

ECOSYSTEM ON THE GULF OF YEONG-IL IN THE EAST SEA OF KOREA

1. Introduction of physico-chemical and biological studies

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ABSTRACT: Marine environments of the Gulf of Yeong-il located in the East Sea of Korea are naturally influenced by topography, climate, and both of cold and warm currents, and artificially by waste waters induced from Pohang City and mammoth iron industry.

Near the Gulf of Yeong-il the cold water masses collide with the warm Tsushima Current (a branch of the Kuroshio), and result many interesting problems: upwelling phenomena, water blooms, forming optimal fisheries and diverse hydrological variations etc.

Intense marine pollutions give often gigantic red tides, particularly in summer. Consequently, these pollutions must be controlled in order to conserve marine water resources and ecological equilibrium.

Physico-chemical and biological parameters are measured for this study: climatical parameters (winds etc), temperature, salinity, density, pH, alkalinity, dissolved oxygen (% saturation), BOD, COD, phosphates, nitrates, diverse chlorophylls, phaeopigments, heavy metals, phytoplanktons and zooplanktons, benthos etc. According to the measured parameters, 7 water mass groups are identified. This first note corresponds to the introduction of each parameters of the serial researches.

Introduction

Influenced by the cold Rieman and the warm Tsushima currents, the Gulf of Yeong-il which is directly connected to the deep sea shows various ocean characteristics. Specifically, thermal stratification and upwelling phenomena not only give good reasons for long-term research of hydrology, but also confer possibilities of development of fisheries, and study of fisheries on the Gulf.

The Gulf of Yeong-il is located on the mouth of Hyeongsan river, the length of 62 km, which flows in the East Sea of Korea acting as beneficial resource of water for agriculture, industry and urban district. The flux of water is too small to create a brackish water ecosystem.

There are many artificial factors which affect upon the conditions of the Gulf. The polluted water caused from habitants of Pohang City, popularity of about 300,000, directly streams in the Gulf without any procedures of sewage purification through old port "Guhang" and streamlet Naeng-Chun. This phenomena make it hard to modernization. The pollution and sanitary problems caused from fishing activities of the destitute and treatment procedures of fishes, make occurrences of deformed fishes and taking fishes of polluted environment as a source of food are critically serious problems.

Import and export activities of Pohang steel works which boasted the largest amount on the East Sea of Korea, (25, million tones a year) and construction work of the breakwaters are significantly affecting on the changes of the en-

vironment of water. The traffics of various kinds of ships polluted the ocean seriously by spill-out of oil. This contamination leads to further pollution of environment. Pohang Iron and Steel Plant gives great influences upon the environmental factors in the Gulf. As a result of gigantic industrial activity, around 120 million tones of daily used water is created and the out-flow of discarded oil with this used water influence dreadfully upon marine ecosystem. Not only the dust from Pohang Iron and Steel Plant acts as a source of pollutions that makes smog phenomena in the air but turbidity of sea-water and increasing amount of seston originate red tides.

As described above, the pollution in the Gulf is very serious because many factors are acting together or acting as concentration factors. The water qualities of north region, Song-Do and Doku Beach where the population increases sharply in summer season as resorts along the coast line, are recorded over ten times of the environmental standard that must be less than 3ppm according to chemical oxygen demand.

The Gulf is one of the frequent red-tides area and the degree of red-tides is also critical. The study of the sources of red-tides which devastates the resources of the sea, is required and the countermeasure of damages should be made urgently along with protection from the phenomena, considering the vast region of the East Sea of Korea. Especially, the organisms causing the red-tides, including dinoflagellate, should be investigated in various ways with many kinds of parameters such as increase or decrease of solute oxygen, the alteration of water temperature and limiting factors of heavy metals.

The main purpose of this research, as basic study of marine ecology, is to build monograph for each parameters and close relations between those parameters.

