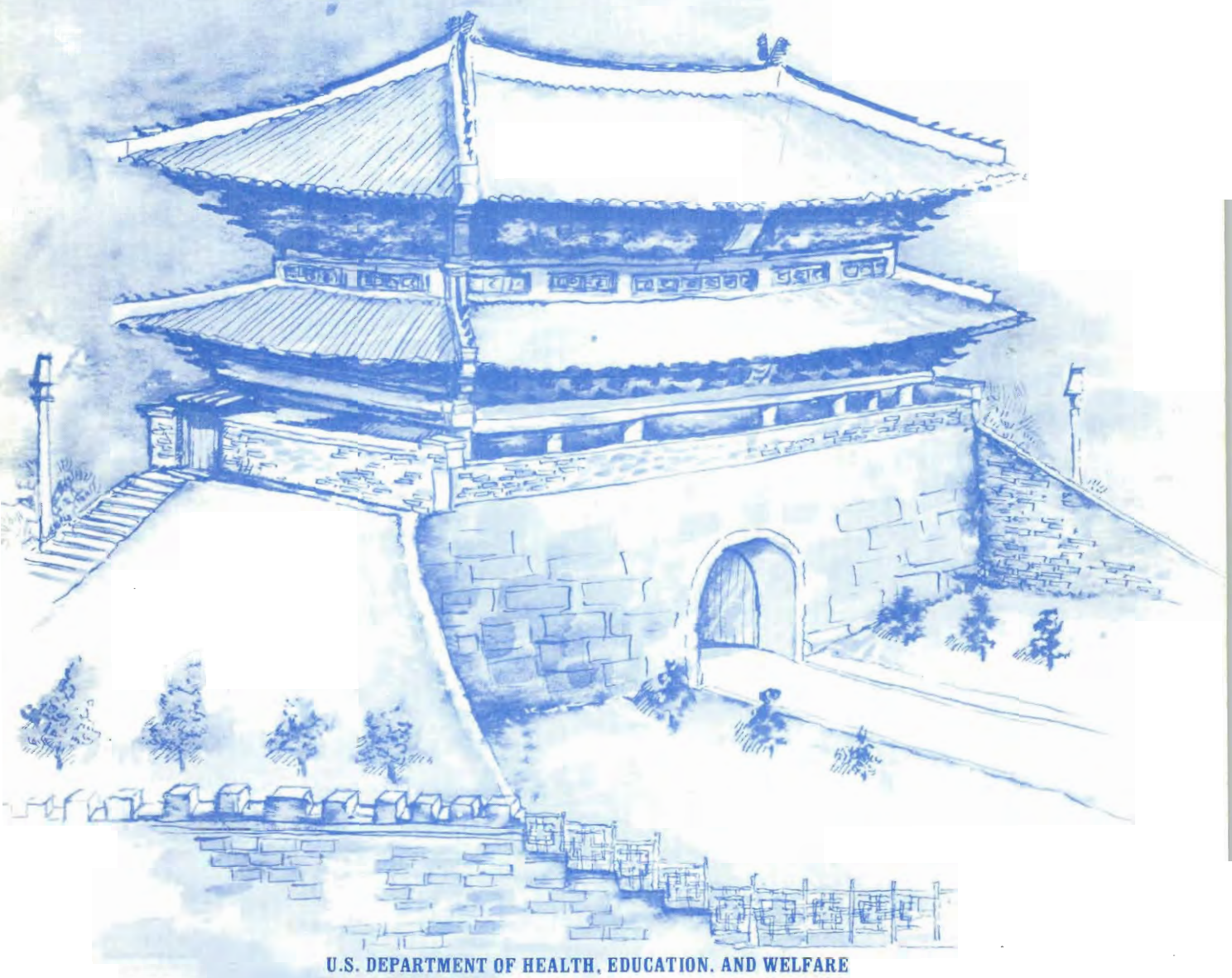
SANITARY CONTROL OF SHELLFISH IN KOREA



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service

U.S. DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service

U.S. OPERATIONS MISSION TO KOREA

SANITARY CONTROL OF SHELLFISH IN KOREA

Report of a study made for the Agency for International Development, U.S. Department of State, at the request of the Government of the Republic of Korea.

C. B. Kelly, R. J. Hammerstrom, J. B. Engle,
Seong Jun Kim, Kyung Man Bae, and Chun Ku Lee

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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AUTHORS

Mr. C. B. Kelly, Pharmacist Director, U.S. Public Health Service, is Chief, Marine Health Sciences Research and Development, Water Supply and Sea Resources Program, Environmental Control Administration, Cincinnati, Ohio.

Mr. R. J. Hammerstrom, Sanitary Engineer Director, U.S. Public Health Service, is Director, Gulf Coast Marine Health Sciences Laboratory, Water Supply and Sea Resources Program, Environmental Control Administration, Dauphin Island, Alabama.

Mr. J. B. Engle, Biologist, U.S. Fish and Wildlife Service, is Chief, Shellfish Advisory Service, Bureau of Commercial Fisheries, Oxford, Maryland.

Mr. Seong Jun Kim, Microbiologist, Office of Fisheries, Republic of Korea, is in charge of microbiological studies of the Utilization and Food Technology Section, Fisheries Research and Development Agency, Pusan, Korea.

Mr. Kyung Man Bae, Biologist, Office of Fisheries, Republic of Korea, is in charge of shellfish culture studies of the Aquiculture Section, Fisheries Research and Development Agency, Pusan, Korea.

Mr. Chun Ku Lee, is a member of the staff of the Rural Development Division, U.S. Operations Mission to the Republic of Korea, Seoul, Korea.

FOREWORD

Early in 1967, the Government of the Republic of Korea submitted a request through the United States Operations Mission to Korea (USOM/K) to the Agency for International Development, U.S. Department of State, to provide technical consultation and advice in the development of an effective oyster production program that would satisfy the U.S. Public Health Service requirements for oysters imported into the United States. A mission was formed by the Agency for International Development to comply with this request. The U.S. Public Health Service participated by assigning two USPHS officers to the Mission. The U.S. Fish and Wildlife Service assigned a Fishery Biologist. The study was made during the period September 8 to October 16, 1967.

For several years, the U.S. Public Health Service, through the U.S. Department of State and the Embassy of Korea, has carried on discussions with various Korean Government Agencies on the administrative and technical aspects of the sanitary control of shellfish. Laws and ordinances were reviewed as they were developed, and similar United States documents were furnished to the Korean Government. Analytical and other technical data were submitted for review and comment. In 1961, the Government of Korea assigned a member of the technical staff of the Fisheries Research and Development Agency to visit the United States for a period of more than 6 months to receive in-service training in the sanitary aspects of the control of shellfish. The information gathered over the years was valuable to the Mission in the preparatory stages as well as in the review of the program in Korea. The Public Health Service will be pleased to continue collaboration with United States and Korean agencies in the exchange of information pertaining to shell-

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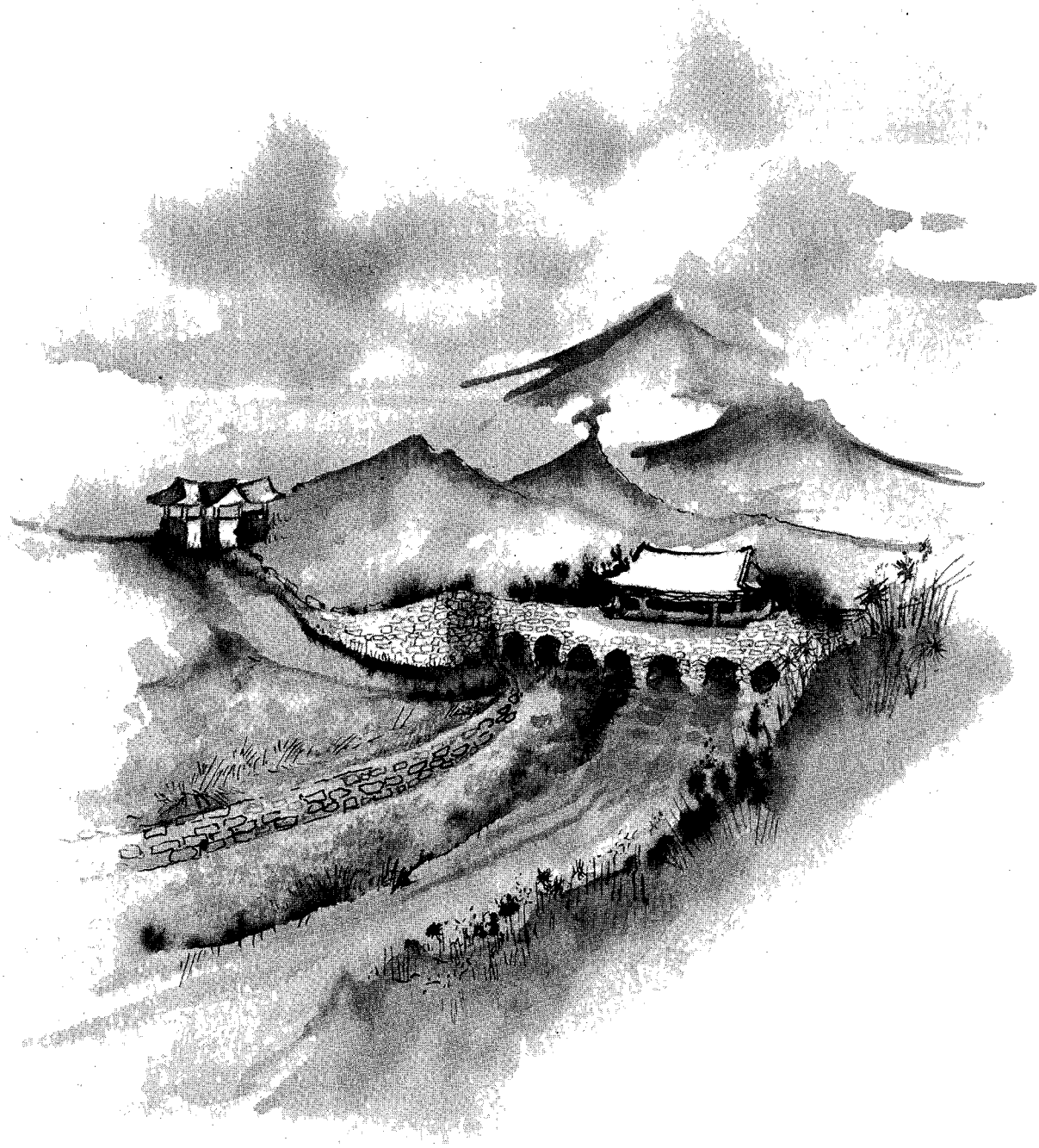
fish sanitation and the fulfillment of the Korean program objectives.

Because of the interest in exporting raw and fresh-frozen shellfish to the United States, the shellfish sanitation practices in the United States were used as the primary standard of comparison in evaluating the shellfish sanitation program in Korea. These practices are fully described in PHS Publication No. 33, National Shellfish Sanitation Program Manual of Operations, Parts I, II, and III (1965).[1] These manuals were made available to the Korean Government agencies.

The Mission acknowledges with thanks the wholehearted cooperation of USOM/K both at Seoul and Pusan, several agencies of the Office of Fisheries, the Bureau of Public Health of the Ministry of Health and Social Affairs, the Fisheries and Health Agencies of Kyung Sang Nam Province, and the shellfish industry in Korea. The number of persons who contributed is so great that it precludes a complete listing of their names here, but a list is included in the Appendix. Particular note, however, is made of the untiring efforts of the Korean counterparts who served as part of the Mission team and are coauthors of this report. Grateful acknowledgment also is made of the work of Mrs. Anita Ralph, U.S. Public Health Service secretary, for the preparation of the manuscript of this report.

CONTENTS

SUMMARY AND RECOMMENDATIONS



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Part I

SUMMARY AND RECOMMENDATIONS

SUMMARY

In response to a request by the Government of the Republic of Korea, through the Agency for International Development, U.S. Department of State, a joint Mission of the U.S. Public Health Service and the U.S. Fish and Wildlife Service was formed to render technical consultation and advice to the United States Operations Mission to the Republic of Korea (USOM/K), and to the Government of the Republic of Korea in establishing an effective oyster production program. The Mission consisted of C. B. Kelly, Pharmacist Director, U.S. Public Health Service; R. J. Hammerstrom, Sanitary Engineer Director, U.S. Public Health Service; and J. B. Engle, Biologist, U.S. Fish and Wildlife Service. This report covers the public health aspects of the Mission, which in these respects had two objectives: to conduct a review of existing Korean laws and regulations, administrative practices, sanitary control measures, and commercial handling practices to determine the extent to which they are equivalent in effectiveness to those endorsed by the U.S. Public Health Service for use in the U.S. National Shellfish Sanitation Program; and to consult with and advise USOM/K and the various national and provincial agencies, and, through them, the shellfish industry, in the development of an effective program for production and for control of production of shellfish.

In accordance with the national policy to develop and expand fisheries in the Republic of Korea, great advances have been made in shellfishery. New laws and ordinances have been promulgated, and national and provincial fisheries and health agencies have been reorganized, with increases in staff and facilities. Improved methods for shellfish culture have been developed and are being utilized.

As a result of this increased effort, production of oysters has increased rapidly, and long-range plans call for an even greater rate of increase. Therefore government agencies and the fishing industry are developing means of expanding production for export. One means is the development of an agreement to export fresh and frozen oysters to the United States.

The Mission recognized the extent of the oyster production areas in Korea and concluded that the best approach in developing the export program would be for the Government to concentrate its initial effort in a limited geographical area and

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Figure 1. Oyster growing area in Korea.

then expand the program to cover the remaining sections of the country. The Mission, therefore, considered those aspects of organization, legislative authority, administrative practices, and technical activities that pertained to a national program and then directed its principal efforts and attention to the field aspects in a study area in Kyung Sang Nam Province. The work of the Mission was greatly facilitated by the availability of extensive materials and information concerning all aspects of the culture of oysters and the sanitary control of oyster production.

The Mission believes that the existing organizational resources within the national, provincial, and local governmental framework of Korea are adequate for establishing and administering a program for the production and sanitary control of raw and fresh-frozen oysters for export. A significant step was taken for the establishment of such a program with the promulgation in 1966 of the Office of Fisheries Ordinance No. 218,[2] which applies specifically to shellfish products for export. It is the opinion of the Mission that Ordinance No. 218 together with the fishery inspection laws and the health and sanitation laws provide generally adequate legal authority for this export program.

The Government of Korea is to be highly commended for the outstanding work accomplished since 1961 in conducting bacteriological studies of shellfish growing waters and oyster meats. The

results of these studies have clearly shown that, surface runoff, during and following periods of rainfall, with attendant increased streamflow from rice and other grain fields fertilized with night soil, is the principal source of pollution affecting the quality of the growing waters and shellfish. While some of the growing areas studied are not satisfactory for safe oyster culture, many areas are potentially so. There is a great need to conduct comprehensive sanitary surveys of the latter areas and to select those of suitable quality for oyster production.

In evaluating shellfish production and control activities in Korea, the Mission considered the applicability of United States shellfish sanitation standards to the Korean program. The comparable incidence of enteric diseases in the two countries and Korea's potential for utilizing shellfish growing areas that are free of pollution and for establishing shucking and packing plant facilities of adequate sanitary design and operation, led the Mission to conclude that the shellfish sanitation standards followed in the United States can be applied and can be met in Korea.

The Mission believes that adequate organizational and other resources are available in Korea for exercising surveillance over the harvesting of oysters. This function is greatly simplified in the Kyung Sang Nam Province study area, where most of the oysters are produced by hanging culture, a method that eventually may replace bottom culture, particularly on the south coast of Korea.

The Mission visited several establishments that were canning and freezing fish and shrimp. These plants are of good sanitary design and well equipped and operated. No plants designed for the shucking and packing of shellfish were visited because the Mission was informed that there were no plants in the study area that would conform to requirements of the U.S. National Shellfish Sanitation Program. There is, therefore, the need to develop design criteria for such plants and to provide technical assistance in the construction and operation of a model plant.

Recent activities of the Office of Fisheries and other agencies of the Republic of Korea have resulted in the development of strong programs to develop and control the production of shellfish. Developments in the sanitary aspects have been particularly noteworthy. It is the opinion of the Mission, however, that certain administrative and technical changes would improve the program and, at least in the culture and harvesting phases of the production of shellfish, would be as effective in Korea as corresponding measures and practices have been in the United States. These recommendations are grouped by general class, without respect to priority. All are important to the development of an effective control program.

RECOMMENDATIONS

I. Administration

A. Establish an organizational unit within the Office of Fisheries at a sufficiently high administrative level to be responsible for the interministerial and intraministerial administrative and technical coordination of the shellfish sanitation program.

B. Develop an interministerial agreement between the Office of Fisheries and the Bureau of Public Health that would provide an adequate basis for cooperation and continuing exchange of information between the two ministries and their respective component units involved in the shellfish sanitation and control programs.

II. Laws and Regulations

A. Add to Article 14 of Ordinance No. 218 an additional item allowing harvesting of oysters only during daylight hours.

B. Revise Article 16 of Ordinance No. 218 to include the statement that ''Only shellfish that have been harvested from designated areas or subjected to an approved purification treatment shall be processed for export in registered plants.''

C. Revise Ordinance No. 218 and certain appendices of the ordinance to include references to important facilities requirements, processing standards, operational practices, and standards of shellfish quality, as discussed within the body of this report, so that the requirements of the Korean shellfish export program more nearly equal those of the U.S. National Shellfish Sanitation Program.

D. Develop, as indicated in the future, more detailed operational standards and guidelines for the shellfish industry and for use by governmental control agencies, based on experience obtained from the construction and initial operations of shellfish handling plants.

III. Sanitary Surveys of Shellfish Growing Areas

A. Assign the principal administrative responsibility for sanitary survey activities to the Fisheries Research and Development Agency and augment Agency personnel resources for this purpose.

B. Develop a comprehensive long-range plan for sanitary surveys of shellfish growing areas.

C. Assign high priority for immediate action to the selection of a few watershed areas and their contiguous estuaries that have the greatest potential for being of good sanitary quality.

D. Conduct comprehensive sanitary surveys of each selected watershed and estuary system.

E. Select for utilization, based on the comprehensive sanitary surveys, those shellfish growing areas that would be considered satisfactory for the production of safe shellfish.

IV. Laboratory Services

A. Recommend, in view of the recommendation that the principal administrative responsibility for sanitary surveys be assigned to the Fisheries Research and Development Agency, that greater emphasis be given to the conduct of sanitary reconnaissance activities, that the increase in staff consist of sanitarians, as discussed in the body of this report.

B. Augment the Fisheries Research and Development Agency bacteriological laboratory with certain scientific

equipment, particularly sterilizers and water bath incubators.

V. Research Needs

A. Assemble a sanitary survey team of diverse competencies, and conduct studies for the development of sanitary survey techniques.

B. Develop and conduct a project that would have as objectives the design and provision of technical assistance in the construction and operation of a model shellfish shucking and packing plant.

C. Initiate studies on the accumulation of microbiological pollutants by shellfish.

VI. Control of Harvesting

A. Adopt the raft-inventory system for the control of harvest of oysters grown by hanging culture.

B. Provide for endorsement by the Bureau of Production of the certificate to harvest, attesting to the satisfactory sanitary and biological condition of the shellfish.

VII. Training Needs

A. Make appropriate arrangements for selected representatives of the Korean Government agencies and the shellfish industry to visit the United States to observe and receive training in the administrative and technical aspects of the U.S. National Shellfish Sanitation Program.

REPORT

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Part II

MISSION TRAVEL AND STUDY ACTIVITIES

This report covers the travel and study activities of the Mission during the period of September 8 through October 16, 1967.

En route to Korea, the Mission made an official visit to Japan to observe oyster culture in the Hiroshima Bay area and to review shellfish sanitation control activities being conducted under the agreement between the United States and Japan relating to the production and handling of oysters intended for shipment between the two countries. The Mission departed from Los Angeles on September 8 and arrived in Tokyo, Japan, on the following date. In Tokyo, conferences were held with the Fishery Attaché in the American Embassy, and with representatives of the Ministry of Health and Welfare and the Ministry of Agriculture and Forestry of the Government of Japan. In the Hiroshima area during September 12 through 16, the Mission visited and held conferences with representatives of the Hiroshima Prefecture Fisheries Experiment Station in Ondo, the Ministry of Agriculture and Forestry Southwest Regional Fisheries Research Laboratory, Nichiro Fisheries, and the Hiroshima Prefecture Public Health Laboratory. Field observations were made of oyster culture methods and oyster seed growing areas. Visits were made to several oyster handling plants that were smaller than the large Nichiro Fisheries, which is the only plant exporting frozen oysters to the United States at the present time.

Figure 2. Government and oyster industry representatives, Chung Mu.

The Mission arrived in Seoul, Korea, on September 19. Conferences on the background of the work of the Mission in Korea were held with representatives of the United States Operations Mission to the Republic of Korea. Following an introductory meeting with the Administrator and other officials of the Office of Fisheries of the Government of the Republic of Korea, discussions were held with representatives of the Office of Fisheries on plans for the work of the Mission and, also, on oyster culture and

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Figure 3. The Mission in conference at the Fisheries Research and Development Agency, Pusan.

production in Korea. The Mission departed from Seoul and arrived in Pusan, Korea, on September 21.

Initial discussions in Pusan were conducted with the USOM/K Advisor to Kyong.Sang Nam Province. A headquarters office for the Mission was established at the Fisheries Research and Development Agency in Pusan. The Mission conducted the majority of its work in the Pusan area and traveled out of the headquarters office on field trips and visits. Daily discussions were held with representatives of the Fisheries Research and Development Agency. Several conferences were held with officials of the Government of Kyong Sang Nam Province, including the Governor and representatives of the Fishery Bureau and the Health and Social Affairs Bureau. A visit was made to the Pusan Branch Station of the Central Fisheries Inspection Office, and the work of the Branch Station was discussed with the Director. Visits also were made to the Pusan Fish Market Center, two large seafood plants in the Pusan area, and to the United Nations Deep-Sea Fishing Training Center.

A 3-day field trip was made to the Chung Mu area, with travel from Pusan to Chung Mu City by USOM/K car. Meetings and conferences were held with the

Figure 4. Modified long line oyster culture, Chung Mu.

Chief of Tongyong County, the Mayor of Chung Mu City, and with the President and other representatives of the Fisheries Cooperatives of Oyster Culture in Chung Mu. Traveling by Republic of Korea (ROK) fisheries boat, the Mission observed rafting and long-line methods of oyster culture, and the environment of oyster growing waters in several areas in the vicinity of Chung Mu. Visits were made to two large seafood plants in Chung Mu. The Mission traveled by ROK fisheries boat from Chung Mu to Masan City, visiting a number of oyster growing areas and observing the methods of oyster culture.

Figure 5. ''String'' of oysters from raft, Chung Mu.

The Mission departed from Pusan and arrived in Seoul on October 5. The Ministry of Health and Social Affairs was consulted further concerning the organization and activities of the Ministry as related to shellfish sanitation and the occurrence of enteric diseases in Korea. Briefing sessions were held with representatives of the USOM/K to acquaint them with the work of the Mission. A final conference was held with the Administrator of the Office of Fisheries and members of his staff to inform them of the observations made by the Mission.

In all the conferences and discussions held by the Mission, attention was directed to the organization, resources, and work of the Korean agencies in the sanitary control of oyster production. Pertinent informational materials were secured for study whenever available. The Mission was accompanied by representatives of the Fisheries Research and Development Agency in the majority of the conferences and discussions held with the Korean agencies, during the field trip to the Chung Mu area, and on visits to seafood plants.

Mr. Kelly and Mr. Hammerstrom left Seoul on October 13 for the return trip to the United States, stopping off in Tokyo for a final debriefing session with the Fishery Attaché of the American Embassy. They arrived in Los Angeles on October 16. Mr. Engle remained in Korea to continue his study of oyster culture.

A listing of the organizations and contacts with whom conferences and discussions were held by the Mission appears in Appendix A, and a complete itinerary and summary of activities of the Mission are shown in Appendix B.

Part III

REVIEW OF OYSTER CULTURE AND PRODUCTION

HISTORICAL BACKGROUND OF OYSTER CULTURE IN KOREA

Fishery resources are very important to the Republic of Korea, which has a coastline of about 19,300 km. They supply high value protein foods for local use, constitute a significant factor in the domestic economy, and, where the supply is adequate, are a possible source of considerable foreign trade. To a certain extent, fish and shellfish have been used for all of these purposes throughout the long history of Korea.

Since records of the traditional history of the utilization of the oyster and other shellfish are fragmentary, any historical survey must be sketchy. As for the oyster, we can be sure that it has been in Korean waters for many centuries and that the Korean people have long used this natural resource as food, especially in coastal communities. The documentation of its use and its culture, however, is confined to a fairly recent period of time.

A history of fisheries development written by Yoshida (1954)[3] reviews the development of Korean oyster culture since about 1891. At this time, seed oysters were gathered and spread to grow in some areas of Wonsan Bay. When they reached marketable size, they were harvested, steam-cooked, and dried in the sun in shallow rice straw baskets for export to China. Undoubtedly, some of these oysters were used domestically, either raw or cooked. This export business was stopped during the Sino-Japanese War, 1894 to 1895.

The culture of oysters was again given a start when the government established a fishing ground control system to protect oyster farmers from random illicit harvesting, or poaching, of oysters. The government then issued permits for engaging in oyster culture on designated plots. Again, spreading of seed oysters was continued and, in addition, a primitive type of the raft hanging method was adopted in Yonghung Bay. Yoshida noted that the growth rate of oysters growing by hanging culture in this Bay was much greater than that of oysters growing by the same method in Japan.

Various practices of oyster culture were developed in other places. In the Cholla Namdo area, stone culture was tested and became the principal way of growing oysters in the intertidal zone. The site of these experiments and the subsequent oyster culture was in the waters between Shichong Myon and Konichong Myon. These operations in the

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vicinity of Mokpo were started in 1907 and are still being continued in much the same way although some rack-hanging culture is beginning to be used.

In 1921, a fisheries research station was established in the Pusan area on Kadok Island in Kyongsang Namdo. This is now the location of a fine national fisheries research station, which is the administrative office and main laboratory of the Fisheries Research and Development Agency of the Republic of Korea. Through the research efforts of the predecessors of the current agency, stone culture of oysters was initiated here in the Kadok Island area in 1923 with encouraging results.

