attempt of improving environmental condition for shrimps in the farming pond by effective aeration.

Practical way to maintain a sufficient DO in cultural water is achieved by aeration. Roughly following three methods are commonly used for aeration in aquaculture and in water treatment; 1) bubbling of pressured air from micro-porous material, 2) mechanically bubbling by beating water surface with rotating paddle wheel, and 3) bubbling a fine air by cavitation of a high speed rotating propeller. The last method is developed only recently and gradually becoming popular in fish farming pond in Japan and also in USA. In order to achieve healthy condition for organisms in aquaculture by improving DO in water with effective aeration, we would like to introduce here some performance test results on a cavitation type aerator (Karbos Aerator®) in comparing with that of other types. These studies were carried out in the Marine Research and Training Center of Hawaii Institute of Marine Biology (MRTC/HIMB), University of Hawaii, U. S. A. for main part of performance studies, and in Tokyo University of Fisheries, Japan and also in National Taiwan Ocean University, ROC for other studies.

MATERIALS AND METHOD

Aerator

Karbos Aerator® is specially designed to be able to produce a fine air bubble by cavitation of a high speed rotating propeller, where air is drawn into the center pipe and expelled into water from backward of the rotor blades. AerO2 of Aeration Industries Co. tested here is used the same principle of Karbos aerator but has some differences in a detailed structure. The aerator is classified into three types, i. e. S, SP, and P, by its shape of rotor (Fig. 1). S type has a flat plate rotor, and it is used for aeration of tanks or container. SP and P types having a propeller rotor are used for producing both air bubble and current mainly in farming pond. In this study both SP type (1 ps) and P type (0.7 sp) of Karbos aerator, AerO2, and a conventional paddle wheel type aerator were used for the performance studies. Where the propeller pitch of the Karbos aerator are 50 mm for 0.7 ps of P type and 80 mm for 1.0 ps of SP type. And electric current in operation of the aerator is 2 amperes for P type and 3.3 amperes for SP type.

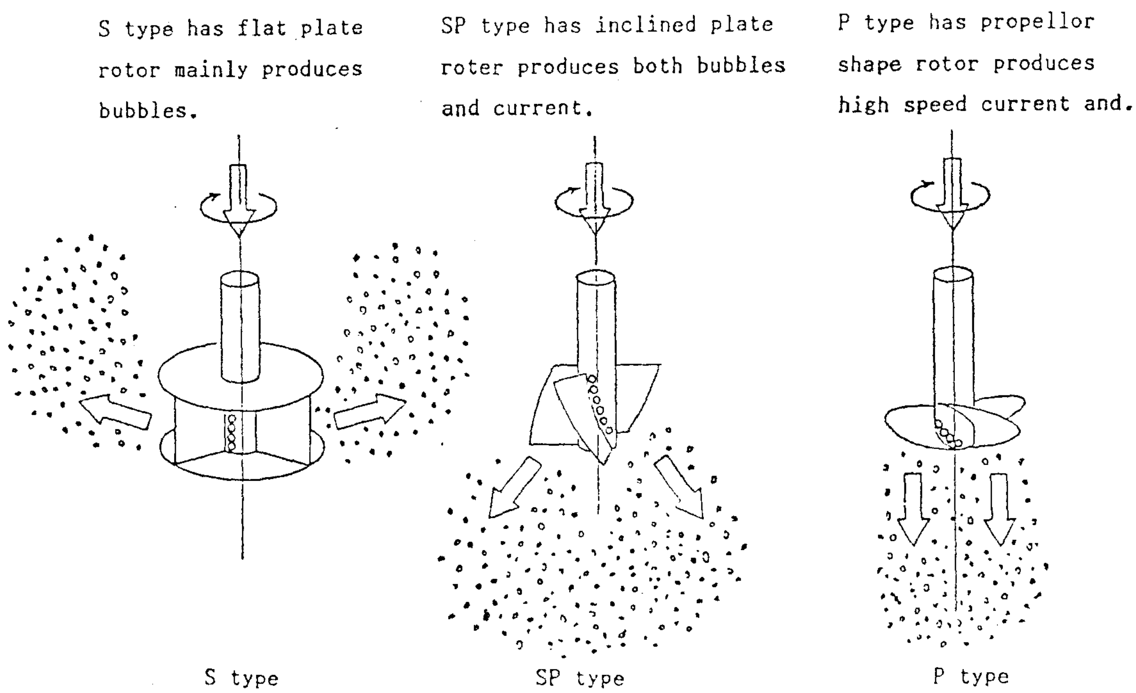

Fig. 1. Illustration of various type of rotor of the aerator, (Karbos) with their generation of air bubble and current.