Outline of research, stations

Gulf of Yeong-Il defines here the water area inside the straightline from north point Dal-Man-Kap to South point Chang-Ki-Kap. (Fig. 1)

As a result of many trials of calculations, the area of this place is about 115 km² and the amount of water is around 2 billion tons.

The mouth of this Gulf is rather wide to contact naturally with the peculiar tides of the East Sea of Korea. As important environmental elements, the old harbour (stations: 4.5.H.I) working as collecting point of waste water, and the new port constructed in Pohang Iron and Steel Plant and many breakwaters disturb the currents of tides in the gulf.

As a source of fresh water, there are a Hyeong-San river, 62km, (station 6) which originates from Seu-Myun, Ulju-Kun Kyungnam to the Gulf through Kyung-ju and Pohang city and streamlet Naeng Chun (station 6B) which carries the sewage water of Pohang city.

The Gulf and East Sea of Korea that gives oceanological influence upon the Gulf are widely studied including the range from 120°22'-120°35' of east longitude to 35°59'-36°54' North Latitude.

The 19 Stations of researches were chosen along the coast. Various parameters were studied from Young Han-Dong (station I) that situated in the very end of Dalmangap to Yangpo through the old port, the interior of Pohang Iron and Steel Plant and Jangigap are examined and studied. On the other hand, with the help of 44 tone ship named as Kyung-Buk No. 958 belonged to the Pohang Port Office, related researches were fulfilled on the area which ranges from the East Sea of Korea (station A, Aa) to the middle of the Gulf in the field of hydrology and Biology. (Fig. 1)

For grasp the characteristics of water according to the depth of it, the study were practiced horizontally and vertically on the depths of 0, 5, 10, 20, 30 and 54m.

A. The latitudes of the stations

All kinds of parameters were researched in accordance with the depth and the surface water of which were fixed from stations of central water area of the Gulf to the old port covering 11 experimental stations and from Dalmankap, the north of the gulf, to Kuryongpo harbor and Yangpo harbour in the East Sea of Korea passing by Janggigap, the south shore, covering 19 stations. The exact latitudes of each stations are illustrated in table 1.

B. The environment of the experimental stations.

The stations studied with ship in and out of the Gulf are total 11 stations including 2 stations, located slightly out of the Gulf (St. A, Aa), the central portion of the Gulf (St. B, Ba, C), the water area of the Pohang Iron and Steel Plant (St. D, E, F) and the old port (St. H, I). Although the stations located in the coast line, 54km coverage, passing from Dalmangap which is south part of the Gulf to Yangpo through Janggigap are summed up to 19 stations, the important stations which are regularly researched are 12 stations.

(1) The central water area of the Gulf and the East Sea;

These stations make it possible perspective to study characters of the parameters in the field of hydrology as well as the diffusion process from the pollution source by spatio-temporal factors.

Station A (the sector of the East Sea of Korea): The area, 7.5 km out of the mouth of the Gulf, is not only clean water sector which enables scientists to seize the characters of outer ocean but also showing severe temperature dif-

