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Continuous Records of DO Contents by Cruising in the Coastal Culture Farms - I*[1]

Relation Between DO Content and Fish Density in Cages

Shusaku KADOWAKI,*[2] Teruo KASEDO*[2] and Tsurayuki NAKAZONO*[2]

Abstract

The present experiment was made to record DO contents in the surface seawater by cruising around the fish cages in order to find oxygen consumption of red seabream cultured.

A small boat (0.2 t) was employed for DO recording by cruising at 3 kt speed. DO meter (YSI model 57) was set at an inlet of fish stock tank of the boat. The DO variation was recorded by an universal pen recorder (YEW model 3047) on the floor of the boat.

When the boat was sailing from the offshore into the fish cages, DO content in the water decreased gradually in the range of 0.2 to 0.8 ppm. The rate of DO decline was closely related to the population density of red seabream cultured in cages.

1. Foreword

As in recent years the degree of auto-pollution accompanying fish culture is rising, the need has arisen for more active and more rapid control of the fish culture grounds environment.

Inoue (1977) stressed that one of the required measures for the control of fish culture fishing grounds was to examine the DO variations inside and outside the fish cages. Meanwhile Hirata et al (1978 a, b)

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attempted continuous recording of DO by cruising in tuna fishing grounds and found the method extremely convenient. As the precision is high, such method should provide important clues in the inspection of fishing grounds.

So, in the present study, the ideas of Inoue (1977) were put to practical use with the methods of Hirata et al (1978 a) to examine the oxygen consumption within the clusters of fish cages in the coastal fish culture farms.

At the beginning of this article, I wish to thank Shinjiro p. 274
KOBAYASHI, honorary professor at the Hokkaido University, Hachiro HIRATA, assistant professor at the Fisheries Department, Kagoshima University and Dr. Gunzo KAWAMURA who gave me valuable advice. I am also grateful to P. GABASA, Masatoshi KODAMA, Koji MAE, Tatsuya YAMAUCHI, graduate students at the Fisheries Department, Kagoshima University as well as to Takashi MAKITA, fourth-year student at the same department, for the cooperation provided during the investigation.

2. State of the fish farming grounds

The fish farming grounds which we examined are the sea area of the marine experimental station belonging to the Fisheries Department of Kagoshima University located in Nagashima at the northern tip of the Kagoshima Prefecture. In the pelagic region extending from there to the south of the Amagusa islands in the Kumamoto Prefecture there are 3 islands and the waves are relatively gentle. This area is also the channel of the Eastern China Sea and of the Shiranui Bay, and the current reaches at times 3-4 kt. Moreover the depth of the fishing ground does not exceed 15-20 m and the exchange of waters is easy to see. Consequently, according to the classification made by Inoue et al (1970), the present ground may be said to be of the typical small-strait usage type. The bottom matters are mainly made of clay slate and sandstone. In the coastal light-receiving area, there is a formation of eelgrass grounds.

The area of the present fishing ground does not exceed 10 ha, and 302 mesh cages with an angle of 7 m have been installed. During all four seasons, 360 tonnes of red seabream and young yellowtail are being cultured. The ground is run by 18 farmers. Most of the feed fish is produced by the farmers themselves through adjoined fishing of sardines with round haul nets.

3. Continuous DO recording method by cruising

The survey boat was 5.4 m long, made of glass fiber and weighing 0.2 t (12 sp outboard engine from Yamaha, model W-19 SF). The cruising speed during measurements was set at about 3 kt.

Almost like in the report by Hirata et al (1978 a, b) the DO meter, DO sensor and self-recorder were respectively of the YSI-57 type, YSI-5739 type and of the Yokogawa 3047 type. As for the DO sensitivity field, a width of 24 mm was chosen to indicate 1 ppm on the recording paper. The take-up speed of the recording paper was set at 1 cm/min. To generate power aboard the boat we used a 0.25 kw Honda E 300 type unit.

As shown in Fig. 1, the DO continuous recording by cruising was performed in the surface fixed-attachment manner. To measure, we p. 275
attached the DO sensor (C) with the gum bung (D) to the inlet (B) of the

live fish tank (A) in the boat. In the bung, we opened the hole (E). As the boat was moving, seawater kept running inside the tank and escaped through the outlet (F).