Observation of general performances of Karbos Areator® with special reference to mixing effect of top water and bottom water

No. 4 pond, one of the experimental pond of MRTC located in Kaneohe Bay, Oahu Island, was selected for study. It has water volume of 2,000 m^3, 0.5 acre (2,025 m^2) area and 1 m depth, for telapia and shrimp farming (Fig. 2).

With installation of the aerator on the float (Fig. 3) mixing effect of top and bottom waters was observed at four sites in the pond by measuring water temperature or DO as parameters at 5, 20, 40, 60, and 80 cm depth in each site as shown in Fig. 4. Temperature measured by thermometer was recorded automatically in the laboratory.

Pond	Size	
	acre	m^2
1	.6	2,430
2	.4	1,620
3	1.5	6,070
4	.5	2,025
5	.5	2,025
6	.5	2,025
7	.5	2,025
8	1.0	4,050
9	.5	2,025
10	.5	2,025
11	1.5	6,070
12	1.0	4,050

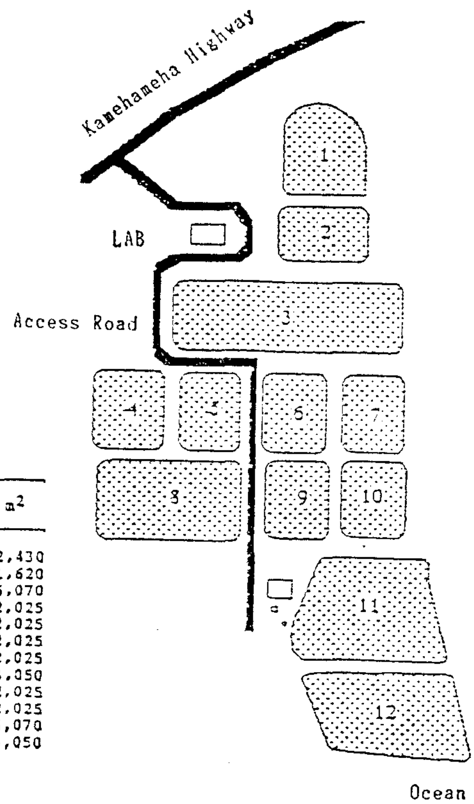

Fig. 2. Schematic of ponds at the Mariculture Research and Training Center of the Hawaii Institute of Marine Biology.

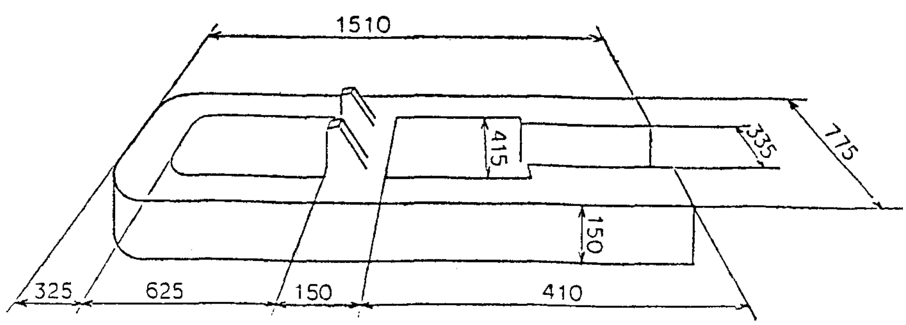

Fig. 3. Illustration of the float of aerator.

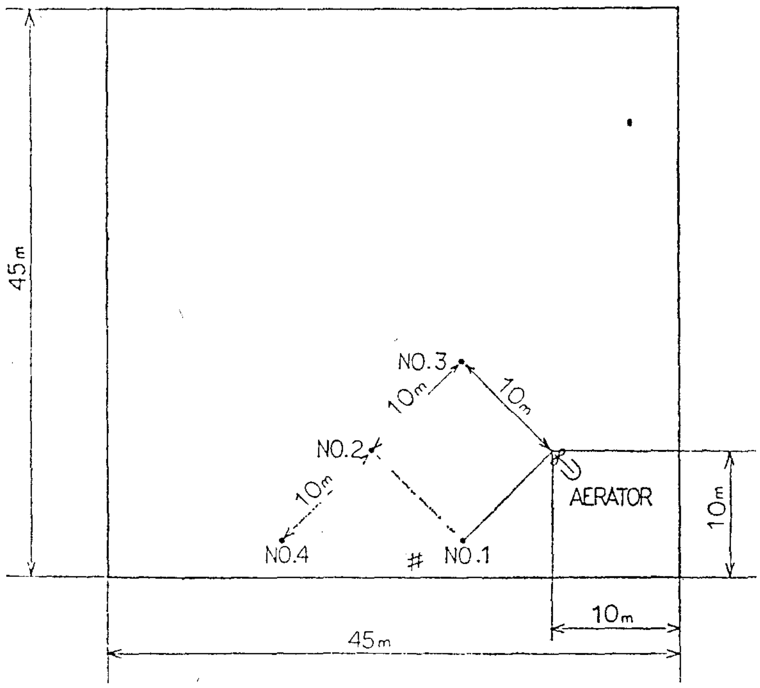

Fig. 4. Sampling sites for measurement of water temperature and dissolved oxygen in No. 4 pond.
♯ sampling st. for DO.