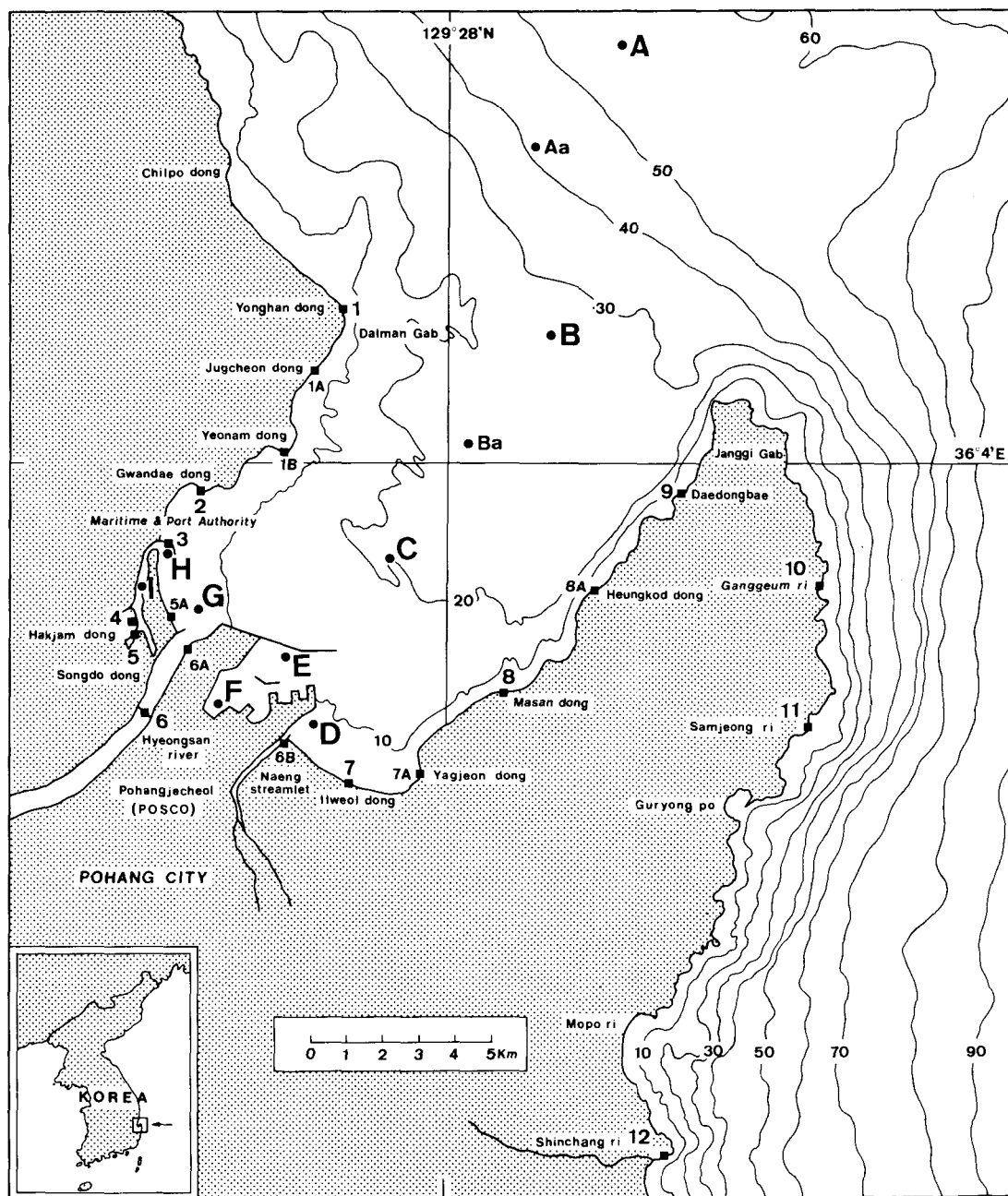


Fig. 1. Location of the sampling station, Gulf of Yeong-il in the East Sea of Korea.

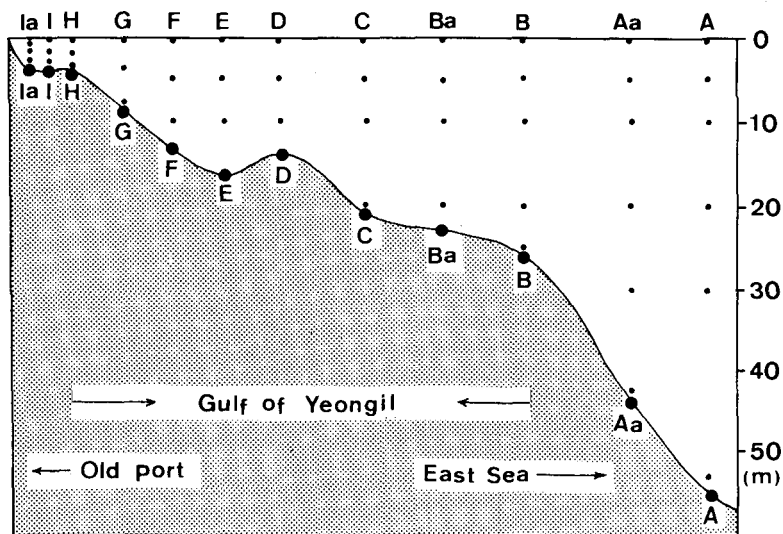


Fig. 2. Profile of the stations. small dots: Water sampling sites. Big dots: bottom sampling sites.

