DEVELOPMENT OF THE COASTAL FISHERIES IN CAMBODIA

SURVEY REPORT

(DRY SEASON)

MARCH 1970

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

City of Sihanoukville was given its former name, Kompong Som, after the political change in Cambodia on March, 1970.

PREFACE

In compliance with the request of the Government of Cambodia, the Government of Japan agreed to undertake a survey for the development of coastal fisheries (dry season) and entrusted the Overseas Technical Cooperation Agency with its execution around the end of 1968.

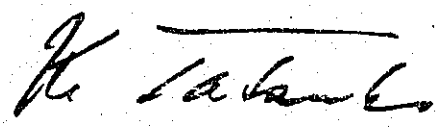
The Agency accordingly organized a survey team comprising six fisheries experts headed by Mr. Yoshitsugu Shiji, Counsellor of Japan Fisheries Association, and despatched it to Cambodia on January 26, 1969. The team stayed in Cambodia for about one month during which survey activities were conducted with its members divided into three groups: fisheries (shrimps, crabs and bottom fishes); cultivation (oyster); and fisheries administration, circulation and processing. Survey was carried out mostly in Sihanoukville and its vicinities with the view to promoting the fisheries development with emphasis placed on shrimp fishing and oyster culture.

Since its return to Japan, the team has directed its efforts to the compilation of data and identification of specimens collected during the survey for the preparation of the report hereby presented.

It is my sincere hope that this report, which is an outcome of joint endeavours of peoples of Cambodia and Japan, will serve for the future development of Cambodia, its fisheries development in particular, and at once contribute to the furtherance of amity and economic cooperation between the two countries.

This report will be ensued by another report which would give the results of follow-up surveys scheduled to be conducted in the near future to clarify the feasibility of developing oyster culture in Cambodia on a commercial basis.

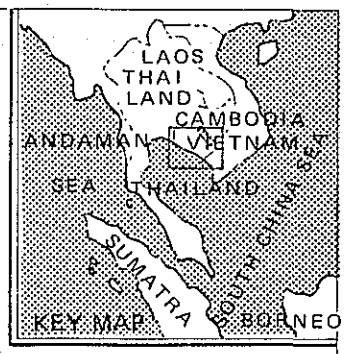
On behalf of the Agency, I take this opportunity to express my heartiest gratitude to the Government of Cambodia and other competent authorities for their valuable cooperation without which smooth and efficient execution of the survey would not have been possible.



Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

December, 1969

LOCATION MAP



Interim report was presented to
the Minister of Agriculture

Results of the survey was reported
to Director of Fishery Service

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PART I SUMMARY AND RECOMMENDATIONS

CHAPTER I INTRODUCTION

1-1 Outline of the Cambodian Fisheries

Economic development of Cambodia can never be achieved without the development of primary industries though it is largely dependent on the promotion of secondary industries. Of a number of primary industries such as agriculture, livestock farming, fisheries, etc., fisheries are, in effect, the only source of supply of cheap animal protein in Cambodia.

Fisheries in Cambodia can be broadly classified into two categories, the fresh water fisheries and the coastal fisheries. The former is substantially developed, reportedly enjoying an annual catch of about 200 thousand tons in the extensive fishing grounds embracing many rivers, brooks, lakes, and particularly the Great Lake, whereas the latter, operating along the 435 km coast line, is rather backward with its annual landing not even reaching the 40 thousand ton level and with the motorization of fishing boats still remaining in the initial stage.

The desired development of the Cambodian fisheries calls for the implementation of a number of measures such as the development of fishing ports, exploitation of fishing grounds, improvement of productivity, and establishment of improved preservation system to be coupled with the availability of cold storage, ice manufacturing facilities and processing plants. These measures, however, should be preceded by basic and ecological studies on coastal and off shore resources.

The recent decrease in the catch of fresh water fishes which is due to the silting up of the Great Lake and the sharp population growth justify the projected development of marine resources because it will serve to secure the supply of much needed animal protein and contribute, at the same time, to the economic stabilization of the country through the development of shrimp fishing and oyster culture.

1-2 Background of the Survey

The wet season survey conducted in June 1967 at the request of the Cambodian Government centered upon the following.

1) Market research on various marine products.
2) Research of actual conditions of fishing villages.
3) Oceanographic observations.
4) Fisheries experimental survey by gill net and small trawl net fishing.
5) Survey on shellfishes.

Upon completion of the wet season survey, the team recommended that a dry season survey be carried out with emphasis placed on the fisheries experimental survey which was impeded by high waves and produced no sufficient data for mapping out the plan for coastal fisheries development. Having acceded to this recommendation, the Cambodian Government officially requested Japan's assistance in May 1968 in the execution of the dry season survey, which the Japanese Government accepted and entrusted the

Overseas Technical Cooperation Agency (hereafter called OTCA) with the task of its execution. The dry season survey team organized by OTCA left Japan on January 26, 1969 and engaged in survey activities for a period of about one month with Sihanoukville as the base of its activities. (Advance group consisting of Asano and Kimura left on January 19 for prior arrangements and preparations)

The present dry season survey was conducted on fisheries of shrimps, crabs, bottom fishes, Plathou; oyster culture; and fisheries administration, and circulation and processing of marine products. All these survey items were considered to be of controlling importance for the desired development of sea fishing. Efforts were made to find means and measures to justify the commercial production of these fishes on a larger scale.

Prior to its departure to Japan on March 3, the team prepared a preliminary report entitled "Rapport Provisoire sur le Developpement des Pêches Côtières au Cambodge, Fevrier 1969" which was submitted to the Minister of Agriculture and to the Director of the Fishery Service.

On presenting the above-mentioned preliminary report, the team requested the cooperation of the Cambodian Government in the continued survey on oyster culture.[1] All the equipment and facilities needed for the continued survey were therefore left at the Japanese Embassy in Cambodia and at the Cambodian Oceanographic Institute in Sihanoukville.

All specimens of fishes, shellfishes and other marine lives collected during the survey were airborne to Japan for identification by the following experts.

Name	Position	Speciality
Dr. Takaharu Abe	Dr. of Science, Technical Officer, Tokai District Fisheries Research Institute	Fishes
Dr. Takuo Chiba	Dr. of Agriculture, Prof. of the Fisheries College, Ministry of Agriculture and Forestry	Plankton
Dr. Masaru Amio	Dr. of Agriculture, Asso. Prof. of the Fisheries College, Ministry of Agriculture and Forestry	Crustacea
Dr. Tadashige Habe	Dr. of Science, Curator of National Museum	Shellfishes

1) A minimum of one year is required for the continued survey which should comprise:

1. Growth and mortality survey to be conducted at least every two months,
2. Collection and survey of planktons and spats to be carried out once in 15 - 20 days, and

3. Management of the four experimental oyster culture grounds.

1-3 Formation of the Survey Team

Formation of the survey team was as follows.

	Name	Position	Assignment
Leader	Yoshitsugu Shiji	Counsellor, Japan Fisheries Association	General control
Member	Takumi Takeuchi	Chief, Hiroshima Fisheries Experiment Station	Shellfish (oyster culture)
"	Masakuni Kitani	Chief, Shallow Sea Fishing Experimental Laboratory, Oita Prefectural Government	Shrimp, crab, bottom fish & plathou
"	Tsukasa Shiokawa	Chief, Research Section, Nagasaki Fisheries Experiment Station	"
"	Yoshiharu Asano	2nd Ocean Fisheries Division, Production Department, Fishery Agency	Fisheries administration, circulation & processing
"	Hiroshi Kimura	Staff member, Development Survey Division, OTCA	Liaison

1-4 Itinerary of the Survey

The main group of the survey team (Takeuchi, Kitani and Shiokawa led by Leader Shiji) left Japan on January 26, 1969 for Phnom Penh. Prior to this, the advance party consisting of two members, Asano and Kimura, left Tokyo on January 19 to make previous arrangements for the survey including selection of a suitable location in coastal waters near Sihanoukville for temporary preservation of seed oysters immediately after arrival of the main group.

Date and Day	General Survey Group	Fisheries Group	Culture Group
	(Fisheries administration, circulation and processing inclusive)	(Shrimp, crab, bottom fish and plathou)	(Oyster)
	Shiji, Asano and Kimura	Kitani and Shiokawa	Takeuchi
Jan 19, Sun	Departure of the Advance Group (Asano and Kimura) from Japan by AF 195.		
Jan 20, Mon	Courtesy call on Vice-Minister for Agriculture, Director of Fishery Service, Japanese Embassy in Phnom Penh and OTCA Overseas Office.		
Jan 21, Tue	Arrangements for the survey at the Fishery Service, Japanese Embassy and OTCA Overseas Office.		
Jan 22, Wed	Arrangements with *Fuji Kigyo Co., Ltd.* and at OTCA Overseas Office for procurement of necessary equipment and materials.		
Jan 23, Thu	Phnom Penh ⟶ Sihanoukville *Consultations with the staff of the Oceanographic Institute for preservation of seed oysters to be brought from Japan.*		

Jan 24, Fri	Setting of rafts for oyster preservation in the sea water near the Oceanographic institute. Return to Phnom Penh via Kampot.
Jan 25, Sat	Inspection of 41 cases of survey equipment stored at OTCA Overseas Office.
Jan 26, Sun	Arrival of the Main Group (Takeuchi, Kitani and Shiokawa led by Leader Shiji) at Phnom Penh by AF 195. Departure of Asano for Sihanoukville for preservation of seed oysters immediately after the customs clearance.
Jan 27, Mon	Courtesy call on the Ministry of Foreign Affairs, Ministry of Agriculture and Japanese Embassy by all members excepting Asano. Inspection of bamboo materials for the experimental oyster culture at a bamboo shop located near the Saigon Bridge. Return of Asano from Sihanoukville where he had completed the preservation work.
Jan 28, Tue	Inspection of the central market of Phnom Penh. *Arrangements for the survey schedule and procurement of locally available materials.*
Jan 29, Wed	Visit to the Director of Fishery Service. Loading of survey equipment onto a truck at OTCA Overseas Office. Reception at the Japanese Embassy.

Jan 30, Thu — Departure of all members for Sihanoukville, the survey base.
Visit to the Oceanographic Institute in Sihanoukville.

Jan 31, Fri — Discussions with Mr. Suon Saoroeung, Chief of the Oceanographic Institute.
Interview with the Governor of Sihanoukville City.
Uncrating work of survey equipment at the laboratory of the Oceanographic Institute.

Feb 1, Sat — Inspection and adjustment of survey equipment at the laboratory of the Oceanographic Institute.

Feb 2, Sun — Survey by bottom gill net in the vicinity of Koh Kong Kang in the offing of Sihanoukville under high wave conditions.

Feb 3, Mon — Preparations and arrangements for survey in the area around Koh Kong.

Transfer into Koh Pos Bay of Japanese seed oysters damaged by the high waves on Feb. 2.

Feb 4, Tue — Planned departure before dawn postponed due to intensive wind and rain.

8:15 hrs — Departure from Sihanoukville for Koh Kong area of all members, with Mr. Suon, Chief of Oceanographic Institute and President Ishijima of Fuji Kogyo Co. accompanying the team.

12:15 hrs — Brief rest at the so-called King's Island in Samit Islands.

19:30 hrs — Arrival at Port of Khemarak Phouminville after passing the offing of Koh Kong.
Inspection and overnight stay at SONACOP.
Interview with Mr. Sao Leang, President of SONACOP, who provided information on the current local conditions.

