Analysis of Irrigation Pond Ecosystems. Ⅲ. Vertical Distribution of Concentrations of Photosynthetic Pigments.

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Abstract

Patterns of vertical distribution of concentrations of number of individual plankton and photosynthetic pigments were surveyed in the ecosystem of Haibaraguchi pond once a month from February to September of 1988. For these two patterns, the peaks lay commonly between the subsurface layer and 3 to 5 meters in depth. From these experimental results, the compensation depth of this ecosystem was estimated to be 3 to 6 meters in depth depending on seasons.

Introduction

Photosynthesis is the ultimate source of supply of biotic energy to ecosystems. That amount produced by phytoplankton is able to determine the amount of biomass and diversity of zooplanktonic, nectonic and benthic species found in a given irrigation pond ecosystem. Productivity is expected to form a cline depending on depth due to rapid absorption of sunlight through pond water; a surface layer shows higher productivity than bottom layers. The distribution pattern of productivity is also indicative which is the euphotic zone or production layer and which one is the aphotic zone or consumption layer. The amount of chlorophyll a is directionally proportional to the capasity of production (SCOR/UNESCO 1966; Strickland and Parsons 1968). The amount of photosynthetic pigments per unit volume of pond water was surveyed from surface layer down to bottom layer in a certain irrigation pond, Haibaraguchi, because of its basic ecological information has been accumulated for several years (Yamaguchi *et al.* 1987 and 1988).

Materials and Methods

Haibaraguchi pond is located at an altitude of 110 meters above sea level and is adjacent to the campus of Hyogo University of Teacher Education, Yashiro, Hyogo Prefecture. The pond was constructed for irrigation by the damming of a natural valley. Rainfall is the sole source of inflow of water. It is 0.99 ha in area and a depth of 7.0 meters.

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Using a Meyer's sampling bottle, periodic sampling of the water was done at each meter from the pond surface once a month from February to September of 1988. The measured items were temperature, pH, amount of dissolved oxygen, amounts of chlorophylls a, b, and c, amount of carotenoid, and number of plankton per unit volume of the pond water. The amount of dissolved oxygen was measured by using a DO meter (TOA-DO-30A). The rest of the items were examined in the same way described in Yamaguchi *et al.* (1987 and 1988).

Results

Depth-dependent variation of abiotic components in the ecosystem of Haibaraguchi pond

The abiotic conditions of the pond ecosystem were surveyed from February to September of 1988. These are transparency, amount of dissolved oxygen (DO), degree of oxygen saturation (DO%), water temperature, and pH. The results are summerized in Table 1. The transparency changed from 105 cm in May to 243 cm in February, and the mean value was 180.8. DO showed a clear cline having higher values at top layers and lower values at bottom layers at every month. Typical cline was observed in the summer season of July or August. This season seems to correspond to *stagnation period.* These clinal patterns are also represented in Figure 1. The water temperature also showed clear clinal pattrns as shown in Figure 2. The summer season depicted this tendency more clearly. On the contrary, pH distributed rather constantly independent of the depths as shown in Figure 3. However, there was observed a clear seasonal change. The winter season showed lower values and the summer showed higher ones.

Figure 1. Monthly changes of vertical distribution of amount of DO.