Table 1. Coordinates and depths of the sampling stations.

Station/Location	Latitude (N)	Longitude (E)	Prof (m)
1. : Yonghan-Dong	129° 25' 42"	36° 06' 37"	2
1A. : Jugcheon-Dong	129° 25' 44"	36° 05' 33"	1.5
1B. : Yeonam-Dong	129° 24' 55"	36° 04' 08"	2
2. : Gwandae-Dong	129° 23' 30"	36° 03' 33"	1.5
3. : Pohang Breakwater	129° 23' 00"	36° 02' 52"	0.5
4. : Hakjam-Dong	129° 22' 18"	36° 02' 02"	1.1
5. : Songdo-Dong	129° 22' 24"	36° 01' 51"	0.5
5A. : Songdo-Beach	129° 22' 56"	36° 01' 57"	1.5
6. : Hyeongsan River	129° 22' 33"	36° 00' 30"	1.6
6A. : Pohangjecheol	129° 23' 16"	36° 01' 36"	2
6B. : Naeng Streamlet	129° 25' 00"	36° 00' 05"	0.6
7. : Ilweol-Dong	129° 26' 37"	35° 59' 25"	1.2
7A. : Yagjeon-Dong	129° 26' 37"	35° 59' 39"	1.5
8. : Masan-Dong	129° 29' 27"	36° 00' 48"	1.5
8A. : Heungkod-Dong	129° 30' 55"	36° 01' 21"	1.8
9. : Daedongbae-Dong	129° 32' 04"	36° 03' 30"	3
10. : Ganggeum-Ri	129° 34' 52"	36° 02' 12"	1.2
11. : Samjeong-Ri	129° 34' 34"	36° 00' 02"	1.5
12. : Shinchang-Ri	129° 32' 20"	36° 53' 45"	1.5
A. : East Sea	129° 31' 49"	36° 10' 02"	55
Aa. : East Sea	129° 29' 44"	36° 08' 35"	43
B. : Yeong-il Gulf	129° 29' 20"	36° 06' 04"	26
Ba. : Yeong-il Gulf	129° 28' 20"	36° 04' 18"	25
C. : Yeong-il Gulf	129° 26' 56"	36° 02' 45"	21
D. : Naeng Streamlet	129° 26' 17"	36° 00' 13"	8
E. : Pohangjecheol	129° 24' 56"	36° 01' 20"	12
F. : Pohangjecheol	129° 23' 45"	36° 00' 40"	12
G. : Hyeonsan River	129° 23' 40"	36° 02' 15"	8
H. : Old Port	129° 22' 50"	36° 02' 46"	6
I. : Old Port	129° 22' 18"	36° 02' 28"	5

ferences between surface and bottom, from the warm Kuroshio current and the cold Rieman current.

The depth is about 55m and sampling points were chosen to be 0, 5, 10, 20, 30, 54m depth from the surface vertically.

Station B (central mouth of the Gulf; B, Ba): The central area from Janggigap to Dalmangap is approximately 4-5 km distance from the shore, located at the center of

the Gulf. The red tides phenomena are frequently observed in this area. The depth is about 26m, and the sampling depths 0, 5, 10, 20, 25m.

Station C: This point could represent the whole water area since it is located the heart of the Gulf. Frequent traffic of ships are observed and this area is transporting routes. The depth of water is around 21m and researches were done on the depth of 0, 5, 10, 20m.