Feb 5, Wed	Team divided for trawl net fishing survey and oyster survey.	Departure from Khemarak Phouminville for trawl net survey.	Oyster survey in Koh Kong Bay, overnight stay at Koh Kapik.
Feb 6, Thu	*Ditto*	*Return to Khemarak Phouminville.* Classification of collected specimens.	*Ditto*
Fib 7, Fri	Overnight stay at Koh Kapik.	Departure from Khemarak Phouminville for survey by trawl net and gill net.	Oyster survey in Koh Kong Bay, and preparations for experimental oyster culture facilities. Overnight stay at Koh Kapik.
Feb 8, Sat	Overnight stay at Koh Kapik.	Return to Khemarak Phouminville. Classification of collected specimens.	Oyster survey in Koh Kong Bay and setting of experimental oyster culture facilities. Overnight stay at Koh Kapik.
Feb 9, Sun	4:00 hrs Departure from Koh Kapik. 8:30 hrs Arrival at Samit Port, and brief rest at SOKECIA.	Departure from Khemarak Phouminville for survey by trawl net fishing.	Same as General Survey Group

	13:30 hrs Departure from Samit Port. 18:30 hrs Return to Sihanoukville.		
Feb 10, Mon	Survey with Oyster Goup. Departure of Kimura for Phnom Penh for liaison work.	3:30 hrs Entry into Samit Port. 13:40 hrs Departure from the same. 18:15 hrs Return to Sihanoukville.	Survey of oyster colonies in Ream Port.
Feb 11, Tue	Return to Sihanoukville. Discussions with Mr. Suon of the Oceanographic Institute.	Classification of collected specimens.	Classifications of collected specimens.
Feb 12, Wed	Survey with Oyster Group in Ream Bay.	Classification of collected specimens.	Experimental oyster culture work in Ream Bay.
Feb 13, Thu	Market survey at Ream.	Departure from Sihanoukville for survey by fish lamp in the offing of Samit and Koh Kong. Survey in the offing of Samit conducted at night with Mr. Lonn Kim-Hong of Kg. Som Division accompanying the team. Overnight stay at Samit.	Experimental oyster culture work in Ream Bay.

Feb 14, Fri	Market survey in Sihanoukville.	Departure in early morning from Samit, arrangements with Kg. Som Division at Koh Kapik, and survey by fish lamp and purse seine in the offing of Koh Kapik from 22:00 hrs.	Preparations for installing oyster culture facilities in front waters of Koh Pos on the opposite side of Sihanoukville.
Feb 15, Sat	Inspection of a fishing village, Sre Ambel.	Return to Sihanoukville from Koh Kapik.	Setting of oyster culture facilities in fron waters of Koh Pos.
Feb 16, Sun	Departure for Phnom Penh to report the progress of survey.	Classification of collected specimens.	Classification of collected specimens.
Feb 17, Mon	Classification of collected specimens and coordination meeting with relevant organizations.	Classification of collected specimens.	Departure from Sihanoukville to conduct experimental oyster culture work, with Mr. Ishijima of Fuji Kigyo accompanying the Group.
Feb 18, Tue	Visit to the Japanese Embassy to make arrangements regarding survey equipment and fisheries experts.	Classification of collected specimens.	Oyster survey.

Feb 19, Wed	Return to Sihanoukville from Phnom Penh.	16:00 hrs	Departure for survey by fish lamp and gill net in Kg. Som Bay.	Oyster survey.
Feb 20, Thu	Investigation of a fishing village in Kampot.	Classification of collected specimens.		Departure from Koh Kapik in early morning and arrival at Sihanoukville.
Feb 21, Fri	Investigation of a fishing village in Kampot.	Market survey at Ream.		Oyster survey in front waters of Koh Pos.
Feb 22, Sat	Completion of investigations in Kampot and return to Sihanoukville.	Market survey in Kampot and oceanographic observations.		Oyster survey in front waters of Koh Pos, and classification of collected specimens.
Feb 23, Sun	Classification and arrangement of collected specimens, and drafting of the preliminary report.			
Feb 24, Mon	Discussions with Mr. Suon about the draft of the preliminary report.			
Feb 25, Tue	Adjustment and crating of survey equipment. Departure of Asano for Phnom Penh for data collection.	Adjustment and crating of survey equipment.		Oyster survey in front waters of Koh Pos.

Feb 26, Wed	Return of all members to Phnom Penh.
Feb 27, Thu	Visit to the Japanese Embassy to report on the progress of survey. Completion of the customs formalities of survey equipment and specimens.
Feb 28, Fri	Interview with the Director of Fishery Service, and submission of the preliminary report.
Mar 1, Sat	Interview with the Minister for Agriculture, and submission of the preliminary report with the request for cooperation in the continued survey activities for oyster culture. Dinner with officials concerned.
Mar 2, Sun	Preparations for return to Japan.
Mar 3, Mon	Courtesy call on the Japanese Embassy. Departure from Phnom Penh at 12:00 hrs by CX 068.

1-5 Acknowledgements

The team wishes to express its deep appreciation of the unlimited cooperation extended by all competent authorities and people concerned with the fisheries development, and feels particularly grateful to the following officials of the Cambodian Government whose untiring assistance has been most valuable for the smooth execution of survey activities.

Mr. Sor Teung Leung	Director of Economic Cooperation Bureau, Ministry of Foreign Affairs, Cambodian Government
H.E. Mr. Cuon Saodi	Minister for Agriculture, Cambodian Government
H.E. Mr. Chhan Hi	Vice-Minister for Agriculture, Cambodian Government
Mr. Kao Nath	Director of the Fishery Service, Ministry of Agriculture, Cambodian Government
Mr. Suon Saroeung	Chief, Oceanographic Institute, Sihanoukville
Mr. Sok Mathoeung	Chief, Archives Section, Ministry of Agriculture, Cambodian Government

Chiefs of Divisions of Koh Kapik, Kompong Som, Sre Ambel and Kampot

H.E. Mr. Hing Sakho	Governor, Sihanoukville City
Mr. Sao Leang	President, SONACOP
Mr. Chau Koy	Plant Superintendent, SONACOP

The team further wishes to express its gratitude to the Japanese Embassy in Cambodia, Fuji Kigyo Co., Ltd. and SOKECIA for the cooperation extended throughout the field survey, and also to Dr. Abe, Dr. Chiba, Dr. Amio and Dr. Habe who spared to efforts in identifying the specimens collected.

CHAPTER II OUTLINE OF SURVEY AND GIST OF RECOMMENDATIONS

2-1 Outline of Survey

2-1-1 Fisheries

Shrimp, crab and bottom fish are the major marine products believed to have a close bearing upon the desired development of sea fishing of Cambodia. The present survey was therefore conducted primarily on these three marine lives in the offing of Koh Kong and Koh Samit as well as in Kompong Som Bay and vicinities of Koh Kong using trawl net, gill net, angling, fish lamp, etc., whichever was suitable to clarify their ecological conditions and to devise the best applicable fishing method. It is to be added that the survey was carried on the basis of the results of the wet season survey of 1967.

The survey activities were impeded to some extent by a number of adverse factors such as the difficulty in chartering survey boats with satisfactory equipment and facilities, deficient skill of the crew and their apprehensions about the off-shore fishing caused by the unsolved conflict in the adjoining fishing area.

Results of the survey are as briefed below.

(1) Shrimp

The survey revealed that shrimps are distributed throughout the coastal area of Cambodia. Large prawns belonging to Penaues or Metapenaeus sp. were caught far off shore, while smaller prawns of the same species were caught mostly in areas along the coast. Difference was noticed in the composition of species between areas north and south of Koh Kong. To be more precise, the catch of shrimps in areas north of Koh Kong was occupied predominantly by *P. merguiensis*, Meruguiebi, with some *M. mutatus*, a kind of Yoshiebi, whereas *P. seminsulcatus*, Kumaebi, accounted for the greater portion of the catch in the southern area. The difference, however, is not considered very distinct because the small trawl net fishing survey carried out in the southern area during the previous survey produced a large catch of *P. semisulcatus*. Further, the market survey during the present survey disclosed that youngs of this species were found in substantial quantities in Kampot, indicating that there is no year-round difference in the shrimp distribution between the northern and southern areas.

Shrimps of large size caught during the survey were unexceptionally fully grown or almost so, and most were in the spawning peak. From their maturity observed during the survey and various data available, an inference can be readily drawn that the shrimp resources in Cambodia are not in the least poor.

It is to be added that the present survey produced no data for clarifying the ecology of shrimps, i.e., data needed to establish the relationship between the shrimps in shallow waters along the coast and those caught in off-shore areas, and to discover their ecological conditions including distribution and transfer of fishing grounds.

(2) Crab

Survey was conducted with particular importance attached to two major species in Cambodia, *Seylla serrata*, Nokogirigazami, and *Portunus pelagicus*, Taiwan-gazami.

Portunus pelagicus, Taiwangazami, was caught at all stations where the trawl net survey was performed. Results of the present and the previous surveys are indicative of its wide-spread distribution in areas having a high salinity. The team often noted that this species was mature with eggs, irrespective as to whether the observation was made during the marine survey or market survey. Its spawning season is therefore considered to last from February to April. The female of this species was frequently noticed to be larger than the male.

Seylla serrata, Nokogirigazami, is believed to live in estuaries where mangrove trees grow thickly, and its spawning activity is generally thought to commence with the advent of the wet season. Most individuals found on the market were small and not fully grown, but they would evidently have grown into adult crabs if allowed to go through one or two moulting processes.

(3) Bottom Fish

Fishes collected by the trawl net survey exceeded 71 species, but most were small in size. With the exception of a few species such as *Leiognathus equulus*, Seitaka hiiragi, fishes caught south of Koh Kong differed in composition from those collected in the north. To be precise, while *Pampus argenteus*, Managatsuo, and species similar to *Sepia esculenta*, Koika, were the major catches in the northern area, *Gerres abbreviatus*, Sepparizaki, and *Scolopsis cilatus* (Fam. Itoyoridai) occupied the greater part of the catch in the southern area.

The gill net fishing survey also proved that species living in the two areas differed in composition.

(4) Survey by Fish Lamp

Survey by fish lamp using a fish finder revealed that fish schools gathered in both surface and mid-bottom waters, and that fishes lured and gathered in the mid-bottom waters were larger in both size and density. However, no detailed confirmation of species was possible. Fishes gathered and identified by the use of various fishing gear included *Spyraena picuda*, Kamasu, and *Selariodes leptelepis* (Fam. Aji). The survey proved that the fish lamp is effective for gathering certain species living in the coastal area of Cambodia.

2-1-2 Oyster Culture

In answer to the desire expressed by the Cambodian Government for the promotion of oyster culture, the team treated it as one of major survey items as in the case of the previous survey and studied the possibility of developing the commercial production of oyster. The survey was started with the selection of locations of four experimental grounds convenient for future development and management.

Four grounds selected are respectively located in waters in front of the south-western coast of Koh Salour (Koh Kapik district), the northern coast of Koh Kong, Koh Pos on the opposite side of Sihanoukville, and the northern coast of Koh Russey in Ream. In order to carry out the experimental culture by the hanging method using either rafts or piles, all the required facilities were set up in the four grounds. These experimental grounds are intended for a number of purposes: 1) growth observation by artificial cultivation of natural oysters which attach to prop roots of mangrove trees, 2) detection of causes impeding the cultivation efforts and observation of their adverse effects, 3) clarification of optimum time and method for spat collection, and 4) comparison with oyster seeds brought from Japan. With so limited a survey period, it was obviously impossible to reach any definite conclusion on all these items. However, the experiment made it clear that the spat collection is promising in the area along Koh Kong which is densely wooded with mangrove trees, and that barnacles are perhaps most detrimental to the cultivation of oysters.

2-1-3 Fisheries Administration, Circulation and Processing

Fishing activities, processing and circulation of fishes, and conditions of local consumer markets were investigated at major fishing bases such as Koh Kapik, Sre Ambel, Sihanoukville, Ream, Kampot and Kep. Further, a survey was made in Phnom Penh on fisheries administration, general conditions of central market, and export of marine products.