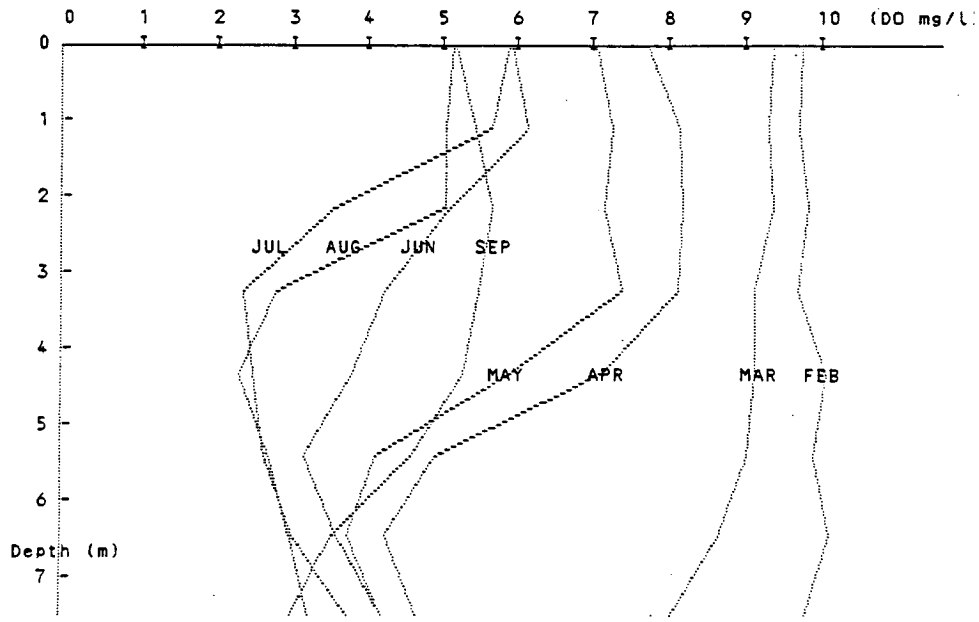


Table 1. Vertical distributions of amount of dissolved oxygen (DO), degree of its saturation (DO%), water temperature (Temp.), pH, and density of plankton (Dens. Plank), chlorophylls a, b, c (Chl. a, Chl. b, and Chl. c), and carotenoid (Carot.) in the ecosystem of Haibaraguchi pond.

Date / Transparency (cm)	Depth (m)	DO (mg/l)	DO% (%)	Temp. (℃)	pH (pH)	Dens. plankton (No. ind./ ml)	Chl. a (μg/l)	Chl. b (μg/l)	Chl. c (μg/l)	Carot. (μg/l)
	0	9.64	88.3	10.0	5.70		1.58	1.72	5.72	0.82
	1	9.61	85.3	8.5	5.70		2.32	1.14	4.60	1.20
	2	9.72	87.0	9.2	5.68		2.43	2.02	7.94	1.10
Feb. 29, 1988	3	9.58	85.6	8.9	5.69		3.12	1.86	6.52	1.02
(243)	4	9.94	89.2	9.1	5.72		3.08	2.13	8.39	1.10
	5	9.78	88.1	8.7	5.80		3.31	2.13	7.20	1.04
	6	9.98	87.5	8.8	5.80		3.78	1.97	6.98	0.98
	7	9.64	86.8	9.2	5.70		4.63	2.35	8.11	1.46
	0	9.28	83.8	9.5	6.41	140	1.96	2.25	7.07	1.12
	1	9.21	81.4	8.5	6.38	170	2.81	2.56	9.29	1.36
	2	9.28	81.9	8.4	6.30	110	1.85	1.37	3.73	0.64
Mar. 19, 1988	3	9.03	79.4	8.3	6.40	45	1.85	1.37	3.73	0.64
(205)	4	9.03	79.3	8.2	6.35	60	1.04	0.64	1.81	0.32
	5	8.94	78.7	8.2	6.31	155	2.31	1.21	3.51	0.60
	6	8.58	74.8	8.0	6.41	80	3.25	0.82	4.15	0.80
	7	7.96	70.1	8.0	6.30	20	6.24	3.79	11.95	2.04
	0	7.70	80.2	16.4	6.00	175	5.12	5.55	20.68	2.90
	1	8.11	85.4	16.3	6.09	355	3.46	2.81	7.58	1.40
	2	8.13	82.5	14.5	6.19	256	6.32	4.95	17.17	2.64
Apr. 27, 1988	3	8.08	77.7	12.0	6.21	700	6.71	3.56	12.82	2.12
(143)	4	7.12	66.6	10.9	6.10	210	8.72	3.62	12.31	2.08
	5	4.97	46.3	10.6	6.03	195	6.49	1.72	7.22	1.24
	6	4.33	39.8	10.0	6.00	215	5.48	2.80	8.16	1.44
	7	4.76	43.9	10.3	5.98	60	8.06	5.36	18.64	2.88
	0	7.06	82.2	21.6	6.60	50	3.88	4.86	14.93	2.38
	1	7.25	82.2	20.2	6.61	55	3.55	2.05	7.09	1.14
	2	7.15	78.9	18.7	6.80	125	4.36	2.77	9.01	1.40
