Eutrophication of Shellfish Farms in Deukryang and Gamagyang Bays

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得粮灣과 鴐莫洋 貝類養殖場의 富榮養化

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南海岸 西部에 위치한 得粮灣과 鴐莫洋에서 1981年 夏季 중 海水의 클로로필-a量과 底泥 중 COD, 強熱減量, 페오파이틴量 그리고 黃化物量을 측정하였다.

得粮灣은 약 300 km^2로서 근래 피조개의 採苗 및 養成이 急增하고 있고, 鴐莫洋은 약 150 km^2로서 垂下式에 의한 굴 養成이 많다.

得粮灣 해수 중 클로로필-a量은 9月에 많아 1.0~5.0$\mu g/l$로서 평균 2.5$\mu g/l$이었다. 量的인 分布에선 得粮島의 西北쪽에서 많았다. 底泥 중 有機物量은 兩灣 모두, COD 5.0~10.0mg/g, 強熱減量 5.0~9.0%, 페오파이틴量 2.0~5.0$\mu g/g$ 乾泥이었으며 黃化物量은 0.1~0.3mg/g 乾泥이었다. 有機物과 黃化物量 모두, 得粮灣에서는 灣入口에서 깊숙히 들어갈수록 증가하였고, 鴐莫洋에서는 灣의 西편과 西北쪽에 많았다. 上記의 모든 量은 閑山·巨濟灣의 量들과 비슷하거나 약간 적었다. 클로로필—a量에 의한 海水의 富榮養化는 閑山·巨濟灣과 같이 中間 수준인데 비해, 底泥의 富榮養化는 初期단계이었다. 底泥중 COD와 페오파이틴量으로부터 산출한 底泥汚染度는 6~11로서, 閑山·巨濟灣의 7~18, 鎭海灣의 11~30에 비해 낮았다. 이는, COD量이 적다는 이유도 있지만, 굴 養成을 많이 하는 閑山·巨濟灣이나 鎭海灣 西部海域과는 달리 페오파인틴量이 COD量보다 적었기 때문이다.

Introduction

Culture of the arkshell, *Anadara broughtonii*, in the western part of the southern coastal seas of Korea has been increasing in recent years and its environmental study is required in the culture ground and potential areas which are likely to be used in the near future.

Both Deukryang Bay and Gamagyang Bay are located along the southern coast of the Korean Peninsula. The Deukryang Bay is 20 m deep with a wide mouth and approximately 300 km^2 in area, and Gamagyang Bay 9m deep with approximately 150 km^2 in area. The bottoms are silty.

Major shellfish cultured are arkshells, by the bottom method in the Deukryang Bay, and the oyster *Crassostrea gigas*, by the off-bottom method in the Gamagyang Bay. Some studies on the arkshell in the Deukryang Bay have been made (Park and Kwon, 1982; Yoo *et al.*, 1977; Choe, 1974). Also, oceanographic investigations including physical geography have been carried out in the Deukryang Bay (KORDI, 1978, 1981) and in the Gamagyang Bay (Shim *et al.*, 1980; Yang, 1977, 1978).

In the shellfish farms, eutrophication is accelerated due to a large quantity of sediments, largely faecal materials of the shellfish in addition to a nutrient loading from land sources. Those sediments precipitate and fresh organic substances are accumulated on the superficial bottom mud, sometimes, leading to deterioration of the productive farm (Kusuki, 1977; Uyeno *et al.*, 1970).

The authors carried out a study on the superficial bottom mud in these two bays. Organic and sulfide contents were determined. In addition, chlorophyll-a in the water was measured in the Deukryang Bay. These are good indicators in estimating the eutrophication level and also are important in knowing their distribution and contents for conservation and enhancement of farm grounds. The basic goal of this study is to increase understanding of the ecology of shellfish farms in these areas for successful production.