Shortly after this time, in the late 1920's, the government started to subsidize and strongly encourage the extensive culture of oysters. One reason suggested for this move was the decline, around 1927, in cod fishery, which had been of principal importance.

Not much additional information concerning oyster fishery in Korea is available for the period 1927 to 1945 although it is reasonable to assume that oyster culture using stone throwing, stick, and perhaps even some manner of hanging culture was being practiced.

Between the years 1945 and 1960, the culture of oysters continued much as it had been during earlier years. During this period, oysters were exported to southeast Asia and to Hong Kong, as dried products; and to Europe, Japan, and the United States as canned, smoked commodities. The domestic market consumed a sizeable portion of the total product. Most of this harvest came from the western coasts of Kyonggi Do (Inchon area) and Chungchong Namdo, and from the southern coasts of Cholla Namdo and Kyongsang Namdo. Stone, stick, and spreading culture accounted for the major part of the oyster production. There was almost no hanging culture as an industry during this period. In 1960, however, the Fishery Research and Development Agency began laboratory controlled studies of hanging culture, first with rafts, then, with long-line culture in Chindong Bay, Kyongsang Namdo area. These experiments led to an increased adoption of hanging culture, especially on the southern coast of Korea.

Between 1961 and 1966, a steady increase in the use of hanging methods of oyster culture developed in Kyongsang Namdo area. In 1964, in Chung Mu City, Tong Yong Gun, the Fisheries Cooperative of Oyster Culture was formed, with a membership of about 150 families. The government, through the Office of Fisheries, is providing financial support to the cooperatives as well as to the oyster culture fishermen. With this organization and with government help, oyster culture, principally the hanging culture, is fast becoming the major method of producing the oyster harvest in this province. A hanging oyster culture depending on racks in relatively shallow water is being developed for the production of seed oysters, mostly for export to the United States.

METHODS OF COMMERCIAL OYSTER CULTURE IN SOUTH KOREA

I. General

The commercial oyster common to Korean waters is *Crassostrea gigas*, Thunberg. Today, this valuable natural

food resource is produced in the Republic of Korea by several methods. In fact, at least seven different ways of growing oysters are practiced in the marine waters of this country. The culture here, as in most places where oysters occur naturally, developed progressively, starting simply with collecting the wild stock and placing it conveniently nearby for harvesting when mature. Then, oyster culture advanced to a sophisticated, highly technical procedure of seed collecting and growing for harvest by some form of the hanging method. The Republic of Korea is now entering this advanced stage of oyster culture with the full support of government, industry, and cooperatives. The seven methods used can be grouped into three categories as follows:

A. Bottom culture (in intertidal waters)

1. Broadcast (spreading shells for seed collecting and possible growth)
2. Stone throwing

B. Stick culture

1. Sticks of any wood, mostly local pine
2. Sticks of bamboo, which must be imported

C. Hanging culture

1. Rack method
   a. Vertical for catching seed
   b. Horizontal for hardening seed
2. Raft method
3. Long-line method

The method to be used, however, sometimes is determined by the hydrographical and sanitary conditions of the water, which may make it necessary to combine several methods of culture. For instance, seed oysters may be caught on shell strings suspended from racks in the intertidal waters, then taken for maturing to rafts or long lines in the deeper and often more sanitary water further offshore. Also, for reasons of local economy and because of tidal conditions, the stone method is a recognized and practical way of producing oysters. Most of the oysters produced on the west coast and on part of the south coast of the Republic of Korea are grown by this method.

II. Description of Methods of Culture

All oyster farming requires gathering the seed and nurturing it to maturity for harvesting. As in land farming, soil or growing medium varies with different areas. Oyster seed collecting may be better in one place than in another. Oyster growth may be better elsewhere than in the seed areas. Oyster fattening for final harvesting of a quality product may require a still different location in the marine area. All these qualifications are determined by precise biological research or by practical experience and observation over an extended period of time. Although the characteristics of the location are not included in the description of culture methods, they frequently determine the type of culture indicated. The various methods are described below.

A. Bottom culture

Two types of bottom culture are in use: spreading, or broadcasting, shells or cultch; and stone throwing, or placing quarried or other rocks in

the intertidal zone, usually in a geometrical pattern. Many hazards, such as predation, muddying, and storms are present in bottom culture, and, at times, result in the loss of the oyster crop.

1. Spreading, which is known as broadcasting in the United States, is seldom used commercially today in the Republic of Korea. It consists of spreading oyster shells on hard clay or sand-mud bottom to catch the oyster seed. The shells must not be placed on loose sand or soft mud, for they will either be washed away by the stormy waters or buried. The area used for this culture method in Korea is the intertidal zone, but, at present, it is used very little. In the United States, however, broadcasting, or spreading, also is conducted, but mostly in deep water below the tidal levels for catching seed.
2. Stone culture, which seems to be peculiar to the oriental countries, has been in use many years and is still responsible for a large portion of the oyster production of Korea. Cahn (1950)[4] describes the stone culture of Japan as rock-studded earthen terraces 40 to 80 meters long, 3 meters wide, and about 0.3 meters high. The stones are put out from early June through July. The spat that catches on them may be left there to maturity or removed in September of the following year for transplanting to deeper waters as seed oysters. Cahn further reports that, since 1909, this culture has been the most successful used in Kumamoto Prefecture, Japan. Records of stone culture in Korea preceded this date. Oysters in Korea grown by this method usually take from 2 to 3 years to mature. Then, they are harvested and smoked, canned, used fresh domestically, or dried for export to southeast Asia.

B. Stick culture

In a method perhaps as old as stone culture, or older, sticks from the branches of pine or other trees are stuck in the bottom of the intertidal area so that oyster larvae can settle upon them. Pine sticks from 120 to 140 centimeters in length are cut and transported to the bay. The sticks are pushed into the bottom mud a distance of 25 to 50 centimeters, leaving 70 to 90 centimeters of branched stick upright along the bottom. These are arranged in rows about 1 meter apart with variable lengths of the rows determined by tidal amplitudes and configurations of the coastline. Crops raised by this culture are utilized in the same manner as in stone culture. The oysters are harvested from 1 to 3 years after the sticks are set and are then marketed raw for domestic use or exported as canned, smoked, or dried oysters.

C. Hanging culture

Hanging culture, by rack, raft, or long line is by far the most efficient way to utilize oyster producing areas. It eliminates or greatly reduces the losses due to predation and storms.

1. Rack culture is the principal method of catching and hardening seed oys-

ters for export. The racks are of several designs, each for a specific use. A long, fence-like structure about 1.2 meters high is made of pine or bamboo. Strings of shells, mostly oyster, are draped over this fence to catch spat for seed use. This fence-like rack is placed in the intertidal zone so that it is normally under water during most, or at least half, of the tidal cycle. This method of seed collecting is used also in the State of Washington, in the United States.

A second type of rack, modified for hardening seed, is constructed like a slatted table 1/2 meter high and 1 meter wide, over which the shell strings with the spat attached are laid horizontally and closely together in a parallel position. The area chosen for this rack is in relatively shallow water where the tide barely covers the shell string at high tide. These racks are used only to prepare seed for export.

A third method of rack culture uses a table-like structure similar to the hardening rack but in deeper water. This rack is about 1-1/2 meters high, 2 meters wide and 5 or more, meters long. Rails are placed lengthwise, four or five to a rack, to support strings of seed oysters, which grow to market size on this rack. When oysters are placed on strings for this method of growing the spat, the shells are separated with 10- to 15-centimeter bamboo spacers. This limits the number of shells to six or seven per string for maturing. This method is not used extensively in Korea today.

2. Raft, or floating culture, is developing in the Republic of Korea and is rapidly becoming the popular as well as the efficient way of growing oysters. There are two forms of floating culture now in use in the Republic of Korea, raft and long-line. The laboratory of the Central Fisheries Experimental Station at Pusan in 1961 instituted research in raft and long-line oyster culture. By 1964, both methods were being used commercially, with financial help from the Government of the Republic of Korea and a newly formed oyster culture cooperative with headquarters in Chung Mu. The majority of the rafts are in the Province of Kyongsang Nam. Rafts vary in size from 50 to 66 square meters or from about 5 by 10 meters to 6 by 11 meters. They usually are constructed of bamboo poles laced or lashed together, but in some places pine poles are substituted. The floats are generally glass balls about 13 inches or 33 centimeters in diameter. The number of balls to a raft varies from 50 to 100. When the raft gets heavier as fouling attaches and the oysters grow, more floats are added to produce sufficient buoyancy. The earlier floats were wooden barrels and steel drums, but at present glass balls are preferred.

   A recapitulation of the number of oysters grown on a raft follows:

Number of lines of strings per raft	10-13
Number of strings 5 meters long	200-250

Number of shells per string	20-25
Total number of shells on raft	4,000-5,000
Total number of spat per shell	10-20
Total number of oysters per raft (4,000 shells)	40,000-80,000

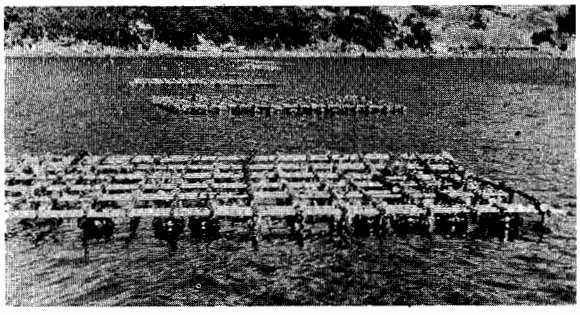

Figure 6. Raft oyster culture, Chung Mu.

Rafts are usually arranged in groups of five tied together with an interval of 3 to 5 meters between them. At each end of the string of rafts, anchors are attached to hold them in position. Sometimes, these lines of rafts are grouped into vast fields of 50 or more.

The hanging culture method has become more prevalent since it began to be used in commercial oyster production in Korea in 1963. The following chart illustrates the annual increase in production and value of oysters grown by hanging culture in Kyongsang Namdo.

These production figures and financial values are more significant in that they represent the effort of one province, Kyongsang Namdo, which is only part of the southern coast of

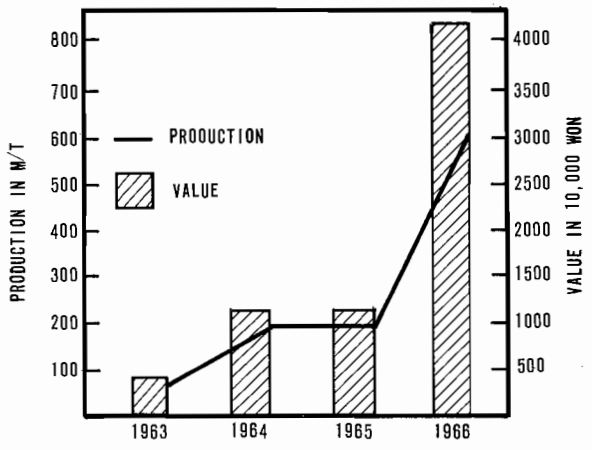

Figure 7. Annual production and value of oysters grown by hanging culture in Kyongsang Namdo.

Korea. To the west of Kyongsang Namdo, lies the province of Cholla Namdo, and, in addition, there are several provinces on the west coast with areas suitable for hanging culture development and with similar potential for this method of growing oysters.

An estimate prepared by the Rural Development Division of USOM/K, showed as of the end of 1966 an area of 159,000 square meters actually used for hanging culture in the Republic of Korea and a potential of 30,741,000 square meters for future development by this method. In Kyongsang Namdo alone, a potential figure of 13 million square meters was proposed by Mr. Dal Yong Park, president of the Fisheries Cooperative of Oyster Culture located at Chung Mu City.

Another statistic shows the increase in area devoted to hanging culture over the past several years in Kyongsang Namdo. With these figures are

the annual subsidies furnished by the Office of Fisheries and the Provincial Government to support and encourage this expansion.

Figure 7 indicates the rapid increase in area used for hanging culture in Kyongsang Nam Province. Funds supplied jointly by the Office of Fisheries and the Provincial Government supported the substantial increase in this aquicultural development.

3. Long-line culture is a modification of raft culture, and it also is an improvement since it provides greater flexibility and durability in rough, stormy water. The long-line system of hanging culture has been in use in the Republic of Korea since 1962 when the Central Fisheries Experimental Station at Pusan began experiments on its use. It was introduced to the Korean commercial hanging culture program in 1963 and shares with the conventional rafts many of the same areas. The method has been in use in Japan since 1947. At first, the technical features included steel drum floats spaced 6 to 7 meters apart in groups of seven joined by Manila or twisted rice rope to form a floating line 50 meters long. The two parallel ropes connected the floats and were used to suspend the shell strings. The strings, about 5 meters in length, were attached to the rope lines at 30-centimeter intervals, making it possible to have about 175 to a line and 350 to a long-line complex.

More recently, in 1964, the use of steel drums was replaced by a glass-ball floating system with four main lines in a unit separated by bamboo poles 2 meters long, which keep the lines about 0.7 meters apart. The bamboo separators are placed at right angles to the main lines and tied to them to hold them in place. The poles are about 5 meters apart, making 20 for each unit. The ends of the main

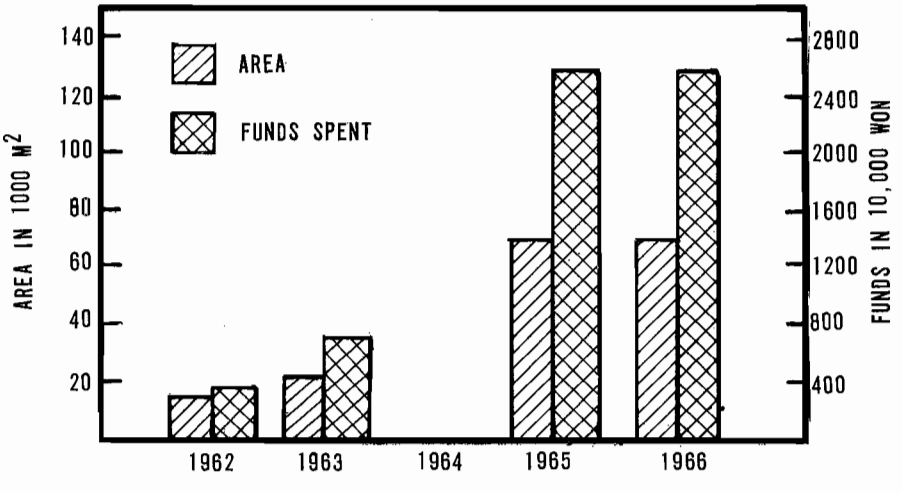

Figure 8. Annual increase in area in use and funds spent by the Republic of Korea for hanging culture in Kyongsang Namdo 1962 to 1966.

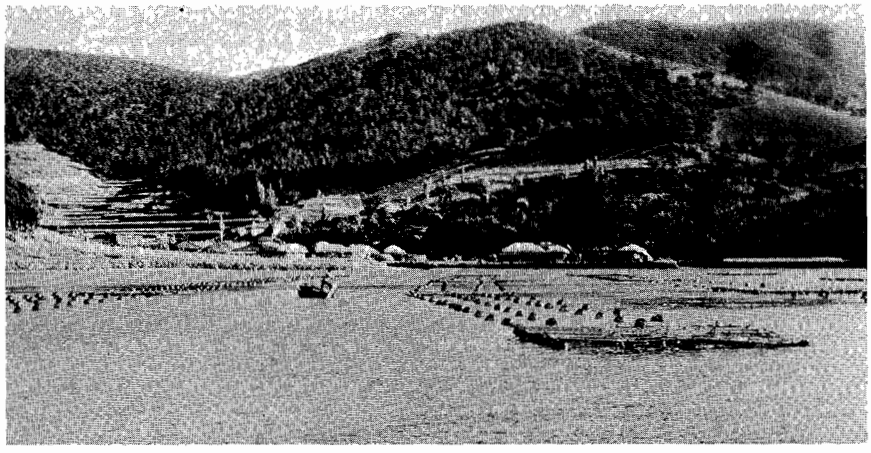

Figure 9. Long line oyster culture, Chung Mu Region.

lines are joined to an anchor line of about 20 meters in length, one at each end, to keep the whole unit in place. Glass balls are used as floats and are secured to the main lines at 1-meter intervals. The total length of a long-line unit is about 100 meters with four lines each, requiring 100 glass balls for a total of 400 balls per unit. Each line in a unit supports about 330 shell strings, with about 1,300 strings in a long-line unit. Today more oysters are raised in the Republic of Korea by long-line culture than on rafts.

Part IV

ADMINISTRATION OF SHELLFISH PRODUCTION AND CONTROL ACTIVITIES

ADMINISTRATION OF SHELLFISH PRODUCTION AND CONTROL ACTIVITIES

Two national government agencies have primary responsibility for the production and sanitary control of shellfish: the Office of Fisheries, and the Bureau of Public Health and the National Institute of Health in the Ministry of Health and Social Affairs. Some agencies in other ministries, also, have responsibilities and functions of interest to the overall program of production, control, and export of shellfish: the Public Works Bureau in the Ministry of Construction, for matters pertaining to sewerage systems; and the Commerce Bureau in the Ministry of Commerce and Industry, for exports and the promotion of export plans, including those concerning shellfish.

The Office of Fisheries has the major responsibility at the national level for shellfish production and control. The organization of the Office of Fisheries is shown in Figure 10. The organizational components of this agency most directly involved in shellfish production and control are listed, and their general functions in these activities are described below.

Office of Fisheries

Production Bureau. This Bureau establishes policy and provides direction, leadership, and guidance in the development of coastal and deep sea fishery resources and the overall fisheries industry to achieve maximum production of fishery products for domestic and export markets. It has an especial interest, in consonance with current national fisheries policy, in the development of cultured fisheries, including those producing shellfish for export as fresh and frozen food products.

Fisheries Research and Development Agency. This Agency, with headquarters in Pusan, is the principal research and development facility of the Office of Fisheries. The Agency is well organized and staffed with competent professional personnel to carry out a comprehensive program of fisheries and oceanography research, provide technical assistance, and conduct training programs in support of Korean fisheries and the fisheries industry. The organization chart of this Agency is shown in Figure 11.

The Aquiculture Section and the Utilization and Food Technology Section have been most directly concerned with shellfish production and control, together with their other responsibilities

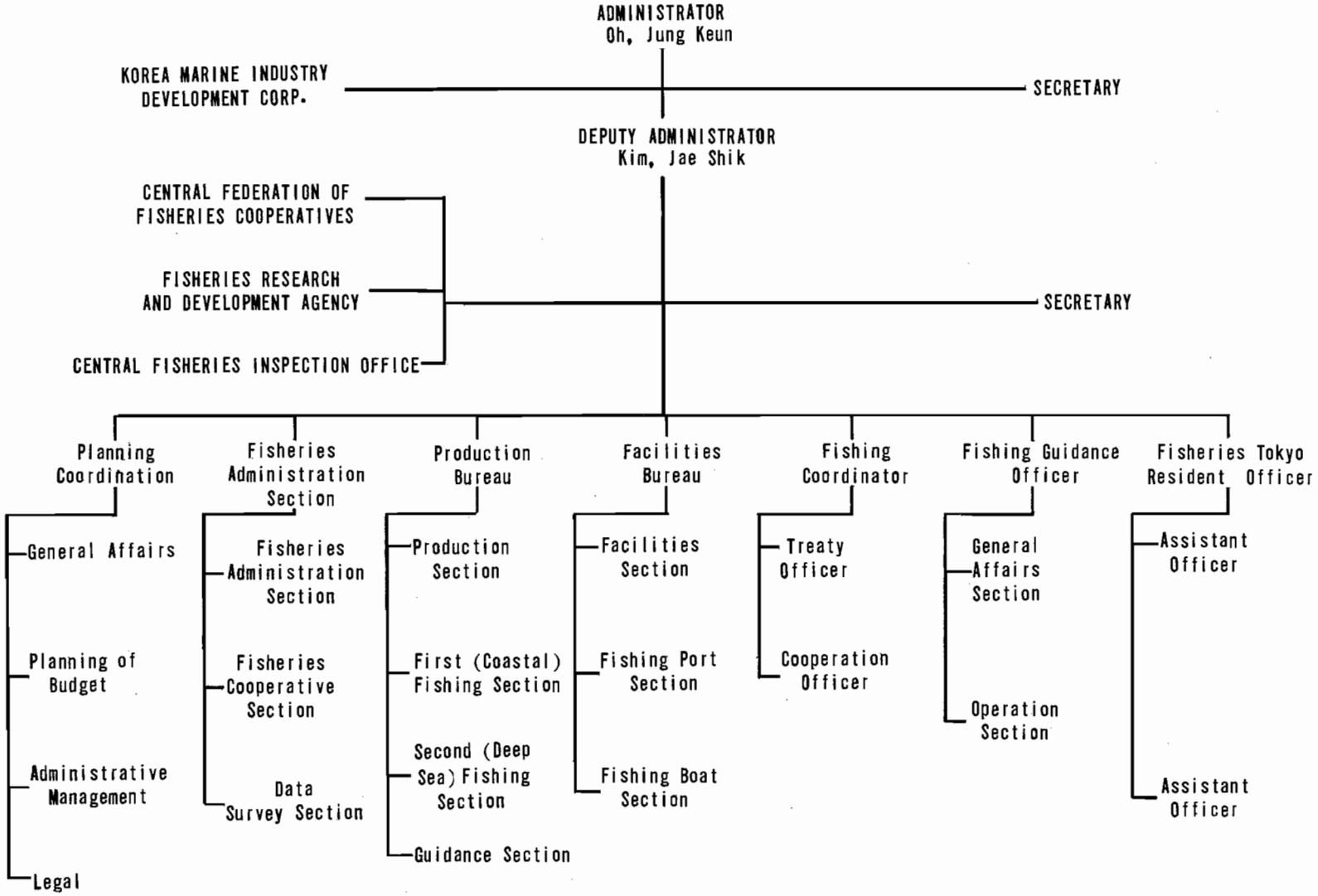

Figure 10. Organizational chart of Office of Fisheries.

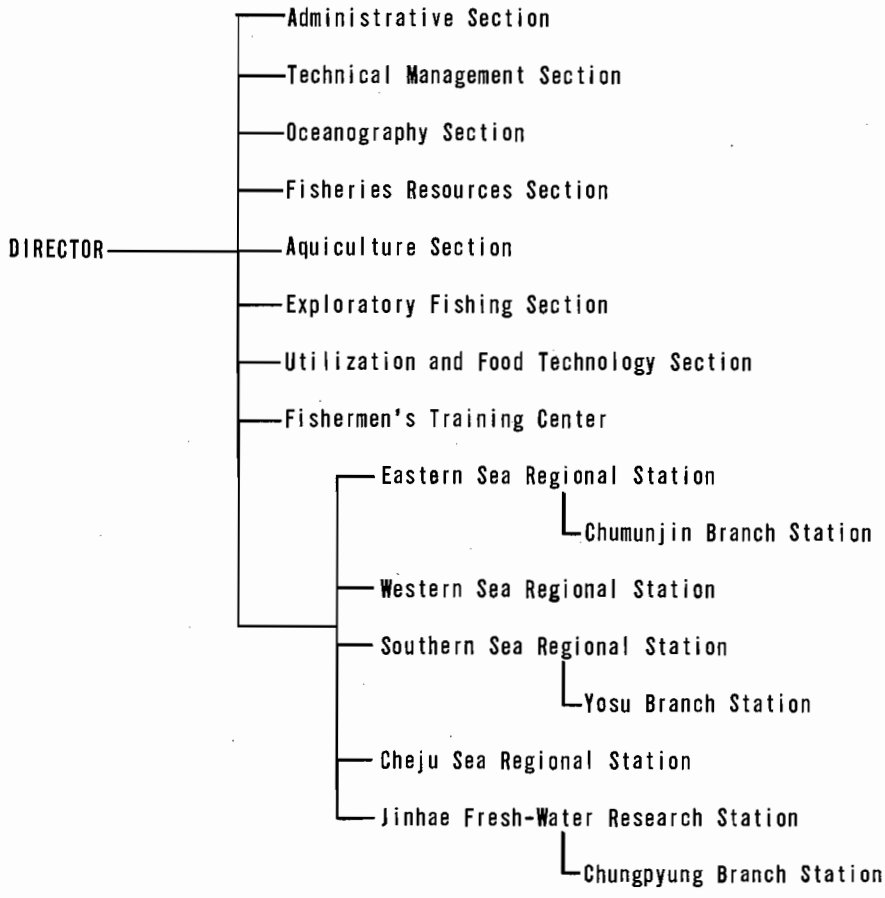

Figure 11. Organization of Fisheries Research and Development Agency.

and functions. The former Section has conducted studies in shellfish culture and has a continuing interest in it. The latter has done outstanding work in conducting bacteriological studies of shellfish growing waters and shellfish meats since 1961, concurrently collecting and analyzing pertinent meteorologic and hydrographic data.

The Utilization and Food Technology Section also has the technical personnel and laboratory resources to conduct other microbiological and biochemical studies related to the sanitary handling of shellfish during processing and marketing. The Oceanography Section is well equipped to provide technical support to the shellfish production and control program through the conduct of oceanographic and hydrographic studies.

Central Fisheries Inspection Office. This Office is established under the Administrator of the Office of Fisheries. The organization of the Office is shown in Figure 12.

