mariculture sites of yellow tail, the other is outer part which has bigger city of Kagoshima. These data on two parts were inputted and discussed separately, because their environmental conditions are different each other. The research by each prefecture was originally made for red tide studies, so observations were concentrated in summer season. Observed layer was 2 m depth in Fukuoka and Imari Bay and the surface in Kagoshima Bay.

In the project, determination of nitrogen nutrients as nitrate, nitrite, and ammonia were done by Strickland and Parsons (1968), and chlorophyll a were measured by fluorometric method based on Yentsch and Menzel (1963).

Results

Data on DIN and Chlorophyll from April to October of 1985 in three bays and of 1986 in Imari and Kagoshima Bay were plotted to Fig. 2. DIN values were widely distributed from 0.02 to 31 ug-at/l, and the range of chlorophyll values were from 0.45 to 45 ug/l. These plotted data showed some tendencies on each bay. Data of Fukuoka Bay distributed to high DIN upper than 10 ug-at/l and lower chlorophyll than 5 ug/l, or lower DIN than 7 ug-at/l and higher chlorophyll than 8 ug/l. Data of Imari Bay distributed in the wide range of DIN from 0.02 to 32 ug-at/l, and chlorophyll from 0.8 to 17 ug/l. On the other hand, data of Kagoshima Bay indicated lower DIN values less than 4.5 ug/l, but chlorophyll values in the inner part were apparently higher than the outer part. From the result of Fig. 2, It is difficult to recognize a common tendencies among three bays. However, if these are classified by each bay or the part, some tendencies described above are easily recognized.

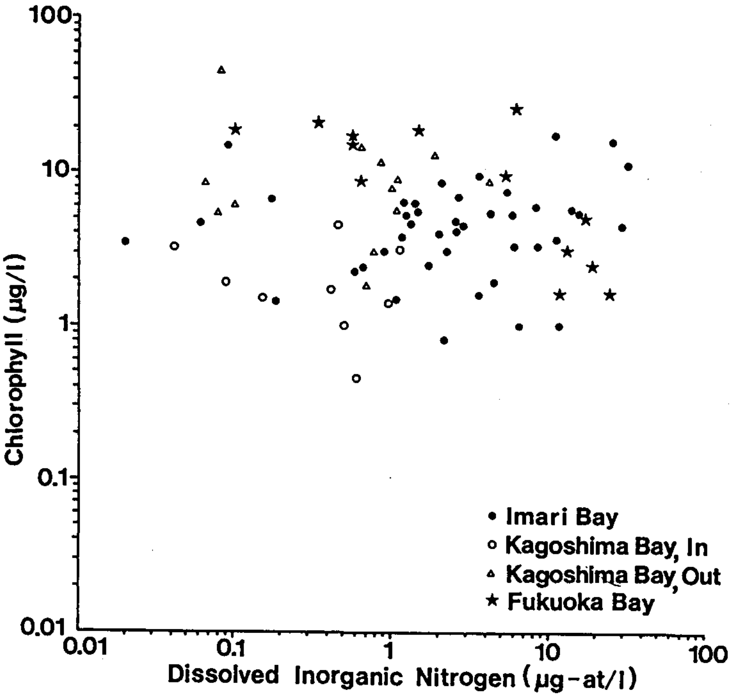

Fig. 2, Relations between DIN and chlorophyll in Fukuoka, Imari, and Kagoshima Bay.

The relation in Fukuoka Bay indicated in Fig. 2 presents a peculiar tendency, i.e. low chlorophyll - high DIN and high chlorophyll - low DIN. Adding data of other months in the bay, the tendency appeared more clearly. Then these plotted data are lined by the order of observations as shown in Fig. 3. The data fluctuated widely, however they converged into low chlorophyll - high DIN range in the season from early winter to early summer.