Efficacy comparision study among three types of aerator

No. 3 pond which has 6,070 m² in area and 1 m in depth was used for the study measuring complete mixing time with temperature, and No. 5 pond which has 2,025 m² and 1 m depth used for that measuring DO. Four temperature probes

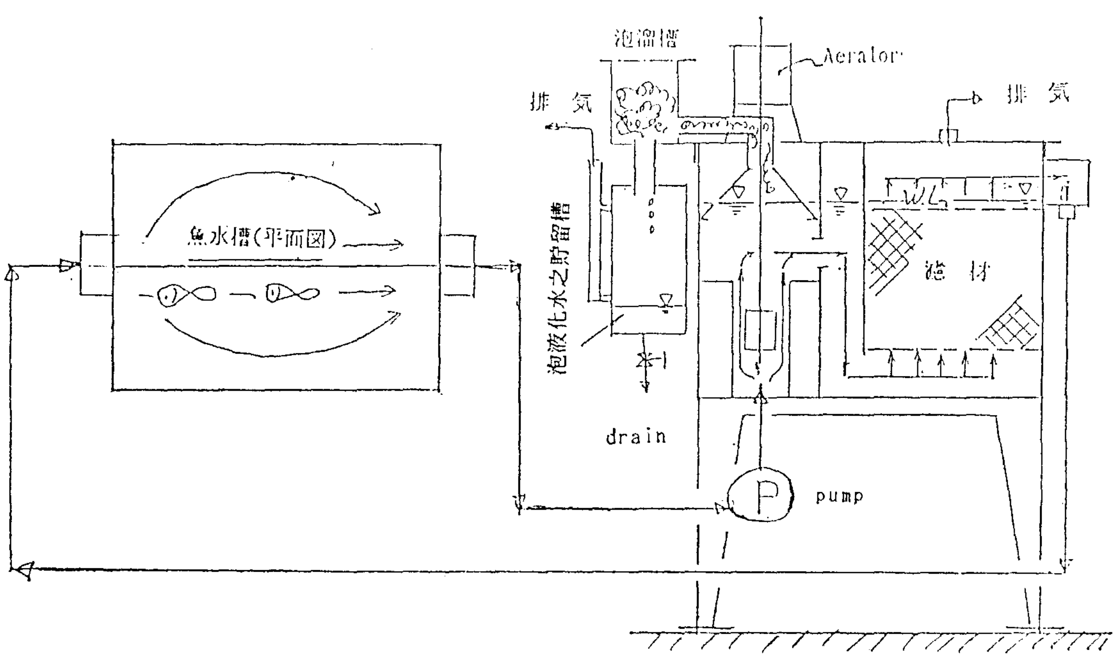

Fig. 5. Circulating system for transportation of alive fish.

were situated in the No. 3 pond, and one DO probe was located at 45° in No. 5 pond.

The study was conducted for 6 days from 1st to 6th of December, 1989. The weather condition was almost constant as maximum temperature of 27-29°C, maximum solar radiation of 0.53-0.84 Kw/m^2 and maximum wind speed of 2.0-2.5 m/s (day time) and 0.5-1.2 m/s (night time).

Study of removal of dissolved organic substances and suspended solids

The study was performed in a 6 m^3 volume aquarium with Karbos S type aerator (150 watts) which was installed in a annexed small together with a foam remover. Aerated water was circulating between the aquarium keeping about 10 kg of fish and the small tank by a small electric pump as shown in Fig. 5.

RESULTS AND DISCUSSION

Studies on efficacy of water mass mixing

The studies were carried out from June 21 to November 27 in 1989 including 160 days durability test.

Mixing efficacy of water mass in a farming pond may be improved by means of generating a stream in the pond not only in surface layer but also in bottom layer. It was effectively achieved by means of both propeller shape rotors of the aerator and its oblique shaft (30° from horizontal plane).

As shown in Figs. 6, 7, 8, and 9, complete mixing of water mass was achieved in a fairly short time within 24 min (No. 3 site) to 105 min (No. 4 site). Mixing speed of water mass with the aerator (SP type 1 ps) was measured in a various direction at NO. 4 pond. Direction of propeller shaft showed the highest speed of progress of mixing as 0.51 m/min, and on the contrary rectangular direction was that of the lowest as 0.15 m/min (Fig. 10). Complete mixing time observed by temperature is shown in Table 1.