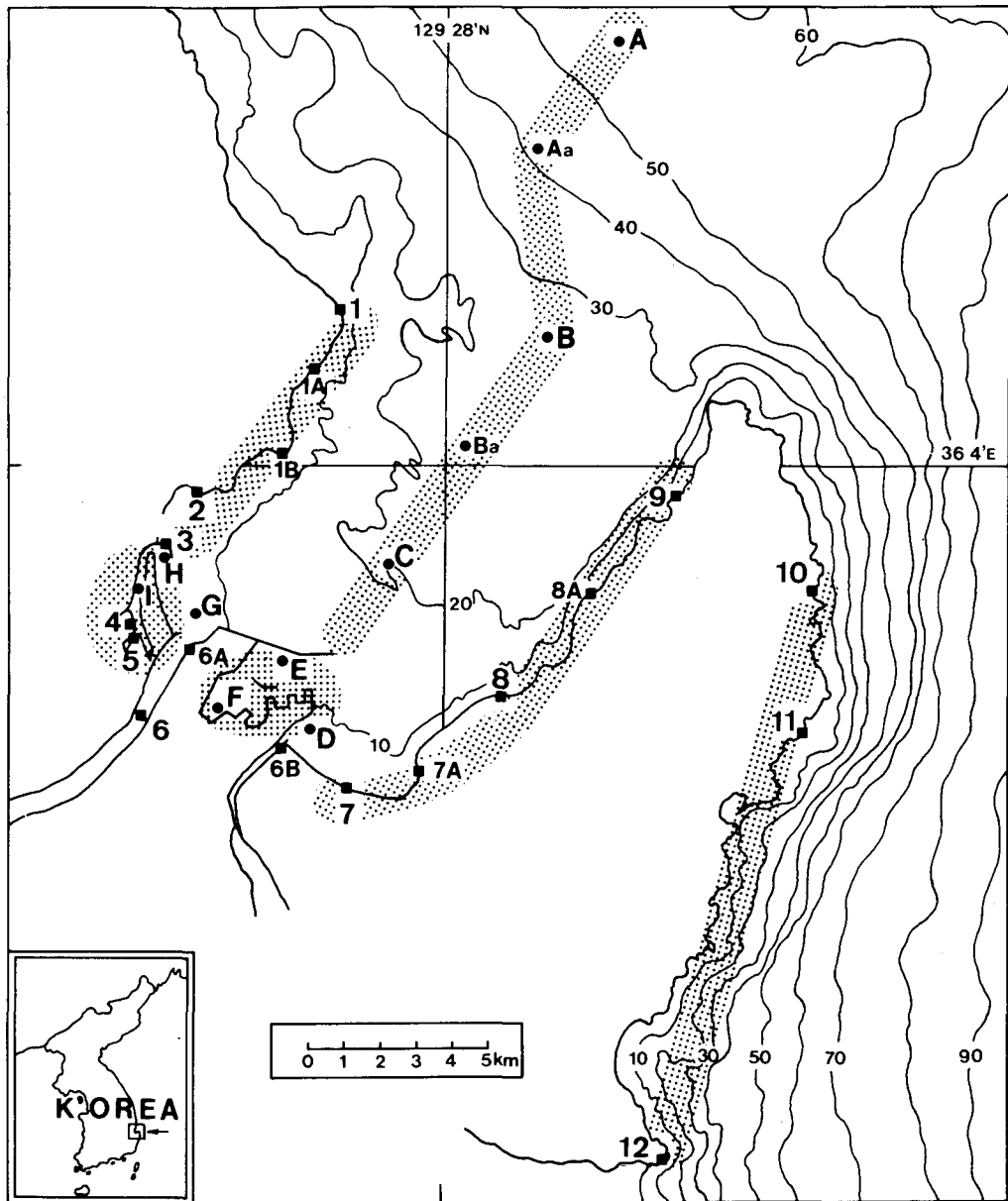


Fig. 3. Water mass groups of study area. Group 1 : stations 1, 1A, 1B, 2, 3. Group 2 : stations 4, 5, H, I. Group 3 : stations 6, 6A, 6B, G. Group 4 : stations D, E, F. Group 5 : stations A, Aa, B, Ba, C. Group 6 : stations 7, 7A, 8, 8A, 9. Group 7 : stations 10, 11, 12.