Through the 14 branch stations, this Office inspects fishery products processed for the domestic market or for export, conducts research and development activities for manufacturing and packag-

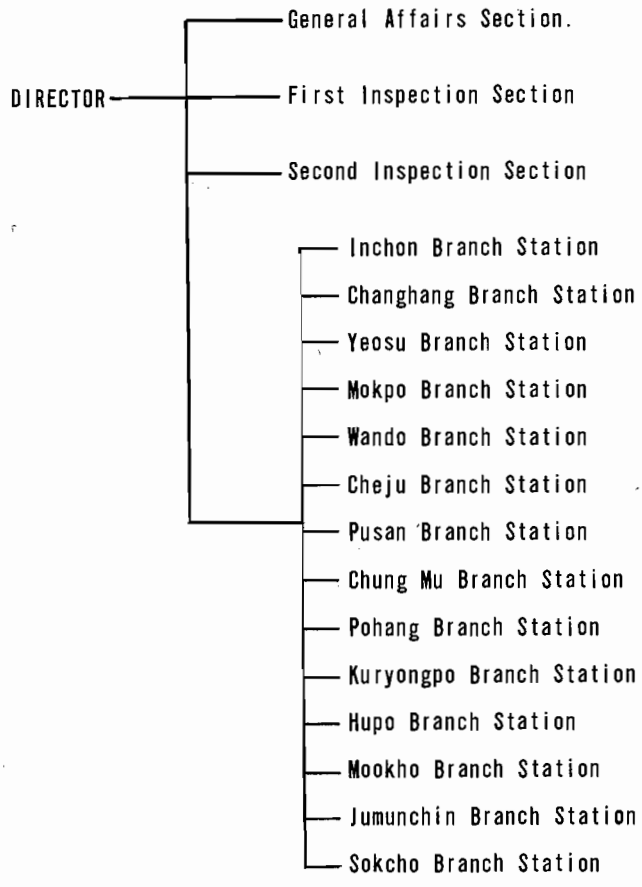

Figure 12. Organization chart of central Fisheries Inspection Office.

ing of fishery products, makes market surveys of fishery products, and compiles inspection statistics. The fishery products inspected include frozen, dried, salt fermented, flavor seasoned, and canned seafoods; fish liver and other fish oils; fish meal; seaweed; and agar-agar. The inspection activities include the production process; physical, chemical, and, in some instances, bacteriological analyses of the product; and final inspection of the packaged product, including quantity and moisture content.

The Central Fisheries Inspection Office has especially designated inspection responsibilities and functions related to shellfish that are to be exported in a raw or frozen state. To date, however, there has been no request for such inspection services because no raw or frozen shellfish have been exported. Inspection responsibilities include the issuance of certificates of harvesting and the inspection of boats used for harvesting, the entire harvesting process, processing plants and shellfish handling practices in the plants, and the final product for conformance with established quality standards.

Central Federation of Fisheries Co-

operatives. This is a federation of affiliated fisheries cooperatives. It includes 99 district (county or city) cooperatives, which, in turn, embrace 2,023 fishing village cooperatives, 18 cooperatives by kind of business, and 3 manufacturing cooperatives. The Federation is organized at the national level and includes 9 provincial branches. The task of the Federation is to guide and supervise affiliated cooperatives, promote the common interests of fishermen, and develop the fishing industry so as to improve the economic and social status of fishermen as well as achieve the balanced development of the national economy. Among the functions of the Federation are guidance activities, such as economic surveys, the fostering of economic fishing units, extension and training services, and operation of fisheries radio stations. Other functions include business and financial activities, such as procurement and distribution of supplies, marketing, provision of fish processing facilities, and the handling of loans and other funds for cooperatives. The functions of the Federation directly affect the county, city, and village cooperatives, some of which may be primarily concerned with the production and marketing of shellfish. The Mission visited and consulted with the officials and members of the oyster cooperative at its headquarters office in Chung Mu City, Kyongsang-Nam Province. The activities of this cooperative will be discussed later in this report.

The Ministry of Health and Social Affairs has the responsibility at the national level for certain sanitary aspects of shellfish control and for the prevention of health hazards associated with the human consumption of shellfish. The organization of this Ministry is shown in Figure 15.

Figure 13. Headquarters of Tongyong Oyster Cooperative, Chung Mu.

Figure 14. Members of Mission with conference group at Chung Mu.

The agencies of the Ministry of Health and Social Affairs most directly concerned with shellfish sanitation, and their general functions related to this program, are discussed below.

Bureau of Public Health

Environmental Sanitation Section. This Section was established by Presidential Decree No. 2910 on February 11, 1967, with some of the functions carried

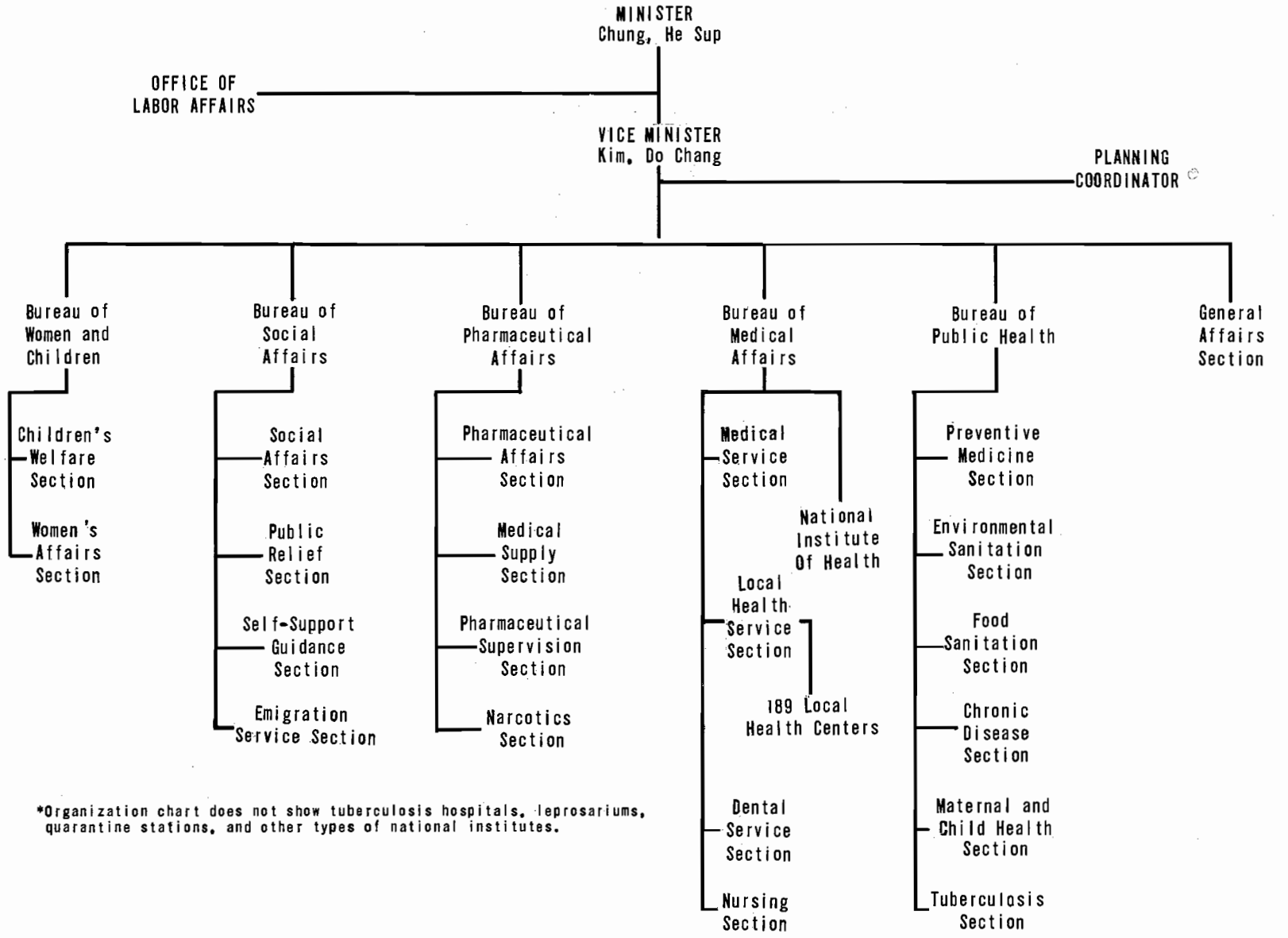

Figure 15. Organizational chart* of Ministry of Health and Social Affairs.

out by the former Sanitation Section being assigned to the new organizational unit. Among other functions, this Section is responsible for matters pertaining to the sanitary aspects of sewerage systems and the disposal of domestic and industrial wastes. This responsibility is carried out through the provision of technical supervision and guidance to the provincial government offices.

Food Sanitation Section. This Section also was established under the above mentioned Presidential Decree and organized from the former Sanitation Section. Among other functions, this Section is responsible for matters concerning the sanitary aspects of manufacturing, processing, cooking, and selling food products, including licensing, establishment of standards for plant and equipment facilities, specifications for packing of food products, and inspection of food products. These responsibilities are carried out by providing technical supervision and guidance to the provincial government offices. With regard to marine food products, some of the above responsibilities are carried out in consultation with the Office of Fisheries.

Bureau of Medical Affairs

National Institute of Health. Among other functions, this Institute conducts studies directed toward the prevention of infectious diseases and performs microbiological research on food products. The Institute, therefore, has an interest in shellfish-borne diseases and the microbiology of shellfish.

Organization of the Provincial Government

Each of the nine provinces of Korea has a governmental organization consisting of the governor, deputy governor, and a group of bureaus and offices. The bureaus and offices, in some respects, are counterpart organizational units of the national ministries and other national offices, and are responsible for carrying out, at the provincial level, the policies and programs of the national government. The provincial government, in turn, also provides supervision and guidance to and works with the smaller governmental and political jurisdictions, such as the counties and cities. The organization of Kyong Sang Nam Province, in which the Mission reviewed the oyster production and control activities, is shown in Figure 16.

The provincial government bureaus most directly involved in shellfish production and control are the Fishery Bureau and the Health and Social Affairs Bureau.

The Fishery Bureau provides supervision, guidance, and assistance to oyster fisheries in order to encourage and facilitate oyster production in line with provincial and national government goals. The Bureau handles national government funds for loans to individual oyster fishermen and augments national government subsidies to fishing villages. Through the Production Section, the Bureau handles the licensing of oyster fishermen. Applications for licenses are received from individual fishermen or through the oyster cooperatives. Representatives of the Bureau then inspect the proposed culture areas for pollution, hazards to navigation, and competition with other types of fishing. The Bureau also has some responsibility for the inspection of plants and facilities used in processing oysters.

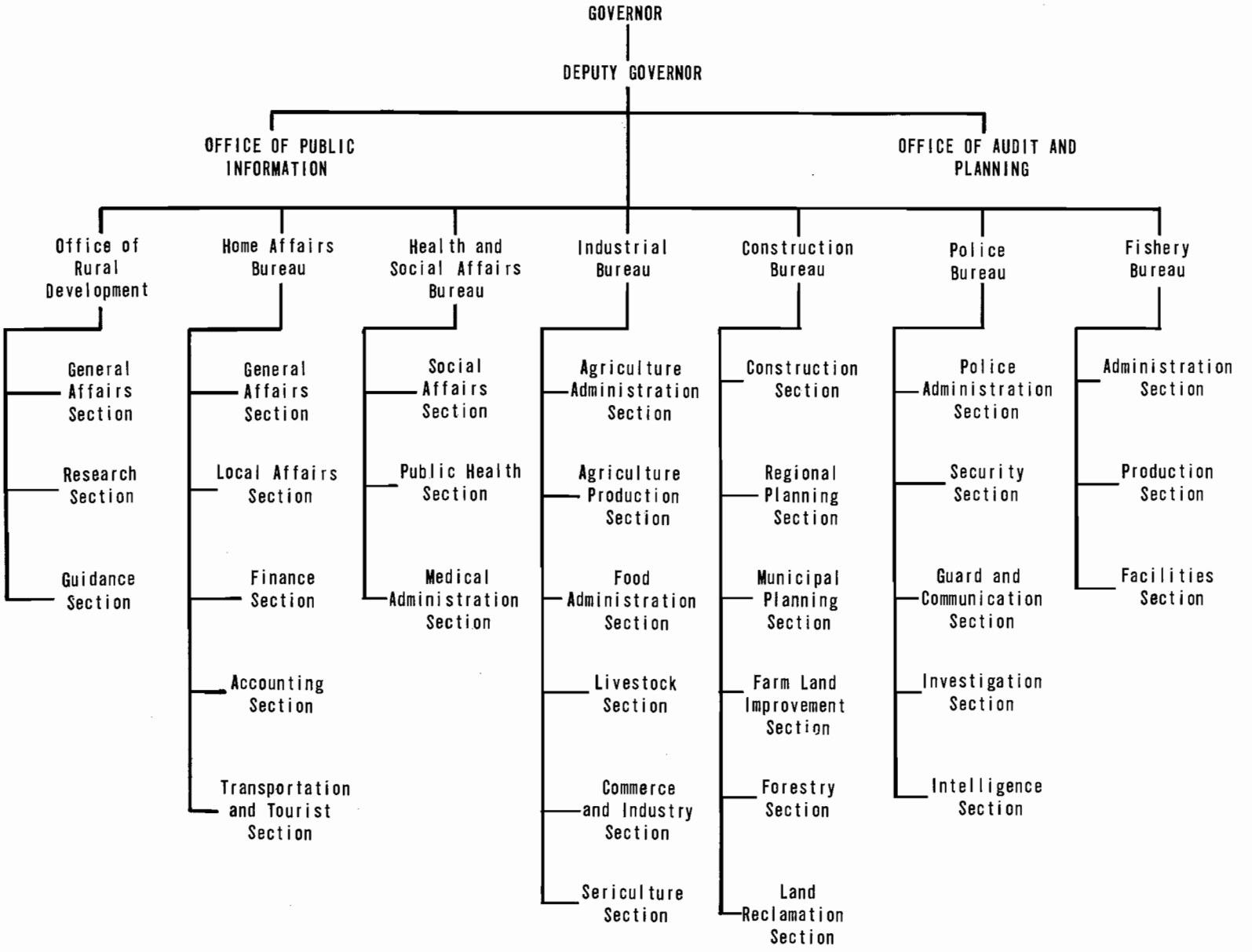

Figure 16. Organizational chart of provincial government.

The Fishery Bureau works closely with the oyster cooperatives which, in turn, provide direct assistance to the oyster fishermen. The cooperative, such as the Fisheries Cooperative of Oyster Culture at Chung Mu City, previously referred to, assists the fisherman in securing his license, buys the materials needed for oyster culture and sells them to the fisherman, and sells the oysters for the fisherman. In addition to carrying out the program activities of the bureaus of the Office of Fisheries, the Provincial Fishery Bureau maintains close working relationships with the Fisheries Research and Development Agency and with the Central Fisheries Inspection Office and its branch stations on all matters relating to shellfish production and control.

The Provincial Health and Social Affairs Bureau has a major responsibility for the prevention of infectious diseases, which include those enteric infections associated with the consumption of contaminated shellfish. With regard to shellfish, this responsibility is carried out by the Public Health Section through the enforcement of the provisions of the Food Sanitation Law. The Public Health Section provides supervision and guidance to city and county health centers, which are responsible for inspection and other control activities required by the Food Sanitation Law. Inspection activities of the local health centers are concerned, primarily, with the health of personnel working in fishery processing plants, sanitation of the plants, sanitary aspects of water supply, and waste disposal practices. Similar inspections are made of restaurants and all other food handling establishments. Inspections are carried out for purposes of licensing and for sanitary control of operations. The Food Sanitation Law also requires a thorough investigation and report on each case of food poisoning.

The Public Health Section conducts laboratory analyses of canned shellfish products to detect any bacteria, other contaminants, and adulterants that may be present. Such analyses are performed primarily on products for the domestic market. Neither the Public Health Section nor the local health centers make analyses of raw shellfish.

The provincial and local health offices do not exercise any control over shellfish growing areas or shellfish harvesting practices. In conferences, however, with representatives of the Public Health Section in Kyung Sang Nam Province, the Mission obtained valuable information and data on population, rainfall, and waste disposal practices pertinent to the development of comprehensive sanitary surveys of shellfish growing areas. In addition, the Public Health Section is in the process of conducting an industrial waste survey of the Province, which will provide useful information relating to the sanitary quality of shellfish growing waters. Thus, the experience of the technical personnel, and the information and data available in the Public Health Section, are important for making the needed comprehensive sanitary surveys of shellfish growing areas.

CONCLUSIONS AND RECOMMENDATIONS

The Mission believes that the existing organizational resources within the national, provincial, and local governmental framework of Korea are adequate

for establishing and administering a program for the production and sanitary control of raw and frozen oysters for export. The principal responsibility for the production and control of oysters at the present time is in the Office of Fisheries. The Mission believes that the Office of Fisheries should continue to be the focal point for administration of the program. However, since the functions related to various parts of the overall shellfish sanitation program are assigned to and carried out by a number of different agencies within the Office of Fisheries, close administrative and technical coordination of the activities of these agencies is needed. Close coordination between the Office of Fisheries and the Ministry of Health and Social Affairs on administrative and technical aspects of the shellfish sanitation program, also, is needed for more effective utilization of the resources of the Ministry of Health and Social Affairs in the program.

The Mission recognizes the excellent work that has been accomplished by the Fisheries Research and Development Agency in conducting bacteriological studies of oyster growing waters and oyster meats. This Agency has also collected and analyzed meteorologic and hydrographic data in conducting surveys of oyster growing areas. There is a need, however, to expand these activities to include the making of comprehensive sanitary surveys of the oyster growing areas utilized in the export program. The Mission recommends that principal administrative responsibility for sanitary survey activities be assigned to the Fisheries Research and Development Agency and that the Agency personnel resources be augmented for this purpose, especially for the conduct of sanitary reconnaissance activities. The Agency should utilize, through appropriate administrative coordination, the technical resources, information, and data available from the Public Health Section of the Provincial Health and Social Affairs Bureau on all matters relating to comprehensive sanitary surveys.

The Mission recognizes a need for a clear definition of administrative and operational responsibility for inspectional services related to shellfish handling, from the harvesting area through the processing plant. Both the Central Fisheries Inspection Office, through its branch stations, and the Bureau of Public Health, through the provincial offices and local health centers, have important inspection responsibilities. For the most part, the inspectional services of these two agencies are complementary. At the present time, however, there is an apparent division of responsibility in regard to products for export and products for the domestic market, with the Central Fisheries Inspection Office concerned primarily with the former, and the Bureau of Public Health, with the latter. The Mission, therefore, believes that the inspection responsibility and activities of these two agencies should be utilized in a complementary manner, especially in connection with the handling of oysters for the export program.

In view of the need for intraministerial and interministerial administrative and technical coordination and exchange of information, the Mission recommends

that an organizational unit or individual within the Office of Fisheries, at a sufficiently high administrative level, be assigned the coordinating responsibility to meet this need. The Mission also suggests that the Office of Fisheries and the Bureau of Public Health consider the development of an interministerial agreement that could provide an adequate basis for cooperation and the continuing exchange of information between the two ministries and their respective component units involved in the shellfish production and control program. Such an agreement, executed at a high administrative level, should define the program objectives and responsibilities of each agency and prescribe how the component units of the agencies are to cooperate in carrying out the program. The execution of such an agreement, together with the designation of a coordinator by the Office of Fisheries, as recommended above, should provide for a strong and well-coordinated program for the production and sanitary control of shellfish for export and lead eventually to the adoption of a similar program for the domestic market.

Part V

REVIEW OF LEGISLATIVE AUTHORITY FOR NATIONAL SHELLFISH SANITATION PROGRAM

Adequate sanitary control of shellfish production can be achieved only if the official agencies concerned have legislative authority to exercise supervision and control over all aspects of growing, harvesting, and packing shellfish. While the general fisheries and health laws usually provide some legislative authority for such supervision and control by the official agencies, laws and regulations that apply specifically to shellfish production are generally necessary to achieve adequate sanitary control. The administration of shellfish sanitation program activities in the United States is carried out under such specific legislative and regulatory authority. The Mission, therefore, observed this concept in evaluating the legal authority for shellfish sanitation control activities in Korea.

Administrative control over the sanitary production of shellfish in the Republic of Korea is accomplished by the national and provincial governments under provisions of national laws and regulations. In previous correspondence and during discussions by the Mission with representatives of the Government of the Republic of Korea, a number of laws and regulations were cited as applicable to the production of shellfish. Not all of these legislative documents, however, were made available to the Mission. The following national laws and other legislative documents, which apply either generally or specifically to administrative control over the sanitary production of shellfish, were secured and reviewed by the Mission:

Name or Title	Date Promulgated
Fisheries Industry Law as Amended, No. 1780	April 23, 1966
Enforcement Decree of Fisheries Industry Law as Amended, No. 2526	May 10, 1966
Fishery Products Inspection Law as Amended, No. 1784	April 23, 1966
Office of Fisheries Ordinance No. 218, Regulations Governing Sanitary Control of Shellfish, Their Growing Areas, Harvesting and Processing and Inspection of Shellfish Products for Export	August 12, 1965
Food Sanitation Law, No. 1007	January 20, 1962
Enforcement Decree of Food Sanitation Law as Amended, No. 2808	November 26, 1962
Law on Prevention of Public Nuisances, No. 1436	November 5, 1963
Cleaning Law, No. 914	December 30, 1961

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Parasitic Diseases Prevention Law, No. 1789	April 25, 1966

Only the Office of Fisheries Ordinance No. 218 applies in its entirety to shellfish sanitation. The ordinance will be discussed later in this report. The other laws and enforcement decrees apply generally to the fisheries industry or to health and sanitation matters that include some aspects of the sanitary control of shellfish production. The Mission, however, fully recognizes the importance of the legal authority contained in the more general laws and decrees that provide for additional control over certain aspects of shellfish production when properly executed.

Brief comments on the general laws and related enforcement decrees pertaining to fisheries and to health and sanitation are presented in the following discussion.

Fisheries Industry Law and Enforcement Decree. This law provides a basic system for development and control of the industries catching, culturing, and processing fish, including shellfish, and for the protection and control of fisheries resources. The enforcement decree sets forth the administrative procedures to be followed. Under the provisions of the law, the Office of Fisheries and the provincial governments license and control fishermen and fish processing establishments. The law also provides for the granting and management of fishing rights; designation, protection, and use of fishing waters; and the granting of government subsidies for fishing, fish processing, and related business activities.

Fishery Products Inspection Law. The purpose of this law is to improve the quality of fishery products. The law provides authority for the Central Fisheries Inspection Office and its branch stations to conduct inspections on specified types of fishery products, including refrigerated and frozen products. Inspections cover raw materials, packing, weight, various types of processing, and other matters as stipulated by Presidential Decree. The law provides for the inspection of all fishery products for domestic sale or for export. It also sets forth administrative procedures and provides for the promulgation of presidential decrees and ministerial ordinances. Legal authority for inspection of shellfish and shellfish products for export, as cited in the Office of Fisheries Ordinance No. 218, is contained in this basic Fishery Products Inspection Law.

Food Sanitation Law. The purpose of this law is to protect and enhance public health through prevention of foodborne infections and other health hazards arising from food products, and through the improvement of nutrition. The law prohibits the import, manufacture, processing, sale, or other handling of food products hazardous to health. Provisions of the law also relate to food manufacturing, the handling of equipment and utensils, food additives, and to the packaging, labeling, and marking of food products. The law provides authority for the Ministry of Health and Social Affairs and the provincial governments through constituent agencies, such as the Provincial Public Health Section and local health centers, to conduct inspections of food products, equipment, and utensils manufactured for sale. The law also provides for licensing, establishing

facilities design and operation standards, regulating, and inspecting all types of food manufacturing and handling establishments; requiring health examinations of employees; and licensing cooks and dietitians. One of the provisions of the law relates to investigation and reporting on causes of food poisoning. Investigation includes the autopsy of any person who has died of a disease associated with food products and food-handling equipment. The law also provides authority for the Ministry of Health and Social Affairs to conduct nutrition surveys and to provide guidance on the nutrition of the people. In relation to the sanitary control of shellfish products, the Food Sanitation Law, therefore, provides authority to the Ministry of Health and Social Affairs for health and sanitation regulatory and inspection activities in the processing and handling of shellfish in the plants.

Law on Prevention of Public Nuisances. The purpose of this law is to prevent hazards to public health and sanitation, resulting from pollution of the air and rivers by industrial and business establishments. The law prohibits the pollution of air by soot and smoke, dust, bad odors, and gas; the pollution of rivers by chemical, physical, or biological agents; and noise and vibration that may result in harmful effects on the human body. Legal authority for enforcing the provisions of the law is vested in the Ministry of Health and Social Affairs. The law requires the Ministry to designate public health nuisance prevention zones and requires the industrial and business organizations within such zones to report on their operations and the production and discharge of harmful wastes materials. It, also, provides for the Ministry to conduct inspections of industrial operations and waste-handling practices and to order that such measures as necessary be taken to abate public nuisance. The Law on Prevention of Public Nuisances has a direct bearing on the enhancement of the sanitary quality of shellfish growing waters that could receive biological, chemical, and other pollutants from the waste discharges of industrial and business operations.

Cleaning Law. The purpose of this law is to enhance the public health by keeping the environment clean through sanitary disposal of garbage, night soil, carcasses of dogs and cats, and other refuse. The law provides for the establishment of special or seasonal cleaning districts in the major cities and in the provinces, and requires the sanitary storage and disposal of the above items of refuse. Provisions of the law apply specifically to night soil, including restrictions on the use of night soil as a fertilizer and the installation and operation of night soil disposal facilities. The law also provides for the licensing and regulation of garbage and refuse disposal businesses. Legal authority, at the national level, for administering the law is vested in the Ministry of Health and Social Affairs, with inspection and regulatory duties being carried out by environmental sanitation workers in the city and provincial governments. The Cleaning Law is of interest in the shellfish sanitation program in that it prohibits the disposal of night soil into rivers and restricts such disposal on the surface of the sea in the vicinity of cleaning districts.

Parasitic Diseases Prevention Law. The purpose of this law is to improve and promote public health through the prevention and eradication of parasitic diseases. The legal authority, at the national level, for administering this law is vested in the Ministry of Health and Social Affairs, with delegation of some of the powers to the provinces and to the cities of Seoul and Pusan. The law requires the Ministry of Health and Social Affairs to designate those areas where there is high risk of infection from parasitic diseases. It further requires: annual medical examination and treatment of all persons living in such areas and of all those who, living in any other area, have much contact with the general public; examination of all school children at least twice each year and medical treatment for those found infected; the establishment of public toilets by cities and provinces, which, also, are responsible for keeping them sanitary. The law reinforces the Cleaning Law in regard to restrictions on the use of night soil as fertilizer.

The Office of Fisheries Ordinance No. 218 was developed to apply specifically to the production of shellfish for export. It follows rather closely the requirements set forth In Parts I and II of the United States National Shellfish Sanitation Program Manual of Operations,[1] but is not as detailed, especially in regard to operational requirements. The emphasis in Ordinance No. 218 is on administrative procedures and the legal bases for criteria and standards, which are described in Articles 1 through 20. Appendices outlining standards and sanitary requirements for facilities and operations are a part of the ordinance.