Table 1. Complete mixing time in minutes

Site	Observating date	
	June 23	June 24
1	74.4	60.0
2	70.2	63.0
3	15.0	24.0
4	103.0	105.0

Observation of DO profile in day time was conducted in the NO. 4 pond with operation of the aerator for three hours, from 2:37 p. m. to 5:20 p. m., on July 24, 1989. As shown in Fig. 11, without aeration DO of surface water in the pond had been reached to such a saturation as 9 mg/l at 32.4°C of water temperature by dint of photosynthesis of phytoplankton. On the other hand DO of bottom water was only 3 mg/l at 25.9°C of water temperature which was apparently some what

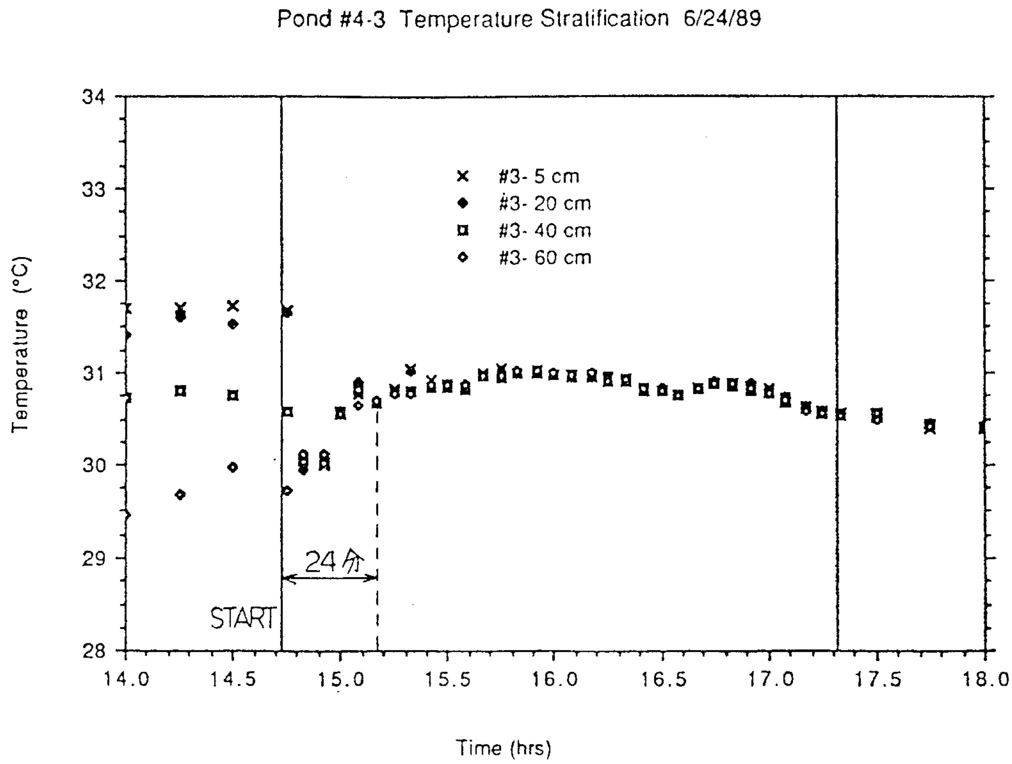

Fig. 6. Observation of temperature stratification profile at St. 3 (10 m distance from the aerator on a line of propeller shaft) in No. 4 pond.