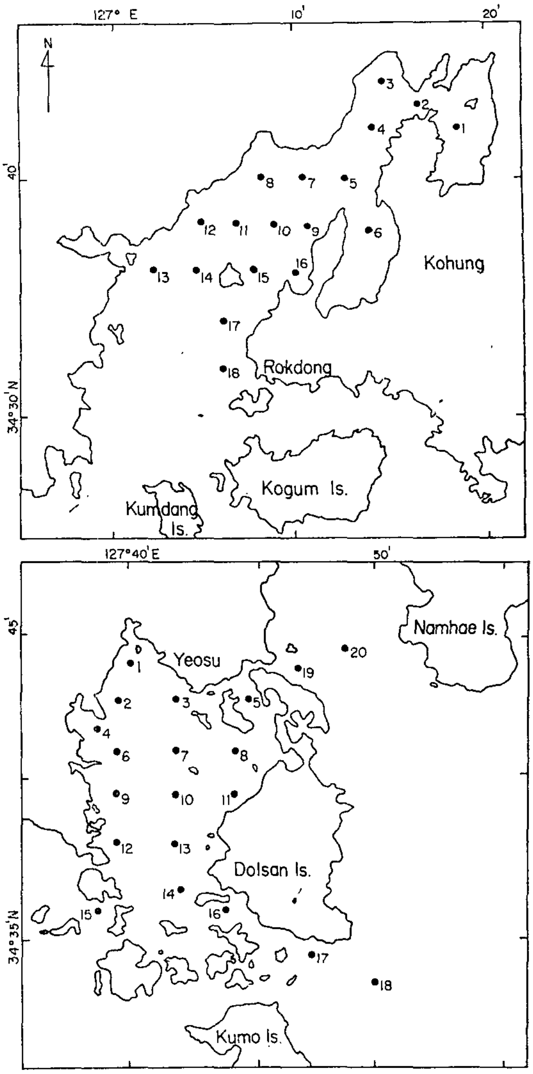

Fig. 1. Maps showing the Deukryang Bay (the upper figure) and the Gamagyang Bay (the lower figure). Sampling stations show in numbers.

Methods and Materials

The authors set up 18 stations in the Deukryang Bay and 20 stations in the Gamagyang Bay as shown in Fig. 1. The study was made during the summer season in 1981.

Sample collections were conducted by using a Van Dorn cast for water and a core sampler for bottom mud. Inner diameter of the core was 30 *mm*. Sampling was duplicated at each station. The columned mud was cut with a knife at 5 *cm* from the surface of bottom and the upper part was used for the chemical analysis. Each sample was taken in a polyethylene cask. All samples were then placed in ice chests and they were moved into a room for analysis within a day.

The samples were analyzed at the laboratory for COD by the $KMnO_4$ consumption method, for sulfide by the titrimetic (Iodine) method, and for chlorophyll and phaeophytin pigments by the method of Strickland and Parsons (1968) by using a Shimazu UV-200S spectrophotometer.

For ignition loss, samples were ignited in an electric furnace at 700°C for 2 hours.

Results

1. Deukryang Bay

(1) Chlorophyll-a in the water

Chlorophyll-a contents in the seawater at 1*m* layer under the surface were from 1.26 μg/l to 4.87 μg/l with an average of 2.44 μg/l. High contents, about 3.0 μg/l were found in the central area of the bay and low, 1.0—2.0 μg/l in the eastern side (Fig. 2).

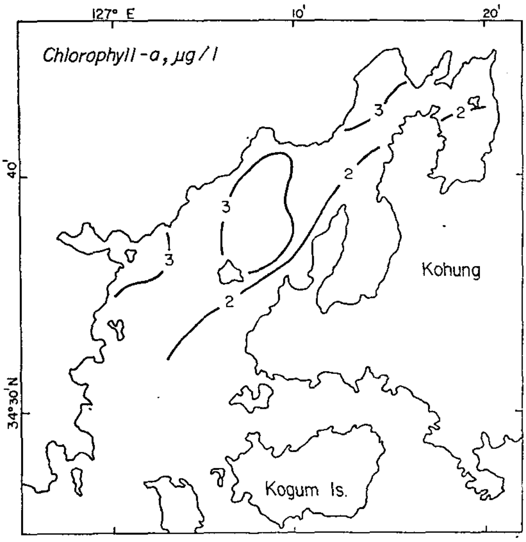

Fig. 2. Distribution of chlorophyll-a content in the seawater of 1*m* layer under the surface in the Deukryang Bay in September 1981.