(1) Fisheries Administration

Administrative measures taken by the Government in recent years are basically aimed at two goals, the one is to seek the source of animal protein supply in the sea fishing so as to cope with the sharp population growth, and the other is to increase foreign currency earnings through export promotion of marine products. Measures for fisheries development are consequently intended for the inducement of modern fishing gear and methods based on the results of scientific research of fish resources in the coastal areas of the country. Revision or abolition of laws and regulations currently governing the sea fishing is under consideration for preservation and rational utilization of fish resources.

(2) Fishing Conditions and Activities

The climatic characteristic of Cambodia divides the whole year into two seasons, the wet and dry, and this is well known to be affecting the fish catch.

Apart from the above-mentioned climatic factor, the development of the Cambodian fisheries will be largely influenced by the conditions of individual fishing villages, i.e., their location and the extent of their dependence on the fishing industry. The survey revealed that the fishing activities differed by these two conditions in each area.

It was noticed that the number of fishermen and fishing boats (including powered boats) as well as the fish production have been on the upward trend.

It was felt, however, that despite the efforts for motorization, analyses or studies are as yet to be made on the increased efficiency and catch, or on the improved fishing management brought about by the use of powered boats.

(3) Circulation and Processing

Fishing boats and gear are purchased with loans advanced by brokers who often bind the fishermen to the condition that they make the reimbursement in terms of fish.

To help stabilize such poor financial standing of fishermen, the Government has already incorporated, in its administrative measure of top urgency, a plan for organizing them. Unfortunately, however, the team failed to witness any evidence of movements for its materialization.

Freshness maintenance and processing of catches are of utmost importance for increasing the consumption of marine products by inhabitants in inland areas because the country is situated within the tropical zone and the atmospheric temperature stands at a high degree throughout the year. The prevailing method of freshness maintenance is to simply fill ice pieces in fish cages when the landed catches are shipped to consuming areas. The team observed neither the use of ice inside the fishing boat, nor fishing ports provided with efficient landing facilities and suitable wetdocks. Cold storage cars for fish transportation were not found either. Use of ice was found neither at the landing bases nor at fish markets, and this is probably responsible for the constant price fluctuation of fishes. Processing methods devised to cope with the seasonal fluctuation of fish catch in the absence of modern processing facilities are all primary methods such as salting, boiling, smoking and processing into fish sauce.

It deserves attention, however, that SONACOP (Société Nationale de Conserverie de Poissons, a state-owned canning corporation), operating since 1967, is equipped with modern facilities for manufacturing ice at low cost for fisheries use, cold storage facilities for preservation of fishes, canning facilities, and equipment for fish meal production. With three trawlers of its own, SONACOP secures the supply of raw materials it requires, and is contributing to the maximum utilization of fish resources and development of Cambodian fisheries.

(4) Export of Marine Products

The survey revealed that the export value largely fluctuates almost every year by whether the fishes exported to Singapore are composed of fresh plathou or boiled and salted plathou.

Export values appearing in the statistics are considered to be lower than the planned values.

Cold storage and export of shrimps are a matter that awaits future studies and development. Basic studies were therefore made with respect to the economic and technical aspects of shrimp production.

2-2 Recommendations

Cambodia has been favoured since olden times with numerous lakes and rivers that have provided its people with lots of fresh water fishing grounds and supplied a rich variety of fishes that enrich the nation's food life. However, due to the progress of industrial development and other factors, these lakes and rivers are now subjected to various adverse effects which are inviting the reduction of both fishing grounds and catches.

The sharp population growth of the country will effect a change to the nation's food life which has hitherto been dependent on the fresh water fishing for the supply animal protein. The Government's measure for sea fisheries development is therefore to be highly evaluated as being quite opportune. However, the desired development of sea fisheries must be preceded by research activities to clarify the marine resources in the coastal areas. And data on the catchable resources, when made available by such activities, should be utilized to the maximum extent for decision on the optimum kinds and scale of fishing operation.

It goes without saying that the Government should take the lead in the above-mentioned research activities. It is preferable, however, that the actual research work be conducted by the joint efforts of the Government and the fishermen living along the coast, so that the latter's experience and skill cultured over many years of actual operations may be made best use of.

The initiative taken by the Government for the sea fisheries development has a direct and close bearing upon the elevation of economic and social standing of coastal fishermen. For this reason, the fishermen should fully cooperate with the Government, and the Government should spare no efforts in enlightening and educating fishermen for improvement of their capabilities. Efforts are therefore desired to be made for the rearing and fostering of fisheries cooperative associations and for the training of leaders needed for fishing villages.

(1) Shrimp

The survey by trawl net fishing disclosed that it is quite likely that the coastal area of Cambodia is favoured with rich resources of shrimps, and that the development of trawl net fishing in future is promising. However, the survey has not covered the entire coastal areas, nor has it produced sufficient ecological data relating to the distribution, composition, transfer of fishing grounds with growth, etc. It is therefore recommended that further surveys be made to provide a firm scientific basis upon which to establish the production plan incorporating measures for preservation of resources and to determine an optimum scale of fishing operation.

For the desired export of frozen shrimps, use of fishing boats equipped with cold storage facilities may be expedient pending the completion of the refrigerating facilities on land. It is recommended that studies be made in advance on the relationship between the export prices and the world market situation.

(2) Crab

It was noted that *Scylla serrata*, Nokogirigazami, is generally small in size. This is considered attributable to the fact that this species lives mostly in estuaries and is consequently subjected to a high fishing intensity. Hence, it is desirable to place restrictions on fishing operation during the spawning season as well as on fishing grounds, and also to prohibit the catch of adult crabs with eggs. If such measures are impracticable, it would then be necessary that grown crabs be stocked temporarily to accelerate the hatching of eggs before they are put on the market. Since the resources of this species are evidently on the decline, it is imperative that proper measures be taken for their preservation and effective utilization.

(3) Bottom Fish

The fact that the greater portion of catches by trawl net fishing was occupied by small miscellaneous fishes indicates the necessity for increasing the demand for useful fresh marine fishes other than shrimps so that they may eventually take the place of freshwater fishes.

Other miscellaneous fishes not suited for the abovementioned purpose should be processed into fish sauce, fish meal, feed-stuff, etc. If marine products such as feed-stuff come to be used widely in the live-stock industry, the increased output of live-stock products will serve for stabilization of national economy.

(4) Survey by Fish Lamp

Plathou, one of the most important and abundant marine fishes in the Cambodian coastal area, is caught without the use of the fish lamp. This is perhaps because the fishermen are convinced, through many years of experience, that this fish cannot be lured by the lamp.

However, fish lamps and fish finders employed in many countries of the world will have to be used in future surveys on useful fishes that can be gathered by the fish lamp. Such surveys should naturally be intended for the establishment of efficient fishing methods and rationalization of fishing management.

(5) Oyster Culture

Development of oyster culture for production on a commercial basis must await the results of future studies and researches. It is desired that the Government will extend full cooperation in the continued survey of experimental oysters in the four selected grounds. The team wishes that the cooperation of the Government will be given to the survey on the growth and mortality rate of oysters, collection of planktons, spat collection, and maintenance and management of all four experimental grounds.

(6) Propagation of Marine Fishes for Food

Cambodian people are accustomed to, and have a strong taste for, freshwaster fishes, and it does not seem quite so easy to effect a drastic change to their food life by the introduction of marine products. Efforts should therefore be made at every possible opportunity for the propagation of marine fishes for food.

PART II DETAILED DESCRIPTION

(7) Preservation and Resources

Fishing operations and fishing grounds in the Cambodian coastal area are controlled according to the provisions of the Fisheries Law enacted in 1957. Situations have changed largely since that time, and at present, certain provisions of the law do not conform to realities or are entirely meaningless. With the increasing concern about the sea fisheries and development of new resources, it is not at all unlikely that the marine resources, now available in abundance, will be exhausted as have been often the case in many countries, if no actions are taken to provide against excessive fishing intensity. It is therefore recommended that the relevant laws and regulations be so revised and consolidated as will conform to the existing situation and protect the resources.

(8) Maintenance of Freshness

Sales expansion of marine products in future can never be achieved without giving due attention to the freshness maintenance. Most of freshwater fishes are sold alive on the market, whereas sea fishes are sold as fresh fishes but without using sufficient ice to keep their freshness. This naturally leads to the drop of freshness and nutritive value, and further incurs a decrease of commercial value. In view of the desired export promotion of marine products, utmost attention must be given to the freshness maintenance. It must be noted that freshness directly affects the quality of processed export products made from sea fishes. It is therefore desirable that ice for fish preservation be manufactured at low cost and in large quantities and distributed to all fishing bases without delay. It is also advisable that the fish hold of ordinary fishing boats be remodelled, and that fishing boats be loaded with a sufficient amount of ice to keep the catch fresh.

(9) Rearing and Strengthening of Fishery Cooperative Associations

If the production increase is to be attained concurrently with the modernization of fishing industry and elevation of economic and social standing of fishermen, the means adoptable in Cambodia would be to push forward activities for raising fishermen's living atandard in regard to their economic standing, welfare and cultural life, with their cooperative associations serving as the core of such activities.

It is therefore recommended that the Government take progressive and positive measures for rearing and fostering fishery cooperative associations, and further arrange for providing the associations with long-term loans at low interest rates so that they may be allowed to perform their functions such as joint purchase of fishing gear and equipment, joint sales of products, and introduction of new and effective handling and processing methods.

(10) Consolidation of Statistics and Materials

The desired development of sea fisheries demands the full understanding of all prevailing problems entailed therein, and also calls for basic oceanographic and biologic surveys. The Government is therefore advised to establish a system under which a uniform method can be employed in collecting data required for statistics on catches, fishing efforts, fishing boats, fisheries management, labour condition, circulation and processing.

CHAPTER III BOTTOM FISH

3-1 Survey by Trawl Net Fishing

3-1-1 Purpose

The survey on bottom fishes, including shrimps and crabs which are regarded to have a close bearing on the future development of Cambodian sea fisheries, was conducted to achieve a dual purpose on the basis of the results of the previous survey of 1967.[1)] One of the purposes was to clarify the resources of bottom fishes and their ecology such as distribution and transfer of fishing grounds. Trawl net fishing was conducted for this purpose. The other purpose was to carry out the plankton survey, larva net survey and oceanographic observations in the entire coastal area of Cambodia to clear up the living environments and life of bottom fishes.

However, the originally planned survey activities had to be largely altered and reduced in scale for a number of reasons such as the difficulty in obtaining boats of suitable type with satisfactory equipment, problems involved in chartering them, poor skill of the crew, and the fisheries conflict in the adjoing fishing area which has made the crew anxious about going out into the offing. Therefore, the survey did not produce the expected results.

3-1-2 Time, Area and Method of Survey

The survey was conducted every other night on six days from February 5 to 10, not including February 14 when the net was broken. Two to three operations were conducted each night, spending 65 to 85 min. for each trawling operation with the exception of 45 min. at Station 8 where the engine went out of order (See Table 3-1).

1) See Par. 3-5

The fishing boat* used for the survey at Stations 1 and 2 was a 20 ton trawler with a 50 hp engine. This boat belonged to SONACOP and was manned by a crew of eight men. The gear of chemical fiber consisted of the net measuring 30 m in length, the float rope and sinker rope each measuring 28 m and 24 m. The mesh size increased from 16 setsu[1] of cod-end to 8.5 setsu of mouth of hoop net.

When trawling the net, a bamboo boom of 5.5 m length was stuck out from either side, with the otter-board also employed. The overall length of one warp was 80 m.

For the survey at Stations 3 through 8, two privately-owned trawlers, 10 t and 45 hp, were employed.** The number of crew and the gear were practically the same, with a minor difference in the length of bamboo boom which measured 4.5 and in the mesh size which was 12.5 setsu and 8 setsu at the cod-end and at the mouth of hoop net respectively.