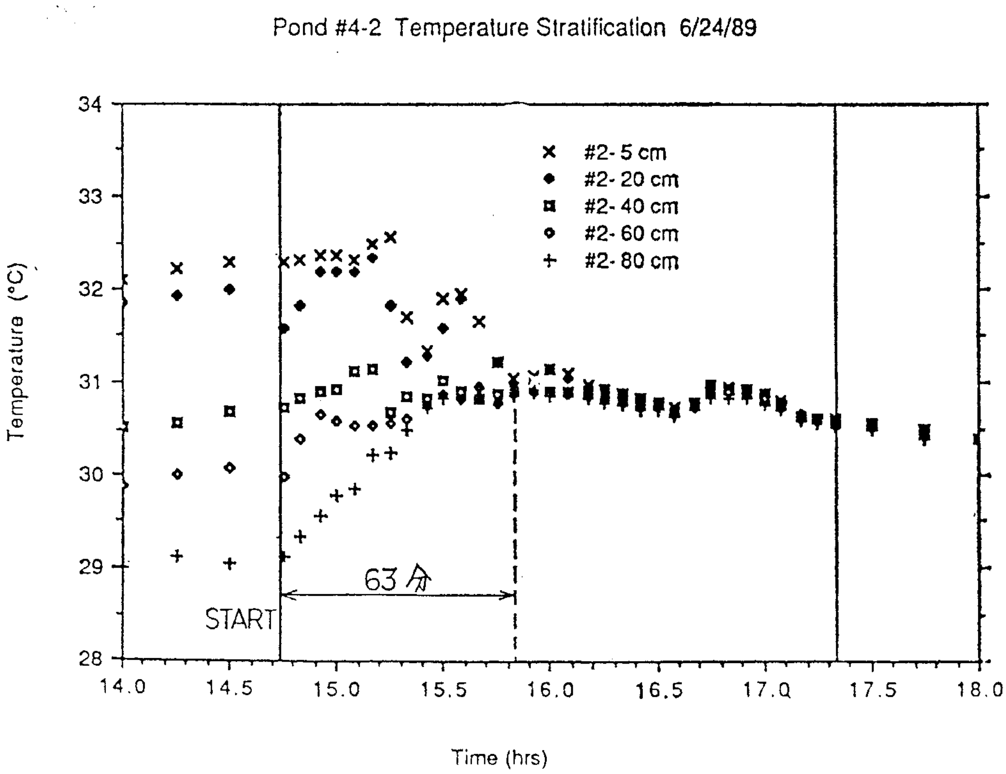

Fig. 7. Observation of temperature stratification profile at St. 2 (10 m distance from St. 3 on a right angle line to the propeller shaft line) in No. 4 pond.

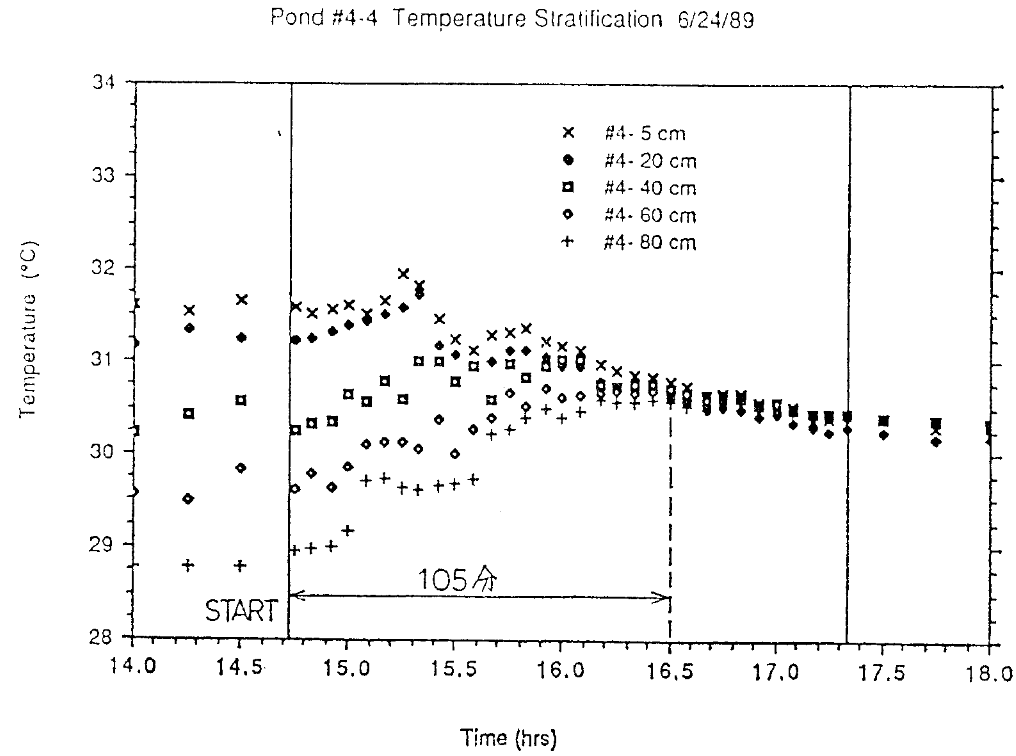

Fig. 8. Observation of temperature stratification profile at St. 4 (20 m distance from St. 3 on a right angle line to the propeller shaft line) in No. 4 pond.