(2) Organic matters in the bottom mud

COD contents in the superficial bottom mud were on the whole 4.4—10.5 *mg/g* dry mud, with an average of 7.6 *mg/g*. It was about 6.5 *mg/g* dry mud at the mouth of the bay and it gradually increased toward the innermost area of the bay (Fig. 3). The high content was found at Sts. 2 and 4.

Ignition loss at the mouth of the bay was about 5.0% but it was around 6.5% at Sts. 1—4 in the innermost part of the bay (Fig. 3). The maximum content was found at St. 1 and the mean of all stations was 5.8%.

Contents of phaeophytin pigment varied between 2.3 μg/g and 5.0μg/g dry mud, with an average of 3.5 μg/g. At the mouth and in the central part of the bay the content was 2.0—3.0 μg/g dry mud and it gradually increased toward the innermost area of the bay (Fig. 3). The highest value was found at St. 1.

(3) Sulfide in the bottom mud

Sulfide content in the superficial bottom mud had a wide variation from 0.06 *mg/g* to 0.27 *mg/g* dry mud, with an average of 0.14 *mg/g*. Low content was found at the mouth and it was high in the innermost part of the bay (Fig. 3). The maximum was found at St. 2.

2. Gamagyang Bay

(1) Organic matters in the bottom mud

The highest value of COD was 19.2 *mg/g* dry mud at St. 4, but this was exceptionally high. The rest were between 6.4—10.7 *mg/g* dry mud. The mean content in the whole bay except St. 4 was 8.5 *mg/g* dry mud. As shown in Fig. 4, high content was found in the innermost and the western area of the bay, around 9.1—10.3 *mg/g* dry mud, while there was a low, of about 7.0 *mg/g* dry mud in the mouth of the south eastern part of the bay.

Ignition loss was from 6.4% to 9.2% and the average on the whole bay was 7.6%. It was about 7.5% at stations located out of the bay to the south and 6.5% at St. 20, outside of the north east mouth of the bay. On the whole, high contents around 9% were found at Sts. 1—4 and St. 19 while there was about 7% in the rest (Fig. 4).

The highest phaeophytin content was 5.8 μg/g dry mud and the lowest, 2.5 μg/g dry mud. As shown in Fig. 4, high values were found in the western area of the bay and low contents, 2.0—3.0 μg/g dry mud, in the southern mouth and the rest of the bay. In the outside of the bay, a slightly high value, 4.2 μg/g dry mud was