Ordinance No. 218, together with the fisheries industry and inspection laws and the health and sanitation laws cited previously, comprise the principal legal basis and authority for a national shellfish sanitation program in Korea for the export of shellfish products. An analysis has been made comparing the provisions of these legislative documents with the legal elements and requirements of the National Shellfish Sanitation Program in the United States, which are set forth in the NSSP Manual of Operations. The comparative analysis of the two programs is shown in Table 1.

It is the opinion of the Mission that the Office of Fisheries Ordinance No. 218, the fisheries industry and inspection laws, and the health and sanitation laws cited in this report provide generally adequate legal authority for establishing and carrying out an effective program for the sanitary production of shellfish for export as raw or frozen products. The Mission, however, noted certain discrepancies between the provisions of Ordinance No. 218 and the program requirements and criteria of the U.S. National Shellfish Sanitation Program. These discrepancies are as follows.

Sanitary requirements for ''designated area''

The criteria for a ''designated area'' as set forth in Article 3, Ordinance No. 218 are generally the same as for an approved area under the U.S. program except that there is no reference to shellfish poison or toxin in Ordinance No. 218. Although the Mission was informed that no shellfish poison or toxin was known to have occurred in Korea, the inclusion of criteria for such materials in determining a ''designated area'' for

Table 1. COMPARISON OF REQUIREMENTS OF OFFICE OF FISHERIES ORDINANCE NO. 218 AND OTHER KOREAN LEGISLATION WITH U.S. NATIONAL SHELLFISH SANITATION PROGRAM MANUAL OF OPERATIONS

U.S. NSSP manual of operations	Ordinance No. 218 and other legislation	Remarks
Part I, Section A Item 1: Legal authority for:		
a. Classification of growing areas on basis of sanitary surveys and sanitary quality	Articles 3 and 5, Ord. 218, designation of "designated" areas	Same criteria as for NSSP except no reference to shellfish toxins
b. Control of shellfish harvesting	Articles 6 and 7, Ord. 218, abolition of "designated area" and limitation of shellfish harvesting season Article 14, Ord. 218, application for harvest and certification of harvest of shellfish for export Article 54, Enforcement Decree of Fisheries Industry Law, limitation or prohibition on collection of shellfish from contaminated areas	
c. Regulation and supervision of relaying, depletion, wet storage, and purification	No legal authority	Relaying, depletion, wet storage, and purification not practiced at present
d. Prevention of contamination of shell stock from the growing area to the shipper	Article 8, Ord. 218, registration of processors of shellfish for export Article 14, Ord. 218, application for harvest and inspection of harvesting process Article 15, Ord. 218, registration of harvest boats and cleanliness of trucks used in transporting shellstock Appendix 2, Ord. 218, boat sanitation requirements Article 3, Fisheries Products Inspection Law, inspection of raw fishery products	
e. Prohibit possession or selling of shellfish from noncertified sources, not produced in accord with program standards, or unfit for human consumption	Article, 3, Food Sanitation Law, prohibition of selling or otherwise handling food products hazardous to health Article 8, Fishery Products Inspection Law, prohibition of sale or export of fishery products failing to pass inspection	
f. Establish sanitary standards and regulate operations of shellfish handlers and shellfish shucking and packing establishments in accordance with Part II, NSSP Manual of Operations	Article 9, Ord. 218, minimum sanitary requirequirements for processing establishments as described in Appendix 1 Article 16, Ord. 218, processing of shellfish for export according to standards in Appendix 3, Article 17, Ord. 218, personnel sanitation standards as specified in Appendix 4 Article 22, Food Sanitation Law, criteria for facilities for food-handling establishments	Requirements for export essentially equal to those of Part II, NSSP, Manual of Operations
g. Restrict harvesting and shipping of shellfish in public health emergencies	Article 6, Ord. 218, abolition of "designated areas"	

shellfish culture would provide additional desirable control over the quality of growing waters.

Sanitary surveys of sea water of ''designated area''

Article 7, Item 1, Ordinance No. 218, states that the Office of Fisheries shall conduct a sanitary survey of the sea water more than once a month in shellfish harvesting seasons. The Mission believes that the intent of this Article is to require bacteriological examinations of the sea water and related hydrographic determinations at this stated frequency. In the U.S. program, the term, sanitary survey, refers to a comprehensive evaluation of all factors influencing the sanitary quality of a growing area and includes bacteriological examinations of the sea water. The NSSP Manual of Operations requires that the classification of a growing area for shellfish production be based on a comprehensive sanitary survey and that the factors influencing the sanitary quality of each approved shellfish growing area be reappraised at least biennially. The Manual of Operations further requires that a complete resurvey be made of each approved growing area at least once every ten years.

Control of use of shellfish from nondesignated areas

The criteria for a ''designated area'' apply specifically to the growing of shellfish for export. During the early years of the development of the program for the export of frozen oysters, there will be far greater production of oysters in growing waters that, while not contaminated, may not meet the higher sanitary standards for ''designated area'' growing waters. Therefore, it is essential that legal authority be established and procedures developed to assure that shellfish harvested from nondesignated areas are not processed for export in registered plants.

Facilities requirements, processing standards, operational practices, and standards of shellfish quality

While not as detailed as the NSSP Manual of Operations, Ordinance No. 218 refers to the majority of important facilities requirements, processing standards, and operational practices. In several instances, however, the descriptions used in the ordinance could be strengthened and some omissions included to more nearly equalize the requirements of the Korean export program with those of the NSSP. The specific items are discussed below.

Facilities requirements

Water Supply - Where reference is made to water supply for drinking purposes in the plants for the processing of shellfish, the ordinance specified: ''an abundant supply of water under pressure'' and ''chlorinated water and an abundant supply of water under pressure.'' The reference to water supply would be more complete if the terminology, ''ample water supply of a safe and sanitary quality as approved by the Provincial Public Health Section,'' were used.

Plumbing - Ordinance No. 218 makes no reference to plumbing. The sanitary requirements should prohibit cross connections between the approved water supply and water from a nonapproved source. Fixtures through which the approved water

supply might be contaminated by back siphonage also should be prohibited.

Boats - The ordinance does not indicate that boats should be kept clean to prevent contamination of shellfish. This requirement could be added by inserting a sentence under Article 15 of Appendix 2.

Processing standards

Shellfish processing - The ordinance does not indicate a standard to be observed in chilling oysters following the washing process. This requirement could be added by inserting a new item following item 4: ''shucked shellfish shall be chilled to 5°C or less within 2 hours after shucking, and maintained at this temperature.''

Operational practices

Storage of equipment and utensils - The ordinance does not make any reference to sanitary storage of equipment and utensils. This requirement can be made by adding to Appendix 3, Shellfish Processing Standards, the sentence: ''All equipment and utensils that have been cleaned and given bactericidal treatment shall be stored so that they are protected from contamination.

Records - The ordinance does not refer to records kept by shellfish dealers. Records of where shellfish were harvested, from whom they were purchased or secured, and the names and addresses of persons or companies to whom shellfish were sold are essential to assist public health officials in investigating shellfish-borne disease outbreaks. Consideration should be given to including the subject of records as an article in the ordinance.

Standards of shellfish quality

Ordinance No. 218 establishes a bacteriological standard for oysters of a ''median coliform MPN less than 230, respectively, per 100 grams of sample.'' The comparable standard used in the U.S. National Shellfish Sanitation Program, and which is applicable to all species of fresh and frozen oysters at the wholesale market level, requires a fecal coliform density of not more than 230 MPN's per 100 grams. The background of the adoption of this standard is discussed in Appendix A of Part I of the NSSP Manual of Operations.

RECOMMENDATIONS

The Mission recognizes the effort and progress that is being made in Korea toward the development of an effective program for the sanitary control of production of oysters for export as raw or frozen products. It also recognizes that the most feasible approach is to initiate the development of the program for export in a limited geographical area and, then, extend it countrywide to include all shellfish producing areas. This will result in essentially two programs; the production of shellfish for the domestic market and the production of shellfish for export, being carried out at the same time.

The development of the export program will progress through the increasing effort in shellfish culture, sanitary control of growing areas and harvesting, and the con-

struction and operation of shellfish-handling plant facilities. The higher sanitation standards for growing areas and harvesting and the more rigid requirements for plant facilities and operations must necessarily apply to the export program. The following recommendations, therefore, are made to strengthen the legislative authority and to provide for more effective administrative and technical controls over the sanitary production of shellfish for export.

1. Revise Article 3, Ordinance No. 218, designated areas, to include in the criteria reference to shellfish and other marine poisons and, thereby, bring the criteria into agreement with requirements of the NSSP Manual of Operations for an approved shellfish growing area.

2. Revise Article 7, Ordinance No. 218, sanitary surveys of sea water of a designated area, to specify that sanitary surveys of sea water be conducted more than once a month in shellfish harvesting seasons. It is suggested that the terminology, ''bacteriological examinations and related hydrographic determinations,'' be used.

3. Revise Article 16, Ordinance No. 218, processing of shellfish, to include the statement: ''Only shellfish that have been harvested from designated areas or subjected to an approved purification treatment shall be processed for export in registered plants.''

4. Revise Ordinance No. 218 to include references to important facilities requirements, processing standards, operational practices, and standards of shellfish quality to more nearly equalize the requirements of the Korean shellfish export program with those of the U.S. National Shellfish Sanitation Program.

5. Develop, as may be indicated in the future, more detailed operational standards and guidelines for the shellfish industry and for use by governmental control agencies, based on experience obtained from the construction and initial operations of shellfish-handling plants.

Part VI

INCIDENCE OF ENTERIC DISEASES IN KOREA

The relative incidence of waterborne or foodborne enteric diseases in the United States and in Korea, especially in Kyung Sang Nam Province, is an important factor in the application of United States sanitation standards in Korea. More specifically, the applicability of United States shellfish sanitation standards in Korea is determined by the degree of similarity between the two countries as to quality of shellfish growing waters, prevalence and nature of shellfish-borne diseases, and sanitary practices in handling shellfish. Since information and data on specific shellfish-borne infections or outbreaks in Korea are generally not available, consideration was given to the relative incidence in the United States and in Korea of selected diseases that may be transmitted by shellfish.

The reported monthly incidence of typhoid, paratyphoid, and dysentery (including bacillary dysentery, amebiasis, and other dysentery infections) in Korea for the period 1962 to 1966 is shown in Table 2. Typhoid is the most prevalent enteric disease, with annual case rates varying from 10.2 to 18.7 per 100,000 population over this 5-year period. The

Table 2. MONTHLY INCIDENCE OF SELECTED ENTERIC DISEASES IN KOREA, 1962 TO 1966

Year	Disease	Number of cases												Total	Case rate per 100,000 population
		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
1962	Typhoid (040)[a]	186	70	36	71	226	422	518	396	276	262	127	92	2,682	10.2
	Paratyphoid (041)	2	3	2	-[b]	-	12	20	1	1	-	2	-	43	0.2
	Dysentery (045-048)	3	2	3	-	2	11	7	40	9	23	1	-	101	0.4
1963	Typhoid (040)	123	91	137	139	240	410	859	795	942	635	355	193	4,919	18.7
	Paratyphoid (041)	-	2	-	-	2	5	8	7	1	1	-	1	25	0.1
	Dysentery (045-048)	3	22	1	1	2	59	47	88	532	15	29	19	818	3.1
1964	Typhoid (040)	184	207	233	221	349	561	779	853	470	262	254	207	4,380	15.5
	Paratyphoid (041)	7	8	3	-	5	4	6	-	2	1	-	1	35	0.1
	Dysentery (045-048)	-	-	2	-	14	42	109	98	78	87	8	-	434	1.5
1965	Typhoid (040)	157	188	83	53	184	456	849	572	473	370	242	175	3,760	13.1
	Paratyphoid (041)	3	-	-	1	-	1	8	1	-	9	1	-	22	0.1
	Dysentery (045-048)	26	3	5	10	1	45	170	39	9	22	12	13	355	1.2
1966	Typhoid (040)	182	122	218	157	319	483	518	484	304	248	196	265	3,454	11.8
	Paratyphoid (041)	1	-	-	-	28	1	1	2	2	-	-	1	34	0.1
	Dysentery (045-048)	-	-	2	11	3	52	44	1	12	4	1	3	133	0.4

[a] Numbers after diseases are category numbers from Manual of the International Classification of Diseases, Injuries, and Causes of Death, 1955 (7th rev.).[5]

[b] No cases reported.

highest frequency of occurrence of typhoid is during the summer and early autumn months.

The reported incidence of paratyphoid was generally very low. The annual case rates were 0.2 per 100,000 population for 1962 and 0.1 per 100,000 for the period 1963 to 1966. Although diagnostic sera are produced by the National Institute of Health for other salmonella serotypes, paratyphoid is the only reportable salmonella infection. In discussions with representatives of the Public Health Section of Kyung Sang Nam Province, the Mission was informed that diagnosis and reporting of other salmonella infections are incomplete.

The reported incidence of dysentery, including bacillary dysentery, amebiasis, and other dysentery infections, is generally low. The occurrence of 532 dysentery cases in September 1963 contributed heavily to the annual case rate of 3.1 per 100,000 population in that calendar year. Otherwise, the annual case rates varied from 0.4 to 1.5 per 100,000 over the period 1962 to 1966.

Infectious hepatitis is not a reportable disease in Korea, and no data are available on its prevalence.

Comparison of the incidence of several enteric diseases during the same period of 1962 to 1966 in Kyung Sang Nam Province, in all Korea, and in the United States is shown in Table 3. The only direct comparison is that of typhoid. The incidence of this disease is much higher in Korea than in the United States with the annual case rates varying from 7.8 to 16.7 per 100,000 population in Kyung Sang Nam Province and from 10.2 to 18.7 per 100,000 for all Korea. The annual case rates in the United States were 0.3 per 100,000 for 1962 to 1964 and 0.2 per 100,000 for 1965 and 1966.

The reported incidence of paratyphoid in Korea was much lower than the reported morbidity from this disease in the United States. The annual case rates for salmonellosis in the United States varied from 6.7 to 8.9 per 100,000 population over the period 1962 to 1966, and it is estimated that paratyphoid accounts for approximately 15 to 20 percent of the salmonella infections in this country.

The reported incidence of dysentery in Korea also was lower than the reported morbidity from this group of diseases in the United States. The annual case rates from shigellosis and amebiasis in the United States varied from 7.1 to 8.5 per 100,000 population, whereas in Korea the annual case rates for the group of dysentery infections varied from 0.4 to 5.2 per 100,000 for Kyung Sang Nam Province and from 0.4 to 3.1 per 100,000 for the entire country. It is interesting to note that the annual case rates for dysentery for 1964, 1965, and 1966 were greater in Kyung Sang Nam Province than for the country as a whole.

In discussions with representatives of the Public Health Section of Kyung Sang Nam Province, the Mission was informed that approximately 90 percent of the oysters consumed in Korea are eaten raw. The health officials indicated that no illness attributed to the eating of raw shellfish had been reported in the Province during the past several years. It was reported to the Mission that no paralytic shellfish poison or other shellfish toxins had been encountered in Kyung Sang Nam Province.

Table 3. COMPARATIVE INCIDENCE OF SELECTED ENTERIC DISEASES, KOREA AND UNITED STATES 1962 TO 1966

Year	Kyung Sang Nam Province		All Korea		United States		
	Disease	No. of cases	Rate per 100,000 population	No. of cases	Rate per 100,000 population	Disease	No. of cases	Rate per 100,000 population
1962	Typhoid (040)[a]	475[b]	10.8	2,682	10.2	Typhoid (040)	608	0.3
	Paratyphoid (041)	-	-	43	0.2	Salmonellosis (041-042)	9,680	5.2
	Dysentery (045-048)	40[c]	0.9	101	0.4	Shigellosis (045) (bacillary dysentery)	12,443	6.7
						Amebiasis (046)	3,048	1.6
1963	Typhoid (040)	253	7.8	4,919	18.7	Typhoid (040)	566	0.3
	Paratyphoid (041)	2	0.1	25	0.1	Salmonellosis (041-042)	15,390	8.2
	Dysentery (045-048)	13	0.4	818	3.1	Shigellosis (045) (bacillary dysentery)	13,009	7.0
						Amebiasis (046)	2,886	1.5
1964	Typhoid (040)	491	15.2	4,380	15.5	Typhoid (040)	501	0.3
	Paratyphoid (041)	6	0.2	35	0.1	Salmonellosis (041-042)	17,144	8.9
	Dysentery (045-048)	168	5.2	434	1.5	Shigellosis (045) (bacillary dysentery)	12,984	6.8
						Amebiasis (046)	3,304	1.7
1965	Typhoid (040)	445	13.9	3,760	13.1	Typhoid (040)	454	0.2
	Paratyphoid (041)	10	0.3	22	0.1	Salmonellosis (041-042)	17,161	8.9
	Dysentery (045-048)	103	3.2	355	1.2	Shigellosis (045) (bacillary dysentery)	11,027	5.7
						Amebiasis (046)	2,768	1.4
1966	Typhoid (040)	532	16.7	3,454	11.8	Typhoid (040)	378	0.2
	Paratyphoid (041)	5	0.2	34	0.1	Salmonellosis (041-042)	16,841	8.6
	Dysentery (045-048)	66	2.1	133	0.4	Shigellosis (045) (bacillary dysentery)	11,888	6.1
						Amebiasis (046)	2,921	1.5

[a]Numbers after diseases are category numbers from Manual of the International Classification of Diseases, Injuries, and Causes of Death, 1955 (7th rev.).[5]

[b]Cases for 1962 include Pusan City.

[c]No cases reported.

The Food Sanitation Law requires an investigation by a public health or city official of each reported case of food poisoning. If a person dies from food poisoning, the investigation must include an autopsy. The report of this investigation is made through the Provincial Governor to the Minister of Public Health and Social Affairs. Table 4 shows the number of incidents, cases, and deaths related to food poisoning from the consumption of fish, shellfish, and their products in Korea during the period 1963 to 1966. Efforts to secure from the Ministry of Health and Social Affairs information concerning the relationship of shellfish to specific food poisoning cases and deaths were not successful. Such information would provide valuable epidemiological evidence of the role of shellfish in disease transmission and human poisoning.

The prevalence of enteric diseases in any area is related to the level of sanitation, and especially with respect to that of the water supply, human waste disposal, and the production and handling of food products. While the enteric diseases considered above may be transmitted through the consumption of contaminated shellfish, the occurrence of these diseases may well be related to other

Table 4. FOOD POISONING IN KOREA ATTRIBUTED TO FISH,[a] SHELLFISH, AND THEIR PRODUCTS IN 1963 TO 1966

	1963	1964	1965	1966	TOTAL
Incidents	6	9	4	6	25
Cases	84	126	73	81	364
Deaths	1	2	1	0	4

[a]Does not include poisoning cases from swellfish *(Tetrodo)*, which in above period was responsible for 25 incidents, 210 cases, and 139 deaths.

sanitation factors. The Mission was able to secure only limited information concerning the direct relationship of shellfish to the prevalence of enteric diseases in Korea. Morbidity data indicate that typhoid is more prevalent in Korea than in the United States. Since the diagnosing and reporting of paratyphoid, other salmonella infections, shigellosis, and amebiasis in Korea may be incomplete, the Mission recognizes that available morbidity data tend to show a much lower incidence in Korea than in the United States. The Mission believes, however, that the shellfish sanitation standards followed in the United States can and should be applied in Korea to the production and handling of shellfish as raw and frozen food products for export. The position of the Mission in making this recommendation is supported by the incidence of enteric diseases, the potential for utilizing shellfish growing areas that are free from pollution, and by the capability of Korea for establishing plant facilities as adequate for the sanitary handling of shellfish as were those observed by the Mission for the handling of shrimp and other marine food products.

Part VII

LABORATORY SERVICES

Laboratory services associated with the sanitary control of shellfish are conducted chiefly at the main station of the Fisheries Research and Development Agency at Pusan. An organization chart of the Agency is shown in Figure 11.

Current activities consist of microbiological studies, primarily, and some chemical analysis associated with sanitary surveys of shellfish growing areas. These sanitary surveys are conducted by laboratories of the Utilization and Food Technology Section, but other sections of the Agency may be called on for technical assistance and advice in oceanography and marine biology. The Central Fisheries Inspection Office of the Office of Fisheries is responsible for inspection of fish and shellfish handling and for quality control, including analytical work, of the products. Laboratory service by the Inspection Office, however, is directed toward control of food value, not sanitary quality, and, therefore, is physical and chemical in nature. If microbiological problems are encountered, the Fisheries Research and Development Agency conducts the analysis at the request of the Central Fisheries Inspection Office.

The main microbiology laboratory, Figures 17 and 18, where sanitary microbiology is conducted, is adequate in space for the current level of work. The staff consists of three microbiologists, three technicians, and two aides. The staff is self-supporting. The responsibilities include collection of samples of water and shellfish from the growing areas, preparation of media and glassware, and assays. The laboratory has conducted some research, but effort in this field has been limited because of the need for work in sanitary surveys of shellfish growing areas.

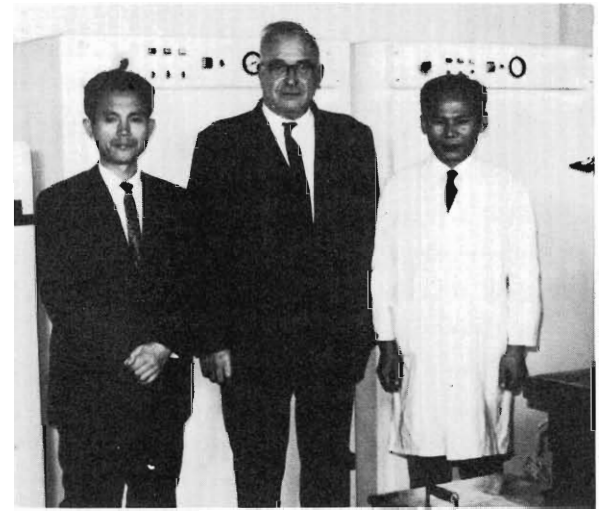

Figure 17. Senior microbiologists, Fisheries Research and Development Agency, with member of the Mission.

The laboratory, in general, is well equipped, but certain items, although in

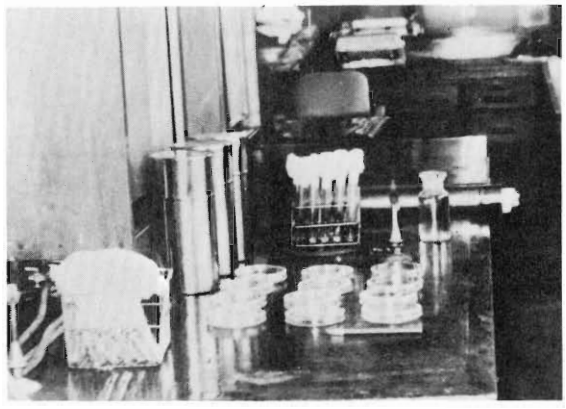

Figure 18. Microbiology laboratory, Fisheries Research and Development Agency.

good operating condition, are hardly of sufficient capacity for the large volume of work currently undertaken. They will be inadequate if the contemplated increased activity in sanitary survey work is initiated. Incubation associated with the EC test for fecal coliform organisms is conducted in an air bath incubator of limited capacity. It is recommended that the laboratory acquire one or two water baths of adequate size. This test requires precise temperature control, which is more readily accomplished in a water bath.

Methods of analysis, including sampling procedures were reviewed. Laboratory techniques were demonstrated by the microbiologists.

SAMPLING PROCEDURES

Samples of water are collected in glass-stoppered bottles. Depth samples are collected with the aid of a sampling device shown in Figure 19. The sampler has two lines: one to lower the samples to the desired depth and return, the other to actuate a lever that controls the raising and lowering of the stopper.

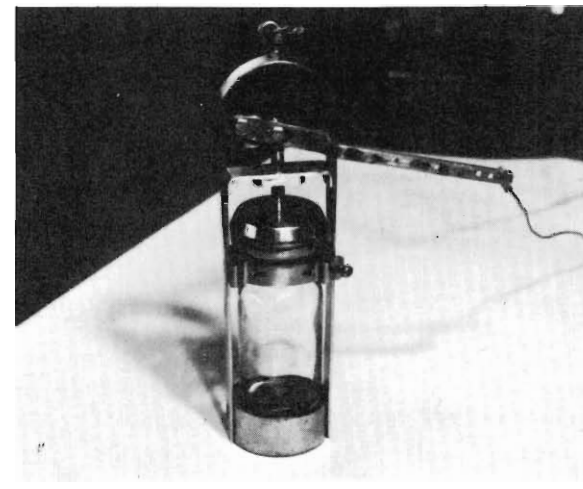

Figure 19. Bacteriological water sampler.

Samples of shellfish are collected from the bottom by hand or rake. Samples of oysters from hanging culture are taken by hand from all levels on the "string" so that the resulting sample is pooled. Shellfish are transferred to stainless steel cans, which are packed in ice for transportation to the laboratory.

The requirements of the (APHA) American Public Health Association Procedures for Laboratory Examination of Sea Water and Shellfish[6] regarding time between collection and examination of samples are strictly adhered to. Water as well as shellfish samples is refrigerated in transit and pending examination at the laboratory.

MICROBIOLOGICAL TECHNIQUES

The staff demonstrated the techniques followed in conducting plate counts and other microbiological tests for coliform and fecal coliform organisms. Strict conformity with APHA procedures was observed. Adequate dilutions and replicates of tubes or plates were prepared,

thus reducing to a minimum the frequency of indeterminate results. Equipment for 35°C incubation is operating satisfactorily and is currently adequate in capacity. The air bath incubator used for the EC test is limited in capacity and difficult to control so that it will maintain the temperature tolerances required by the test. We repeat the recommendation that adequate water bath incubators be acquired. The tanks are easily fabricated, and other components are obtainable in Korea. The Mission will furnish drawings and specifications for the components to the unit.

CHEMICAL AND PHYSICAL TESTS

Salinity and temperature are determined on all samples of sea water. Salinity is determined by the Knudsen method, involving titration with standardized solution of silver nitrate. This is a time-consuming method, although capable of a high degree of precision. The hydrometric technique[7] is much simpler; it can be performed in the field in a few seconds and, in the opinion of estuarine oceanographers, is of ample precision and accuracy for the purpose. Temperature of the water is determined by a reversing thermometer, shown in Figure 20.