Fig. 3-4 shows the rough sketch of the SONACOP's boat and its gear as obtained from the present survey and from the Report of Mr. Nakada of Nichiro Gyogyo Kaisha, Ltd. (Nichiyo Fisheries Co.)[2] and the "Trawl Fisheries in Thailand."[3]

The fishing grounds selected for the survey had little undulations and extended in the offing of Koh Kong and Koh Samit where the depth recorded 13 to 28 m.

The record of fish finder is given in Fig. 3-3.

The atmospheric temperatures and surface water temperatures during the survey were 22.2 - 27.6°C and 27.8 - 28.8°C respectively as indicated in Table 3-1.

* Length - 15 m, width - 3.3 m, depth - 1.4 m, tonnage - 13.5 t

** Length - 13.5 m, width - 3 m, depth - 12 m, tonnage - 9.5 t

1) Number of meshes per 15 cm; employed as a unit for indicating mesh size.

2) See Par. 3-5.

3) See Par. 3-5.

Table 3-1 Data of Observations during Trawl Net Fishing Survey

Station / Item	1	2	3	4	5	6	7	8	9
Date	Feb 6	Feb 6	Feb 7	Feb 7	Feb 8	Feb 9	Feb 9	Feb 10	Feb 14
Time	0:30 – 1:35	7:50 –9:15	19:05 –20:15	22:14 –23:25	1:54 –3:03	20:15 –21:25	22:35 –23:52	1:10 –1:55	20:30 –22:50
Duration of drawing (min)	65	85	70	71	70	70	77	45	Net was broken
Depth (m)	20–25	14	17	15	20	22–25	24	25	
Surface water temperature (°C)	28.2	28.2	28.8	–	27.9	–	–	27.8	
Atmospheric temperature (°C)	25.8	22.2	27.6	–	25.0	–	–	27.2	

Fig. 3-1 Rough Sketch of Trawler and Its Gear

Fig. 3-1 - (1) Trawler and Gear (20 t, 50 hp)

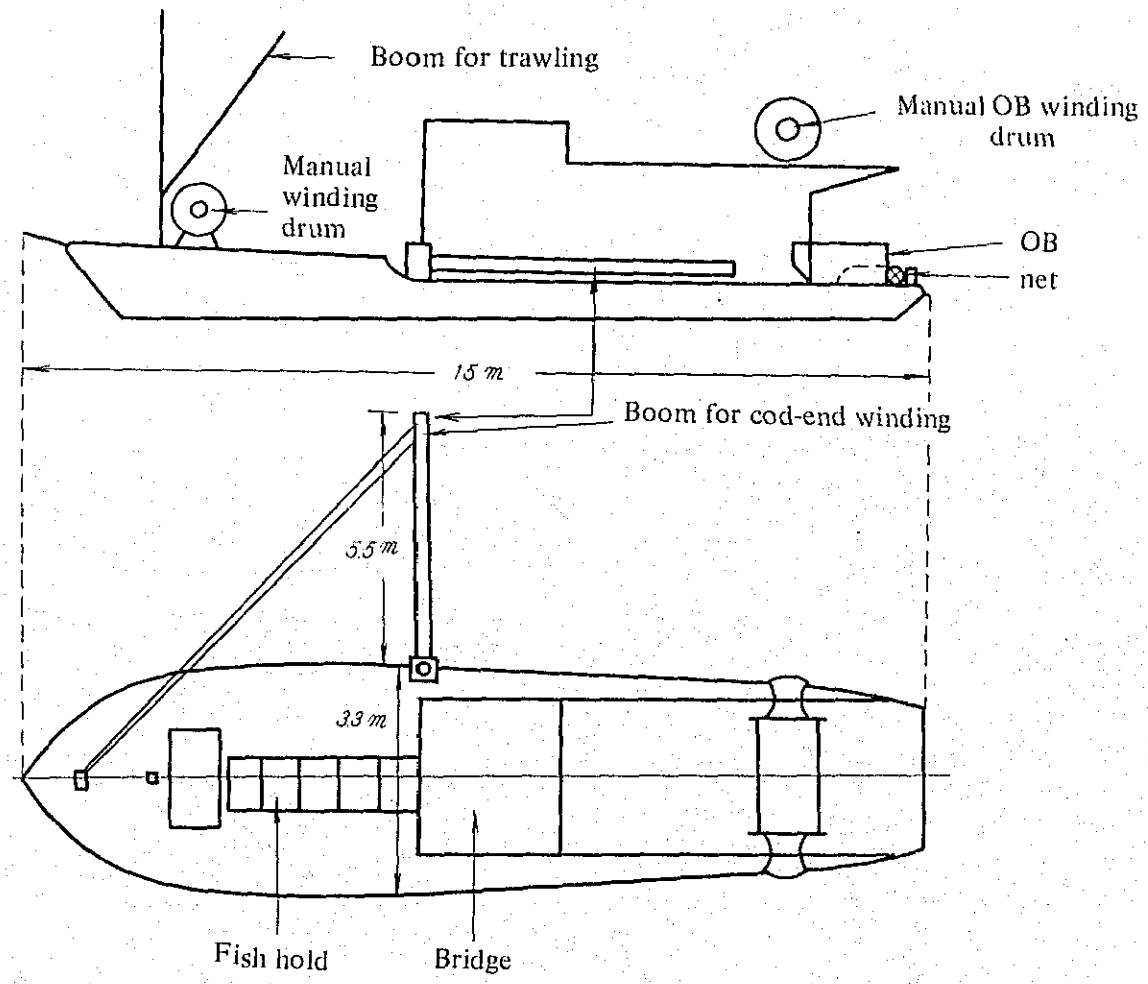
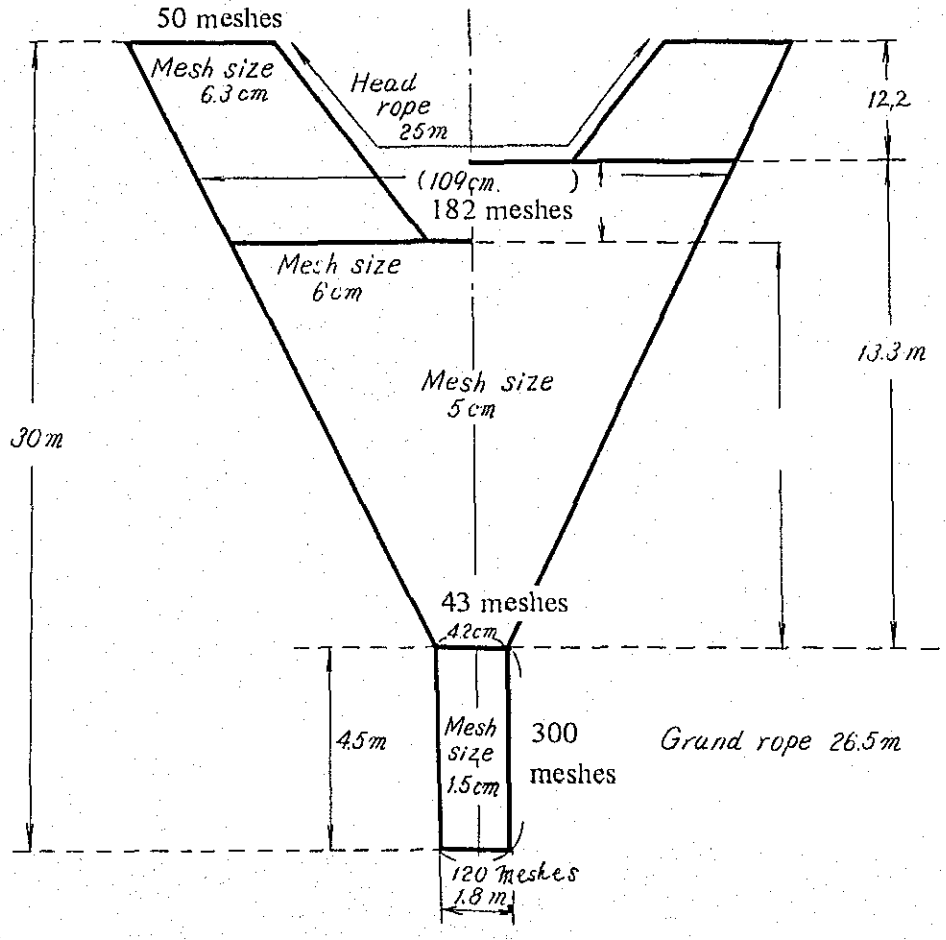


Fig. 3-1 - (2) Sketch of Gear



Outer-board

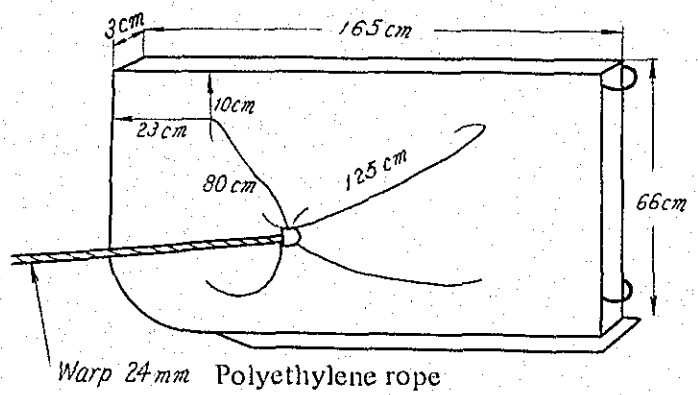
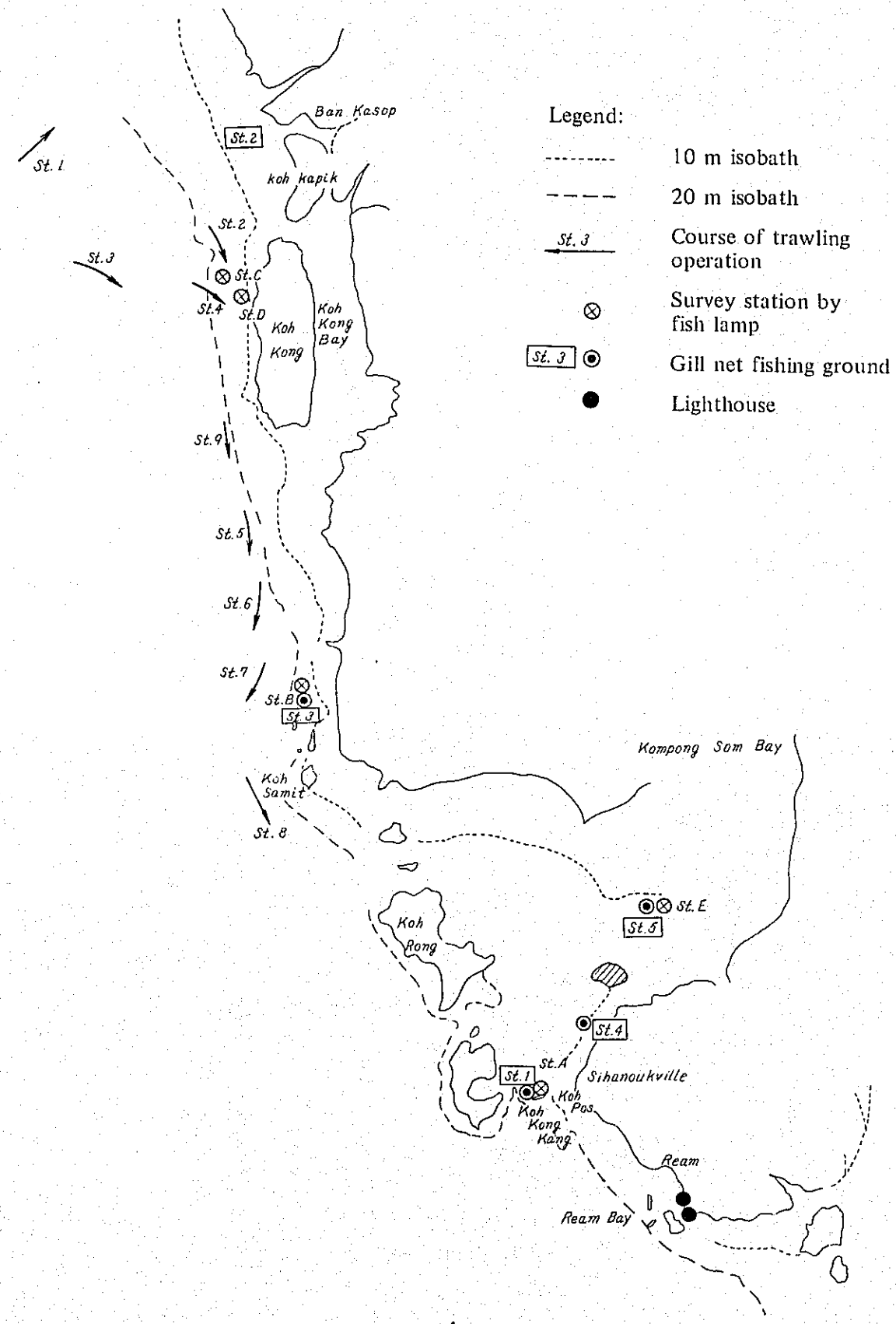


Fig. 3-2 Map of Fishing Grounds



3-1-3 Results of Trawl Net Fishing Survey

(1) Species Collected, and Similarity between Survey Stations

Results of studies on samples weighing 4 - 5 kg drawn at random from the total catch (population) of each trawling operation are given below.