May. 28, 1988	3	7.37	76.0	15.0	6.80	345	6.56	3.02	10.27	1.74
(105)	4	5.93	58.8	13.0	6.82	565	8.99	3.34	9.25	1.74
	5	4.21	40.5	11.8	6.82	460	9.46	3.11	10.11	1.60
	6	3.86	37.2	11.7	6.68	250	9.30	4.42	14.35	2.40
	7	4.31	42.9	13.3	6.81	140	11.16	3.94	11.29	2.16
	0	5.97	73.1	24.5	6.60	30	2.47	1.75	6.06	1.04
	1	6.18	75.3	24.3	6.62	15	3.01	0.90	4.27	0.82
	2	5.18	60.4	21.4	6.70	35	7.49	2.71	9.82	1.76
Jun. 23, 1988	3	4.34	47.2	17.6	6.57	65	6.45	2.06	8.01	1.48
(147)	4	3.91	40.1	14.6	6.60	45	6.17	2.63	6.74	1.32
	5	3.29	32.8	13.1	6.54	220	7.99	2.35	6.65	1.38
	6	3.72	36.7	12.8	6.55	190	8.99	3.41	8.16	1.66
	7	4.31	43.1	13.2	6.80	30	9.69	3.18	7.83	1.64
	0	5.94	74.4	26.1	6.80	10	4.72	5.31	14.98	2.52
	1	5.72	71.6	25.9	6.80	40	5.25	2.73	10.44	1.62
	2	3.70	44.9	24.0	6.91	95	7.57	2.02	8.25	1.70
Jul. 29, 1988	3	2.51	28.8	20.6	7.00	95	6.64	2.40	7.61	1.50
(175)	4	2.63	28.3	17.2	6.80	60	5.13	1.92	6.02	1.22
	5	2.77	28.7	15.1	6.88	90	8.37	2.96	6.92	1.46
	6	3.14	31.9	14.3	7.02	100	11.62	3.85	9.99	2.32
	7	3.87	39.7	14.6	7.08	53	14.32	5.38	18.11	3.66
	0	5.21	66.5	27.6	7.21	15	3.66	2.86	11.51	1.72
	1	5.12	65.2	27.1	7.22	80	3.93	2.58	8.44	1.38
	2	5.12	64.9	26.7	7.15	40	5.79	2.03	6.47	1.16
Aug. 31, 1988	3	2.94	36.4	25.8	7.23	110	8.50	1.70	7.81	1.30
(213)	4	2.46	29.9	24.1	7.13	90	6.22	2.14	8.12	1.32
	5	2.83	32.7	21.4	7.20	70	8.84	2.65	8.86	1.68
	6	3.10	34.4	18.9	7.13	100	29.78	18.30	8.90	2.88
	7	3.38	36.7	18.0	7.13	60	21.27	9.76	11.59	2.94
	0	5.26	62.7	22.9	7.10	35	2.93	1.52	6.93	0.94
	1	5.50	65.5	22.8	7.10	55	3.43	3.01	10.54	1.64
	2	5.71	67.6	22.4	7.20	85	5.33	2.11	7.78	1.40
Sep. 30, 1988	3	5.54	65.8	22.3	7.20	30	4.48	1.66	7.73	1.22
(215)	4	5.33	62.9	22.1	7.40	55	5.98	2.22	8.23	1.46
	5	4.68	54.8	21.7	7.38	110	6.87	2.25	8.58	1.46
	6	3.65	42.0	20.7	7.30	120	9.99	4.48	9.68	2.24
	7	3.10	34.4	19.1	7.50	40	22.41	9.13	20.50	5.50