(2) the Pohang Iron and Steel Plant (stations 6A, D, E, F): The facilities of the coast line were constructed on the purpose of the steel industry, first of all there are a lot of breakwaters and berths. These facilities interrupt the flow of currents, various kinds of pollution materials from industrial activities can be enriched or precipitated and pollutions from ships are serious problems. The phenomena of red tides are frequently observed.

Station D: Naengchun, as a part of sewer flows into the Gulf through this area. Even if the amount of sewage is not much, the foul water threatens the ecology since the degree of pollution in the sewage is heavy. Often yellowish brown colour of water, a phenomenon of red tides, is observed. The depth of water is nearly 8m, study was done on the depths of 0, 3, and 6m.

Station E: This station is inside breakwaters at the new port in the area of the Plant. Factory wastes aggravate the degree of water contamination. Especially, the red tides are notable in this region. The most deep part of water is 12m, water samplings were done in the depth of 0, 5 and 10m.

Station F: This point is located in the plant, the place as the anchorages for ships for import and export. Dissolved oxygen value is decreased according to oil spills, contaminated by ore and coal. It is 12m deep and 0, 5, and 10m are water sampling depth.

(3) The old port (stations 4, 5, H, I): The sewage effluent from Pohang city flows in this area. This area represents the extreme case of pollution, words expressing, "culmination of pollution" is appropriate. Dissolved oxygen value recorded "0", frequently the records of various parameters are mostly out of regulations, so it is urgently required to construct polluted water treatment facilities.

Station H: It is front side of Pohang breakwaters, close to the old port and represents black colour of water indicating polluted state. In the vicinity of breakwaters, a lot of wastes are existed, red tides are observed in summer like station G. It is 6m deep, 0, 2.5, and 5m depth are water sampling points.

Station I (interior of the old port): It located at the inner area of the old port. This area is contaminated with black water and intense fetid, the characteristic region of polluted area. Effluent from Pohang city streaming into here without treatment, this area could be named as gathering place of wastes. The depth is 5m, water sampling is carried out on the depths of 0, 2, and 4m. Researches is performed according to each parameters.

Station 4: This point located in Hakjamdong, where the Pohang ferry terminal is located 10m southwards from this point and also adjacent to Jukdo market. Many fishery boats are anchored and pollution from waste water of industry, city sewage, and the internal organs of fishes contaminate this areas. Particularly, the bubbles form the bottom layer is one kind of seasonal phenomena from June and to November and in August and September very offensive odour generates in this area. Black colour of water, oil and filth of water surface are characterized by this area.

Station 5: About 20m south from Jukdo market, the water sampling was collected at the center part of Songdo bridge which connect Songdo dong and Jukdo dong. In most case, the water colour is black and the degree of foul smelling is heavier than the case of point four (Hakjamdong).

(4) The northern coast line of the Gulf (stations 1, 1A, 1B, 2, 3, 5A): Generally speaking, the northern coast line is less polluted area comparing with the other points in the Gulf, but northern summer resort (station 2) was contaminated and the degree of pollution was intense according to the summer visitors.

Station 1: Located at Yonghan dong, the most part of the seashore is consisted of sandy beach and the minor part is formed of rock beds. Sampling is taken at the small boat berthing port and sea weeds and alga are collected at adjacent place from here and rock beds. This area is clean water region. Where the place is consisted of fine sand and rock, occasionally the water forms turbid when the tide is fairly high on the hill of coast, roughly 50 households are inhabited forming a small village.

Station 2: It is located in Kwandaedong. At the port, nearly 300m inside from northern resort, the water sampling was taken. Apart 4 km southwards from this point, Pohang Iron and Steel plant is located and 1 km westward, Port Office sited.