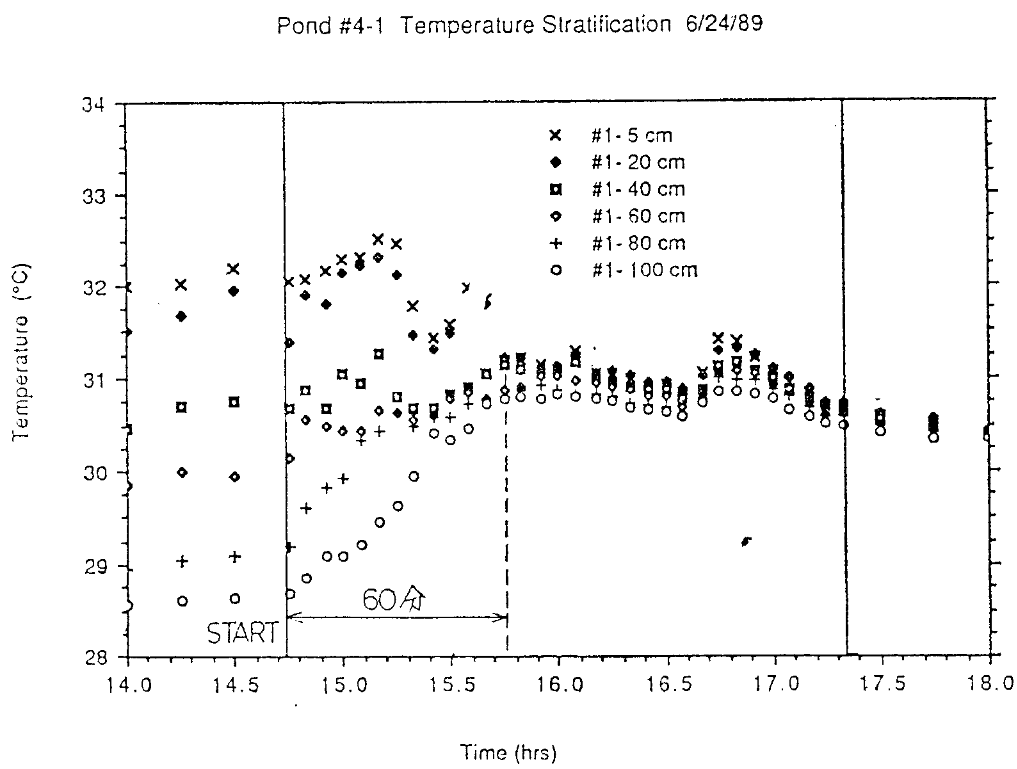

Fig. 9. Observation of temperature stratification profile at St. 1 (10 m distance from the aerator on a right angle line to the propeller shaft line) in No. 4 pond.

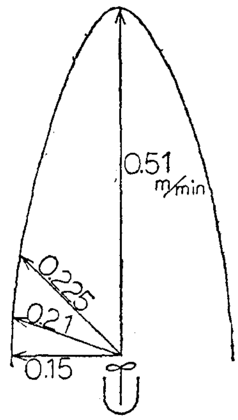

Fig. 10. Measurement of mixing speed of water mass with aeration in No. 4 pond.

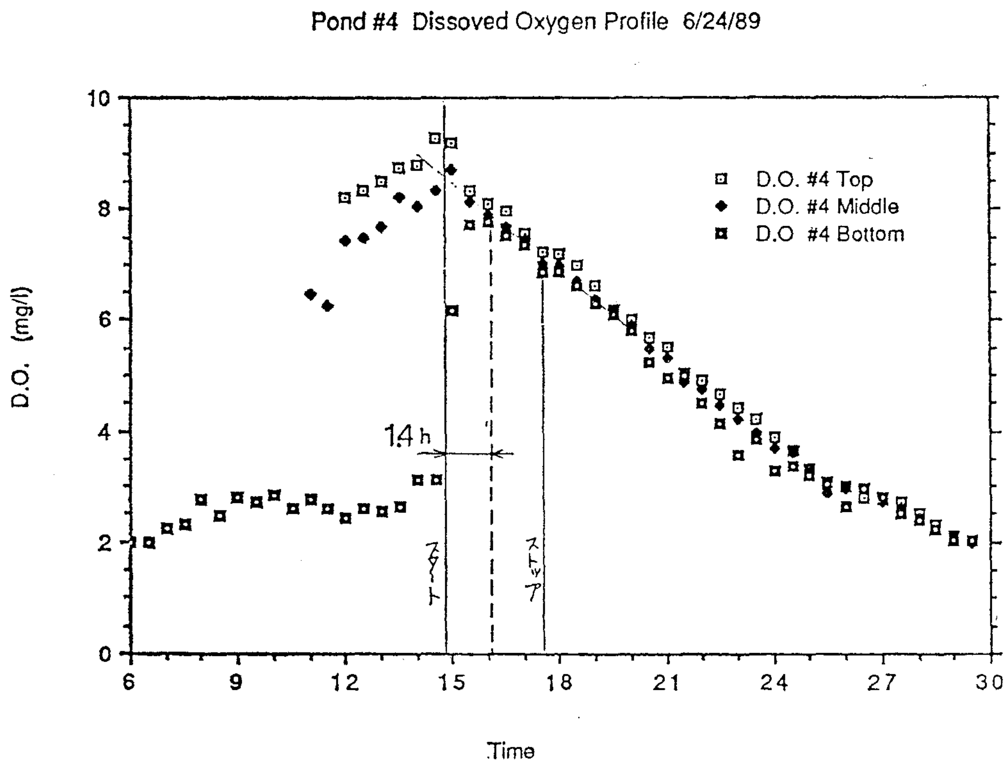

Fig. 11. Time course dissolved oxygen profile in No. 4 pond, before and after aeration with the 1 HP type Karbos aerator, (3 hour operation). Sampling depth: 10 cm, 40 cm and 10 cm above bottom.

shortage of oxygen for shrimps. Such stratification of water as 6.5°C difference in temperature from surface to bottom is not easy to break up under natural condition. As shown in Fig. 12, from the observation data of DO at top, middle, and bottom water of No. 4 pond with installation of the aerator (SP type 1 ps) complete mixing of water mass seemed to be achieved within 54 min, after started aeration.