Figure 2. Monthly changes of vertical distribution of water temperature.

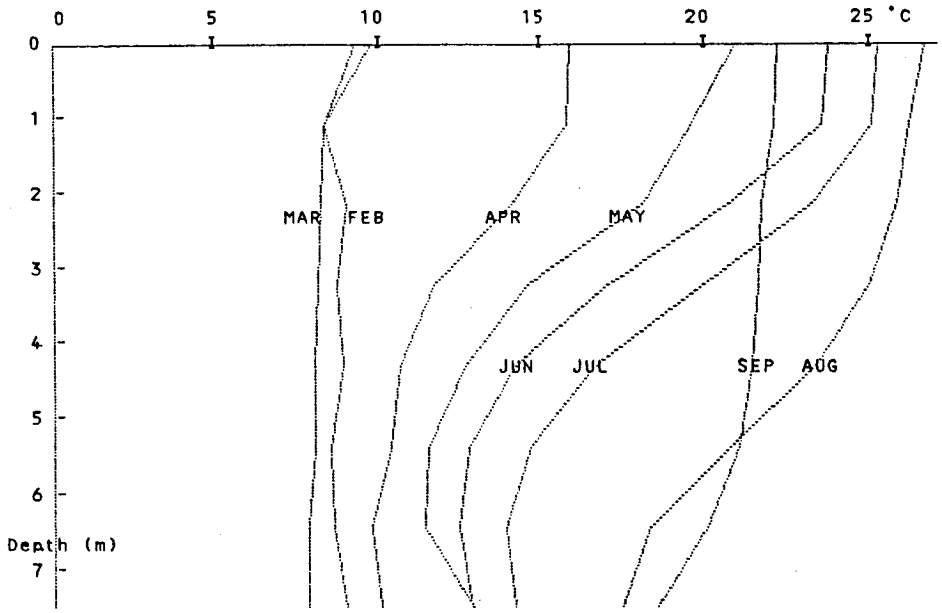
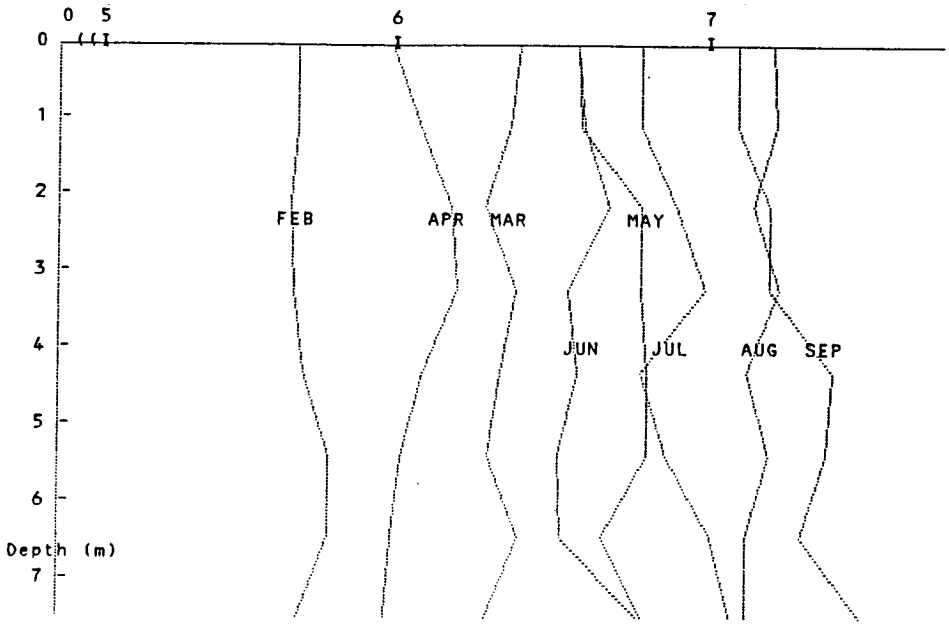


Figure 3. Monthly changes of vertical distribution of pH.



Vertical distributions of concentrations of plankton and photosynthetic pigments

Number of individual plankton per one mililiter of the pond water were surveyed vertically in this ecosystem. The experimental results were obtained by direct counting of number of plankton. The results are shown in Table 1 and Figure 4. There was no consistent vertical distribution, however the maximum density was seen in subsurface layers or near bottom layers. A part

Figure 4. Monthly changes of vertical distribution of concentration of plankton.