As shown in Fig. 2, the DO survey route was 2.5 m away from the fish cages upstream and downstream. As shown in Fig. 2-b the respective DO volumes are denoted as DO·1 and DO·2, and the DO consumption p. 276
volume of the group of fish cages was calculated as 「DO·1 - DO·2 = DO·3」.

4. Results and discussion

Fig. 3 shows the DO-variations records accompanying the ebb and flow difference of the daytime variations. In the Figure, a, b, c and d denote respectively the results for the high tide, the middle period of the ebb tide, the low tide and the middle of the high tide. These figures indicate that the DO changes around the fish cages are extremely varied.

When, in order to analyze these variations, we read the DO recorded values, we have the arrangement shown in Fig. 4 and Fig. 5. The dotted and solid lines in Fig. 4 correspond respectively to DO·1 p. 277
(upstream of the fish cages) and to DO·2 (downstream of the fish cages) shown in the conceptual Fig. 2. We find the amount of oxygen consumption of the group of fish cages, i.e. DO·1 - DO·2 = DO·3 from Fig. 4. The results are shown in Fig. 5 and Table 1. If, on the basis of this table, we examine the amount of oxygen consumption of the fish cages according to ebb and flow, we see that the amount consumed at high tide did not exceed 76 ppb/cage. At low tide it was 204 ppb/cage which is about 3 times the low-tide amount and which represents the highest value. At rising and ebbing tides times, the amount of oxygen

consumption by the fish cages is 123-133 ppb/cage (average of 128 ppb/cage) and was computed as being roughly the 140 ppb average value of the 2 former values.

Although the present method is based on macro-measurements, it seems that the obtained data may be used for comparative micro-analysis. Regarding the oxygen consumption of fish cages, many attempts have been made in the past to make measurements (Inoue 1965-1977; Kitaka 1959). Yet the methods were always stationary. We carried out fixed-point surveys corresponding to the traditional methods. Yet because of the circular movements of the fish around the fish cages, there are complicated countercurrents and the analysis of the obtained samples was p. 278 difficult. On the other hand, the continuous recording of DO by cruising presently performed is simpler and very precise, and it seems to be applicable for the environmental control of fish farming grounds.

If we examine the correlation between the fish-holding density and the volume of DO consumption by the fish cages, we note a strong correlation at low-tide time as shown in Fig. 6. Thus, when the fish-holding density was 6 kg/m^3 the oxygen consumption was around 50-60 ppb. The amount of oxygen consumption increases with the density. We computed the high 300-500 ppb value with a density of 22 kg/m^3.

However, no very clear correlation was noted between the fish-holding density and the amount of oxygen consumption at high tide. The reason seems to be that at high tide, the effective water amount increases. Meanwhile the drop in DO in coastal fish farming grounds is not only related to the above cultured fish density. One must also consider the floating and suspended matters as well as the bacteria. This will be examined later.

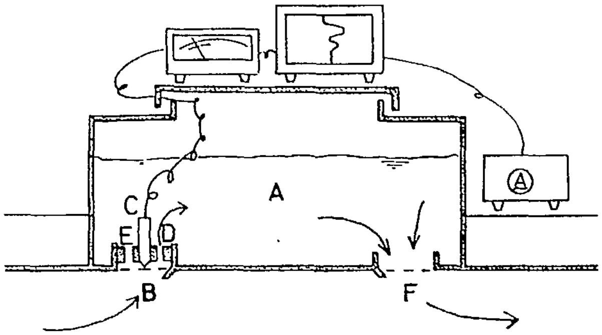

Fig. 1. Schematic view of continuous DO recorder. A: alive fish stock tank, B: water inlet, C: DO sensor, D: gum bung, E; small openings and F: water outlet.