If the water currents are vigorous, Algae species are pushed up and piled along the seaside. Along the coast line, approximately 30 households are settled and formed a little village.

Station 3: This point is in the area of breakwaters of port office. Water sampling is done on the middle region of breakwaters, 150m length. It is a heavily polluted area, many kinds of wastes are come into noticed.

(5) The south coast of the Gulf (stations 7, 7A, 8, 8A, 9): The south coast area is more severely polluted than

the north seashore. In summer, red tides are formed especially Im Kokdong (station 7), and bottom sea organs die with stifling with the reason of pollution. In order to find the effects of the Gulf in the matters of pollution source, the study of currents is required.

Station 7: This area is a sandy seashore connected to the Pohang Iron and steel Plant, inside Doku beach. After a storm, many wastes are aggravating by forces of currents. Sampling for test is carried out central part of the swimming beach.

Station 8: It is situated in Masandong of Donghaemyun of Youngilkun. Testal materials and Algae species were collected at the port and rocks inside the port. The water appeared green. Along the seashore, about 30 households are distributed, it is easily observed to process of echinoderm.

Station 9: At the tip of port in Daedongbaedong, testal materials and Algae species were gathered. This area is comparatively clean water area and shows green or dark green colour. There is a small village consist of about 30 haouses along the seashore.

(6) The seashore of the East Sea of Korea outside the Gulf of Yeong-il (stations 10, 11, 12): This region is located outside of the pollution affected area of the gulf, and this region shows clean water area.

Station 10: Located at Kangkumli of Kuryongpo harbour, water sample collection was carried out at the end of the port, 30m away from Kangkumbridge. Shells and molluscs, are observed, and echinoderm is fed by artifically here. As a clean water area, the colour of the sea is clean blue. Around 40 households are inhabited along the seashore.

Station 11: Collecting of water samples was done at Sam chung 2 dong port which is approximately 1Km away from Kurongpo Eup. The water is very limpid and green as clean water area. Nearly 60 households are scattered following the seashore.

Station 12: This region, clean water area, is located between Mopo harbour and Yangpo harbour. Experimental materials are collected from the rocks surface beneath of water.

(7) Influx of fresh water (Hyungsan river: stations 6, 6B, 12A, G): Since the river of Hyungsan including city sewage and agricultural chemicals mixed with waste water from the Plant at the mouth of the river, the degree of pollution is very severely heavy. Cold sewer of Pohang city, streamed ento sea water is another considerable

source of pollution.

Station G: This area as the mouth region of the Hyungsan river, acting as important source of fresh water to the Gulf of Yeong-il, is located between the Songdo swimming beach and Pohang Iron and Steel Plant. Fresh water fishes and ocean plankton is easily seen. With the reason of the spilling oil from the Plant, order of oil is frequently perceived, the appearances of red tides are incessant. The 8m deep water samplings were accomplished in the depths of 0, 3, and 6m.

Station 6: This area is joining region of the river of Hyungsan and sea water. Water sampling is carried out at the central part of old Hyungsam bridge. The colour of water is mostly greenish brown.

Station 12A: This point located at the mouth of Changki stream. Although the amount of water is small, the degree of pollution is relatively amall. The activity of sweet fish is vigorous and very youthful eels are going up here from marine environments.

Method and research parameters

The whole content of this research covers the fundamental marine sciences of Physics, Chemistry and Biology. On the other hand, it contains important facts of the source of pollution of the Yeong-il Gulf from the Pohang Iron and Steel Plant and Pohang city. The subject of research and methods are as follows.