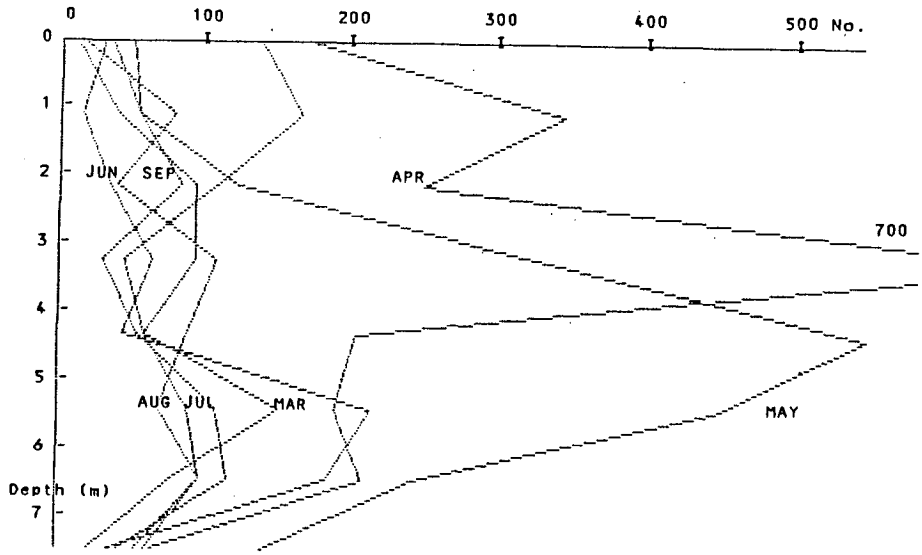
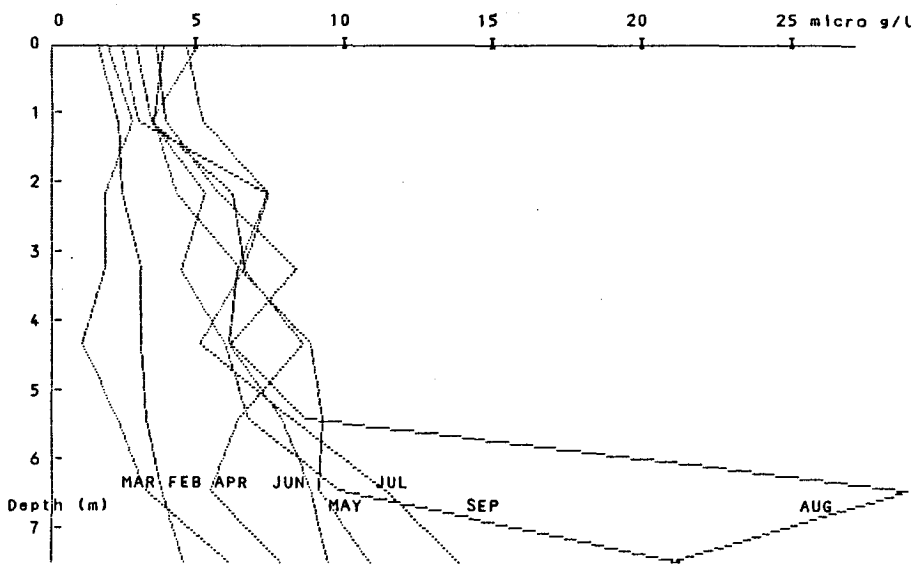


Figure 5. Monthly changes of vertical distribution of amount of chl. a.



of this reason seems to be ascribed to a small volume of the pond water examined. The concentrations of chlorophylls a, b and c, and carotenoid are also shown in Table 1 and Figure 5. A clear bimodal distribution pattern was seen in the case of chlorophyll a at every month. One peak with the maximum value was at the bottom layer, and the other peak was seen in a range from 1 to 4 m in depth depending on months. The patterns of vertical distribution of chlorophyll c and carotenoid seem to be almost parallel to that of chlorphyll a. This parallelism indicates that the main producers of this ecosystem are diatoms (Yamaguchi *et al.* 1988).

Discussion

Chlorophyll a is the active pigment of photosynthesis. The remaining supplementary pigments have a role to transfer the energy of sunlight to the active site. Therefore, the concentration of chlorophyll a is a direct indicator of productivity. The vertical distribution of this quantity had two peaks. One is seen at the bottom layer and seem to be ascribed to diatoms with large bodies attached to the bottom deposit. The other peaks were seen in a range between the subsurface layers. For instance, in June, this peak was seen in 2 m-layer at 7.49 $\mu g/l$, and was above the turning points of thermocline and DO cline. In the same way, that of August was seen in 3 m-layer at 8.50 $\mu g/l$ above both the turning points. From these results, it is concluded that the compensation depth of this ecosystem is in a range of 3 to 5 meters in depth, in another ward, the production layer is layed above this line. This estimation was confirmed from another calculation, 3.0 to 6.0 meters of the conpensation depth gained from a quantity of the transparency multiplied by 2.5 (Hogetsu 1974). There was a significant variability about this quantity between the depths and between months as shown in Table 2.

Table 2. Analysis of variance of vertical distributions of densities of plankton and chlorophyll a in the ecosystem of Haibaraguchi pond.

Density of plainkton					
Source of variation	SS	DF	MS	F	P
Depth	382247	6	65374.5	5.85	P<0.01
Month	134856	7	19265.2	1.72	P>0.05
Error	469123	42	11180.8		
Total	998226	55			
Density of chlorophill a					
Depth	407.6	7	58.2	4.92	P<0.01
Month	559.7	7	80.0	6.76	P<0.01
Error	579.7	49	11.8		
Total	1547.0	63			

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