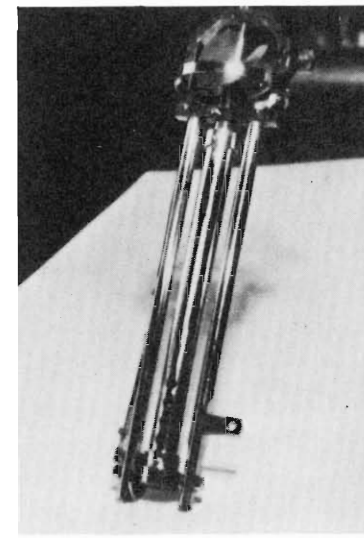

Figure 20. Reversing thermometer.

SUMMARY AND RECOMMENDATIONS

1. The Mission observed that the laboratory facilities at the Fisheries Research and Development Agency were adequate for the current workload. Increased interest in development of the shellfish industry may indicate the need for additional laboratory space.
2. The size and composition of the staff also are adequate for current routine activities, although not sufficient to allow time for research activities that are needed to provide technical knowledge.
   When increases in staff are considered, the Mission recommends the selection of sanitarians who can conduct sanitary reconnaissance and collect samples for the sanitary survey, and, also, assist the Oceanography Section in the collection of hydrographic data.
3. More of certain types of scientific equipment is needed, particularly sterilizers, both steam and hot air. Water bath incubators for the EC test, also, should be acquired. The Mission will assist the Fisheries Research and Development Agency in the acquisition of the water bath.
4. The staff of the microbiology laboratory is to be commended for strict adherence to established procedures and for the orderliness with which the laboratory is maintained and operated.

Part VIII

SANITARY SURVEYS OF OYSTER GROWING AREAS

SELECTION OF STUDY AREA

To demonstrate the application of the sanitary survey in the assessment of the sanitary quality of shellfish growing waters, a study area, which was used as a model, was selected. This area, lying entirely within Kyung Sang Nam Province, was chosen on the basis of its topographical characteristics and river flows influencing the general drainage of the land mass into the oyster growing waters. Some types of information and data concerning the area were readily available through the Provincial Office: population of cities, villages, and rural areas; rainfall; location and types of industrial activities; and practices of disposing of human and industrial wastes. In the actual practice of sanitary control of shellfish production, a field survey would be conducted to supplement the above information and data with the results of field observations and measurements of the environmental factors influencing the shellfish growing waters. Such a field survey, however, was beyond the work objectives of the present Mission. The study area was selected also because it represented present major oyster growing areas and because, since 1961, the Fisheries Research and Development Agency had conducted bacteriological studies of the growing waters in selected locations of the area. Some hydrographic information and data on the oyster growing area waters also were available through the bacteriological studies and other work of the Fisheries Research and Development Agency and the provincial Fishery Bureau.

DESCRIPTION OF THE STUDY AREA

The study area, Figure 21, may be defined as the land mass lying within the

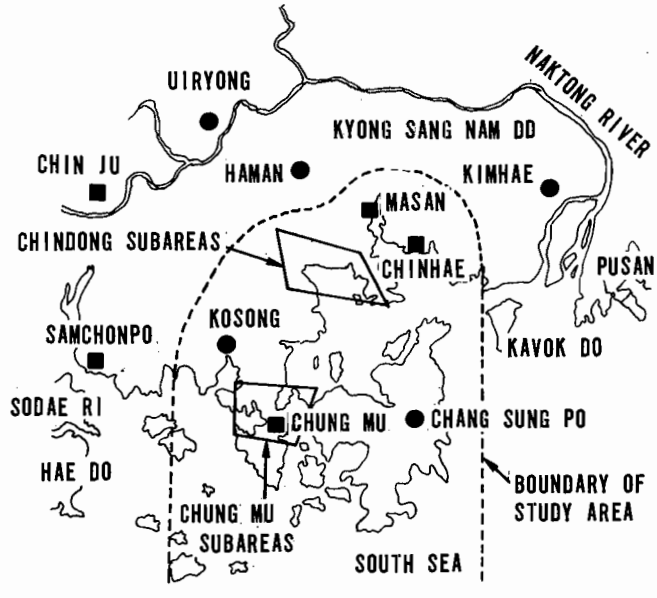

Figure 21. Location of study area and subareas in Kyong Sang Nam Province.

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geographical boundary of a line drawn from the south coast at a point approximately 20 kilometers west of Kosong City in a northeasterly direction, along the highest mountain ridges, to a point approximately 10 kilometers north of Masan City and, then, in an easterly direction, along the higest mountain ridges, to the western edge of the Naktong River basin area. This boundary outlines an overall general drainage basin. The topography of the land mass and the direction of flow of the rivers in this area are such that rainfall in the area drains generally toward the south coast and the adjoining coastal waters. The study area also includes the adjoining estuarine waters and many islands along the southern coast of the land mass described above. Drainage from these islands influences the quality of the estuarine water adjacent to their shore lines. The study area includes all or parts of the following guns (counties): Kimhae, Haman, Changwon, Kosung, Tongyong, and Koje Do.

The principal cities in the study area and their estimated present populations are as follows: Masan, 158,000; Chinhae, 76,000; Chung Mu, 52,000. The study area also includes a number of towns and villages. The estimated present population of the towns, villages, and rural sections of the study area is 500,000. Thus, the present total population of the study area is estimated at approximately 786,000.

The lower end of the Naktong River, which drains a large area of central and southern Korea, was not included in the specific study area. It should be noted, however, that bacteriological studies of oyster growing waters at Nulcha Ri northeast of Kadok Do were conducted during July 1961 through June 1962. The results of these studies indicated that the increased flow and discharge of the Naktong River into coastal waters during the rainy months of July and August adversely affected the bacteriological quality of the estuarine waters at this sampling station. During this rainy period, these estuarine waters would be considered unsuitable in quality for the growing of oysters for direct harvesting for human consumption as a raw or frozen food product.

SANITARY SURVEYS

The complete sanitary survey of a shellfish growing area to evaluate the degree of pollution that exists, or may prevail under the most unfavorable hydrographic and seasonal conditions, is the most important element in a shellfish sanitation program. In the United States, the National Shellfish Sanitation Program is conducted cooperatively among the States, the shellfish industry, and the Public Health Service. Under the Program, the shellfish control agency in each state is required to make a comprehensive survey of all factors influencing the sanitary quality of a growing area, keep the survey information up to date, and revise it as may be necessary. The growing area is classified for use in the harvesting of shellfish on the basis of the sanitary survey information.

The purpose of the sanitary survey is to identify and evaluate all of the factors influencing the sanitary quality of the growing area. The most important factors are the sources of actual and poten-

tial pollution that are discharged into the estuarine areas or inflowing rivers: municipal sewage, pollutants from industrial activities, wastes resulting from agricultural practices, and human wastes from fishing boats, merchant ships, pleasure craft, and other types of vessels. Other factors influencing the sanitary quality of a growing area include: the amount and seasonal distribution of the rainfall, which may produce surface runoff from polluted areas; and hydrographic conditions, especially the tidal currents prevailing in the waters of the growing area.

Three general sources of pollution are present in the study area: night soil, which may reach the oyster growing waters indirectly as runoff from rice fields and other crops; industrial wastes; and urban area drainage, which also may include effluents from septic tanks. Information concerning wastes from these sources and their influence on oyster growing waters is presented and discussed below.

NIGHT SOIL DISPOSAL

At the present time, there are no municipal sewage treatment plants in Korea, but it was reported to the Mission that United States and Korean military bases have sewage treatment facilities. A survey for the construction of a sewage system, including a treatment plant in Seoul, is now underway.

The common practice in the study area as well as throughout Korea is to dispose of human wastes as night soil. In the urban areas, night soil is collected from individual households in tank trucks and transported to concrete holding vaults, or digestion tanks. The night soil is stored in the digestion tanks for a period of 2 to 3 months and is then dried on drying beds. The collection and handling of night soil in the urban areas is carried out generally under contract, with supervision provided by municipal authorities. In the rural areas, there is generally no treatment of night soil.

There is extensive use of night soil as a fertilizer on rice fields and other crops throughout Korea. In view, however, of the high incidence (estimated to be about 80 percent) of the intestinal parasites among the human population, the Ministry of Health and Social Affairs and the Office of Fisheries have recently issued a joint proclamation to become effective March 1, 1968 to substitute the use of chemical fertilizers for night soil in agricultural practices relating to the growing of green vegetables.

Throughout the study area and on all watersheds of the oyster growing areas, rice fields were observed by the Mission. While the extent of rice culture varied with the particular area, the rice fields generally were located along the shorelines and extended up the sides of hills and mountains or were situated in the valleys of rivers and streams. The physical locations of rice fields were such that surface runoff and increased stream flow from rainfall would pass through the fields to the estuarine areas. Rice fields are prepared, and planting is accomplished generally at the beginning of the periods of heavy rainfall. It is the opinion of the Mission that surface runoff from rice fields and other crops fertilized with night soil is the principal source of pollution of oyster growing areas. Reduced use of night soil as a

fertilizer will result in less pollution of oyster growing waters following heavy rainfall and surface runoff. It appears that the most effective immediate approach would be to locate the oyster growing areas where the polluting influence of runoff from rice fields can be avoided.

INDUSTRIAL WASTES

The discharge of untreated industrial wastes in estuarine areas may create undesirable conditions in the waters for the growing and direct harvesting of shellfish for human consumption. This is particularly true if the industrial wastes include heavy metals, pesticides, or various chemicals that may be taken up from the marine environment and concentrated by the shellfish. The sanitary survey, therefore, should include a determination of the types and locations of industrial plants, the kinds of products manufactured, and information on the wastes produced, their treatment, and their final disposal. The information and data on industrial waste treatment and disposal should be analyzed and evaluation made of the effect that final disposal practices may have on shellfish growing waters.

National Law No. 1436, promulgated November 5, 1963, provides legislative authority to the Minister of Public Health and Social Affairs to prevent hazards to public health and sanitation that may result from pollution of air and rivers caused through the operation of factories and places of business. An ordinance to implement and enforce this law was promulgated by the Ministry of Public Health and Social Affairs on May 14, 1967. As a result of this ordinance, the Bureau of Public Health and Social Affairs of Kyung Sang Nam Province is conducting a survey of industrial establishments and the handling of industrial wastes in the Province. Available information on the industrial establishments in the Masan and Chinhae areas is shown in Table 5.

The Mission visited a present oyster growing area located in a small bay of Masan Man approximately 5 kilometers south of Masan City. No studies have been conducted on sea water or oyster meats from this area to determine the presence of any industrial wastes in the water or the accumulation of these materials by the oysters.

The Mission also visited two fishery plants, one a cannery and the other a frozen products plant, in Chung Mu City. The plants were not operating at the time of the visit. It was reported to the Mission, however, that waste fishery products are used for the production of fish meal for chicken and cattle feed and that liquid wastes from these plants are discharged into the waters of the harbor area. The final disposal of these liquid wastes does not affect the quality of the oyster growing waters because of the intervening distance to the oyster growing areas and the dilution provided by the waters of the harbor area.

DRAINAGE FROM URBAN AREAS

Cities and other urban areas in Korea are provided with surface and subsurface drainage systems primarily for the purpose of draining the areas of storm and other surface waters. These drainage systems discharge into larger open drainage channels, streams, and rivers. While the predominant practice in urban areas is

Table 5. INDUSTRIAL WASTES DISCHARGED TO MASAN AND CHINHAE BAYS

Name of plant	Nature of product	Metric tons of wastewater per day	Treatment of wastewater	Effluent discharged to
Masan Area				
Yuwon Industrial Co.	Alcohol	1	No treatment	River
Baikwang Brewery	Wine	2	No treatment	River
Namsung Textile Co.	Woolen materials	5	No treatment	River
Taeyong Co.	Cotton clothes	5	No treatment	River
Monggo Soy Sauce Co.	Food products	2	No treatment	River
Mikwang Soy Sauce Co.	Food products	1	No treatment	River
Kunsul Paper Mill	Reprocessing of paper products	5	No treatment	River
Taeyong Industrial Co.	Metal manufacturing	1	No treatment	River
Hunga Plant	Cotton clothes	5	No treatment	River
Sanchung Chemical Co.	Chemical materials	1	No treatment	River
Taeyong Textile Co.	Woolen materials	5	No treatment	River
Samyan Paper Co.	Reprocessing of paper products	5	No treatment	River
Yangtuk Paper Co.	Reprocessing of paper products	5	No treatment	River
Hwakwang Dyeing Plant	Cloth dyeing	3	No treatment	River
Tong A Textile Co.	Textile products	5	No treatment	River
Jeil Chemical Plant	Medicines	1	No treatment	River
Kwasung Textile Plant	Textile products	5	No treatment	River
Korea Textile Plant	Textile products	5	No treatment	River
Masan Rubber Plant	Reprocessing of rubber products	3	No treatment	River
Taeshin Paper Plant	Reprocessing of paper products	5	No treatment	River
Masan Paper Plant	Reprocessing of paper products	5	No treatment	River
Taepung Fisheries Co.	Canned food	1	No treatment	River
Korea Woolen Co.	Woolen materials	5	No treatment	Sea
Taerim Paper Plant	Reprocessing of paper products	5	No treatment	Sea
Masan Food Co.	Food products	1	No treatment	Sea
Hanil PVC Plant	Plastics (PVC products)	600	Complete treatment	River
Chinhae Area				
Chinhae Brewery	Rice wine	2	No treatment	River
Shinhung Industrial Co.	Metal products	1	No treatment	River
Shinjin Chemical Plant	Welding materials	1	No treatment	River
Chinhae Chemical Plant	Urea fertilizer	40,000	No treatment	Sea
Chinhae Industrial Co.	Food products	3	No treatment	River
Chinhae Beverage Plant	Soft drinks	2	No treatment	River
Hasung Brewery	Rice wine	2	No treatment	River
Uishin Textile Plant	Textile products	10	No treatment	River
Taepyong Yang Brewery	Rice wine	2	No treatment	River

to dispose of human wastes as night soil, many larger buildings are served by septic tanks from which effluents may find their way to storm water drains or to streams and rivers. In the study area, the distance of the principal oyster growing areas from the cities would indicate that surface drainage from these urban areas is not likely to be a major source of pollution affecting the oyster growing waters at the present time.

METEOROLOGIC AND HYDROGRAPHIC STUDIES

In making an evaluation of the sanitary quality of a shellfish growing area, the meteorologic and hydrographic factors responsible for the dilution and dissemination of polluting materials in the shellfish growing waters must be studied. These factors include rainfall, discharges of rivers into the estuarine areas, volume of receiving waters in relation to surface runoff and river discharges, wind velocity and direction, and tidal currents and flow patterns in the receiving waters and in oyster growing areas.

A limited amount of meteorologic and hydrographic information and data relating to the study area were available to the Mission. Information on monthly rainfall from 1963 to date in 1967 for Tongyong Gun, Changwon Gun, and Kosung Gun is shown in Tables 6 through 8. These Guns include all of the specific areas in which bacteriological studies have been conducted and are now being conducted, as described later in this report following this section. The rainfall pattern shows that in all these areas the period of heaviest rainfall and runoff occurs generally from April through August. This period corresponds to the latter part of the harvest season for the early set of oysters but does not include any of the harvest season for the late set of oysters. The data in Tables 6 through 8, however, indicate that the

Table 6. RAINFALL[a] IN TONGYONG GUN AREA[b]

	1963	1964	1965	1966	1967	Average
January	0.8	26.8	40.2	20.0	27.5	23.1
February	0	130.8	31.7	76.1	49.1	57.5
March	41.0	63.0	31.2	122.4	103.3	72.2
April	203.1	336.8	106.5	125.4	165.3	187.4
May	298.9	26.9	89.0	124.0	49.3	117.6
June	924.0	190.6	65.2	117.5	144.8	288.4
July	424.4	106.4	484.2	164.0	151.2	266.0
August	84.5	8.5	380.5	295.3	88.7	171.5
September	93.1	181.6	19.0	33.2	32.0	71.8
October	46.2	20.6	38.9	91.4	-	49.3
November	3.0	2.2	147.2	109.9	-	65.6
December	36.6	0	34.2	12.1	-	20.7
Total	2,155.6	1,144.2	1,467.8	1,991.3	-	1,689.7

[a] Rainfall in millimeters.

[b] Includes all Chung Mu subareas. (See Table 9.)

Table 7. RAINFALL[a] IN CHANGWON GUN AREA[b]

	1963	1964	1965	1966	1967	Average
January	0	67.6	45.9	10.9	23.9	29.5
February	0	53.0	24.5	54.1	86.9	43.7
March	49.3	58.5	37.3	188.1	86.7	84.0
April	262.5	301.1	92.7	128.8	161.1	189.2
May	215.0	61.2	77.0	143.2	93.0	117.9
June	876.3	181.4	33.4	101.3	178.8	274.2
July	319.2	169.9	574.1	192.7	177.9	286.7
August	115.8	64.8	286.5	251.1	41.1	151.9
September	29.4	333.6	16.2	35.3	47.5	92.4
October	59.2	12.2	38.2	51.7	-	40.3
November	9.5	2.1	130.8	128.8	-	67.8
December	32.0	0	34.6	11.1	-	19.4
Total	1,968.2	1,307.4	1,391.2	1,297.1	-	1,491.0

[a]Rainfall in millimeters.

[b]Includes major parts of Chinjen and Chindong subareas and all of So-Su Island and Yong Ho subareas. (See Table 9.)

Table 8. RAINFALL[a] IN KOSUNG GUN AREA[b]

	1963	1964	1965	1966	1967	Average
January	0.4	72.2	37.3	15.6	30.6	31.2
February	3.0	65.7	29.9	58.3	64.4	44.3
March	52.5	65.6	28.3	177.7	93.5	83.5
April	219.0	315.5	110.3	126.8	182.0	190.7
May	236.2	95.3	105.8	133.6	50.4	124.3
June	1,455.7	105.7	38.9	111.4	162.2	374.8
July	383.4	51.0	483.3	141.0	203.8	252.5
August	139.5	57.0	277.9	279.4	36.0	158.0
September	57.2	204.3	6.7	37.4	57.5	72.6
October	11.0	10.9	53.1	52.8	-	31.9
November	7.2	3.6	144.1	84.8	-	59.9
December	22.7	0	50.6	10.0	-	20.8
Total	2,587.8	1,046.8	1,366.2	1,228.8	-	1,557.4

[a]Rainfall in millimeters.

[b]Includes all of So Po subarea. (See Table 9.)

amount of rainfall varies considerably even during the drier months in which heavy rainfalls may occasionally occur.

Two rivers, the Chinsan and the Chindong, are located within the study area and discharge into bodies of water that are parts of Chinhae-Man. The discharges of these rivers, especially during the periods of increased stream flow, would affect oyster growing areas. Efforts to obtain river flow and discharge data on these two rivers were unsuccessful, and it was reported to the Mission that such data are not available. This information would be important in evaluating the quality of oyster growing waters in the areas receiving the river discharges.

Information and data on tidal heights, temperature, salinity, and pH of the sea water were obtained during bacteriological studies conducted by the Fisheries Research and Development Agency. The Agency and the provincial Fishery Bureau also have limited information on flow patterns in the oyster growing waters of the study area. During the field visit to the oyster growing areas in Tongyong Gun, the Mission observed noticeable tidal currents. The flow patterns resulting from tidal currents would have a significant effect on the dissemination of any polluting materials that might reach the oyster growing waters. It is the opinion of the Mission that more detailed hydrographic studies with special attention to tidal currents, flow patterns, and wind velocity and direction should be made and incorporated in the sanitary surveys of oyster growing areas.

BACTERIOLOGICAL STUDIES

Bacteriological studies of selected oyster growing areas within the study area have been conducted since 1961. The first survey, conducted during the period July 1961 through January 1965, was a preliminary reconnaissance over a wide area. Ten sampling stations were established, mostly in the Chindong and Chung Mu regions, representing different levels of sanitary quality of growing area and type of culture of oysters. Sampling tours were conducted monthly for periods of 12 to 18 months.

In 1966, a more detailed study of three subareas in the Chindong region was conducted. Twenty-six water-sampling stations and five oyster-sampling stations were established. Sampling tours were conducted twice monthly from May 1966 to May 1967. Detailed study of three subareas west of Chung Mu was initiated in April 1967 and will continue through May 1968.

The subareas of the Chung Mu and Chindong regions in which bacteriological studies have been conducted are listed in Table 9. The locations of the Chung Mu subareas with the watershed areas outlined are shown in Figures 22 and 23. The locations of the Chindong subareas with the watershed areas outlined are shown in Figure 24. An illustration of the topographic features and land utilization of these subareas is shown in Figure 25. Each of the subareas is described below.

Details of methods utilized in the bacteriological studies for the collection of water and oyster samples will be found in the section of this report on the evaluation of laboratory methods. Bacteriological methods were in accordance with APHA Recommended Procedures for the Bacteriological Examination of

Table 9. SUBAREAS OF CHUNG MU AND CHINDONG REGIONS

Chung Mu Region Subareas	Chindong Region Subareas
I. Puk Man	I. Chinjen
II. Popsong Po	II. Chindong
III. Tong Nae	III. So Su
IV. Gen Nae Raeng	IV. So Po
V. Do Sun Ri	V. Yong Ho
VI. Yong Un Ri	
VII. Punghwa Ri	

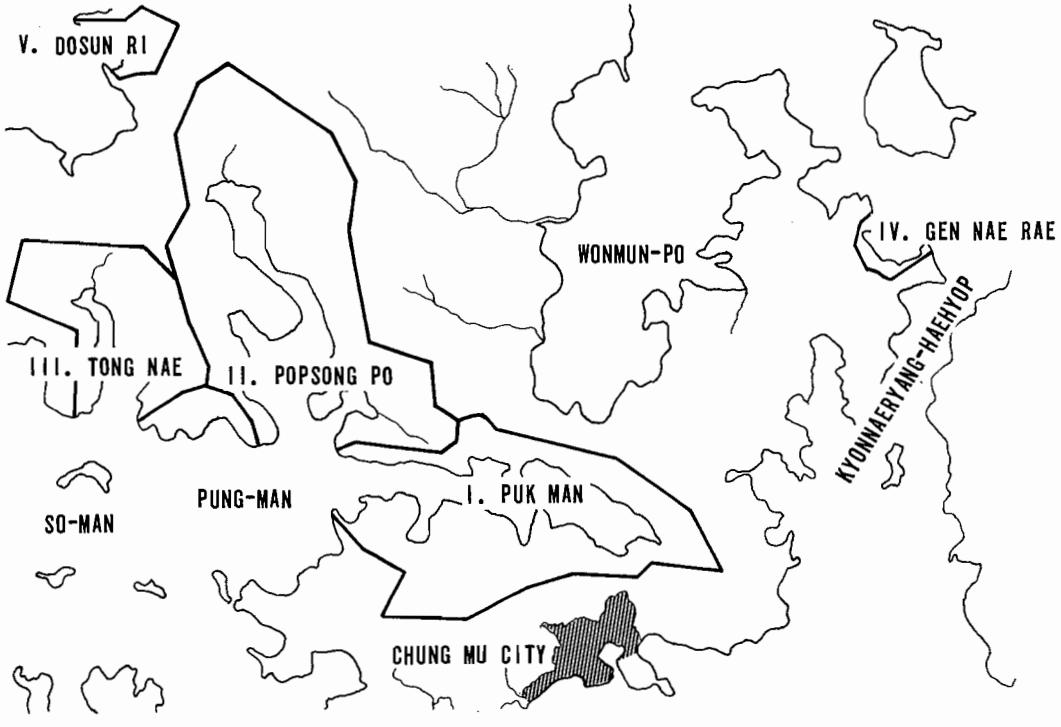

Figure 22. Chung Mu subareas.

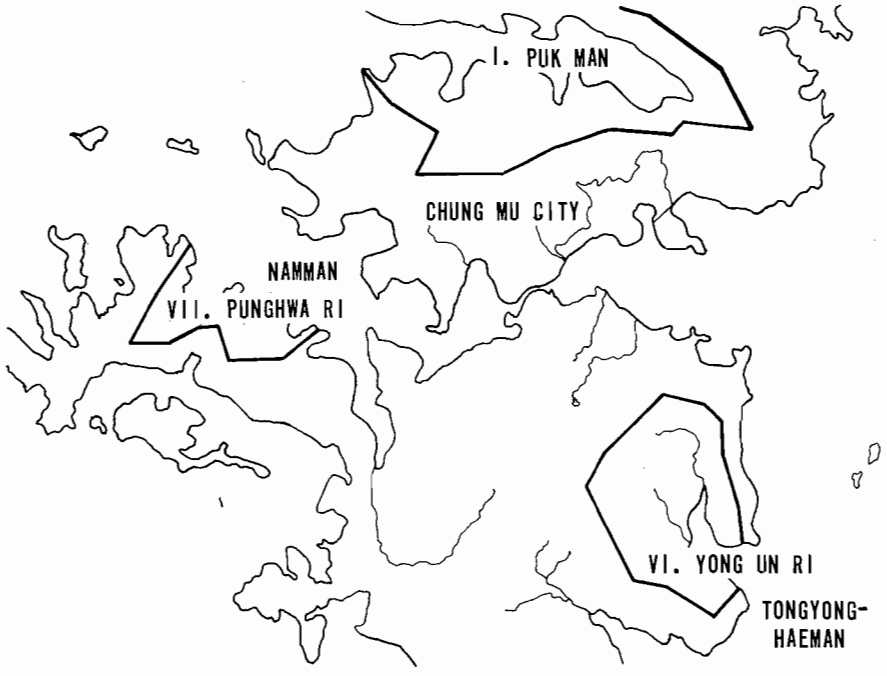

Figure 23. Chung Mu subareas.

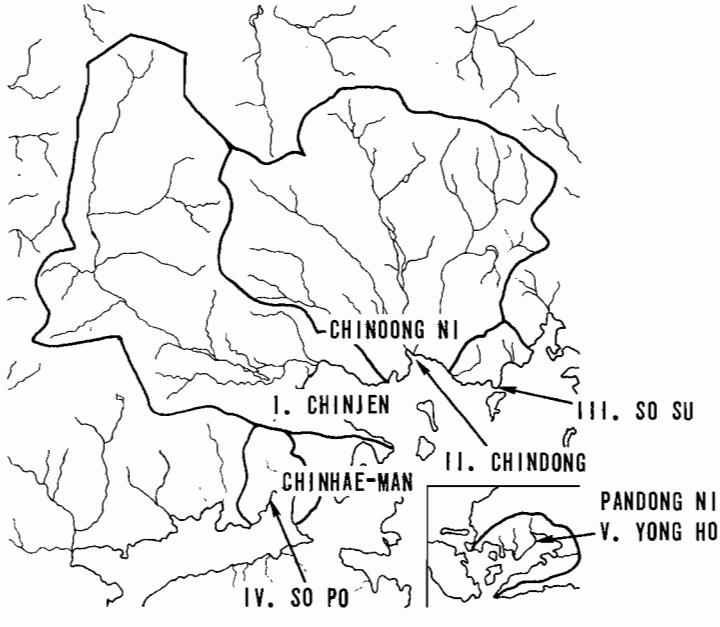

Figure 24. Chindong subareas.