As indicated in Table 3-2, number of species caught by the trawling operation exceeded 71, in which fishes occupied the largest portion of 82% with 58 species, followed by crustacea of 13% with more than 9 species, and mollusca of 5% with 4 species.

Grading the survey stations by the number of species, Station 4 ranks top with 36 species, then come other stations in the following order:

Station 3 (34 species)→Station 2 (32 species)→Station 6 (24 species)→ Stations 1, 5, 7 & 8 (14 species).

It was observed that the northern area is inhabited by more species than the southern area, and the heavy conversion of different species was found in the area around Koh Kong. This is considered ascribable to the existing distribution of fishes and crustacea, particularly of fishes.

Table 3-3 was prepared in an attempt to indicate the similarity and difference between stations by means of Jaccard's coefficient. Jaccard's coefficient in this case is the quotient obtained with the sum of all species caught at each two stations taken as the divisor and the sum of common species collected at these two stations taken as the dividend. This table indicates that the values of coefficient between Stations are suggestive of an appreciable difference between Stations 1 and 4 and between Stations 5 and 8. The coefficients are also indicative of a difference in fish fauna between the southern and northern areas.

The table also clarifies that the similarity between Stations 2, 3 and 4 are all higher than that noticed between Stations 1 and all these stations (Stations 2, 3 & 4), despite the fact that all the four stations are located close to each other. The Station 1 area is therefore considered more or less unique in the northern area.

In the southern area, Station 7 presents a higher similarity to Station 6 than to Station 8; and Stations 5 and 6 are more similar to Stations 6 and 7 respectively than to other stations. Stations 6 and 7 are therefore considered to represent the southern area.

Table 3-2 Number and Weight of Collected Fishes by Species and Stations

(W = Weight in gr)

Station No.	1	2	3	4	5	6	7	8	Total	Japanese Name
Species	No. (W)	No. (W)	No. (W)	No. (W)	No. (W)	No. (W)	No. (W)	No. (W)		
1. *Chiloscyllium colax*		1 (200)							1 (200)	Tenjikuzame
2. *Scoliodon sorrakowah*		3 (431)	1 (117)			1 (35)			5 (583)	Hiroankozame
3. *Amphotistius sp.*		1 (131)	3 (212)	2 (291)	2 (252)	4 (605)			12 (1491)	(Sub-gen. Suguei)
4. *Gymnura poecilura*			1 (350)						1 (350)	Onagatsubakuro
5. *Himantura sp.*		1 (29)	1 (33)		1 (60)				3 (122)	(Sub-gen. Otomeei)
6. *Urolophus sp.*		1 (187)	3 (590)						4 (777)	(A kind of Hirataei)
7. *Anodontostoma chacunda*	11 (510)			2 (52)					13 (562)	Nanyokonoshiro
8. *Dussumiria hasselti*		1								Niseginiwashi
9. *Sardinella sp.*	18 (386)	6 (141)							24 (527)	(Gen. Yamatomizun)
10. *Opisthopterus tardoore*				1 (42)					1 (42)	Hiramodoki
11. *Thrissa hamilton*	11 (281)	8 (167)							19 (527)	Chosentarekuchi

12.	*Thrissa mystax*								6 (94)	6 (94)	Hokushikatakuchi
13.	*Saurida tumbil*	5 (74)	7 (216)	8 (373)	3 (53)	2 (66)			3 (273)	28 (1055)	Wanieso
14.	*Tachysurus thalassinus*	20 (505)	4 (184)	10 (82)	10 (86)	5 (145)	1 (47)		1 (29)	51 (1078)	Oosakahamagigi
15.	*Mugil sp.*			1 (37)	1 (40)		1 (33)			3 (110)	(Fam. Bora)
16.	*Trichiurus haemula*		1 (153)							1 (153)	(Fam. Tachiuo)
17.	*Selarioides leptolepis*			1 (28)	3 (108)		2 (50)	1 (24)		7 (210)	(Fam. Aji)
18.	*Leiognathus equulus*	124 (1796)	300 (3626)	78 (1226)	32 (804)	85 (1140)	128 (1910)	62 (1192)	77 (2396)	886 (14070)	Seitakahiiragi
19.	*Leignathus lineolatus*				9 (143)	7 (23)				16 (166)	Itohiiragi
20.	*Lactarius lactarius*	5 (139)								5 (139)	Akutauo
21.	*Pampus argenteus*		3 (367)	3 (73)	3 (62)					9 (502)	Managatsuo
22.	*Upeneus tragula*				1 (29)	1 (59)				2 (88)	Yomehimeji
23.	*Pseudupeneus cinnabarius*	16 (320)			1 (44)				6 (254)	23 (618)	Kirarahimeji
24.	*Upeneus sulphureus*							1 (27)		1 (27)	Kohakuhimeji
25.	*Apogon cuadrifasiatus*				6 (18)		8 (25)			14 (43)	(Fam. Tenjikudai)

26.	*Apogon sp.*			7 (32)			2 (14)			9 (46)	(Fam. Tenjikudai)
27.	*Johnius sina*	8 (281)	2 (198)	2 (122)		5 (777)		1 (50)	2 (85)	20 (1513)	(Gen. Konibe)
28.	*Johnius dussemieri*	2 (54)	5 (109)	1 (20)	7 (174)		2 (14)	1 (59)		18 (430)	(Gen. Konibe)
29.	*Otithes argenteus*		2 (83)		4 (292)					6 (375)	(Fam. Nibe)
30.	*Sillago sihama*				3 (128)					3 (128)	Kisu
31.	*Gerres abbreviatus*						5 (79)	1 (27)	2 (47)	8 (153)	Sepparizaki
32.	*Gerres sp.*		10 (135)	1 (13)	4 (50)	1 (18)				16 (216)	(Gen. Kurozaki)
33.	*Scolopsis cillatus*			11 (99)	3 (79)					14 (179)	(Fam. Itoyoridai)
34.	*Nemiterus bleekeri*					1 (84)	4 (66)	3 (82)		8 (232)	(Fam. Itoyoridai)
35.	*Pomadasys olivaceus*		6 (40)	14 (162)	16 (240)	19 (399)	18 (341)	54 (1160)	16 (449)	143 (2791)	(Fam. Isaki)
36.	*Therapon puta*	6 (178)		1 (19)	1 (32)					8 (229)	(Fam. Shimaisaki)
37.	*Therapon theraps*		1 (21)						1 (51)	2 (72)	Himekotohiki
38.	*Phinogobius cringer*		2 (10)							2 (10)	(Fam. Kumohaze)
39.	*Drepane longimana*						2 (76)	2 (97)		4 (173)	Sudaredai

40.	*Siganus oramin*				1 (20)					1 (20)	(Fam. Aiko)
41.	*Triacanthus brevirostris*	2 (15)	20 (155)	5 (31)	10 (64)	1 (9)	1 (9)			39 (283)	Gima
42.	*Amanses pardalis*	1 (8)								1 (8)	Amimeumazura
43.	*Lagocephalus lunaris spadiceus*		1 (52)							1 (52)	(Gen. Sabafugu)
44.	*Cynoglossus macrolepdotus*			1 (57)						1 (57)	(Gen. Minokasago)
45.	*Vespicula trachionoides*		3 (13)	18 (56)	5 (18)					26 (87)	(A kind of Hachi)
46.	*Minous monodactylus*		1 (16)	19 (222)	2 (28)					22 (266)	Himeokoze
47.	*Grammoplites scaber*		2 (69)			1 (24)	12 (59)	12 (91)	8 (142)	33 (385)	(Sub-gen. Tokagegochi)
48.	*Suggrundus sp.*			6 (168)	2 (10)		2 (35)	4 (39)	1 (16)	15 (268)	(Gen. Megochi)
49.	*Platycephalus indicus*	2 (42)					6 (57)			8 (99)	Kochi
50.	*Elates thompsoni*								28 (264)	28 (264)	(Sub-gen. Tokagegochi)
51.	*Psettodes erumei*	2 (62)								2 (62)	Bozugarei
52.	*Pseudorhombus arsius*		17 (368)	11 (323)	1 (366)	3 (114)		5 (221)		37 (1392)	Tenjikugarei
53.	*Pseudorhombus javanicus*			1 (25)	3 (70)					4 (95)	(Gen. Ganzobirame)

54.	*Synaptura sp.*					1 (4)				1 (4)	(Gen. Minamishima-ushinoshita)
55.	*Synaptura orientalis*	25 (152)		2 (12)	17 (101)					44 (265)	Minamishimaushinoshita
56.	*Cynoglossus lingua*	1 (5)			1 (11)	2 (138)	1 (139)			5 (293)	(Gen. Inunoshita)
57.	*Cynoglossus macrolep-tidotus*							4 (90)	1 (26)	5 (116)	Tenjikuinunoshita
58.	*Cynoglossus sp.*			6 (135)						6 (135)	(Gen. Inunoshita)
Sub-total		267 (4726)	410 (7163)	216 (4617)	154 (3455)	137 (3312)	201 (3621)	150 (3132)	152 (4126)	1673 (34152)	
59.	*Sepia esculenta*	2 (155)	1 (53)	2 (98)		1 (45)	2 (142)			8 (493)	Koika
60.	*Sepialla inermis*	7 (215)		2 (46)	1 (15)					10 (276)	(Species resembling Shiriyakeika)
61.	*Loligo duvauceli*		1 (26)							1 (26)	(Species resembling Yariika)
62.	*Amusium pleuronectes*						7 (26)	7 (25)		14 (51)	Takasagotsukihi
Sub-total		9 (370)	2 (79)	4 (144)	1 (15)	1 (45)	9 (168)	7 (25)		33 (846)	
63.	*Penaeus merguiensis*	17 (841)	16 (764)	6 (255)	19 (913)					58 (2773)	Meruguiebi
64.	*Penaeus monodon*	3 (197)								3 (197)	Ushiebi

65.	*Penaeus semisulcatus*	48 (679)	2 (25)		17 (219)	11 (377)	11 (426)	4 (153)	6 (235)	32 (1191)	Kumaebi
66.	*Metapenaeus mutatus*										(A kind of Yoshiebi)
67.	*Metapenaeus stridulans*						2 (37)			69 (960)	(Species resembling Akaebi)
68.	*Metapenaeopsis barbeensis*										
69.	*Parribacus sp.*							1 (2)		1 (2)	(Species resembling Zoriebi)
70.	Other shrimps			— (93)	13 (31)			19 (70)		32 (194)	
71.	*Portunus pelagicus*		1 (119)	5 (518)	1 (211)					7 (848)	Tanwangazami
72.	Other erabs			— (250)	8 (24)	2 (7)	5 (12)	19 (33)		34 (326)	
73.	*Squilla oratoria*			2 (91)	1 (8)		1 (5)			4 (104)	Shako
Sub-total		68 (1717)	19 (908)	13 (1207)	59 (1406)	13 (384)	19 (480)	43 (258)	6 (235)	240 (6595)	
Total		334 (6813)	432 (8150)	233 (5968)	214 (4876)	151 (3741)	229 (4269)	200 (3415)	159 (4361)	1951 (41593)	

(2) Composition of Species

As shown in Table 3-2, a total of 1951 fishes were caught by trawl net fishing. Species collected can be arranged as follows in the order of the number of catch.