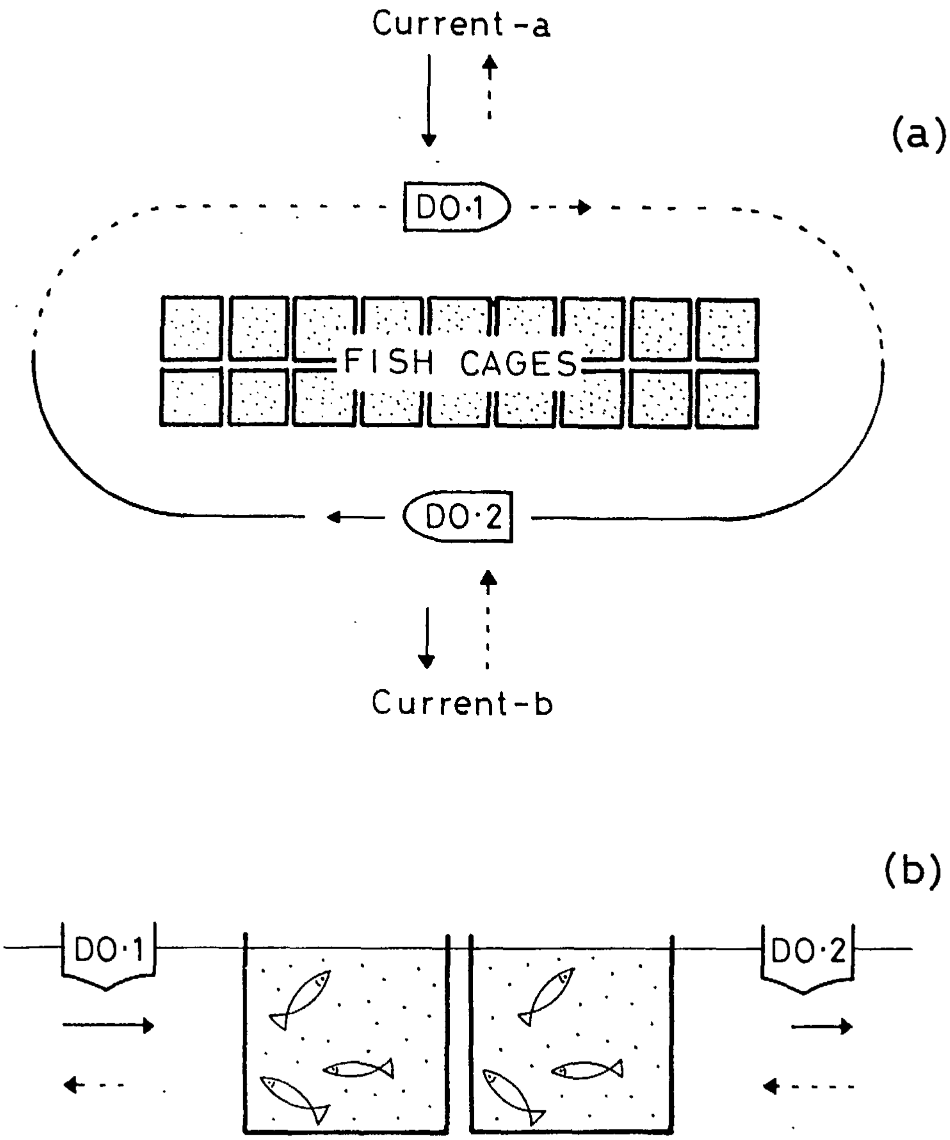

Fig. 2. Schematic diagram of DO measurement by cruising near fish culture cage. DO consumption (DO·3) of the cage is estimated by a following formula: DO·1−DO·2=DO·3. (a): plane view of DO measurement by cruising, (b): cross section of DO measurement by cruising.