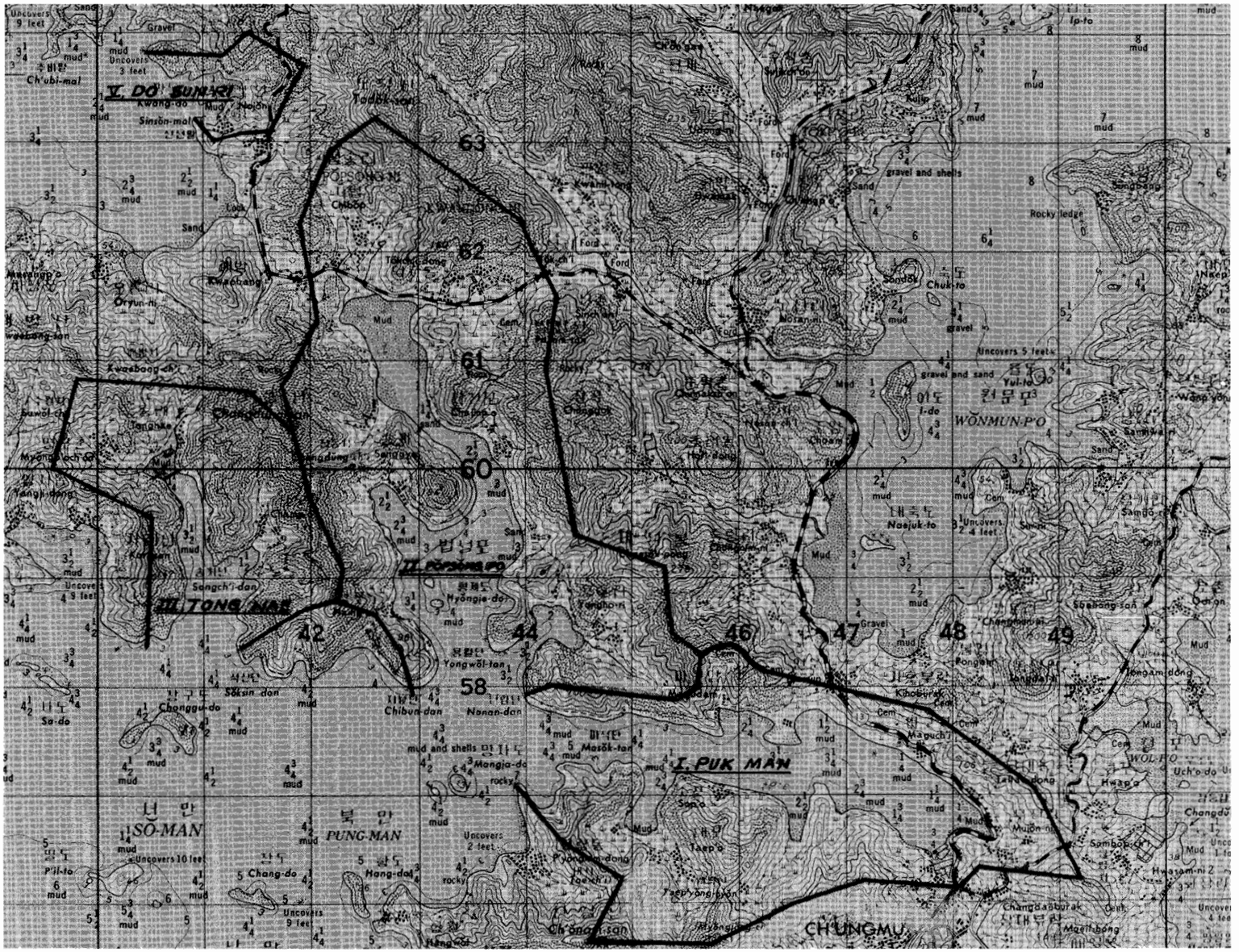

Figure 25. Topographical map of oyster producing areas.

Sea Water and Shellfish.[6] Salinity was determined by the Mohr titration method.

Detailed summaries of laboratory results are given in Tables C1 through C4 in Appendix C. Discussions of the results are presented in the comments on the subareas that follow.

CHUNG MU REGION

SUBAREA I: PUK MAN

The Puk Man subarea is located immediately northwest of Chung Mu City. The water area is approximately 4.5 kilometers long and 0.5 kilometers wide, lying generally in an easterly-westerly direction with the western end opening into Pung Man. The watershed is approximately 6.3 square kilometers in area. Almost the entire eastern end of the watershed is characterized by relatively low land and by hills gently rising to elevations of about 100 to 120 meters. Extensive rice crops are located along the shoreline of the entire eastern end. The western end of the watershed is more mountainous, with peaks rising to over 250 meters. Since rice is grown in the valleys between the steep hills, the quality of the water area is influenced considerably by drainage from the rice fields, especially in the eastern end. Little if any drainage from Chung Mu City flows into the water area.

Bacteriological studies in the Puk Man subarea were initiated in April 1967 and will continue through May 1968. Twelve sampling stations were established for the collection of water samples. At 2-week intervals, oyster samples were collected from rafts located at three of these stations.

Relatively high coliform and fecal coliform MPN's were found in water samples collected at the eastern end of the bay and in two coves at the western end. Fecal coliform MPN's of the oyster samples reflected the high water values. Seven of the 11 oyster samples taken at one station and 5 at another showed fecal coliform MPN's in excess of 230 per 100 grams, the currently recognized upper limit for oysters at the market level in the United States.

The results reported on this subarea and on Popsong Po and Tong Nae (discussed below) were obtained during the rainy months and, therefore, may reflect considerable influence by runoff from the adjoining farmlands. Final judgment on the quality of these areas should be deferred until sampling is conducted during the oyster harvesting season.

SUBAREA II: POPSONG PO

The Popsong Po subarea adjoins the northwest watershed boundary of the Puk Man subarea. The water area, which lies in a northerly-southerly direction, is approximately 2.5 kilometers in length and the width varies from 0.2 kilometers at the upper end to approximately 1.0 kilometer at the southern end, which opens into Pung Man. The water area previously extended 1.3 kilometers further north, but this area has been filled in behind a dam located at the present upper end and the filled in area is currently being used for growing rice. The watershed is approximately 8.5 square kilometers in area.

The upper or northern end of the watershed is characterized by a steep mountainous terrain with peaks reaching an

elevation of 300 meters. The southern end of the watershed is less mountainous. Extensive rice crops are grown in the northern end of the watershed area, and the surface runoff from the rice fields would influence the quality of the water area, especially in the more northerly parts of the estuary.

Nine water-sampling stations were established in the Popsong Po subarea. Oyster samples were collected from rafts at two of these stations.

The effect of runoff is clearly demonstrated in the results of bacteriological tests of water samples. Exceptionally high fecal coliform MPN's were obtained at almost all stations on July 1, following heavy rains. Coliform and fecal coliform densities of the oysters reflected the increase in fecal coliform in the water. Oysters showed fecal coliform MPN's of more than 180,000 and 98,000 of the samples collected July 1. High fecal coliform values in oysters continued during the rainy period of July and August.

SUBAREA III: TONG NAE

The Tong Nae subarea adjoins the western boundary of the Popsong Po subarea. The water area lies in a northerly-southerly direction, with the southern opening into So Man. The bay is approximately 1.7 kilometers in length and varies in width from 0.1 kilometers at the northern end to 1.8 kilometers at the southern end, or mouth, of the bay. The watershed is approximately 4.0 square kilometers in area. The northwest part of the watershed is characterized by relatively low land near the water, increasing to an elevation of about 200 meters at the northern boundary of the watershed, where two villages are located. Rice is grown throughout this subarea. In the northeastern and southern parts of the watershed where the terrain is generally more hilly, less rice is grown.

The results of bacteriological tests in the Tong Nae subarea were similar to those obtained in the Puk Man and Popsong subareas. A sharp rise in fecal coliforms of the water and oysters occurred in July, and the fecal coliform MPN's of the oysters continued to be high during the month of August, followed by a sharp reduction in September.

SUBAREA IV: GEN NAE RAENG

The Gen Nae Raeng subarea is located northeast of Chung Mu City on the far northeast coastal edge of the mainland. The water area may be described as a semicircular cove with a radius of approximately 0.7 kilometers, and opening into the northern end of Kyonnaeryang-Haehyop. The watershed area is a strip of relatively low level land from 0.1 to 0.2 kilometers wide, bordering the cove. A small village is located on the western edge of the watershed. There are no other unusual characteristics of the watershed. The waters of the bay, however, may be influenced by surface drainage from rice fields lying to the west of the watershed and across Kyonnaeryang-Haehyop on Koje Island, depending upon tidal currents and water movement through Kyonnaeryang-Haehyop.

The Gen Nae Raeng subarea was studied for an eleven-month period from March 1964 through January 1965. Thus, a complete cycle of seasonal variation was encompassed.

The low bacteriological test results obtained at this station reflect the small immediate watershed and the wide opening into a large bay. Influence by runoff is seen only during the season of heavy rain, when sharp rises in fecal coliforms occur in water and oysters. The small contributing watershed, however, and free circulation into the outer estuary result in quick recovery and in good quality of water and oysters during the harvesting season.

SUBAREA V: DO SUN RI

Do Sun Ri subarea is located northwest of the Popsong Po subarea. The water area is a small cove opening in a westerly direction into Kosong Man. The cove is approximately 0.5 kilometers in length and 0.3 kilometers in width at the entrance, where a small island, Kwang-do, is located. The watershed is approximately 0.7 square kilometers in area and is characterized by hills reaching an elevation of about 100 meters on the north and northeast sides. Rice is grown along the eastern side of the cove, and runoff from this area may affect the quality of the water. A small village is located in the southern part of the watershed along the shoreline of the cove.

A bacteriological survey of the Do Sun Ri subarea was conducted over a ten-month period, starting in March 1964. With the exception of one sample collected in May, excellent results were obtained from bacteriological tests. The results of this one sample, however, and of those that immediately preceded and followed it showed that the oysters responded rapidly to changes in the coliform content of the water, increasing in coliform content in proportion to the increase in that of the water and recovering rapidly as the water returned to normal low values.

SUBAREA VI: YONG UN RI

Yong Un Ri subarea is located south of Chung Mu City. The water area, Minik Po, is a small L-shaped bay opening in an easterly direction into Tongyong Haeman. The water area is approximately 1.5 kilometers in length from the head of the bay to the opening into Tongyong Haeman, where it is approximately 0.9 kilometers in width. The watershed, approximately 3.7 square kilometers in area, is large in relation to the water area. The extreme western part of the watershed is characterized by mountains with one peak reaching an elevation of over 400 meters. Rice is grown in the northern and southern parts of the watershed, and three small villages are located along the western edge of the water area.

The bacteriological results reflect the presence of a relatively large watershed. In addition to peaks in fecal coliform MPN's in the water and oyster samples in June, there are fluctuations in the oyster fecal coliform MPN's during the fall and winter. This suggests an influence by occasional rains during these periods.

SUBAREA VII: PUNGHWA RI

Punghwa Ri subarea is located southwest of Chung Mu City. The water area includes three small coves opening into Namman and provides for free and rapid interchange of water with the larger bay. The watershed is approximately 1.5 square kilometers in area. The western part of

the watershed has hills ranging up to over 150 meters; the eastern part is less hilly. Rice is grown in the central part of the watershed, and surface drainage from this area may be expected to influence the quality of water in the two more westerly coves.

A bacteriological survey of the Punghwa Ri subarea was conducted during an 11-month period, beginning in March 1964. Some effect by runoff was found in oyster and water samples during the rainy season. Three of four oyster samples showed fecal coliform MPN's in excess of 230. Rapid recovery, however, to low fecal coliform MPN's of water and oysters occurred in July, and low values prevailed during the oyster harvesting season.

The low bacteriological test results reflect the topographic characteristics of this subarea, which are similar to those of the Gen Nae and Do Sun Ri Raeng subareas: a small open cove leading into a large estuary and a relatively small contributing watershed.

CHINDONG REGION

SUBAREA I: CHINJEN

The Chinjen subarea is located west of Chindong Ri and Masan Man. The water area, trapezoidal in shape, lies in a northwesterly-southeasterly direction and is approximately 3.5 kilometers in length and 1.2 kilometers in width. The mouth of the bay is part of Chinhae Man. The upper one-third of the bay is very shallow, varying in depth up to 1 meter. The watershed, approximately 70.5 square kilometers in area, is one of the most extensive of all of the subarea watersheds considered in this report. The boundary of the watershed, especially in the northern part, is formed by high mountain ridges with elevations up to 600 meters. The area is drained by eight small streams that come together at different points to form the large Chinsan River system that flows into Chindong Man, which is part of Chinhae Man. Rice is grown extensively along the Chinsan River system and in the valleys of all the smaller tributary streams. Surface runoff from these rice fields would directly influence the quality of the water in the bay, especially in the more shallow upper end of the bay.

A preliminary survey of the Chinjen subarea was conducted during the period, July 1962 to December 1963, and one sampling station (E-3) was established for collection of water and oyster samples. A detailed study was conducted from May 1966 to May 1967. Thirteen sampling stations were established in the Chinjen subarea, and samples of oysters were collected from a bottom culture area located at the head of the bay.

Wide fluctuations occurred in the water and oyster fecal coliform MPN's. Excessively high values prevailed from June through October, and occasional rises in water fecal coliform MPN's resulted in corresponding increases in those of the oysters. The increases in fecal coliform MPN's of the water and oyster samples usually were accompanied by reduction in salinity, indicating the association with freshwater runoff.

SUBAREA II: CHINDONG

The Chindong subarea is located west of Masan Man. The water area is a cove

with a shoreline of approximately 6 kilometers, which faces Chinhae Man. Chindong Ri is located on the shore of the cove. The upper part of the cove is shallow, with depths of up to 1 meter. The watershed, approximately 73.0 square kilometers in area, is the largest of all the subarea watersheds considered in this report. The boundary of the more northerly part of the watershed is formed by a ridge of mountains with peaks over 600 meters in elevation. The watershed is drained by four major stream systems, three of which join to form the large Chindong River that empties into the water cove and Chindong Man, which is the upper part of Chinhae Man. Rice crops are grown extensively in the valleys of all of the streams in the watershed and along the Chindong River, especially in the vicinity of Chindong Ri at the entrance to the water cove and Chindong Man. Surface runoff from these extensive rice growing areas would definitely influence the quality of the oyster growing waters.

Bacteriological studies were conducted in the Chindong subarea during the same period in which the detailed study of the Chinjen subarea was made. Nine water sampling stations were established, and oyster samples were collected from a bottom culture bed and from a raft culture in close proximity to each other.

As would be expected from the topographic features, the Chindong area fluctuates widely in water and oyster fecal coliform MPN's, reaching very high values during the rainy season. Of perhaps greater significance is the fact that similar peaks in MPN's, although lower than in the spring, occur throughout the oyster harvesting season, suggesting quick response to and recovery from occasional rains in some portions of the very large watershed.

SUBAREA III: SO SU

The So Su subarea is located southeast of the Chindong subarea and includes the northern part of Su-U Island. The water area lies between the mainland and the north shoreline of Su-U Island, and comprises approximately 0.5 square kilometers. The watershed on the mainland is approximately 2.75 square kilometers in area, with the northern boundary defined by mountain ridges reaching elevations of over 200 meters. The northern part of Su-U Island, comprising an area of about one-eighth of a square kilometer, also, is a watershed to the body of water between the Island and the mainland. Rice is grown in the valleys of streams draining the watershed of the mainland and discharging into the sea at the eastern and western ends of the watershed area. Rice also is grown in valleys on the mainland immediately adjacent to the oyster growing waters. Surface runoff from these rice growing areas, therefore, may be expected to influence the quality of the oyster growing waters.

The results of bacteriological tests in the So Su area are similar to those obtained in the Chinjen and Chindong areas. This is to be expected since they are closely interrelated estuaries, and exchange of water probably occurs among these areas. The influence of the Chinjen and Chindong watersheds, as well as others, can be determined only by oceanographic studies of the entire Chinhae

Man. Because of the fluctuating and unpredictable bacteriological quality, the Chinjen, Chindong, and So Su areas should be considered the most undependable of those studied.

SUBAREA IV: SO PO

The So Po subarea is located southwest of the Chinjen subarea. The water area, lying in a northeasterly-southwesterly direction, is approximately 2.5 kilometers in length and varies in width from 0.3 to 2.0 kilometers. The water area forms part of the neck of a relatively narrow and shallow estuary, approximately 15 kilometers in length, opening into Chinhae Man. The water area has two immediate watershed areas, one along the northwestern shoreline and the other along the southeastern shoreline. The northwestern watershed is approximately 3.5 square kilometers in area and is bounded by hills and mountain ranges with elevations varying from 100 to 300 meters. Rice is grown along a stream and in valleys draining into the water at several points along the shoreline. The southeastern watershed is approximately 0.75 square kilometers in area and includes a relatively low level shoreline area rising up the side of a mountain with peak elevation of 270 meters. Rice is grown extensively throughout the length of the southeastern shoreline The entire estuary receives drainage from extremely large watershed areas lying to the northwest and southeast in which rice crops are grown extensively in the valleys of numerous large streams. The surface runoff from these extensive rice growing areas, together with the relatively shallow depth of the estuary, would be expected to produce rather sudden and pronounced changes in the quality of the estuarine waters, including the waters of the So Po subarea.

A bacteriological study of the So Po subarea was conducted during the period, September 1962 to December 1963. Samples of water and oysters were collected at one station. The samples were assayed for total coliform organisms only, because in 1962 supplies and equipment for testing for fecal coliform organisms had not been acquired. Judging from the results of the tests, the area is at times influenced by the large watershed that drains into the enclosed, long, narrow embayment of which the So Po subarea is only a small part.

Judgment of the quality of this and adjoining areas can be made only after conducting comprehensive sanitary surveys of the entire area. Current studies are of particular importance in determining the water flows within the area and the exchange of water with the large outer estuary.

SUBAREA V: YONG HO

The Yong Ho subarea is located southeast of the So Su subarea. The water area is a bay approximately 2.5 kilometers in length, and varying in width from 0.5 to 1.5 kilometers at the mouth, which is protected to some extent by the location of Cho Do and two smaller islands. The bay lies in a northeasterly-southwesterly direction, with the mouth opening into Chinhae Man. The U-shaped watershed surrounding the bay has an area of approximately 4.25 square kilometers. The watershed area is bounded by ranges of hills and mountains with elevations vary-

ing up to 180 meters. Rice is grown throughout the lower level of the shoreline areas and especially in the northeastern end of the watershed.

A bacteriological study of the Yong Ho subarea was conducted during the period, July 1962 to December 1963. Samples of water and oysters were collected monthly at one station established at the mouth of the bay. As in the So Po subarea, samples of water and oysters were assayed for total coliform organisms only.

Coliform densities of the water were usually low, with 13 of 18 samples showing less than 1.8 per 100 ml. Two samples showed coliform MPN's greater than 230. Coliform MPN's of the oysters were not as low as would occur in the United States in waters of this quality. The median density was 330, and 2 of 16 samples showed MPN's in excess of 2400. Since the high relative coliform densities occurred in the summer, there is the possibility of greater feeding activity at the higher prevailing temperature on the south coast of Korea than in the Pacific Northwest where the water temperature is much lower.

SUMMARY OF RESULTS OF BACTERIOLOGICAL TESTS

In contrast to the situation in the United States, where population centers influence the quality of the estuary, the most important factors that influence water quality in Korea are the extent of the agricultural use of the watershed, the extent of the watershed areas in relation to the size of the receiving estuary, and the amount of rainfall, or runoff. This difference between the two countries exists because of the practice of using night soil to fertilize the grain fields in Korea.

The effect of the watershed on the estuary is shown in plots of water and oyster fecal coliform densities obtained in two estuaries having different topographical characteristics. The Do Sun subarea is an open cove opening into a large outer estuary, and it has a very small watershed. The Chinjen subarea is a funnel-shaped cove that receives drainage from a large, complex river basin with many subwatersheds on which extensive cultivation of rice and other grains is practiced.

Results of bacteriological tests on water and oysters obtained from these subareas are shown in Figures 26 and 27. Monthly rainfall at Masan, the nearest

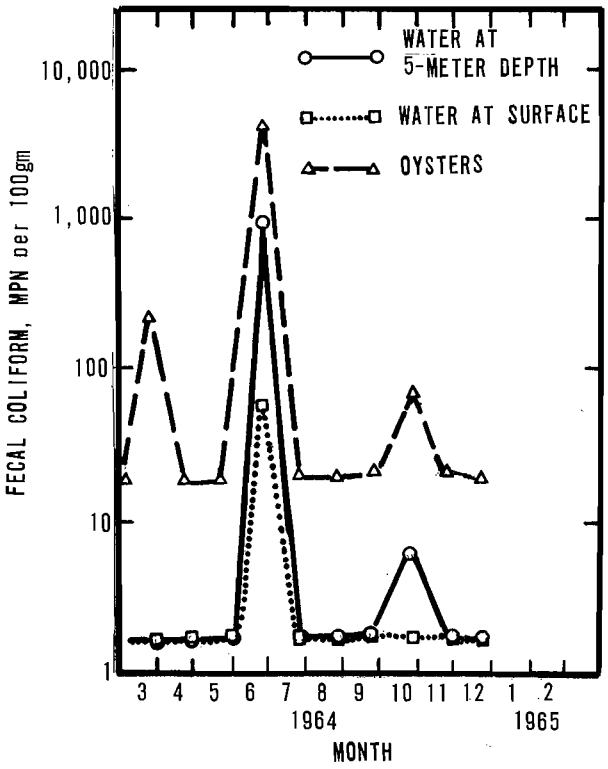

Figure 26. Chung Mu Area, Subarea V, Do Sun, Station E-10.

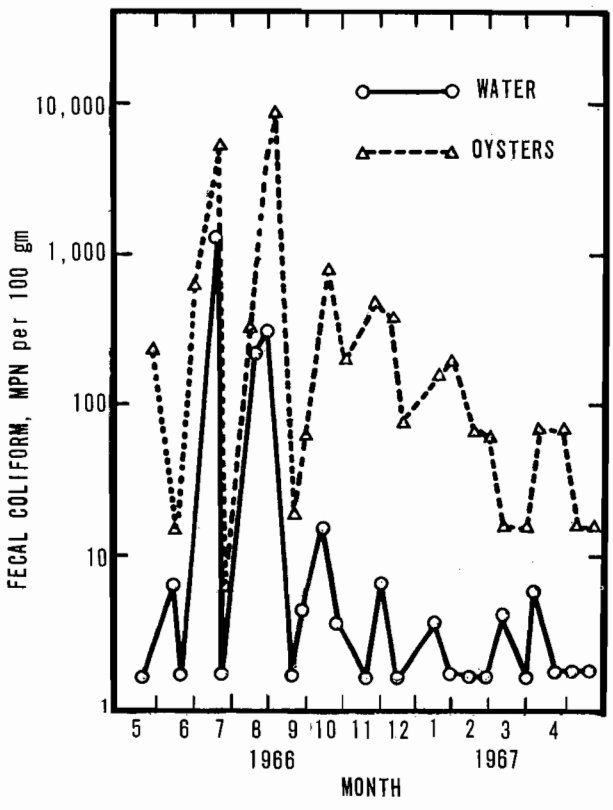

Figure 27. Chindong Area, Subarea I, Chinjen, Water Station 3, Oyster Station 1.

meteorological station, is shown in Table 10. The rainfall data should be regarded as indicative of a general seasonal pattern only. In mountainous terrain, such as that found in Korea, the rainfall pattern varies greatly from one watershed to another, and, therefore, data collected at Masan might not apply exactly to other watershed areas.

The patterns of the water and oyster coliform curves for these two areas generally reflect the type of watershed as well as the occurrence of rainfall. Both plots show sharp increases in water and oyster fecal coliform MPN's during the rainy period, usually, April through August. Since the Do Sun watershed is small and simple, involving a single drainage area, a quick response to and recovery from runoff occurs in the water. The oyster curves also show reaction to the changes in the water. In contrast, the patterns presented by the water and oyster curves of the Chinjen data are

Table 10. MONTHLY RAINFALL, MASAN

Year	1964	1965		1966		1967	
Month	mm Rainfall	mm Rainfall	Rainy days	mm Rainfall	Rainy days	mm Rainfall	Rainy days
January	71.2	43.3	5	10.8	2	24.1	2
February	78.8	39.0	3	52.7	4	73.1	9
March	64.6	37.7	4	179.3	12	87.0	11
April	297.2	86.2	6	110.1	6	162.7	10
May	82.8	83.0	9	125.7	7	33.1	4
June	172.4	28.5	2	115.6	11	178.0	7
July	55.9	550.0	21	158.3	12		
August	79.3	286.4	9	272.3	12		
September	383.6	13.4	3	58.6	6		
October	5.1	36.3	2	39.0	5		
November	4.7	112.5	9	95.3	4		
December	0.2	48.0	2	10.0	1		
Total	1,295.8	1,346.3	71	1,205.7	82		

much more complex, revealing numerous high peaks during the rainy season but also occasional smaller rises during the dry season. This pattern can be explained by the occurrence of several subwatersheds that could receive rainfall at different times.

SUMMARY AND RECOMMENDATIONS

A general summary of the results of bacteriological tests on water and oyster samples is presented in Table 11. This table includes test results obtained at all oyster sampling stations, but at only those water sampling stations in the immediate vicinity of the oyster stations. Occasionally, two water stations were involved, and logarithmic averages of the two were used to derive the statistics given in the table.

In general, the median coliform and fecal coliform MPN's of the water are very low, indicating high quality water at least half of the time during the study periods. The results at various stations, however, differ in the occurrence of high values (coliform >230, >700 and fecal coliform >33, >330). Subareas I, II, and V in the Chindong area show more than 10 percent of the samples with coliform MPN's greater than 230, the currently accepted United States criteria, but in all cases no more than one sample at each station was in excess of 700. The currently available data for Subareas I, II, and III of the Chung Mu areas should not be reviewed for conformity to these criteria since they represent results obtained largely during the rainy season. Subareas IV, V, VI, and VII of this area show very low coliform and fecal coliform results.