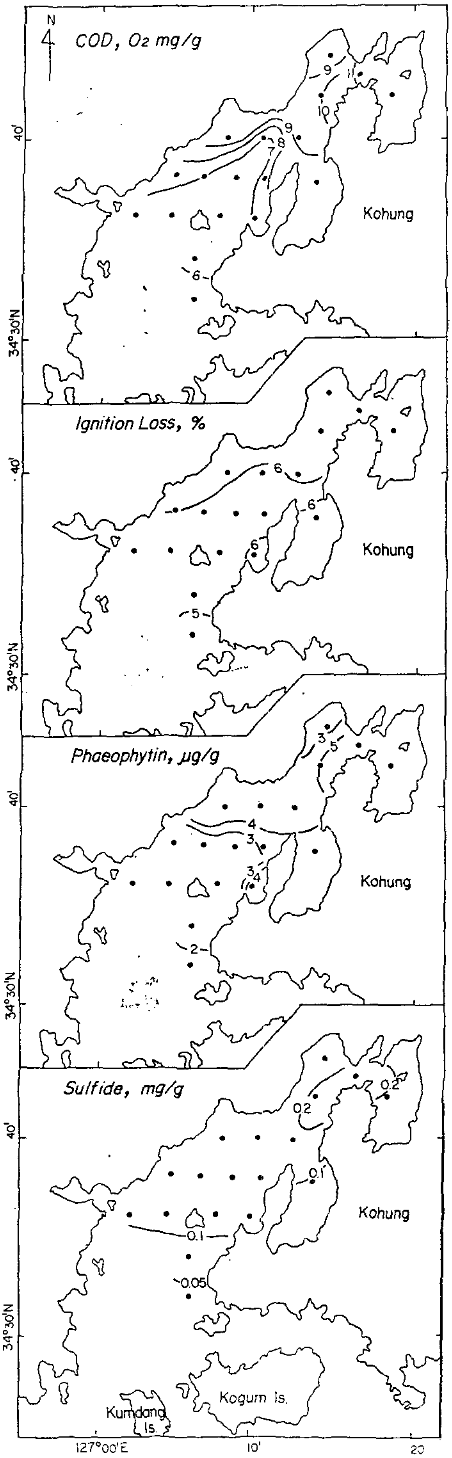

Fig. 3. Distributions of COD, ignition loss, phaeophytin contents in dry base in the superficial bottom mud in the Deukryang Bay in summer 1981.

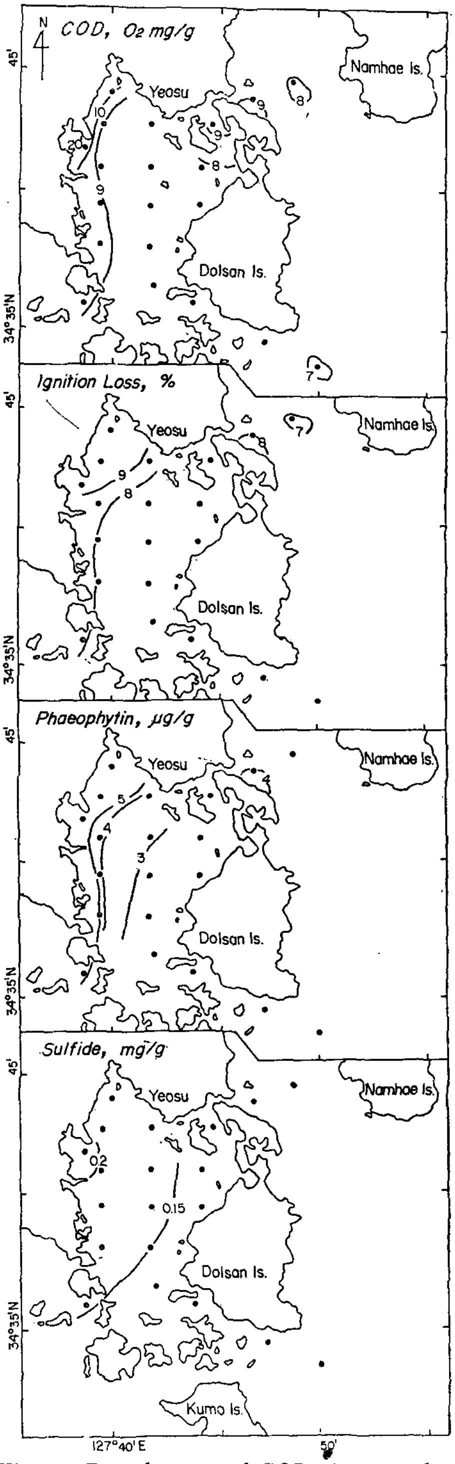

Fig. 4. Distribution of COD, ignition loss, phaeophytin contents in dry base in the superficial bottom mud in the Gamagyang Bay in summer 1981.

found at St. 15 in the south-eastern part of the bay, and it was 2.0—3.0 $\mu g/g$ dry mud at the other outside stations, with almost the same quantities in the central and the eastern areas of the bay.

(2) Sulfide in the bottom mud

Sulfide contents were higher in the western area than in the eastern part of the bay(Fig. 4). The highest was 0.27 mg/g dry mud at St. 4. The low contents were a little more or less than 0.1 mg/g dry mud in the eastern and southern areas of the bay.

(3) Pollution level in the bottom mud

Distribution of pollution level in the bottom mud was figured out from COD and phaeophytin contents (Figs. 5 and 6). The method to determine the pollution index followed Sawada and Taniguchi (1969). The range was 6—11 as shown in Figs. 5 and 6. The high pollution levels were found in the innermost area in the Deukryang Bay and in the north-western part in the Gamagyang Bay.