1) *Leiognathus equulus*, Seitakahiiragi: 886 (45.3%)
2) *Pomadasys olivaceus* (Fam. Isaki): 143 (7.3%)
3) *Metapenaeus mutatus* (a kind of Yoshiebi): 69 (3.5%)
4) *Penaeus merguiensis* (white), Meruguiebi: 58 (3%)
5) *Tachysurus thalassinus*, Oosakahamagigi: 51 (2.6%)
6) *Synaptura orientalis*, Minamishimaushinoshita: 44 (2.2%)
7) *Triacanthus brevirostris*, Gima: 39 (2%)
8) *Pseudorhombus arsius*, Tenjingarei: 37 (1.9%)
9) *Grammoplites scaber* (Sub-fam. Tokagegochi): 35 (1.8%)
10) *Penaeus semisuleatus*, Kumaebi: 32 (1.6%)

Unlike Table 3-2, Table 3-4 was prepared to classify, by weight, all important fishes caught at all stations as well as those fishes whose comparatively large size attracted attention from the commercial viewpoint.

Table 3-4 indicates that a total of 41.6 kg of catch was obtained by trawling operations. Fishes listed in this table can be arranged as follows in the order of weight.

1) *Leiognathus equulus*, Seitakahiiragi: 14 kg (34%)
2) *Pomadasys olivaceus* (Fam. Isaki): 28.8 kg (7%)
3) *Penaeus merguiensis*, Meruguiebi: 2.8 kg (7%)
4) *Trygonidae* (Fam. Akaei): 2.7 kg (7%)
5) *Sciaenidae* (Fam. Nibe): 2.3 kg (6%)
6) *Pseudorhombus arsius*, Tenjingarei: 1.4 kg (3%)
7) *Penaeus semisulcatus*, Kumaebi: 12 kg (2.9%)
8) *Tachysurus thalassinus*, Oosakahamagigi: 1.1 kg (2.6%)
9) *Saurida tumbil*, Wanieso: 1.1 kg (2.5%)
10) *Platycephalidae* (Fam. Kochi): 1.0 kg (2.4%)

Table 3-3 Similarity between Survey Stations based on Jaccard's Coefficient

St.	1	2	3	4	5	6	7	8
1		11 0.25 42	10 0.23 44	13 0.29 44	6 0.19 31	7 0.19 37	3 0.08 36	5 0.17 30
2	11 0.25 42		19 0.40 47	16 0.31 52	12 0.32 38	10 0.22 45	6 0.14 43	7 0.17 40
3	10 0.23 44	19 0.40 40		25 0.55 45	12 0.29 41	13 0.29 44	9 0.20 44	6 0.14 42
4	13 0.29 44	16 0.31 52	25 0.55 45		12 0.28 43	14 0.31 45	6 0.13 46	6 0.14 44
	6 0.19 31	12 0.32 38	12 0.29 41	12 0.28 43		11 0.34 32	8 0.25 32	7 0.27 26
6	7 0.19 37	10 0.22 45	13 0.29 44	14 0.31 45	11 0.34 32		12 0.40 30	7 0.22 32
7	3 0.08 36	6 0.14 43	9 0.20 44	6 0.13 46	8 0.25 32	12 0.40 30		8 0.33 24
8	5 0.17 30	7 0.17 40	6 0.14 42	6 0.14 44	7 0.27 26	7 0.22 32	8 0.33 24	

Note: 1) Top figures denote the numbers of common species collected at each two stations compared for similarity indication.
2) Bottom figures denote the sum of all species caught at each two stations.
3) Figures on the right are the Jaccard's coefficient obtained by dividing the top figure by the bottom one.

Table 3-4 Weight and Percentage of Catches of Important Fishes by Station

N.B. 1) Weight in gr.
2) Values in parentheses indicate percentages

	1	2	3	4	5	6	7	8	Total	Japanese Name
1. Trygonidae		347 (4)	1185 (20)	291 (6)	312 (8)	605 (14)			2740 (7)	(Fam. Akaei)
2. *Anodontostoma chacunda*	510 (8)			52 (1)					562 (1)	Nanyokonoshiro
3. *Sardinella sp.*	386 (6)	141 (2)							527 (1)	(Gen. Yamatomizun)
4. Engraulidae	281 (4)	167 (2)						94 (2)	542 (1)	(Fam. Katakuchi-iwashi)
5. *Saurida timbil*	74 (1)	216 (3)	373 (6)	53 (1)	66 (2)			273 (6)	1055 (3)	Wanieso
6. *Tachysurus thalassinus*	505 (7)	184 (2)	82 (1)	86 (2)	145 (4)	41 (1)		29 (0.7)	1072 (3)	Oosakahamagigi
7. *Selarioides leptolepsis*			28 (1)	108 (2)		50 (1)	24 (1)		210 (1)	(Fam. Aji)
8. *Leiognethus equulus*	1776 (26)	3626 (45)	1226 (21)	804 (17)	1140 (31)	1910 (45)	1192 (35)	2396 (55)	14070 (34)	Seitakahiiragi
9. *Leioguathus lineolatus*				143 (3)	23 (1)				166 (0.4)	Itohiiragi
10. *Pampus argenteus*		367 (5)	73 (1)	62 (1)					502 (1)	Managatsuo

11. Mullidae	320 (5)			73 (2)	59 (1)	27 (1)		254 (6)	732 (2)	(Fam. Himeji)
12. Apogonidae			32 (1)	18 (0.4)		39 (1)			89 (0.2)	(Fam. Tenjikudai)
13. Sciaenidae	335 (5)	390 (5)	142 (2)	466 (10)	777 (21)	14 (0.3)	109 (3)	85 (2)	2318 (6)	(Fam. Nibe)
14. Gerridae		135 (2)	13 (0.2)	50 (1)	18 (1)	79 (2)	27 (1)	47 (1)	369 (1)	(Fam. Amagi) (Fam. Kurozaki)
15. Hemipteridae			99 (2)	79 (2)	84 (2)	66 (2)	82 (2)		410 (1)	(Fam. Itoyoridai)
16. *Pomadasys olivacus*		40 (1)	162 (3)	240 (5)	399 (11)	341 (8)	1160 (34)	449 (10)	2791 (7)	(Fam. Isaki)
17. Theraponidae	178 (3)	21 (0.3)	19 (0.3)	32 (1)				51 (1)	301 (1)	(Fam. Shimaisaki)
18. *Triacanthus brevirostris*	15 (0.2)	155 (2)	31 (1)	64 (1)	9 (0.2)	9 (0.2)			288 (1)	Gima
19. Scorpanidae	13 (0.2)	113 (2)	18 (0.4)						144 (0.3)	(Fam. Mebaru) (Fam. Fusakasago)
20. Platycephalidae	42 (1)	69 (1)	168 (3)	10 (0.2)	24 (1)	151 (4)	130 (4)	422 (10)	1016 (2)	(Fam. Kochi)
21. *Pseudorhombus arsius*		368 (5)	323 (5)	366 (8)	114 (3)		221 (7)		1392 (3)	Tenjikugarei
22. *Synaptura orientalis*	152 (2)		12 (0.2)	101 (2)					265 (1)	Minamishima-ushinoshita
23. Sepiidae	370 (5)	53 (1)	144 (2)	15 (0.3)	45 (1)	142 (3)			769 (2)	(Fam. Koika)
24. *Penaeus merguiensis*	841 (12)	764 (9)	255 (4)	913 (19)					2773 (7)	Meruguiebi

25. *Penaeus monodon*	197 (3)								197 (1)	Ushiebi
26. *Penaeus semisulcatus*					377 (10)	426 (10)	153 (5)	235 (5)	1191 (3)	Kumaebi
27. *Metapenaeus mutatus*	679	25		219		37			960	(A kind of Yoshiebi)
Metapenaeopsis spp.	(10)	(0.3)		(5)		(1)			(2)	(Species resembling Akaebi)
Sub-total of shrimps	1707 (25)	789 (10)	255 (4)	1132 (24)	377 (10)	463 (11)	153 (5)	235 (5)	5121 (13)	
28. *Portunus pelagicus*		119 (2)	518 (9)	211 (4)					848 (2)	Taiwangazami
29. Other fishes	152	950	970	402	149	332	317	26	3298	
Total	6813 (100)	8150 (100)	5968 (100)	4876 (100)	3741 (100)	4269 (100)	3415 (100)	4361 (100)	41,593 (100)	

From the data given in Table 3-4, fishes caught at respective stations can be graded as follows by percentage.

Station 1:
1) *L. equulus*, Seitakahiiragi (26%)
2) *P. merguiensis*, Meruguiebi (12%)
3) *Metapenaeus mutatus* (a kind of Yoshiebi) (10%)
4) *Anodontostoma chacunda*, Nanyokonoshiro (8%)
5) *T. thalassinus*, Oosakahamagigi (7%)

Station 2:
1) *L. equulus*, Seitakahiiragi (45%)
2) *P. merguiensis*, Meruguiebi (9%)
3) *Sciaenidae* (Fam. Nibe) (5%)
4) *Pampus argenteus*, Managatsuo (5%)
5) *P. arsius*, Tenjikugarei (5%)

Station 3:
1) *L. equulus*, Seitakahiiragi (21%)
2) *Trygonidae* (Fam. Akaei) (20%)
3) *Portunus pelagicus*, Taiwangazami (9%)
4) *S. tumbil*, Oosakahamagigi (8%)
5) *P. arsius*, Tenjikugarei (5%)

Station 4:
1) *P. merguiensis*, Meruguiebi (19%)
2) *L. equulus*, Seitakahiiragi (17%)
3) *Sciaenidae* (Fam. Nibe) (10%)
4) *P. arsius*, Tenjikugarei (8%)
5) *Trygonidae* (Fam. Akaei) (6%)

Station 5:
1) *L. equulus*, Seitakahiiragi (31%)
2) *Sciaenidae* (Fam. Nibe) (21%)
3) *P. olivaceus* (Fam. Shimaisaki) (11%)
4) *P. semisulcatus*, Kumaebi (10%)
5) *Trygonidae* (Fam. Akaei) (8%)

Station 6:
1) *L. equulus*, Seitakahiiragi (45%)
2) *Trygonidae* (Fam. Akaei) (14%)
3) *P. semisulcatus*, Kumaebi (14%)
4) *P. olivaceus* (Fam. Shimaisaki) (8%)
5) *Platycephalidae* (Fam. Mebaru) (4%)

Station 7:
1) *L. equulus*, Seitakahiiragi (35%)
2) *P. olivaceus* (Fam. Shimaisaki) (34%)
3) *P. arsius*, Tenjikugarei (7%)
4) *P. Semisulcatus*, Kumaebi (5%)
5) *Platycephalidae* (Fam. Mebaru) (4%)

Station 8:
1) *L. equulus*, Seitakahiiragi (35%)
2) *P. olivaceus* (Fam. Shimaisaki) (10%)
3) *Platycephalidae* (Fam. Mebaru) (10%)
4) *S. timbil*, Oosakahamagigi (6%)
5) *Mullidae* (Fam. Himeji) (6%)

Shrimps accounted for 4 to 25% of the total catch at each station, and were found more abundant in the northern area than in the southern area. In the area north of the southern tip of Koh Kong, the catch of shrimps was composed mostly of *P. merguiensis*, Meruguiebi, with some *M. Mutatus* (a kind of Yoshiebi). But in the southern area, *P. semisulcatus*, Kumaebi, was predominant. Thus, the two major species of shrimp, *P. merguiensis*, Meruguiebi, and *P. semisulcatus*, Kumaebi, were found to be distributed in the north and south respectively.