It is of interest that the corresponding coliform and fecal coliform densities in oysters are somewhat higher than those found in the same species grown in the United States in water of similar quality. The reason is not clear from the information available. We were informed that in many cases the oysters sampled were not of market size, but were young, small, and probably "thin." In addition, the prevailing temperatures in South Korea are higher than those in the United States and probably in Japan. This matter should be investigated in greater detail to provide information concerning the significance of these high coliform and fecal coliform values in oysters tested.

There is ample bacteriological evidence, gathered in comprehensive studies during the past 5 years, to indicate that there are many coves and embayments in the study area that are of excellent sanitary quality. These subestuaries are characteristically those that have relatively small immediate watersheds with a minor portion used for cultivation of rice or other crops; have free circulation within the subarea and into the outer estuary; and are sufficiently deep throughout the area, with no shallow mud flats to provide for mixing and dilution of the runoff from the watershed.

In contrast, there is equally ample bacteriological evidence to indicate that certain embayments are of questionable sanitary quality. A review of topographical maps of the watersheds of such areas indicates that these embayments are characterized by relatively large, and often complex, watersheds with relatively large proportions used for the

Table 11. SUMMARY OF RESULTS OF BACTERIOLOGICAL TESTS ON WATER AND OYSTER SAMPLES - CHUNG MU AND CHINDONG REGIONS

Subarea No.	Name	Period	Water: Coliform MPN's: No. of samples	Median	% >230	% >700	Fecal coliform MPN's: No. of samples	Median	% >33	% >330	Oyster: Coliform MPN's: No. of samples	Median	% >2.400	% >24.000	Fecal coliform MPN's: Median	% >730	% >2.400
	Chung Mu Region																
I	Puk Man																
	Station O-1-W 2S, 3S[1]	4/14-09/27/67	22	13	23	9	7.4	32	9	10	6,000	60	30	600	70	30
	W 3O	4/14-09/27/67	11	2.5	0	0	2.0	0	0							
	Station O-2-W 8S	4/14-09/27/67	11	4.5	18	0	2.0	18	0	11	4,900	55	27	490	64	36
	W 8O	4/14-09/27/67	11	7.8	0	0	4.5	0	0							
II	Pop Song Po																
	Station O-4-W 15S	4/14-09/27/67	11	6.8	9	9	2.0	9	9	11	24,000	82	55	3,300	82	41
	W 15O	4/14-09/27/67	11	4.0	9	0	<1.8	9	9							
	Station O-5-W 18S, 19S	4/14-09/27/67	22	5.2	9	9	2.8	9	9	10	3,600	80	40	1,300	80	40
	W 18D, 19D	4/14-09/27/67	22	6	0	0	3	0	0							
	Station E-9-O-EW 9S	3/64-01/65	11	<1.8	9	0	<1.8	9	0	10	78	10	10	20	10	10
	EW 9D	3/64-01/65	11	<1.8	9	0	<1.8	9	0							
III	Tong Nae																
	Station O-6-W 22S, 23S	4/14-09/27/67	22	1.8	9	9	1.8	9	9	8	12,000	63	37	1,600	63	50
	W 22D, 23D	4/14-09/27/67	22	<1.9	0	0	<1.8	0	0							
IV	Gen Nae Rang																
	Station E-6-O-EW 6S	3/64-01/65	12	<1.8	8	0	<1.8	8	0	12	270	25	8	130	33	8
	EW 6D	3/64-01/65	11	<1.8	0	0	<1.8	0	0							
V	Do Sun Ri																
	Station E-10-O-EW 10S	3/64-12/64	11	<1.8	9	9	<1.8	9	9	11	45	9	0	20	9	9
	EW 10D	3/64-12/64	10	<1.8	0	0	<1.8	0	0							
VI	Yong Un Ri																
	Station E-7-O-EW 7S[1]	3/64-02/65	12	1.8	8	8	<1.8	8	8	12	330	17	8	170	25	9
	EW 7O	3/64-02/65	11	2.0	9	0	1.8	9	0							
VII	Punghwa Ri																
	Station E-8-O-EW 8S	3/64-01/65	12	4.5	8	0	2.0	0	0	12	230	8	0	68	25	0
	EW 8D	3/64-01/65	11	2.0	0	0	1.8	0	0							
	Chindong Region																
I	Chinjen																
	Station O-1-W 3S	5/66-05/67	24	6.8	12	8	2.0	12	8	24	490	29	0	78	33	8
	Station E-3-O-EW 3	7/62-12/63	18	20	17	5	-	-	-	18	790	28	6	-	-	-
II	Chindong																
	Station O-2-W 2O	5/66-05/67	23	6.8	8	8	2.0	8	8	24	950	37	8	330	50	21
	Station O-3-W 19S	5/66-05/67	24	2.0	12	4	1.9	8	4	24	1,200	30	13	200	48	17
	W 19O	5/66-05/67	24	2.0	0	0	<1.8	4	0							
III	So Su																
	Station O-4-W 23S, 25S	5/66-05/67	48	2.0	8	4	<1.8	8	4	24	1,700	42	25	150	46	21
	W 23D, 25D	5/66-05/67	48	2.0	2	0	<1.8	4	0							
	Station O-5-W 24S	5/66-05/67	24	2.0	4	4	1.9	8	4	24	480	29	8	56	29	4
	W 24O	5/66-05/67	24	2.0	0	0	<1.8	4	0							
IV	So Po																
	Station E-4-O-EW 4	9/62-12/63	16	2.9	6	6	-	-	-	16	330	13	6	-	-	-
V	Yong Ho																
	Station E-2-O-EW 2	8/62-12/63	18	<1.8	11	0	-	-	-	16	330	13	0	-	-	-

[1] O - Oyster-sampling-station number.
W - Water-sampling-station number
S - Surface water sample.
O - Water sample at 5-meter depth.
E - Number assigned to the station in the preliminary surveys, 1961 to 1965.

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cultivation of rice and other crops, and that circulation in the subarea, particularly into the outer estuary, is often restricted.

These observations have been made only after reviewing the bacteriological data and studying the geographical features and land use as shown on topographical maps of the areas. To confirm these findings, the following other essential components of a sanitary survey are needed:

1. sanitary reconnaissance of the watershed to determine the location, nature, and extent of the sources of pollution, from man or animal, attention also being given to discharges of industrial wastes that might impart toxicity to the shellfish;
2. oceanographic studies to determine the current flows within the estuary and the exchange with the outer estuary; and
3. a thorough review of all available data to delineate those subareas, or portions of them, from which oysters or other shellfish would be safe for human consumption.

It is obviously impossible, within a short period of time, to develop such information on all shellfish producing areas even within the model area. The Mission, therefore, recommends that

1. a comprehensive long range plan be developed for sanitary surveys of of growing areas;
2. high priority for immediate action be given to a selected few watershed systems that have the greatest potential for being of good sanitary quality--information on selection of study areas and rationale for selection is included in Appendix D;
3. comprehensive sanitary surveys be conducted of these selected areas; and
4. as a result of study of these areas, those that would be considered satisfactory for the production of safe shellfish be designated.

It is quite likely that a careful review of topographical maps of the selected areas would reveal subestuaries with watershed characteristics and land use that would almost obviously be of high quality. These would require a minimum of sanitary reconnaissance and laboratory testing of the water systems. Thus, more effort could be placed on other subareas of more questionable quality.

Part IX

CONTROL OF HARVESTING

Control of harvesting is a very important factor in the sanitary control of shellfish. It is essential to ensure that shellfish handled and processed in registered plants are truly from an unpolluted shellfish growing area. The major components of an ideal program for control of harvesting are listed below:

1. clear delineation of approved and unapproved growing areas;
2. controlled cultivation by bottom or hanging methods permitted only in approved areas;
3. harvesting permitted only from approved areas;
4. removal of natural growth from polluted areas;
5. a system of records to identify the source of shellfish being harvested, transported, or processed; and
6. a control program adequately staffed to ensure that the above components are operating effectively. The program should include both patrol of polluted areas to prevent harvesting and surveillance of harvesting in approved areas.

In many respects, the program components outlined above are adaptable to oyster culture in the model area. Practically all oyster culture in this area is by controlled cultivation, the majority of which is by hanging culture. The trend toward production by hanging culture is continuously increasing because of the many good biological features of this method.

The existing laws and regulations, particularly Ordinance No. 218, adequately provide the legal basis for control of harvesting. Article 14 of Ordinance No. 218 specifically pertains to harvesting. This article stipulates that persons wishing to harvest shall submit an application to the Fisheries Products Inspection Office and that surveillance of the harvesting operation shall be provided by inspectors of the Fisheries Products Inspection Office.

Hanging culture offers an excellent opportunity for effective control of harvesting. Since the oysters are growing on fixed floating structures that are visible and accessible at all times; they can be identified by location and assigned a number that likewise is visible. Hanging culture, therefore, is adaptable to continuous inventory throughout harvesting operations.

RAFT INVENTORY SYSTEM

The control authorities in Japan[8] have developed a raft inventory system for

control of harvesting from rafts. As in Korea, an oyster grower must obtain a permit to harvest oysters. The application describes the location, the designated number of the raft, and the number of strings of oysters suspended from the raft. Prior to issuance of the permit to harvest, the control agency may check the location and inventory. When oysters are harvested, the oyster grower maintains a daily record of the number of strings removed and the name of the person to whom the oysters were transported. This information also is supplied to the consignee of the shellfish who, in turn, incorporates it in a record of receipts that is kept on file for a required length of time. The control agency maintains a record of the rafts certified for harvesting, including their location and the number of strings on the raft when it was certified.

From these records, the local inspector has adequate information for control of harvesting. He can visit the raft, count the number of strings remaining, and, by comparing this figure with the record kept by the harvester, can check the accuracy and veracity of the record of harvest. The inspector also may periodically review plant purchase records to check on sources of shellfish that have been processed.

It has been found that, from a statistical standpoint, it is not necessary that each certified raft be inventoried each month. Based on statistical analysis, the minimum number of rafts, *selected at random*, to be inventoried will depend on the total number of rafts and the accuracy desired. An inventory based on Table 12 should produce results that are accurate within 5% of the true value.

The raft inventory system appears to be quite applicable to the control of harvesting of oysters grown by both longline and raft culture in Korea. It also seems feasible that the system, because of its simplicity, could be applied to all harvesting, whether for export or domestic use.

If the raft inventory system were adopted in Korea, application of the system would be enhanced by certain changes in the forms used for control of harvesting.

It is suggested that *Form 5 - Notification of Harvesting of Shellfish for Export* be revised as shown in Figure 28. The change in title to "Application for Harvesting Shellfish for Export" is consistent with Article 14, Item 1 of Ordinance 218, which states that parties wishing to harvest shall submit a request to the Director of the Fishery Products Inspection Office. The text of the application also is revised in accordance with this item.

A suggested revision of *Form 6 - Certificate of Harvest of Shellfish for Export* is shown in Figure 29. As indicated in the revision, it is suggested that the approval to harvest should bear the endorsement of the Bureau of Production, which is the Agency responsible for biological and sanitary control of shellfish culture. Such an endorsement would assure the Central Fisheries Inspection Office that the current biological and sanitary condition of the area where the designated raft or long line is located is satisfactory for the production of shellfish for immediate human consumption.

Table 12. MINIMUM NUMBER OF SHELLFISH RAFTS TO BE SELECTED AT RANDOM FOR INCLUSION IN A SURVEY

Number of rafts	Number to be inspected	Number of rafts	Number to be inspected
1 to 24	all	148 to 167	36
25 to 54	25	168 to 191	37
55 to 59	26	192 to 222	38
60 to 64	27	223 to 262	39
65 to 71	28	263 to 316	40
72 to 78	29	317 to 394	41
79 to 86	30	395 to 514	42
87 to 94	31	515 to 725	43
95 to 105	32	726 to 1,192	44
106 to 116	33	1,193 to 5,000	50
117 to 130	34	5,001 to 10,000	100
131 to 147	35	10,001 and over	200

Form No. 5

Application for Harvesting of Shellfish for Export

TO: Director of the Central Fisheries Inspection Office

Date: _____

Address of notifier:

Name of notifier : Seal

I hereby apply for permission to harvest shellfish for export under the stipulations of Item 1, Article 14 of the Regulations on Sanitary Control of Shellfish Growing Areas, Harvesting, and Processing and Inspection of Shellfish Products for Export.

1. Species and quantity of shellfish to be harvested.
2. The No. of designated growing area.
3. The period of harvest.

Figure 28. Revised Application for Harvesting Shellfish for Export.

Form No. 6

CERTIFICATE OF APPROVAL TO HARVEST SHELLFISH FOR EXPORT

1. Address and name of harvester
2. The number of the designated growing area
3. Species and quantity of shellfish harvested
4. Period of harvest
5. Title and name of public official supervising the harvest.

I certify that the above designated growing area conforms to the stipulations of Item 1, Article 3 of the Regulations on Sanitary Control of Shellfish Growing Areas, Harvesting, and Processing and Inspection of Shellfish Products for Export.

Date:

Bureau of Production
Office of Fisheries

Seal

I hereby approve harvesting of _____ from the above designated area.
(species)

Central Fisheries Inspection Office
Office of Fisheries

Seal

Figure 29. Certificate of Approval to Harvest Shellfish for Export.

Only one change is suggested in *Form 7 - Certificate Tag of Shellfish Harvest*, as shown in Figure 30.

Form 8 - Record of Harvest of Shellfish for Export is a new form suggested to be used by the harvester to maintain a record of harvest. In the interest of uniformity, it could be supplied to the harvester by the Central Fisheries Inspection Office.

The Mission has only one suggestion for control of the harvesting of "stone cultured" oysters. Article 14, Item 2 of Ordinance No. 218 provides for inspection of the harvest operation. We see no alternative to this procedure. Fortunately, since harvesting must be confined to periods of low tide, the need for continuous surveillance is eliminated. We suggest, however, that an additional item permitting harvesting only during the daylight hours be added to Article 14.

Form No. 7

CERTIFICATE TAG OF SHELLFISH HARVEST

Shellfish is harvested as follows:

1. Serial No. of raft or long line
2. Date of harvest
3. Serial No. of ship or vehicle used in the transfer of the harvested shellfish
4. Quantity of shellfish

Date: _____

Supervising Inspector: Seal

Figure 30. Tag for certified shellfish.

Form No. 8

RECORD OF HARVEST OF SHELLFISH FOR EXPORT,
LONG LINE OR RAFT CULTURE

Designated Area
Serial No. of Raft or Long Line

Species
Quantity

Record of Harvest			
Date	No. of strings removed	Delivered to	Balance

Figure 31. Record of harvest of shellfish for export.

SUMMARY AND RECOMMENDATIONS

The existing laws and regulations adequately provide the legal basis for control of harvesting, and the Central Fisheries Inspection Office, with branch offices in major production areas, has an adequate organizational structure to exercise surveillance. The Mission, therefore, recommends:

1. adoption of the raft inventory system for control of harvesting of oysters grown by hanging culture, which would require certain minor revisions of the administrative forms and the addition of one form to be used as a record of harvest;
2. endorsement of the certificate to harvest by the Bureau of Production as to satisfactory sanitary and biological condition of the shellfish; and
3. the addition of an item to Article 14 of Ordinance No. 218 to permit harvesting of shellfish only during daylight hours.

Part X

RESEARCH NEEDS

The Mission is aware that in the research program of the Fisheries Research and Development Laboratory sanitary surveys of shellfish growing areas should have high priority. In the program outlined below, this need is recognized. We also have taken into account that the current Laboratory staff is limited in number and that the problems associated with the distance between the Laboratory and the oyster culture areas should be solved. Establishment of a field laboratory near one of these sites would provide a base for field operations, such as sample collection, oceanographic data collection, and sanitary reconnaissance, as well as the simple laboratory examinations involved in routine sanitary surveys and special field investigations.

The Mission suggests two projects directly related to the development of knowledge concerning the sanitary condition of shellfish growing areas. The first has higher priority, but the second is of almost equal importance since it would provide basic data for interpretation of sanitary findings. A third project is directed toward refinement of the provisions of Ordinance No. 218 to develop plans and specifications for the design, construction, and operation of shellfish shucking and packing plants.

DEVELOPMENT OF SANITARY SURVEY TECHNIQUES

The Fisheries Research and Development Agency, in collaboration with other agencies of the Office of Fisheries, has collected a vast amount of bacteriological and related environmental data on several subareas in the Chung Mu and Chindong areas. Comparable research has not been done with respect to sanitary reconnaissance and oceanographic survey, which are two other essential components of a sanitary survey.

The Mission recommends the development of a sanitary survey team of diverse competencies, drawing from the staff of the Fisheries Research and Development Agency and other agencies, such as the Bureau of Production or its provincial counterparts, as well as agencies in the Ministry of Health and Social Affairs. The team should develop a comprehensive plan for surveys of growing areas and select one or more areas to be used for the development of sanitary survey techniques. An outline of a suggested order of procedure for the project follows.

1. Designate members of sanitary survey team
2. Select study areas
3. Prepare maps of watersheds and subestuaries

4. Locate sampling stations
   a. Fresh water streams
   b. Estuaries
5. Conduct sanitary reconnaissance
   a. Location and measurement of potential sources of pollution
   b. Measurement of flow of major streams
   c. Meteorological data
6. Make field surveys of estuaries
   a. Bacteriological
   b. Chemical
   c. Oceanographic
7. Prepare comprehensive report
   a. Analysis and interpretation of field data
   b. Delineation of approved areas
      (1) Description
      (2) Maps

BACTERIAL RELATIONSHIP BETWEEN SHELLFISH AND THE SURROUNDING WATER

Sanitary surveys of growing areas will reveal the sources of pollution, the course of the pollutants in the estuary, and the residual microbiological and chemical pollutants in active shellfish growing areas. To completely estimate the impact on the quality of shellfish, *in vivo* studies would be required to determine the rate and extent of accumulation of bacteria by shellfish. Ideally, these studies would be conducted in aquaria, where environmental conditions, such as bacterial level of the water, could be controlled. Pending the establishment of a shore-side facility, however, studies might be conducted at a hanging culture device in a carefully selected culture area. Water and oyster samples should be examined simultaneously, and with sufficient frequency to relate water variations to response in shellfish. Seasonal effects should be investigated, as well as salinity and temperature influences.

When a field laboratory has been established, the observations of the field studies could be refined by controlled laboratory studies. Accumulation and retention of other pollutants of chemical or biological nature also could be investigated.

DEVELOPMENT AND EVALUATION OF COMMERCIAL HANDLING PRACTICES

Since large-scale shucking and packing of shellfish in Korea is a newly developing commercial practice, there is the opportunity to introduce in the construction and operation of these plants innovations in construction and equipment materials, in refrigeration, and in handling methods that would be difficult to accomplish in an old established industry. We, therefore, suggest that the Office of Fisheries, in collaboration with appropriate Food Sanitation Agencies in the Ministry of Health and Social Affairs, develop a project that would have the following components:

1. The designing of a model shellfish shucking and packing plant to include:
   a. detailed engineering drawings of a model plant layout, including size and relative location of functionally important rooms;
   b. detailed model specifications for building construction features; and
   c. specifications for food handling and processing equipment, such as shell stock washing and storage facilities, shucking benches,

shucked meat washing, grading and packing utensils and equipment, and shipping containers.

2. Technical assistance to industry in construction and operation of shucking and packing plants

Using the design criteria developed, as outlined, the Office of Fisheries could review plans and specifications for specific plants to ensure conformity with the provisions specified, assist in supervising construction and, when the plant has started operations, conduct such reviews with the laboratory support required to check out the operating effectiveness of the plant. This project is not as difficult and time consuming as might appear at first glance because of the factors listed below.

1. Review of several fish canneries and fish processing establishments in Korea by the Mission has shown that a high degree of knowledge of hygienic requirements is evident in the operation of these plants. The need now is to develop designs for those construction features and the items of equipment that are unique to the handling and processing of shellfish.
2. Such designs have been developed in the United States and in other countries, notably Japan, for plants handling the identical species of shellfish. These designs can be used as examples by introducing modifications or innovations required by the differences in Korean customs or geographical peculiarities.
3. Numerous technological studies have shown that the commercial practices used in the handling of shellfish in both the United States and Japan would be applicable, to a large extent, to the same species in Korea. These studies include research concerning changes in shucking and packing, refrigeration requirements for shellfish and shucked meats, and other practices directly applicable to Korean situations.

Part XI

TRAINING NEEDS

For many years, the agency for International Development (AID) has sponsored the training of personnel of other countries in the United States. This program has involved various types of training for the nationals, including attendance at academic institutions, travel and visitation to observe and discuss governmental program activities and industrial operations, and highly specialized training arranged to meet the particular needs of the trainee. The United States Operations Mission to Korea has adopted a policy of placing emphasis on sponsoring training for Korean counterpart personnel who have worked closely with American professionals and technicians on program activities in Korea. This approach to the training of Korean nationals has proved to be very effective, and the USOM/K is to be commended for this program.

The Mission was requested by USOM/K to consider the training needs of the Korean agencies in the continuing development of a national program for production and control of production of shellfish for export. The training needs are to be met by AID sponsored training in the United States, with appropriate consideration being given to Korean nationals who have worked closely with the Mission during its stay in Korea. The Mission was informed that four positions for training in the sanitary control of shellfish production would be available during the current fiscal year.

The Mission fully recognizes that the Korean agencies are staffed with administrative and technical personnel who are competent to carry out a national shellfish sanitation program. Consideration, therefore, has been given to the fields of training or disciplines that would provide the greatest additional support to such a national program at this time. It is the opinion of the Mission that special training for selected Korean nationals in the following fields of activity or professional disciplines would most effectively fulfill this objective: administrative; microbiology - shellfish sanitation; oceanography; and sanitary engineering - shellfish plants.

Information concerning the participant to be selected for training, the principal subject matter of the training experience, and the duration of the training are outlined below.

1. Administration
   a. Participant: individual who will have high-level responsibility for

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administration and coordination of the national program

b. Subject
   (1) Methods of administration of shellfish sanitation
   (2) Interagency coordination

c. Duration: approximately 1 month

2. Microbiology - shellfish sanitation
   a. Participant: staff member of the Fisheries Research and Development Agency
   b. Subject
      (1) Laboratory and field methods of sanitary control
         (a) Sanitary survey techniques
         (b) Shellfish plant inspection
      (2) Recent advances in bacteriological and virological techniques
   c. Duration: approximately 6 months

3. Oceanography
   a. Participant: staff member of the Fisheries Research and Development Agency
   b. Subject: estuarine oceanography
      (1) Movement of water masses
      (2) Estuarial influences on pollution
   c. Duration: approximately 6 months

4. Sanitary Engineering - Shellfish Plants
   a. Participant
      (1) Staff member of the Office of Fisheries
      (2) Representative of shellfish industry to be considered as accompanying participant
   b. Subject
      (1) Sanitary reconnaissance
         (a) Measurement of waste discharges and stream flow
         (b) Disposal of wastes in estuaries
      (2) Design of shellfish shucking and packing plants
      (3) Sanitary control of shellfish handling practices
   c. Duration: approximately 6 months

The training activities outlined above can be arranged as specialized training involving travel, visitation, and participation as indicated. These activities will utilize the facilities of the U.S. Public Health Service, selected public health agencies and other agencies in the States, and the shellfish industry. The Mission will be pleased to assist in developing itineraries, making arrangements for training, and coordinating the training activities of the participants.

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APPENDICES

Part XII

Appendix A

ORGANIZATIONS AND INDIVIDUALS CONTACTED BY THE MISSION

The individuals with whom the Mission held meetings and conferences or who provided special services to the Mission are listed below and are identified under their respective organizations.