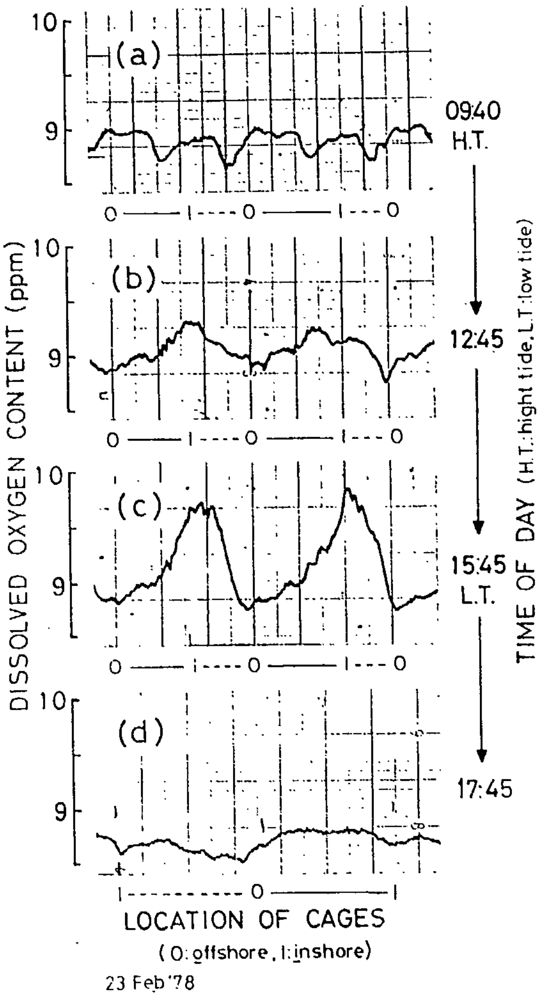

Fig. 3. Examples of continuous DO records by cruising in 0 m depth, (a): high tide, (b): middle of ebb tide, (c): low tide and (d): middle of full tide.

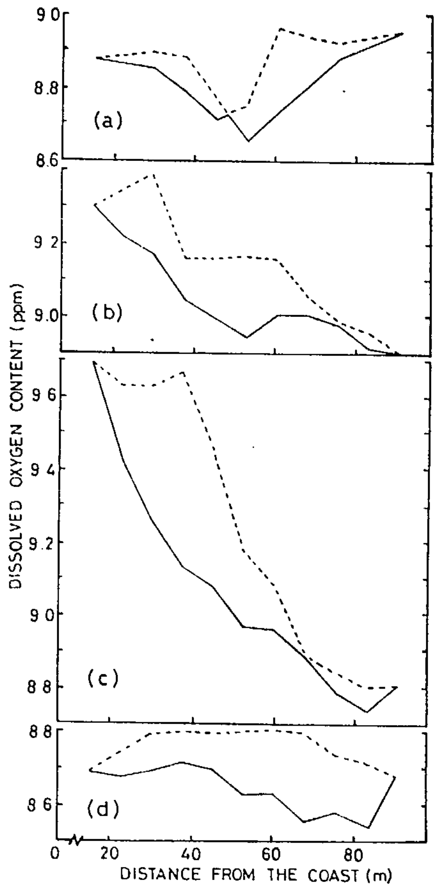

Fig. 4. Variation of DO content from inshore to offshore around the cages. Straight line is outlet, dotted line is inlet. The results of a, b, c and d were calculated after Fig. 3.