Crabs caught in the northwestern area occupied 2 to 9% of the total catch and all belonged to a single species, *Portunus pelagicus*, Taiwangazami.

The most abundant of all bottom fishes other than shrimps and crabs were *L. equulus*, Seitakahiiragi, which accounted for 17 to 55% of the total catch at respective stations. The second abundant species, *P. olivaceus* (Fam. Shimaisaki), registered 0.5 to 34% at respective stations excluding Station 1, and was found in larger quantities in the southern area. These were followed by the seven other species, i.e., Trygonidae (Fam. Akaei) registering 4 to 20% of the total catch in the intermediate area excluding Stations 1, 7 and 8 Sciaenidae (Fam. Nibe) recording 0.2 to 10% and found more in the northern area, *P. arsius*, Tenjikugarei, recording 0.6 to 8% at respective stations excluding Stations 1, 6 and 8, *T. thalassinus*, Oosakahamagigi, recording 0.7 to 7% at respective stations excluding Station 7 and caught in larger quantities at Stations 1 and 5, *S. tumbil*, Wanieso, recording 1 to 6% at respective stations excluding Stations 6 and 7, Platycephalidae (Fam. Kochi) recording 0.2 to 10% at respective stations and showing an increase in catch with the southward shifting of trawling operation, and *Sepiidae* (Fam. Koika) recording 0.3 to 7% at respective stations excluding Stations 7 and 8.

It may be said that the northern area is characterised by the distribution of the aforesaid Sciaenidae (Fam. Nibe) and such other fishes as *Anodontostoma chacunda*, Nanyokonoshiro, Sardinella sp. (Gen. Yamatomizun), *P. argenteus*, Managatsuo, Scorpanidae (Fam. Minokasago), whereas the southern sea is characterized by *P. olivaceus* (Fam. Isaki), Platycephalidae (Fam. Kochi), *Gerres abbreviatus*, Sepparizaki, *Nemiteris bleekeri* (Fam. Itoyoridai), *Drepane longimana*, Sudaredai, and *Amusium pleuronectes*, Takasagotsukihi.

(3) Catch

The catch per hour of trawling operation ranged from 43 to 96 kg. The maximum hourly catch was 171 kg recorded at Station 5, followed by 138 kg of Station 1. No appreciable difference was noticed in the catch between Stations 2, 4, 6, 7 and 8, where the per hour catch ranged from 71 to 90 kg. Station 3 produced the smallest catch per hour of 43 kg. (See Table 3-5)

With respect to useful shrimps whose development is much hoped for, Table 3-5 indicates that the catch per hour of trawling operation ranged from 1.7 to 34.5 kg, with an average of 12.4 kg. The largest catch was 34.5 kg attained at Station 1, followed by 20.4 kg of Station 4, and 17.1 kg of Station 5.

At other stations, the catch was much smaller (9.5 kg at St. 6, 7.1 kg at St. 2, 4.5 kg at St. 7, 4.0 kg at St. 8 and 1.7 kg at St. 3). Thus, the catch was larger in the northern area excluding Stations 2 and 3, becoming smaller with the southward shift of the trawling operation.

Portunus pelagicus, Taiwangazami, was caught virtually at all stations. Some individuals belonging to this species crawled out and escaped at time of sampling at some stations. Yet, an average of 2.9 kg catch per hour was obtained at Stations 2, 3 and 4 in the northwest of Koh Kong.

Catches of fishes included neither high nor middle class fishes. With the exception of *Saurida tumbil*. Wanieso, *Pampus argenteus*, Managatsuo, *Pseudorhombus arsius*, Tanjikugarei, and Sepiidae (Fam. Koika), which were of some value, most were low class miscellaneous fishes. Of all fishes caught, *L. equulus*, Seitakahiiragi, was most abundant with an hourly catch of 31.4 to 53.0 kg recorded at Stations 1, 2, 5 and 6, and 9 to 14 kg at Stations 3 and 4.

The hourly catch of the next abundant species, *Pomadasys olivaceus* (Fam. Isaki), ranged from 4.3 to 30.0 kg at respective stations excluding Stations 1, 2 and 3. Sciaenidae (Fam. Nibe) which was caught by every trawling operation, registered a catch of 0.3 to 36.0 kg per hour, with the largest catch recorded at Station 5. With respect to the hourly catch of other species, Table 3-5 indicates that *Trygonidae* (Fam. Akaei) recorded 2.8 to 13.7 kg at Stations 2 through 6, *Pseudorhombus arsius*, Tenjikugarei, 2.2 to 6.8 kg at Stations 2 through 5 and at Station 7, *Platycephalidae* (Fam. Kochi) 0.7 to 8.0 kg at all stations, *Saurida tumbil*, Wanieso, 0.9 to 4.8 kg at all stations excluding Stations 6 and 7, Mullidae (Fam. Himeji) 0.9 to 6.9 kg at Stations 1, 4, 5, 6 and 8, and Sepiidae (Fam. Koika) 0.3 to 6.9 kg at all stations excluding Stations 7 and 8.

It is to be added that the weight of large rays and skates caught at Stations 2 and 5 are not included in Table 3-5.

Table 3-5 Catch per Hour of Trawling Operation by Species and Station

(Unit: Kg)

Station	1	2	3	4	5	6	7	8	Average	Japanese Name
Total Catch (kg)	150	100	50	100	200	100	115	60	109	
Catch per Hour (kg)	138	71	43	85	171	86	90	80	96	
1. Important shrimps	34.5	7.1	1.7	20.4	17.1	9.5	4.5	4.0	12.4	
2. *Portunus pelgicus*	–	1.4	3.9	3.4	–	–	–	–	1.1	Taiwangazami
3. *Leiognathus equulus*	35.8	32.0	9.0	14.4	53.0	38.7	31.4	44.0	32.3	Seitakahiiragi
4. *Pomadasys olivaceus*	–	0.7	1.3	4.3	18.6	6.9	30.0	8.0	8.7	(Fam. Isaki)
5. Trygonidae	–	2.8	8.6	5.1	13.7	12.0	–	–	5.3	(Fam. Akaei)
6. Sciaenidae	6.9	3.6	0.9	8.5	36.0	0.3	2.7	1.6	7.6	(Fam. Nibe)
7. *Pseudorhombus arsius*	–	3.6	2.2	6.8	5.1	–	6.3	–	3.0	Tenjikugarei
8. *Tachysurus thalassinus*	9.7	1.4	0.4	0.9	6.8	0.9	–	0.6	2.6	Oosakahamagigi
9. *Saurida timbil*	1.4	2.1	2.6	0.9	3.4	–	–	4.8	1.9	Wanieso
10. Platycephalidae	1.4	0.7	1.3	1.7	1.7	3.4	3.6	8.6	2.7	(Fam. Kochi)
11. Sepiidae	6.9	0.7	0.9	0.3	1.7	2.6	–	–	1.6	(Fam. Koika)
12. Mullidae	6.9	–	–	1.7	1.7	0.9	–	4.8	2.0	(Fam. Himeji)

(4) Full Length and Maturity

The range of full length and its mode given below were obtained by actual measurement of individuals of different species. Visual inspection of generative organ was also carried out to check the maturity of respective species which is indicated below by giving the total number of individuals subjected to visual inspection as denominator and the number of mature or fully grown individuals as numerator.

1) *Saurida tumbil*, Wanieso

This species had a full length ranging from 9.0 to 29.9 cm, and constituted two groups having different ranges of full length, one ranging from 9.0 to 19.0 cm and the other from 25.5 to 29.5 cm. Fishes caught at Station 5 in the south of Koh Kong and at Station 8 in the offing of Koh Samit were larger than those collected in the northern area. Maturity: all individuals (♀ 4 and ♂ 1) immature.

2) *Tachysurus thalassinus*, Oosakahamagigi

The full length ranged from 6.5 to 19.0 cm. with three modes existing in the ranges of 7.5 to 8.0 cm, 12.5 to 13.0 cm, and 17.0 to 17.5 cm. Fishes caught at Station 1 were larger than those collected at other places, indicating the uniqueness of the area around Station 1. Maturity: ♀ mature (5/6), ♂ immature (all 14 individuals).

3) *Leiognathus equulus*, Seitakahiiragi

The full length ranged from 5.0 to 15.0 cm, with the mode found in the range from 8.5 to 9.0 cm. The fish size increased with the southward shift of the survey station. Maturity: ♀ mature and partially completed spawning (15/6), ♂ mature (15/15).

4) *Leiognathus lineotatus*, Itohiiragi

The full length ranged from 4.5 to 11.5 cm, with two modes existing in the ranges from 5.5 to 6.0 cm and from 9.0 to 10.0 cm. Fishes caught at Station 4 were larger than those collected at other places. Maturity: ♀ mature (3/4), ♂ mature (4/4).

5) *Pampus argenteus*, Managatsuo

This species was noted to comprise two groups differing from each other in the range of full length. At stations 3 and 4, the full length ranged from 9.0 to 10.5 cm, and at Station 2, from 17.5 to 19.5 cm. Maturity: mature (all individuals).

6) *Pseudopeneus cinnabarius*, Kirarahimeji

The full length ranged from 9.5 to 17.0 cm, with the mode existing in the range from 10.0 to 10.5 cm. Judging from the catches at Stations 1 and 8 alone, it can be said that the southern area is inhabited by large fishes.
Maturity: ♀ fully grown or mature (10/10), ♂ mature or completed spawning (14/18).

7) *Selarioides leptolepsis* (Fam. Aji)

The full length ranged from 11.0 to 15.5 cm, and the mode was found to range from 12.0 to 12.5 cm. No appreciable difference in full length was observed between stations. Maturity: ♀ mature and partially fully grown (5/6), ♂ mature (5/6).

8) *Johnius sina* (Gen. Konibe)

The full length ranged from 12.0 to 25.5 cm, with two modes found in the ranges from 13.0 to 13.5 cm and from 23.0 to 23.5 cm, respectively. With the exception of Stations 2 and 5 where only large fishes were caught, the fish size was noted to increase from north to south. Maturity: larger group collected at Stations 2 and 5 - ♀ and ♂ mature (2/2 and 6/6); smaller group - ♀ and ♂ considered to be mature (1/2 and 3/10).

9) *Johnius dussumieri* (Fam. Nibe)

The full length ranged from 5.0 to 16.5 cm, with the mode existing in the range from 12.0 to 13.0 cm. No marked difference was observed in full length between stations. Maturity: ♀ mature (1/1), ♂ mature (3/8).

10) *Gerres sp.* (Fam. Kurosagi)

The full length ranged from 8.0 to 12.0 cm, with the mode found in the range from 8.5 to 9.0 cm. No difference in full length was noticed between stations. Maturity: ♀ mature (3/4), ♂ mature or completed spawning (4/10).