JAPAN

Tokyo

American Embassy
- Mr. Clinton E. Atkinson, Fishery Attache

Ministry of Health and Welfare
- Dr. Toshiharu Kawabata, National Institute of Health

Ministry of Agriculture and Forestry
- Mr. Ryuzo Oyama, Fisheries Agency

Tokyo Metropolitan Government
- Mr. Takao Katoh, Director, Sanitary Inspection of Central Wholesale Fish Market

Hiroshima

Office of Fisheries, Southwest Regional Fisheries Research Laboratory
- Dr. Takashi Ino, Director
- Dr. Masaru Fujiya

Hiroshima Prefecture
- Dr. Takumi Takeuchi, Director, Fisheries Experiment Station, Ondo
- Dr. Minoru Okinami, Director, Public Health Laboratory
- Dr. Y. Kishimoto, Public Health Laboratory
- Mr. Akira Ando, Chief, Environmental Sanitation Section, Sanitation Division

Nichiro Fisheries
- Mr. Shozaburo Hirabayashi, Manager
- Mr. Sadao Shiraishi, Assistant Manager
- Mr. Masashi Tanaka

KOREA

Seoul

U.S. Operations Mission to Republic of Korea

Rural Development Division
- Dr. Joe R. Motheral, Chief
- Mr. Paul W. Bedard, Deputy Chief
- Mr. Laverne E. Wakefield, Chief Fisheries Section
- Mr. Alvin M. Morgan, Fishery Advisor
- Mr. Kuhn Hong Lee, Fisheries Section, guide and interpreter for the Mission
- Mr. Chun Ku Lee, guide and interpreter for the Mission

USOM/K Program Office
- Mr. Eric Chetwynd

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Public Services Division
Mr. Il Chul Yoon, Assistant to Chief Public Health Advisor
USOM/K Legal Office
Mr. Byung Jae Lee, Legal Advisor
American Embassy
Mr. William Kingsbury, Fisheries Officer
Office of Fisheries
General Jung Keun Oh, Administrator
Mr. Jae Shik Kim, Deputy Administrator
Mr. Hee Un Chang, Director, Production Section
Mr. Ki Young Kim, Chief, First (Coastal) Fishing Section
Mr. Kyun Hyun Kim, Shellfish Specialist, Production Bureau
Ministry of Health and Social Affairs, Bureau of Public Health
Dr. Taek Il Kim, Director
Mr. Won Bae Chon, Chief, Environmental Sanitation Section
Mr. Chung Bae Ro, Chief, Food Sanitation Section

Pusan

U.S. Operations Mission to Republic of Korea
Rural Development Division
Mr. Kenneth H. Sherper, Advisor to Kyung Sang Nam Province
Mr. Tae Il Chung, Program Assistant
Mr. Yung Ho Kim, Administrative Assistant
Kyung Sang Nam Province
Mr. Kae Soon Lee, Governor
Mr. Tai Woo Kim, Chief, Fishery Bureau
Mr. Sun Kon Kim, Fisheries Culture Subsection
Dr. Nam Chull Hwang, Chief, Public Health Section
Mr. Hung Jo Lee, Chief, Public Health Subsection
Mr. Chong Ju Ahn, Sanitation Branch
Mr. Chun Sae Lee, Sanitation Branch
Office of Fisheries
Fisheries Research and Development Agency (FRDA)
Mr. Shin Wook Hahn, Director
Mr. Han Mo Kim, Chief, General Affairs Section
Mr. Dong Kun Park, Chief, Utilization and Food Technology Section
Mr. Seong Jun Kim, Microbiologist, Utilization and Food Technology Section
Mr. Kihyuk Kim, Chief, Aquiculture Section
Mr. Kyung Man Bae, Biologist, Aquiculture Section
Mr. Won Kyo Kim, Chief, Technical Management Section
Miss Kyung Ja Lee, served as secretary to Mission
Central Fisheries Inspection Office
Mr. Jong Sang Won, Chief, Pusan Branch Station
Pusan Fish Market Center
Mr. Jong Ho Choe, Managing Director
Samyang Frozen Seafood Co., Ltd.
Mr. Ju Sung Kak, Managing Director
Shin Hung Refrigeration Company
Mr. Sae Don Oh, Chief, Business Section
United Nations Deep Sea Fishing Training Center
Mr. Kare Larseen, Assistant Manager

Chung Mu

Chung Mu City
Mr. Yeong Hwa Lee, Mayor
Mr. In Ku Kim, Chief, Fisheries Branch
Tongyong Gun (County)

Mr. Chun Do Kim, Chief

Mr. Moon Do Hwang, Director, Education Department

Mr. Dal Yong Park, President, Oyster Cooperative

Mr. Mun Wu Lee, Manager, Oyster Cooperative

Mr. In Ju Lee, Oyster Culture Specialist, Oyster Cooperative

Mr. Chang Hoon Chong, Oyster Grower

Mr. Ho Yon Lee, Oyster Businessman

International Cannery

Mr. Hyo Chan Choi, Chief, Processing Section

Jeil Sang Kong Co., Ltd., Chung Mu Seafood Plant

Mr. San Kwon Kim, Chief, Manufacturing Section

Appendix B

ITINERARY AND ACTIVITIES OF THE MISSION

September

8	Friday	-	Departed from Los Angeles, California, via PAA
9	Saturday	-	Arrived at Tokyo, Japan
10	Sunday	-	Conferred with Fishery Attache, American Embassy
11	Monday	-	Visited National Institute of Health and discussed oyster-borne diseases in Japan
			Visited Tokyo Central Fish Market and discussed inspection methods with Director of Sanitary Inspection
			Departed for Hiroshima via Japanese National Railways
12	Tuesday	-	Arrived at Hiroshima
			Visited Hiroshima Prefecture Fisheries Experiment Station in Ondo and discussed oyster culture and other research activities of Station with Director
			Visited oyster rafting areas and oyster shops in Ondo region
13	Wednesday	-	Visited Ministry of Agriculture and Forestry, Southwest Regional Fisheries Research Laboratory, and discussed Japanese fisheries and research activities of Laboratory with Director and staff.
			Visited oyster seed areas
14	Thursday	-	Visited Nichiro Fisheries, discussed plant problems with manager and staff, and toured plant
			Visited Hiroshima seaweed culture plant and Yoneda Oyster Plant to see depuration facility
15	Friday	-	National holiday
16	Saturday	-	Visited Hiroshima Prefecture Public Health Laboratory, conferred with Director and staff on shellfish sanitation program, and toured Laboratory
			Departed from Hiroshima via All Nippon Airways
			Arrived at Tokyo
18	Monday	-	Participated in briefing session on Korean fishery program with Fishery Attache, American Embassy
			Visited Ministry of Agriculture and Forestry and conferred with representatives of Fisheries Agency
19	Tuesday	-	Departed from Tokyo via Northwest Orient Airlines
			Arrived at Seoul, Korea
			Conferred with U.S. Operations Mission to the Republic of Korea (USOM/K) officials on work of Mission

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20 Wednesday - Visited Office of Fisheries, met with Administrator and staff, and had initial conference with Director, Production Bureau and staff on plans for work of Mission

Conferred with Office of Fisheries representatives on oyster culture and production in Korea

21 Thursday - Participated in conferences at USOM/K

Departed from Seoul via Korean Air Lines, accompanied by USOM/K guide and interpreter

Arrived at Pusan, Korea

Visited Office of USOM/K Advisor to Kyung Sang Nam Province

Visited Fisheries Research and Development Agency (FRDA) and conferred with Director and staff

Conferred with USOM/K Provincial Advisor

22 Friday - Conferred with USOM/K Provincial Advisor

Conferred with Chief, Provincial Fishery Bureau on administration and control of oyster production

Establishes temporary headquarters office of Mission at Fisheries Research and Development Agency

Worked with representatives of FRDA on review of results of laboratory analyses of sea water and oysters and on oyster culture methods

23 Saturday - Worked with representatives of FRDA on sanitary surveys and selection of study area

25 Monday - Conferred with Chief, Provincial Fishery Bureau, on sanitary surveys and plans for Chung Mu field trip

Worked with representatives of FRDA on bacteriological studies, sanitary surveys, and oyster culture

Conferred with representatives of Provincial Public Health Section on sanitary surveys and enteric diseases

26 Tuesday - Conferred with Governor of Kyung Sang Nam Province

Conferred with Chief, Provincial Fishery Bureau on licensing procedures

Departed from Pusan via USOM/K car

Arrived at Chung Mu City

27 Wednesday - Attended meeting at headquarters office of the Oyster Cooperative in Chung Mu City, Tong-Yong Gun Province, and discussed work of Cooperative with President and other officials

Visited International Cannery and toured plant

Visited Jeil Sang Kong Co., Ltd. Chung Mu Seafood Plant and toured plant

Visited oyster rafting areas via Republic of Korea (ROK) fisheries boat

28 Thursday - Met with Mayor of Chung Mu City

Departed from Chung Mu City via ROK fisheries boat and visited oyster growing areas enroute to Masan

Traveled from Masan to Pusan via USOM/K car

Arrived at Pusan

29	Friday	-	Visited Pusan Branch Station of the Central Fisheries Inspection Office and discussed work of Station with Chief and staff
			Worked with representatives of FRDA on shellfish laboratory activities and oyster culture
			Conferred with representatives of provincial Public Health Section on sanitary surveys and enteric diseases
			Conferred with USOM/K Fisheries Advisor
30	Saturday	-	Visited Pusan Fish Market Center
			Visited Samyang Frozen Seafood Co., Ltd.
			Visited Shin Heung Refrigeration Company
October			
2	Monday	-	Met with representatives of FRDA to review and discuss work and future plans of Mission
			Worked with representatives of FRDA on national shellfish program administration, laboratory activities, and oyster culture
			Conferred with representatives of Provincial Public Health Section on sanitary surveys
3	Tuesday	-	National holiday
4	Wednesday	-	Visited United Nations Deep Sea Fishing Training Center
			Worked with representatives of FRDA on various aspects of national shellfish sanitation program
			Met with representatives of FRDA, Provincial Fisheries Bureau, Provincial Public Health Section, and Pusan Branch Fisheries Inspection Station to reveiw and discuss findmngs of Mission
5	Thursday	-	Departed from Pusan via Korean Air Lines
			Arrived at Seoul
6	Friday	-	Worked at USOM/K office with counterpart representatives of FRDA and USOM interpreter on study of documents and information for preparation of report
7	Saturday	-	Worked at South Post quarters with FRDA counterparts and USOM interpreter on report preparation
9	Monday	-	National holiday
			Worked at USOM/K office with FRDA counterparts and USOM interpreter on report preparation
10	Tuesday	-	Worked at USOM/K Office with FRDA counterparts and USOM interpreter on report preparation
			Visited Ministry of Health and Social Affairs and conferred with Director, Bureau of Public Health and staff on shellfish sanitation activities and enteric diseases
11	Wednesday	-	Mr. Engle departed from Seoul with FRDA counterpart and USOM/K interpreter for Kwang Ju, Cholla Nam Province, to continue field studies of oyster culture
			Worked at USOM/K Office with FRDA counterpart on report preparation
12	Thursday	-	Conferred with representatives of USOM/K and American Embassy to review activities and findings of Mission

			Conferred with Assistant to Chief Public Health Advisor, USOM/K on organization and functions of Ministry of Health and Social Affairs
			Conferred with Administrator of Office of Fisheries and staff to review activities and findings of Mission
13	Friday	-	Conferred with Legal Advisor, USOM/K on Korean legislation related to the shellfish sanitation program
			Held final conference with representatives of Rural Development Division, USOM/K
			Departed from Seoul via PNWA
			Arrived at Tokyo, Japan
14	Saturday	-	Worked on report preparation
15	Sunday	-	Conferred with Fishery Attache, American Embassy, to review activities and findings of Mission
16	Monday	-	Departed from Tokyo via PAA
			Arrived at Los Angeles, California

Appendix C

SUMMARIES OF BACTERIOLOGICAL TEST RESULTS

Table C-1. SUMMARY OF BACTERIOLOGICAL TEST RESULTS
WATER SAMPLES
CHUNG MU REGION

Subarea No.	Subarea Name / Station No.	Sampling period	No. of samples	Coliform MPN Median	Coliform MPN >230 No.	Coliform MPN >230 %	Coliform MPN >700 No.	Coliform MPN >700 %	Fecal coliform MPN Median	Fecal coliform MPN >33 No.	Fecal coliform MPN >33 %	Fecal coliform MPN >330 No.	Fecal coliform MPN >330 %
I	Puk Man												
	1-S[a]	4/14-09/27/67	11	12	2	18	1	9	2.0	2	18	1	9
	2-S		11	33	4	36	2	18	7.8	4	36	2	18
	3-S		11	7.8	1	9	0	0	2.0	3	27	0	0
	3-D[b]		11	2.0	0	0	0	0	2.0	0	0	0	0
	4-S		11	2.0	0	0	0	0	2.0	0	0	0	0
	4-D		11	2.0	0	0	0	0	<1.8	0	0	0	0
	5-S		11	14	0	0	0	0	4.5	0	0	0	0
	5-D		11	7.8	0	0	0	0	7.8	0	0	0	0
	6-S		11	21	0	0	0	0	4.5	0	0	0	0
	6-D		11	4.5	0	0	0	0	4.0	0	0	0	0
	7-S		11	11	0	0	0	0	5.6	0	0	0	0
	7-D		11	13	0	0	0	0	4.5	0	0	0	0
	8-S		11	4.5	2	18	0	0	2.0	2	18	0	0
	8-D		11	7.8	0	0	0	0	4.5	0	0	0	0
	9-S		11	7.8	2	18	0	0	2.0	2	18	0	0
	9-D		11	4.5	0	0	0	0	<1.8	1	9	0	0
	10-S		11	23	1	18	1	9	6.8	1	9	1	9
	10-D		11	4.5	0	0	0	0	4.5	0	0	0	0
	11-S		11	2.0	1	9	0	0	2.0	1	9	1	9
	11-D		11	4.0	0	0	0	0	1.8	0	0	0	0
	12-S		11	7.8	1	9	0	0	2.0	1	9	0	0
	12-D		11	4.5	0	0	0	0	4.0	0	0	0	0
II	Pop Song Po												
	13-S	4/14-09/27/67	11	7.8	0	0	0	0	4.5	0	0	0	0
	13-D		11	7.8	0	0	0	0	4.0	0	0	0	0
	14-S		11	7.8	1	9	0	0	2.0	1	9	0	0

Table C-1. (Continued) SUMMARY OF BACTERIOLOGICAL TEST RESULTS
WATER SAMPLES
CHUNG MU REGION

Subarea No.	Subarea Name	Station No.	Sampling period	No. of samples	Coliform MPN Median	Coliform MPN >230 No.	%	>700 No.	%	Fecal coliform MPN Median	Fecal coliform MPN >33 No.	%	>330 No.	%
		14-D		11	2.0	0	0	0	0	<1.8	0	0	0	0
		15-S		11	6.8	1	9	1	9	2.0	1	9	1	9
		15-D		11	4.0	1	9	0	0	<1.8	1	9	1	9
		16-S		11	2.0	0	0	0	0	2.0	1	9	0	0
		16-D		10	3.2	0	0	0	0	2.0	0	0	0	0
		17-S		11	4.5	1	9	0	0	2.0	1	9	0	0
		18-S		11	2.0	1	9	1	9	<1.8	1	9	1	9
		18-D		11	7.8	0	0	0	0	4.5	0	0	0	0
		19-S		11	2.0	1	9	1	9	2.0	1	9	1	9
		19-D		11	4.0	0	0	0	0	2.0	0	0	0	0
		20-S[a]	4/14-09/27/67	11	2.0	1	9	1	9	1.8	1	9	1	9
		20-D[b]		11	7.8	0	0	0	0	2.0	0	0	0	0
		21-S		11	7.8	0	0	0	0	2.0	1	9	0	0
		21-D		11	2.0	0	0	0	0	<1.8	0	0	0	0
		E-9-S[c]	3/64-01/65	11	<1.8	1	9	0	0	<1.8	1	9	0	0
		E-9-D		11	<1.8	1	9	0	0	<1.8	1	9	0	0
III	Tong Nae													
		22-S	4/14-09/27/67	11	4.0	1	9	1	9	2.0	1	9	1	9
		22-D		11	4.0	0	0	0	0	2.0	0	0	0	0
		23-S		11	<1.8	1	9	1	9	<1.8	1	9	1	9
		23-D		11	<1.8	0	0	0	0	<1.8	0	0	0	0
IV	Gen Nae Rang													
		E-6-S	3/64-01/65	12	<1.8	1	8	0	0	<1.8	1	8	0	0
		E-6-D		11	<1.8	0	0	0	0	<1.8	0	0	0	0
V	Do Sun Ri													
		E-10-S	3/64-12/64	11	<18	1	9	1	9	<1.8	1	9	1	9
		E-10-D		10	<18	0	0	0	0	<1.8	0	0	0	0
VI	Yong Un Ri													
		E-7-S	3/64-02/65	12	1.8	1	8	1	8	<1.8	1	8	1	8
		E-7-D		11	2.0	1	9	0	0	1.8	1	9	0	0
VII	Punghwa Ri													
		E-8-S	3/64-01/65	12	4.5	1	8	0	0	2.0	0	0	0	0
		E-8-D		11	2.0	0	0	0	0	1.8	0	0	0	0

[a] S - Surface sample.

[b] D - Sample at 5-meter depth.

[c] E - Number assigned to the station in the preliminary surveys, 1961 to 1965.

Table C-2. SUMMARY OF BACTERIOLOGICAL TEST RESULTS
WATER SAMPLES
CHINDONG REGION

Subarea No.	Subarea Name	Station No.	Sampling period	No. of samples	Coliform MPN Median	Coliform MPN >230 No.	>230 %	>700 No.	>700 %	Fecal coliform MPN Median	Fecal coliform MPN >33 No.	>33 %	>330 No.	>330 %
I	Chinjen													
		E-3[a]	7/62-12/63	18	20	3	17	1	5	-	-	-	-	-
		1-S[b]	5/66-05/67	24	13	5	21	2	8	7.2	4	16	2	8
		2-S		24	8.4	4	17	1	4	2.0	4	16	3	12
		3-S		24	6.8	3	12	2	8	2.0	3	12	2	8
		4-S		24	15.0	3	12	3	12	7.2	4	16	2	8
		5-S		24	4.5	2	8	1	4	1.9	3	12	1	4
		6-S		24	4.3	2	8	1	4	2.0	2	8	1	4
		7-S		24	2.8	2	8	1	4	2.0	5	20	1	4
		8-S		24	2.7	1	4	1	4	2.0	2	8	1	4
		9-S		24	2.0	2	8	1	4	<1.8	3	12	1	4
		9-D[c]		24	2.0	0	0	0	0	<1.8	0	0	0	0
		10-S		24	2.0	2	8	0	0	2.0	1	4	0	0
		10-D		23	<1.8	0	0	0	0	<1.8	1	4	0	0
		11-S		24	<1.8	2	8	0	0	<1.8	2	8	0	0
		11-D		24	<1.8	0	0	0	0	<1.8	0	0	0	0
		12-S		24	4.5	2	8	0	0	2.0	1	4	0	0
		12-D		24	<1.8	0	0	0	0	<1.8	1	4	0	0
		26-S		23	2.0	2	9	0	0	<1.8	3	12	0	0
		26-D		23	2.0	0	0	0	0	<1.8	1	4	0	0
II	Chindong													
		13-S	5/66-05/67	24	400	15	62	9	38	70	15	62	6	25
		14-S		24	7.2	2	8	2	8	2.0	3	12	2	8
		15-S		24	13	8	33	3	12	11	7	29	3	12
		16-S		24	2.0	2	8	0	0	<1.8	2	8	0	0
		16-D		24	2.0	0	0	0	0	1.8	1	4	0	0
		17-D		24	12	5	21	3	12	2.0	4	17	1	4
		18-S		24	13	1	4	1	4	2.0	2	8	1	4
		19-S		24	2.0	3	12	1	4	1.9	2	8	1	4
		19-D		24	2.0	0	0	0	0	<1.8	1	4	0	0
		20-S		23	6.8	2	8	2	8	2.0	2	8	2	8
		21-S		24	<1.8	1	4	0	0	<1.8	1	4	0	0
		21-D		24	1.9	0	0	0	0	<1.8	0	0	0	0
III	So Su													
		22-S	5/66-05/67	24	5.2	2	8	2	8	<1.8	3	12	1	4
		22-D		24	2.0	1	4	0	0	<1.8	1	4	0	0
		23-S		24	3.0	3	12	2	8	2.0	3	12	2	8
		23-D		24	2.0	0	0	0	0	<1.8	1	4	0	0
		24-S		24	2.0	1	4	1	4	1.9	2	8	1	4
		24-D	5/66-05/67	24	2.0	0	0	0	0	<1.8	1	4	0	0
		25-S		24	2.0	1	4	0	0	<1.8	1	4	0	0
		25-D		24	2.0	1	4	0	0	<1.8	1	4	0	0
IV	So Po													
		E-4	9/62-12/63	16	2.9	1	6	1	6	-	-	-	-	-
V	Yong Ho													
		E-2	7/62-12/63	18	<1.8	2	11	0	0	-	-	-	-	-

[a] E - Number assigned to the station in the preliminary surveys, 1961 to 1965.

[b] S - Surface sample.

[c] D - Sample at 5-meter depth.

Table C-3. SUMMARY OF BACTERIOLOGICAL TEST RESULTS
OYSTER SAMPLES
CHUNG MU REGION

Subarea No.	Subarea Name	Station No.	Sampling period	No. of samples	Coliform MPN Median	Coliform MPN >2400 No.	Coliform MPN >2400 %	Coliform MPN >24000 No.	Coliform MPN >24000 %	Fecal coliform MPN Median	Fecal coliform MPN >230 No.	Fecal coliform MPN >230 %	Fecal coliform MPN >2400 No.	Fecal coliform MPN >2400 %
I	Puk Man													
		O-1[a]	4/14-09/27/67	10	6,000	6	60	3	30	600	7	70	3	30
		W-2,3[b]												
		O-2		11	4,900	6	53	3	27	490	7	64	4	36
		W-8												
II	Pop Song Po													
		O-4	4/14-09/27/67	11	24,000	8	82	6	55	3,300	8	82	4	41
		W-15												
		O-5		10	3,600	8	80	4	40	1,300	8	80	4	40
		W-18,19												
		E-9	3/64-01/65	10	78	1	10	1	10	20	1	10	1	10
III	Tong Nae													
		O-6	6/13-09/27/67	8	12,000	5	63	3	37	1,800	5	63	4	50
		W-22,23												
IV	Gen Nae Rang													
		E-6	3/64-01/65	12	270	3	25	1	8	130	4	33	1	8
V	Do Sun Ri													
		E-10	3/64-12/64	11	45	1	9	0	0	20	1	9	1	9
VI	Yong Un Ri													
		E-7	3/64-02/65	12	330	2	17	1	8	170	3	25	1	9
VII	Punghwa Ri													
		E-8	3/64-01/65	12	230	1	8	0	0	68	3	25	0	0

[a] O - Oyster sampling station number.

[b] W - Water sampling station number.

[c] E - Number assigned to the station in the preliminary surveys, 1961 to 1965.

Table C-4. SUMMARY OF BACTERIOLOGICAL RESULTS
OYSTER SAMPLES
CHINDONG REGION

Subarea No.	Subarea Name Station No.	Sampling period	No. of samples	Coliform MPN Median	Coliform MPN >2400 No.	Coliform MPN >2400 %	Coliform MPN >24000 No.	Coliform MPN >24000 %	Fecal coliform MPN Median	Fecal coliform MPN >230 No.	Fecal coliform MPN >230 %	Fecal coliform MPN >2400 No.	Fecal coliform MPN >2400 %
I	Chinjen												
	E-3[a]	7/62-12/63	18	790	5	28	1	6	-	-	-	-	-
	O-1[b]	5/66-05/67	24	490	7	29	0	0	78	8	33	2	8
	W-3[c]												
II	Chindong												
	O-2	5/66-05/67	24	950	9	37	2	8	330	12	50	5	21
	W-20												
	O-3		23	1,200	7	30	3	13	200	11	48	4	17
	W-19												
III	So Su												
	O-4	5/66-05/67	24	1,700	10	42	6	25	150	11	46	5	21
	W-23, 25												
	O-5		24	480	7	29	2	8	56	7	29	1	4
	W-24												
IV	So Po												
	E-4	9/62-12/63	16	330	2	13	1	6	-	-	-	-	-
V	Yong Ho												
	E-2	9/62-12/63	16	330	2	13	0	0	-	-	-	-	-

[a] E - Number assigned to the station in the preliminary surveys, 1961 to 1965.

[b] O - Oyster sampling station number.

[c] W - Water sampling station number.

Appendix D

SELECTION OF PRIORITY STUDY AREAS FOR SANITARY SURVEYS

I. Kosong-Man - Army Map Service Sheet 6818-I, Series L751

Although the Kosong-Man area, located south of Kosong City, is a well protected estuary, this area is not recommended because

1. the bay is probably restricted in circulation because of the narrow and shallow entrance;
2. the watershed is relatively large, long, and complex;
3. proportionately large land areas of the watershed are used for rice cultivation; and
4. the area is near Kosong, a relatively large city.

II. Pung Man - Nam-Man - So-Man Region - Army Map Service Sheets 6818-I and II, Series L751

This area includes many protected coves that might be favorable for oyster culture. Results of the 1967 bacteriological survey to date show severe influence of rainfall on Pung Man, Popsong, and Tong Nae subareas. The southerly estuary, however, in the Punghwa Ri subarea, shows in the 1964 to 1965 bacteriological surveys, the effect of rainfall only during July, with rapid recovery and the prevalence of low values during the harvesting season.

Decision on the northern portion of this region should be withheld pending results on subareas I, II, and III during the dry season. In the meantime, the Mission suggests immediate action on other areas mentioned below. Punghwa Ri, the southerly subarea of the region, might be considered, particularly if the Chodo-Sudo areas to the south were considered. (See item 3 below.)

III. Chodo-Sudo - Army Map Service Sheet 6818 II, Series L751, $^{38}45$ N, ^{4} 46 E

The area to the NNW includes many protected coves with small watersheds. Although the area is small, it has good potential and should be considered.

IV. Southern and Central Portions of Koje Do - Army Map Service Sheet 6918 III, Series L751

Numerous coves on the eastern and western shores of Koje Do and islands to the west seem to conform to the characteristics of good subareas. They might be of secondary interest, however, because of the remoteness of the area and and because the eastern shore is relatively unprotected.

V. Northern Portions of Koje Do - Army Map Service Sheet 6918 IV, Series L751

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The large embayments on the north coast of Koje Do would merit investigation.

Population centers and rice production at the apex of the bay to the northwest might influence the area, $^{38}62$ N, $^{4}64$ E, although the southwestern shore of the bay and the coves along the island to the north might be promising. The passage at the north of the island also appears promising.

All of these areas are accessible by road and ferry to Chung Mu.

VI. Chindong Man - Army Map Service Sheets 6819 II and 6919 III, Series L751, boundaries $^{38}75$ N to $^{38}84$ N, $^{4}52$ E to $^{4}63$ E

This area has an extremely complex watershed system, particularly on the NW, but it would be a very interesting area to study. It is too extensive to study in its entirety as a beginning effort, but a portion, the eastern section east of Suu Do, $^{38}83$ N, $^{4}56$ E, has good prospects *if* there is not much influence by the large river systems flowing into the Chinjen and Chindong subareas. The cove Nampo Man to the east of the region should be of good quality. The cove (unnamed) $^{38}80$ N, $^{4}60$ E protected by Cho Do should be interesting and offer potential for study.

SUMMARY - SELECTION OF STUDY AREAS

The Mission is aware of the widespread interest in the development of oyster culture. Selection of study area, therefore, should represent this interest by suggesting three or more estuaries in the model area.

Priority for conducting surveys should be left to appropriate agencies in the Office of Fisheries because of their knowledge of the biological suitability of the area and the extent of current use. The following suggestions, however, might be of assistance.

Chung Mu Area. The coves in the southerly portions of Nam Man (Sheets 6818 I and II) and those to the south, such as Punghwa and the Chodo Sudo areas (Sheet 6818 II), appear, on review of the topographical maps, to have good potential for oyster growing. These have a land mass that is clearly distinguishable, with promising topographic and land use characteristics. They also are easily accessible from Chung Mu City.

The Northern and Central portions of Koje Do, which also are accessible to Chung Mu City by road and ferry, have numerous subestuaries that are promising. Certain of these might be selected for study.

Chindong and Masan Areas. The eastern portion of Chindong Man (Sheet 6819 III) might offer a number of embayments of good potential if the influence of drainage from the Chinjen and Chindong subarea watersheds is not excessive. The embayments on the east shore of the peninsula (Nampo-Man, Ok-Po) as well as the bay on the south, protected by Cho Do, could be studied at the same time.

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