Discussion

The highest chlorophyll-a content, 4.87 $\mu g/l$ in the water in the Deukryang Bay in September was very similar to those of previous years (KORDI, 1978, 1981). The mean content, 2.44 $\mu g/l$ in September was a little less than those of the Gamagyang Bay in the same month in 1980 (Shim *et al.*, 1980). Its mean content was, however, similar to that of the Hansan-Geoje Bay, one of the productive oyster farms in the eastern

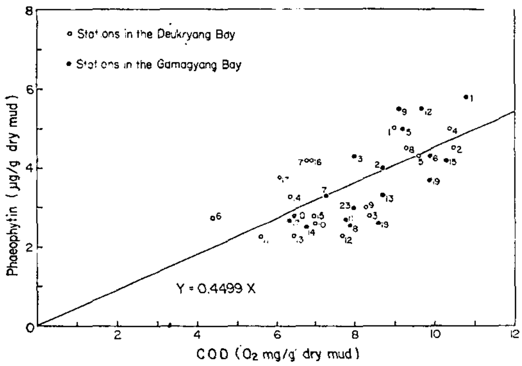

Fig. 5. Relationship between COD and phaeophytin contents in the superficial bottom mud in the Deukryang and the Gamagyang Bays in summer 1981.

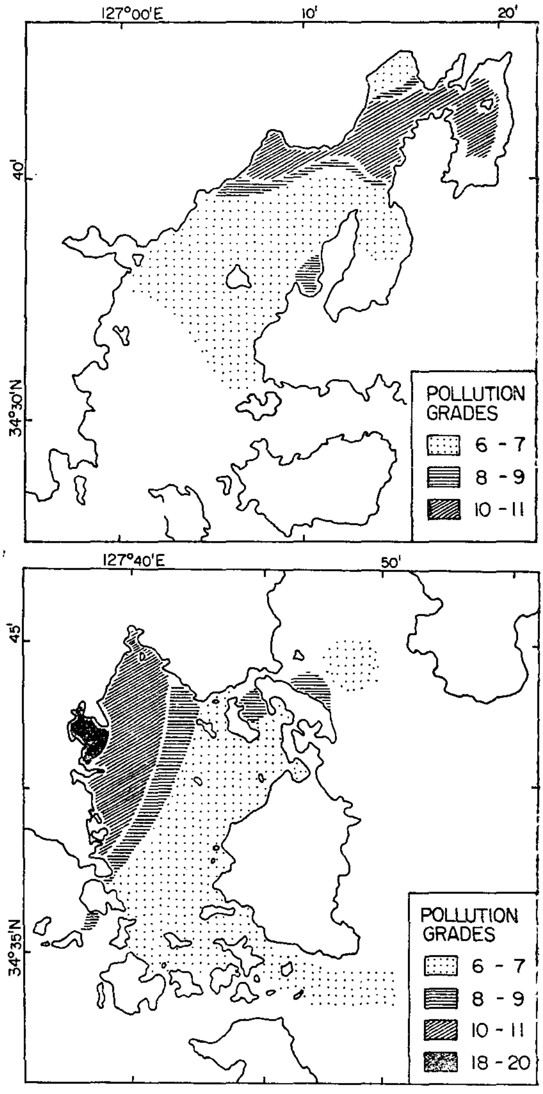

Fig. 6. Distributions of pollution grades in the superficial bottom mud in the Deukryang Bay (the upper figure) and the Gamagyang Bay (the lower figure) in summer 1981. Numbers of legend show pollution grades calculated from the Fig. 5.

part of the southern coastal waters (Yoo *et al.*, 1980; Cho and Kim, 1977; Park, 1975). It means that the chlorophyll-a content in the water in the Deukryang Bay is adequate enough for the shellfish farms unless phytoplankton blooms in extraordinary amounts. It also indicates that the bay water was in the course of eutrophication in terms of chlorophyll-a contents as KORDI(1981) reported.

Organic matters such as COD, ignition loss, and phaeophytin pigment in the bottom mud were alike in distribution patterns and the sulfide contents were also similar to those of the organic substances of both bays (Figs. 3 and 4). The organic matter-sulfide relationship in the Jinhae Bay was correlative, too (Cho *et al.*, 1982).