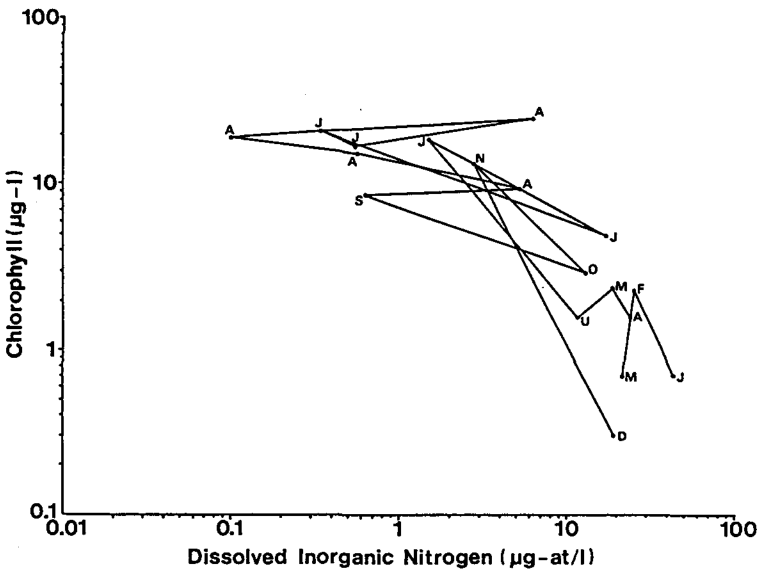

Fig. 3, Seasonal variation of DIN - chlorophyll values in Fukuoka Bay. Months were indicated by the capitals except U of June.

The composition of nitrogen defined as dissolved inorganic nitrogen (DIN), dissolved organic nitrogen (DON), and particulate organic nitrogen (PON) in seawater were also compared each other. Seasonal variation of the composition in Fukuoka Bay is shown in Fig. 4-a. The ratio of these compositions apparently varied with seasons. DIN occupied big portion from December to May, and PON

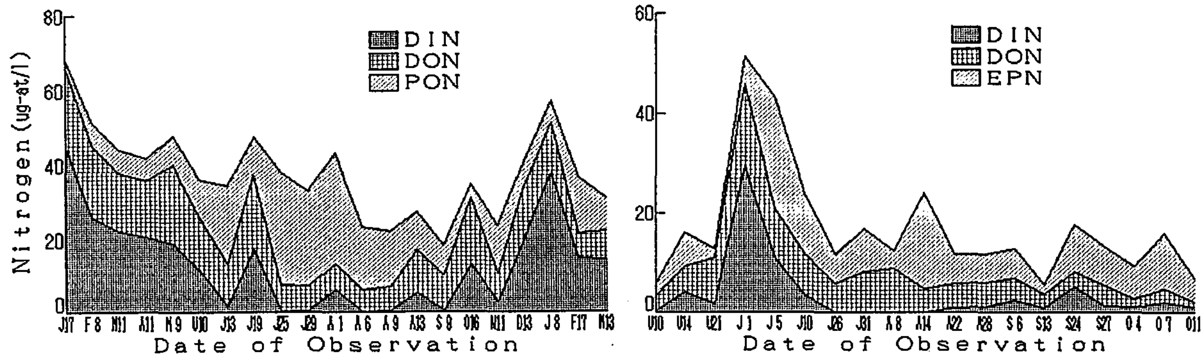

Fig. 4-a (left), 4-b (right), Seasonal variation of DIN, DON, and PON (EPN) in Fukuoka (4-a) and and Imari (4-b) Bay. EPN is converted value from chlorophyll using factors (see text).

occupied it in July and August. DON did not so changed and rarely showed the biggest portion. Total values of these compositions were not stable, it presents maximum in January and minimum in September. The composition in Imari Bay is illustrated in Fig. 4-b in which PON was calculated using Nitrogen/chlorophyll ratio as 17.6 according to Fleming (1940)'s Carbon/Nitrogen ratio of 6 by weight and Holm-Hansen (1969)'s Carbon/Chlorophyll ratio of 100. Then PON was indicated as Estimated Phytoplankton Nitrogen (EPN). The maximum values of nitrogen nutrients from late June to early July have coincided with the big rain fall in these areas. Variations of these components in Fukuoka and Imari Bay were close each other from June to October.

Discussion

Uno (1982) also collected data from nine different sea areas over the world and indicated the relations between DIN and chlorophyll in the euphotic zone as shown in Fig. 5. From this figure, He gave some results; "The higher values of chlorophyll concentration correspond to the higher concentration of nitrogen, and the lower chlorophyll values were found to correspond to the lower nitrogen values", but the highest DIN in Antarctic Ocean did not presents higher values of phytoplankton standing stock, then "it is considered that the chlorophyll concentration in each sea area was affected fairly well by the distance from the land". On the almost data of the figure, it was obvious that nitrogen as phytoplankton did not exceed equivalent DIN values which are calculated by multiplying 1.19 to the chlorophyll values according to the ratios of Fleming (1940) and Holm-Hansen (1969) described above. Only some data from closed coastal seas like as Osaka Bay or Suwo-Nada exceeded the equivalent values.