(1) By the research of climatical factors which influence effects upon the marine ecosystem of the Gulf, movement of water mass and changes of water quality should be studied. (Castelbon, 1972; Kim, 1982)

(2) Water temperature, salinity and density are measured "in situ" and calculated, and studies of thermocline, halocline and pycnocline are drawn and T-S diagram is studied. (Kim, 1979, 1982 et 1985)

(3) By the measuring the Secchi Disc (degree of transparent of water), euphotic, oligophotic and aphotic zone will be studied. The structure of primary pelagic production of the Gulf should be revealed according to the photosynthetic layer. (Kim et Travers, 1983)

(4) pH and alcalinity, the general chemical characters are studied. The value of dissolved CO₂ should be calculated in accordance with salinity and water temperature data. (Minas, 1968)

(5) Dissolved oxygen of sea water will be studied. Oxyclyne will be revealed, and saturation degree will be calculated. O_2 -T diagram and O_2 -S‰ diagram should be drawn. (Travers et Kim, 1986)

(6) Chemical Oxygen Demand (C.O.D.) playing a important roll of indicator for pollution and Biological Oxygen Demand (B.O.D.) will be investigated. (Kim et Ahn, 1985)

(7) Measured the amount of seston, the influences of dust from Pohang Iron and Steel Plant will be studied in the points of tripton and bioseston. (Blanc, 1968; Kim et Travers, 1983)

(8) Various kinds of elements included in the bottom soil of the Gulf especially the heavy metal content, will be researched as a quantitative analysis for the research of the sources of pollution or study of the concentration factor of heavy metals.

(9) The quantitative analysis of $P-PO_4$ and $N-NO_3$ will be carried out for the purpose of analysis of nutrient salts and sunchronizely for investigating the relationship of N/P and the relation between nutrient salts and phytoplankton is studied (Coste, 1971; Kim, 1979)

(10) Quantitative studies of chlorophyll *a* and phaeo pigments *a* by fluorimeter are carried out in order to understand the relationships between their functions and their environments. (Almazon et Boyd, 1978; Kim, 1980a)

(11) Quantitative analysis of chlorophyll *a*, *b*, $c_1 + c_2$ by spectrophotometer are studied as a factor related to the primary production. (Kim, 1980a)

(12) Specific compositions of marine microflora are observed and indentified. (Cupp, 1943; Kim et Travers, 1984).

(13) The study of variation of phytoplankton in accordance with seasonal, annual horizontal and vertical changes will be carried out. (Kim et Travers, 1984)

(14) Plasmic volume of phytoplankton which is related to cellular biovolume with amount of pigments of photosynthesis will be researched. (Kim, 1980b)

(15) Identification of organisms making red tides, density and biovolume are studied. (Kim et Travers, 1984)

(16) The primary pelagic production of this coastal area is studied by the method of ^{14}C . (Kim, 1983)

(17) Taxonomical and ecological works of animal plankton will be carried out. (Devèze, 1959).

(18) The ecology of polychaete will be studied, with other benthos.

For the continuous research of the future accomplishments, the following fields should be studied and developed. Firstly, through establishments of pure culture and mass culture system of marine microflora and macroflora, physiological, and ecological study should be accomplished. Secondly, specific composition of heterotroph living in the water should be revealed and the influences of these species should be studied. The prevention from marine pollution should be processed through the studies of species of this research. Thirdly, the studies of species of fishes inhabiting in the area from the Gulf of Yeong-il to the East Sea of Korea are required. On the fourth, in addition to the study of ATP and DNA, the study of currents in the water area or the research for the development of resources are needed.

Conclusion

The environments of the Gulf of Yeong-il is existed in the urban area where Pohang city industrial complex, and the other activities such as fisheries are entangled and produce complexity. At the Gulf of Yeong-il, pollution from sewage (ports, swage of inhabitants, excrements), industry (heat for cooling system, chemistry, oil), ships (wastes, oil) and fresh water of the river Hyungsan as well as the variations of marine environments like the Kuroshio and Rieman current should be studied continuously.

The various uses of the coast, causes the red tides and threatens the marine ecosystem devastating the marine nature. The main purposes of this research are for understanding the characters of the environment in the East Sea of Korea and some portions of these trials could be considered in the field of protection of natural environment of the East Sea of Korea.

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