Comparison of efficacy in mixing of water mass among the aerators, Karbos

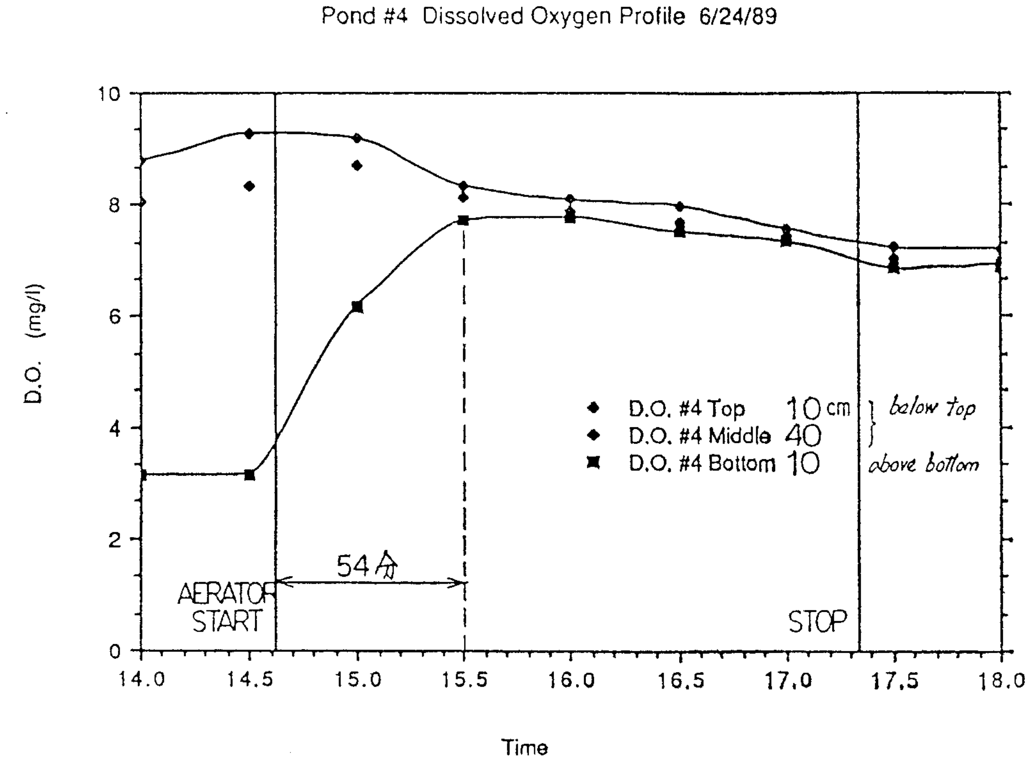

Fig. 12. Time course dissolved oxygen profile in No. 4 pond, before and after aeration with the 1 HP SP type Karbos aerator, (continuous operation). Sampling depth: 10 cm, 40 cm and 10 cm above bottom.

Table 2. Comparison of efficacy of SP type aerator in oxygen dissolving rate with some other type aerator

Aerator	O_2 dissolving rate g O_2/h	O_2 dissolving rate kg O_2/kwh
SP type Karbos** 111 (with 0.15 kw motor)	0.75	
Micro-pore diffusion* (with pure O_2)	55.3	
Fresh-Flo (0.1 kw)*—paddle wheel type	44.0	0.45
Present (0.05 kw)*—paddle wheel type	41.3	0.82
MacDonald	22.7	

* from test results of Boyd (A method for Testing Aerators for fish Tank. Claude E. Boyd. The Progressive Fish-Culturish 48.68-70.1986.)
** M.T. Engineering Co. Ltd., Tokyo, Japan.

(SP type 0.7 sp), AerO2 (1 sp), and a paddle wheel type (1 sp) was made. Where the Table 2, shows a comparison of mixing efficacy of Karbos P type aerator with that of existing several types of aerator calculated from data appeared in the literature.