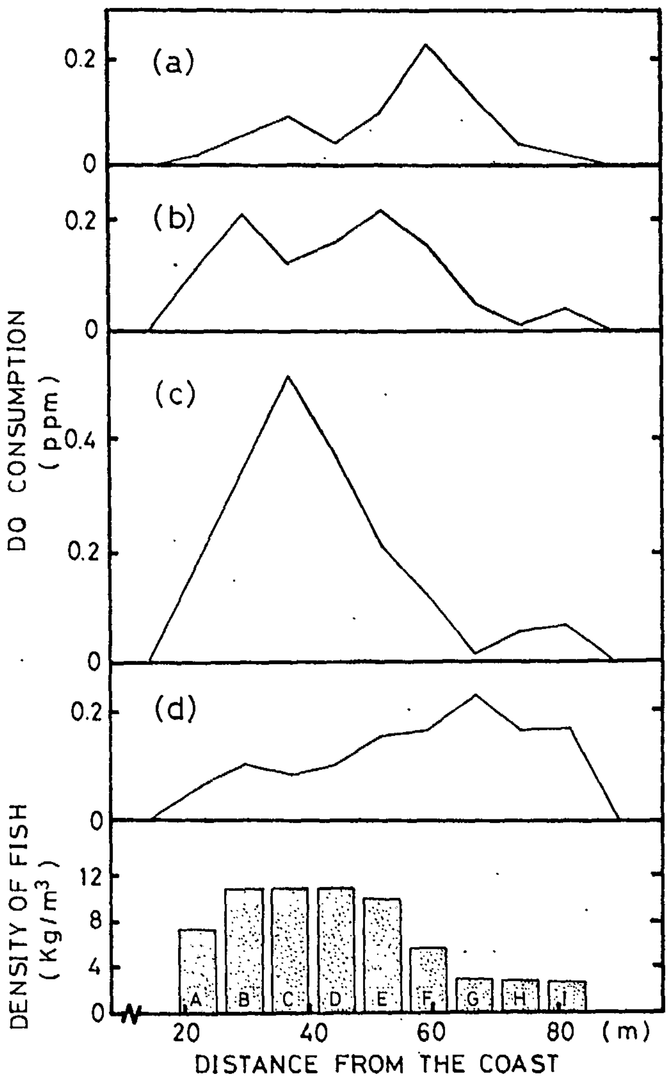

Fig. 5. Variation of DO consumption in each tide. The results of a, b, c and d were re-calculated after Fig. 4.

Table 1. DO consumption around fish cages in each tide.

Cage (mark)	Location from the coast (m)	DO consumption High (ppb)	H → L (ppb)	Low (ppb)	L → H (ppb)	mean (ppb)	Density of fish (kg/m^3)
A	21	21	117	171	54	91	17.6
B	29	57	217	342	100	179	22.2
C	37	92	127	517	80	203	22.6
D	45	44	163	369	98	169	22.3
E	53	57	220	203	154	158	20.0
F	61	225	161	113	163	166	11.6
G	69	132	48	8	225	103	6.3
H	77	42	10	54	158	66	6.3
I	85	21	43	63	163	73	6.3
mean		76	123	204	133	134	15.0

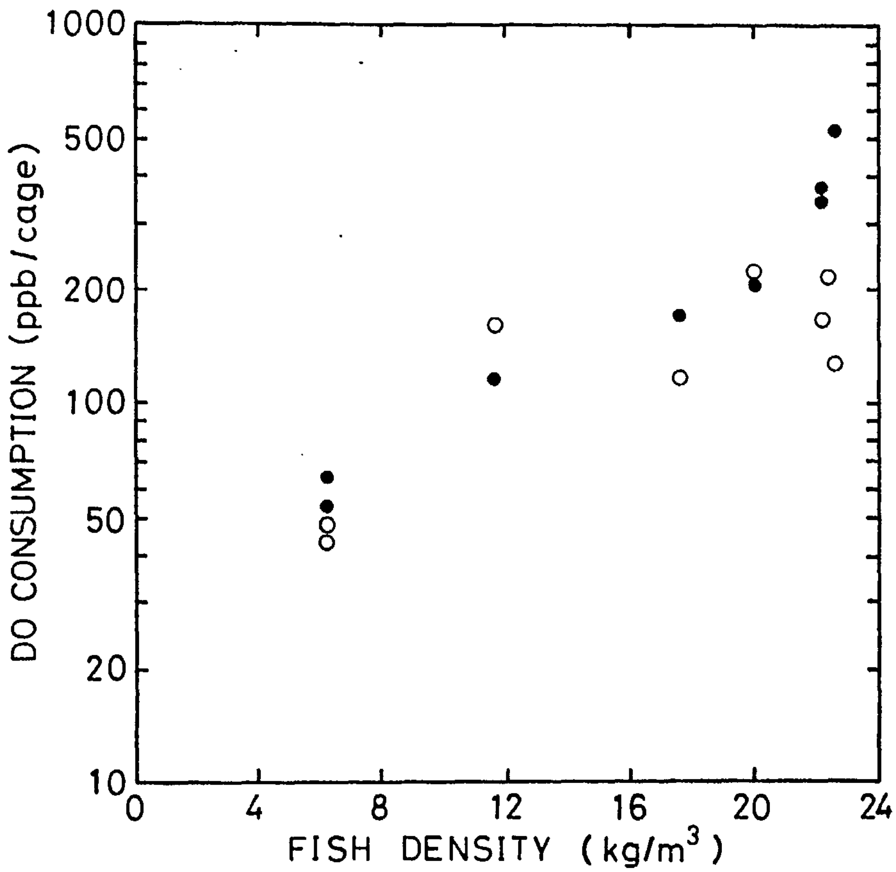

Fig. 6. Relation between fish density and DO consmption.
Open and closed circles indicate the relations in high and low tide, respectively.

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*Translator's note: Probable reading only; other reading not excluded.