There were different conclusions in the organic-sulfide relationship; that is, correlative (Sawada and Taniguch, 1965) and irrelative (Morii *et al.*, 1965), while there was an agreement on an interrelation among COD, ignition loss, and phaeophytin pigment (Joh *et al.*, 1978; Honjo and Hanaoka, 1972; Uyeno *et al.*, 1970). This paper, however, will not deal with this.

Contents of COD, ignition loss, and sulfide in the superficial bottom mud in both the Deukryang Bay and the Gamagyang Bay were a little less than or similar to other shellfish farms, except for Jinhae Bay (Table 1). From the content of three parameters above mentioned we found that the bottom mud of both bays are somewhat in a middle eutrophication level, of 5—30 *mg/g* dry mud in COD and 0.03—0.3 *mg/g* dry mud in sulfide during the summer season from July to September.

Pollution levels of the bottom muds in both bays were 6—11 as shown in Fig. 6 and were very low in comparision with those of the Jinhae Bay, 11—30 (Cho *et al.*, 1982) and of the Hansan-Geoje Bay, 7—18 (Cho, 1980). The fact that the pollution index in the bottom mud is much lower than the other bays, while that in the water in terms of chlorophyll-a is similar to the other bays, probably shows that faecal materials from off-bottom shellfishes have a great influence on the bottom deterioration. The slope of pollution index shown in Fig. 5 also backs up the fact; that is, a low slope indicates that phaeophytin contents originated largely from the faecal substances are less than COD contents.

In short, bottom mud in both bays are not highly eutrophicated at present. It is, however, necessary to investigate a proper culture density in the near future because the shellfish farms in those bays have begun to increase in recent years.

Summary

Some environmental parameters on the shellfish farms in Deukryang and Gamagyang Bays during summer in 1981 were determined to find an eutrophication level for the conservation of the farm.

Table 1. Organic and sulfide contents in the superficial bottom mud in Deukryang Bay and Gamagyang Bay and those of other bays in the southern coastal waters, Korea (Figures in parenthesis indicate mean)

	COD(O_2 *mg/g*)	IL(%)	Sulfide(*mg/g*)	Ref.
Deukryang Bay	4.4—10.5 (7.6)	4.9— 6.8 (5.8)	0.06—0.27(0.14)	
Gamagyang Bay	6.4—10.7 (8.5)	6.4— 9.2 (7.6)	0.08—0.27(0.14)	
Kwangyang &	5.1—14.8	7.0— 9.6	0.06—0.25	FRDA, 1980
Yeosu-Hae Bay		6.5—16.8(12.4)	0.10—0.18(0.14)	Yang, 1979
Goseong-Jaran Bay	6.0—10.0	6.0—10.0	0.21—0.47	FRDA, 1977
Hansan-Geoje Bay	6.2—10.8 (8.6)	6.9— 9.4 (8.2)	0.10—0.26(0.18)	Yoo *et al.*, 1980
	9.3—18.5(14.9)			Cho, 1980
Jinhae Bay	10.3—38.5(23.7)	7.2—14.2(11.17)	0.13—1.07(0.52)	Cho *et al.*, 1982

Chlorophyll-a content in the seawater in the Deukryang Bay in September was 1.0—5.0 $\mu g/l$ with an average of 2.5$\mu g/l$. In the superficial bottom muds, contents of COD were 5—10 mg/g, ignition loss 5—9%, phaeophytin pigment 2—5 $\mu g/g$, and sulfide 0.1—0.3 mg/g dry mud in both bays. High contents of both organic matters and sulfide were found in the innermost area of the Deukryang Bay and in the north western part of the Gamagyang Bay.

All quantities including chlorphyll-a in the water are little less than or similar to those of Hansan-Geoje Bay, one of the most productive shellfish farms in the southern coastal waters in Korea.

Eutrophication on both water and bottom mud was under way like other shellfish farms but pollution indices on the bottom mud calculated from the data of CODs and phaeophytin pigments showed 6—11, which is much lower than those of Jinhae Bay and of the Hansan-Geoje Bay. This means that the bottom muds are in an early stage of eutrophication, unlike the Jinhae and Hansan-Geoje Bays though the water, similar to the other bays, shows a middle stage of eutrophication.

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