The study was carried out in No. 3 pond observing complete mixing time using water temperature sensors during 1 to 6 of December, 1989. As shown in Fig. 13, water temperature sensors in the No. 3 pond were situated at 10 m (site No.) and 20 m (site No. 1) distance from aerator on the line of propeller shaft or of paddle wheel and 5 m (site No. 2) and 10 m (site No. 3) distance from the site

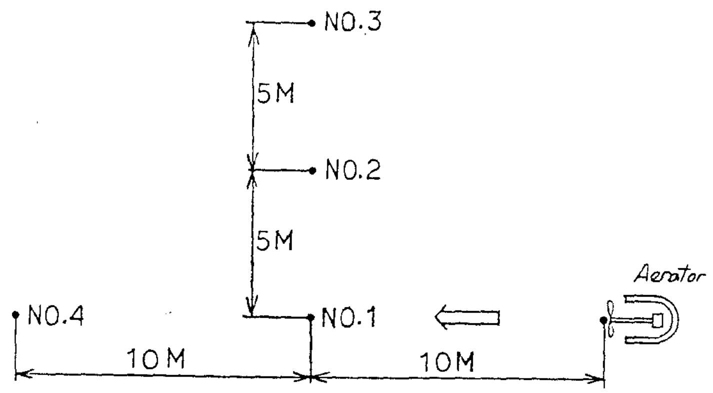

Fig. 13. Measurement station in No. 3 pond for efficacy comparison test.

No. 1 on a rectangular line. Weather condition was stable during the study with 27.7-29°C of air temperature, 2.1-2.5 m of maximum wind velocity, and 0.53-0.84 kw/m^2 of solar radiation. As shown in Table 3 complete mixing time of water mass for each aerator measured by water temperature in the No. 3 pond was observed as follows: Propeller shaft direction site; 2.0 hours (1.75 h, 2.25 h) for Karbos, 2.4 hours (1.5 h, 3.4 h) for AirO2, and 2.0 hours for a paddle wheel, rectangular lateral site; 4.0 hours for Karbos, 5.7 hours for Air O2, and 6.4 hours for a paddle wheel. At the site No. 2 and No. 4 somewhat faster time to achieve complete mixing of water mass was obtained in both a paddle wheel type aerator and AirO2 than Karbos. It may be merely caused by difference of driving power, i. e. 0.7 sp of Karbos P type to 1.0 sp of others. It was, however, clearly observed that Karbos P type achieved such a high lateral proceeding speed at 45° direction calculated from obtained data as 0.06 m/sec. compare with 0.37 m/sec. of a paddle wheel type and 0.04 m/sec. of AirO2. At the same time it may be proved remarkably in energy saying. Further exact comparison of efficacy for water mass mixing Karbos SP type (1 sp) was compared with AirO2 (1 sp) in the same energy consumption. Proceeding speed of water mass mixing with Karbos SP type and AirO2 were found that 0.51 m/sec. and 0.34 m/sec. for the propeller shaft direction and 0.225 m/sec. and 0.18 m/sec. for 45° direction from propeller shaft line, respectively.

Table 3. Complete mixing time measured for each aerator

Kind of aerator	Test date	Complete mixing time (hour)			
		No. 1	No. 4	No. 2	No. 3
Karbos aerator					
(0.7 PS) (P type)	Dec. 6	1.75	1.2	2.3	4
(0.7 PS) (P type)	Dec. 5	2.25		2.3	
Air O_2 aerator					
(1 PS)	Dec. 3	1.5	1	1.75	6
(1 PS)	Dec. 4	3.4	1	1.75	5.5
Paddle Wheel aerator (1 PS)	Dec. 2	2	0.9	1.9	6.4

More detailed works are still going on in MRTC. That results may be reported later in some where else.

ACKNOWLEDGEMENT

Authors would like to express sincere thanks to Dr. Phil Helfich, Director, and Dr. James M. Ebeling, Research Coordinator, Marine Research and Training Center of Hawaii Institute of Marine Biology, University of Hawaii for kindly conducting the studies.

新型簡易曝氣裝置對養殖池之環境改善

吉田多摩夫[1]　黃 登 福[1]　丸山俊朗[2]

益 田 雄[3]　佐藤和順[3]

1. 國立臺灣海洋大學
2. 日本東京水產大學
3. 日本 M.T. 機械工程公司

為了養殖池環境之改善，下列步驟首先被考慮，即池水氧氣供給之效率化，池水上混合之促進，以及除去池水之有機性污染物質等。為了上述這些自行開發之 1 馬力 SP 型曝氣裝置，在夏威夷大學海洋生物研究所海洋研究訓練中心（MRTC/HIMB），利用 2000 m^2 實驗池（水深 1 m）和 10 m^3 圓型實驗水槽，實施了其性能試驗。

試驗項目包含(1)以水溫測定之上下混合試驗。

(2)以溶氧測定之氧氣供給試驗。

(3)檢測泡沫去除效果之溶存有機物質除去效果試驗。

結果顯示水池之上下混合，氧氣供給和去除溶有機物質等效果均甚佳 。若與 Paddle 式空氣攪拌機之裝置效果比較，其混合速度和氧氣供給速度（1.2-1.5 kg O_2/kw·h）約為後者的兩倍以上。