In the present study, chlorophyll values on three bays in summer season almost exceeded the equivalent DIN values. Fig. 3 indicated this results. Data in winter never

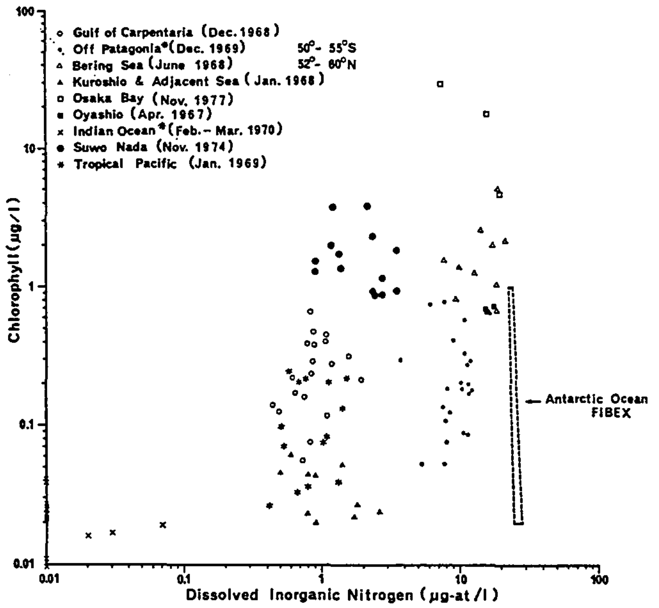

Fig. 5, Relations between DIN and chlorophyll in nine different sea areas (redrawn from Uno, 1982).

Table 1, Comparison of Characteristics and Back Grounds of Fukuoka, Imari, and Kagoshima Bay, in Western Kyushu.

Categories	unit	Fukuoka Bay	Imari Bay	Kagoshima Bay	
				Outer	Inner
Bay					
Area	(Km^2)	120	104	576	243
Maximum Depth	(m)	22	50	230	200
Rivers					
Number of Mouths		5	5	5	9
Land					
Impact Area	(Km^2)	628	430	691	1,053
Areal Population	($x10^3$)	1,500	114	450	330
Production					
Aquaculture	(ton)	0	12,219	7,477	9,030
Rice	(M.¥)	6,305	7,107	2,480	7,954
Crop & Vegetable	(M.¥)	6,600	8,679	14,348	7,873
Animal Husbandry	(M.¥)	5,496	9,615	18,059	20,186

exceeded the equivalent value, but only the data in July and August sharply did it. Low DIN in summer should be caused by consuming of nutrients by phytoplankton. High chlorophyll values should be simultaneously caused as a result of the phenomenon. However, one question still remain. Why phytoplankton standing stock (indicated as chlorophyll) was brought under such a controlled value.

Values from three bays are plotted into wide range of the DIN - Chlorophyll relation in Fig. 2, and shaped different tendencies from the results of Uno (1982). And data from three bays also presented different tendencies each other. To discuss these results, topographical and social backgrounds of three bays were listed in Table 1. The table indicates characteristics of each bay that is Fukuoka bay as narrow, shallow, big population, and no aquaculture production, Imari Bay as narrow, low population, and big aquaculture production, Kagoshima Bay as large, deep, and high agricultural production. Important categories for nitrogen load to bays seemed to be Areal Population, Aquaculture, and Animal Husbandry. Expressing by different units in the Table, these values were converted to Annual Production (ton) by multiplying 4 for Areal Population and 1 (1 M.Yen = 1 ton) for Animal Husbandry. Then main nutrient suppliers in each bay were estimated to be civil sewages and animal husbandry in Fukuoka Bay, aquaculture and animal husbandry in Imari Bay, and animal husbandry and aquaculture in Kagoshima Bay. Topographical features is also an important factor for the presence of DIN. Fukuoka Bay should be too shallow to store DIN according to the result of Kawakami et al (1986). Data fluctuations should be caused by tidal exchange of seawater in Imari Bay, because it has deeper and wide mouth. On the other hand, Kagoshima bay is deeper than 200 m, so nutrients are scarcely supplied from bottom water (Takahashi, 1981). The values on nutrient supplier in Kagoshima Bay are not so differ between the inner and the outer part. But the enrich is more effective in the inner part as the area is a half of the outer. This fact will well explain the difference of chlorophyll values between both parts in Fig. 2.

The importance of organic nutrients from land are pointed out by many scientist, e.g. Prakash and Rashid (1968). In the Fig. 5, extremely low chlorophyll values are obtained from the highest DIN area, Antarctic Ocean. Swift (1980) pointed out that the lack of vitamins in the Antarctic Ocean causes lower phytoplankton production. Results obtained in the present study also suggested the importance of organic supply from the land. All of over-production indicated as excessive chlorophyll against the equivalent DIN value may be gotten by the supply of some organic nutrients. The nutrient load from aquaculture also seems to have an important factor for phytoplankton stock.

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