11) *Pomadasys olivaceus* (Fam. Isaki)

The full length ranged from 5.5 to 13.5 cm. With the mode found to range from 9.5 to 10.0 cm, the fish size was noted to be small in the north, becoming larger with the southward shift of trawling operation. Maturity: ♀ fully grown or mature (20/23); ♂ small fishes - immature (6/6), larger fishes in the southern area - mature (4/5).

12) *Triacanthus brevirostris*, Gima

The full length ranged from 6.0 to 12.0 cm, with the mode existing in the range from 8.5 to 9.0 cm. The fish size increased from north to south. Maturity: ♀ fully grown or mature (2/2), ♂ fully grown or mature (2/3).

13) *Grammoplites scaber* (Sub-fam. Tokagegochi)

The full length ranged from 4.0 to 18.5 cm, with two modes found in the ranges from 6.0 to 6.5 cm and from 15.0 to 15.5 cm. Fishes caught at Station 2 were all large. Maturity: larger fishes - ♀ mature (2/3), ♂ completed spawning (1/3); all other fishes - immature.

14) *Suggrundus sp.* (Gen. Megochi)

The full length ranged from 7.5 to 18.0 cm. This species was found to form two groups depending on the range of full length. Fishes larger than 12 - 13 cm formed the larger group, and those smaller than this size the smaller group. Station 3 produced large fishes, but there was no marked difference in fish size between stations. Maturity: ♀ and ♂ immature (6/6) and (6/6).

15) *Pseudorhombus arsius*, Tenjikugarei

The full length ranged from 6.0 to 20.5 cm and was noticed to increase from north to south. Maturity: ♀ fully grown (1/5), small fishes not exceeding 15 - 16 cm - all immature.

16) *Synaptura orientalis*, Minamishitaushinoshita

The full length ranged from 5.0 to 9.0 cm, with the mode existing in the range from 7.0 to 7.5 cm. No difference in full length was observed between stations. Maturity: ♀ mature or completed spawning (12/15), ♂ completed spawning (10/10).

17) *Sepia esculenta*, Ko.ka

The carapace length was in the range from 5.0 to 9.5 cm.

18) *Sepiella inermis*, Shiriyakeika

The carapace length ranged from 2.5 to 7.0 cm, with the mode found in the range from 5.0 to 6.0 cm.

19) *Penaeus merguiensis* (white), Meruguiebi

The carapace length ranged from 3.0 to 5.0 cm, with the mode existing in the range from 3.5 to 4.5 cm. Maturity: ♀ completed spawning peak (20/32).

20) *P. semisulcatus*, Kumaebi

The carapace length ranged from 2.0 to 4.5 cm with the mode existing in the range from 3.0 to 3.5 cm. Maturity: ♀ in the spawning peak (7/19).

21) *Metapenaeus mutatus* (a kind of Yoshiebi)

The carapace length ranged from 0.5 to 4.0 cm, with the mode found in the range from 2.0 to 2.5 cm. Maturity: ♀ mature and in pre-spawning stage (3/60).

The carapace length of the above three shrimps presented no difference by station.

22) *Portunus pelagicus*, Taiwangazami

The carapace width ranged from 7.0 to 11.0 cm. One third of female individuals were holding eggs on the outside. This species was in the spawning season as will be described later.

23) *Anusium pleuronectes*, Takasagotsukihi

The shell height ranged from 2.0 to 4.5 cm, with the mode showing a range of 3.0 to 3.5 cm.

Since the species other than listed above were caught within limited areas, it was impossible to check the difference in their body size between sations. These species are listed below with the range of full length, its mode, and maturity.

24) *Anodontostoma chacunda*, Nanyokonoshiro

13.0 to 16.0 cm, mode from 14.5 to 15.0 cm. Maturity: ♀ mature or fully grown (6/6), ♂ mature or fully grown (4/7).

25) *Sardinella sp.* (Gen. Yamatomizun)

12.0 to 14.5 cm, mode from 12.5 to 13.0. Maturity: ♀ fully grown (10/11), ♂ fully grown (12/12).

26) *Thrissa hamiltoni,* Chosentarekuchi

13.0 to 25.5 cm, mode from 13.0 to 16.0 cm. Maturity: all immature (♀ 12, ♂ 11) with the exception of one mature and large individual.

27) *Thrissa mystax,* Hokushikatakuchi

11.0 to 15.5 cm. Maturity: ♀ mature (3/4), ♂ immature (1/1).

28) *Otithes argenteus* (Fam. Nibe)

13.0 to 20.0 cm. Maturity: large ♂ mature (4/4).

29) *Lactarius lactarius,* Akutauo

12.0 to 13.0 cm. Maturity: ♂ mature (1/5).

30) *Sillago sihama,* Kisu

15.5 to 18.5 cm. Maturity: ♀ mature (1/1), ♂ mature (2/2).

31) *Gerres abbreviatus,* Sepparizaki

7.0 to 13.0 cm.

32) *Therapon puta* (Fam. Shimaisaki)

10.5 to 13.5 cm. Maturity: ♀ mature or fully grown (2/2), ♂ mature or fully grown (5/5).

33) *Vespicula trachionides* (a kind of Hachi)

4.0 to 6.5 cm.

34) *Minous monodactylus,* Himeokoze

6.0 to 11.0 cm, mode from 8.5 to 9.0 cm. Maturity: ♀ mature (1/1).

35) *Platycephalus indicus,* Kochi

14.5 to 17.0 cm, mode from 15.0 to 15.5 cm. Maturity: ♀ fully grown or completed spawning (2/2).

36) *Elates thompsoni* (Sub-fam. Tokagegochi)

12.5 to 18.5 cm, mode from 16.5 to 17.0 cm. Maturity: ♀ mature (9/10), ♂ immature (8/8).

Description given above on the full length and maturity indicates that more than 20 species are small fishes such as *L. equulus,* Seitakahiiragi, *L. lineotatus,* Itohiiragi, *P. argenteus,* Managatsuo, *P. cinnabarius,* Kirarahimeji, *J. dussumieri* (Fam. Nibe), *Gerres sp.* (Fam. Kurozaki), *P. olivaceus* (Fam. Isaki), *T. brevirostris,* Gima, *Suggrundus sp.* (Gen. Megochi), *P. arsius,* Tenjikugarei, *S. orientalis,* Minamishitaushinoshita. Full length of these species is invariably less than 15 cm. Species of somewhat larger size are *S. tumbil,* Wanieso, *T. thallassinus,* Oosakahamagigi, *Suggrundus sp.* (Gen. Megochi), and *O. argenteus* (Fam. Nibe).

Fishes whose growth condition was judged immature were such large species as *S. tumbil*, Wanieso, and *Suggrundus sp.* (Gen. Megochi) and a minor portion of small fishes like *P. arsius*, Tenjikugarei, *P. argenteus*, Managatsuo, *Johnius sina* (Gen. Konibe); and most fishes were considered to be mature or have completed spawning despite their small size, suggesting that they grow quicker than the fishes in the coastal area of Japan.

Large shrimps were found in the spawning or post- or pre-spawning stage, and *P. pelagicus*, Taiwangazami, was observed to be in the spawning season though its carapace length and width were smaller than those of the same species caught in Japan. Detailed description on shrimps and crabs will be given later.

3-2 Survey by Gill Net Fishing

3-2-1 Purpose

The purpose of the gill net fishing survey was basically the same as that of the trawl net fishing survey described in Par. 3-1-1.

The gill net fishing was conducted to supplement the trawl net fishing because of its following advantages.

1) While the trawl net fishing is carried out to catch chiefly bottom fishes including shrimps and crabs, the gill net fishing can be operated so as to suit the desired catch, i.e., crustacea or bottom fishes.

2) The gill net fishing can be carried out in shallow waters or in those fishing grounds where the submarine topography does not allow the trawling operation.

3) The trawling operation is allowed only during the night, but the gill net can be lowered before dark and hauled in the following morning.

The originally planned number of operations and nets was largely reduced due to the difficulty in obtaining suitable survey boats and to the restrictions imposed by the survey itinerary. As a result, the survey had to resort to a 10 ton trawler not convenient for lowering and hauling operations as well as to a 2 ton seiner.

3-2-2 Time, Area and Method of Survey

As indicated in Table 3-6, the survey was conducted in the morning, evening and night of four days, i.e., February 2, 7, 13 and 19, 1969, and the net was set to the bottom for 1.5 to 14.5 hrs. for one operation.

The survey was conducted in five fishing grounds, three in the northern area and two in the southern area. As shown in Table 3-2, fishing grounds in the northern area are located in the area along the coast of Koh Kong and Khemarak Phouminville and in the offing of Koh Sammit, and those in the southern area at the mouth and in the inner area of Kompong Som Bay. The water depth and surface water temperature at all five grounds ranged from 2 to 20 m and from 28°C to 29°C, respectively.

The fishing gear employed were three kinds of trinal gill nets brought from Japan (See Fig. 3-4). These gill nets were:

1) Trinal gill net for bottom fishes, with a height of 2.4 m and a unit length of 75 m (mesh size: main net - 7.5 cm, outer net - 30 cm)

2) Trinal gill net for shrimps and crabs, with a height of 1.45 m and a unit length of 18 m (mesh size: main net - 1.6 cm, outer net - 18 cm)

3) Trinal gill net for *Panulirus japonicus*, Iseebi, with a height of 2.1 m and a unit length of 37.5 m (mesh size: main net - 8.5 m, outer net - 30 cm)

Several linked units of each of the above nets were employed for the survey.

The fishing boat used at Station 2 was a trawler (10 t, 45 hp), while seiners (2 - 5 t) were used at other stations.

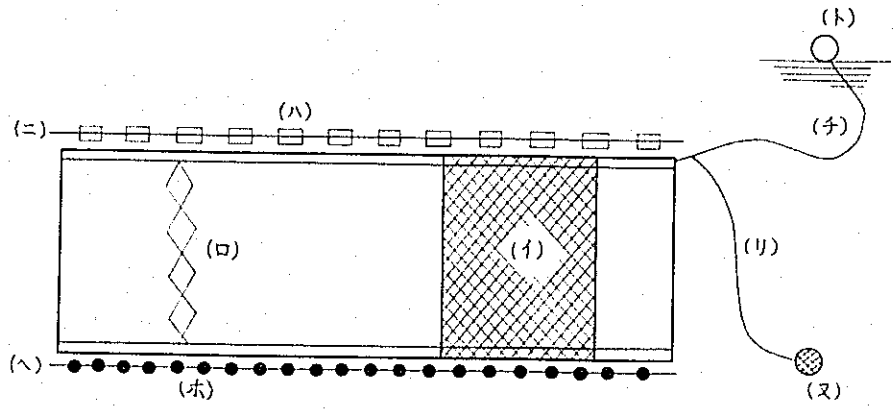
Table 3-6 Data of Gill Net Fishing Survey

Station No.	1	2	3	4	5
Date of Survey	Feb 2, 1969	Feb. 7	Feb. 13	Feb. 19	Feb. 19
Duration of Operation	6:30 - 8:00	17:30 - 7:30	20:00 - 22:30	18:30 - 21:30	19:30 - 21:30
Duration of Setting (hrs)	1.5	14.0	2.5	3.0	1.5
Fishing Ground	Area around Koh Kong Kang	Area around Khemarak Phouminville	Offing of Koh Sammit	Mouth of Kompong Som Bay (close to the shore)	Inner area of Kompong Som Bay
Fishing Gear	(A) 2 gill nets for fishes (75x2.4m)	(A) 2 gill nets for fishes (75x2.4m) (C) 4 gill nets for shrimps (37.5x2.1m)	(A) 2 gill nets for fishes (75x2.4m)	(B) 9 gill nets for shrimps (18x14.5m)	(B) 10 gill nets for shrimps (18x1.45m)
Water Depth (m)	20	2	16	12	10
Atmospheric Temp. (^{o}C)	–	–	27.7	–	28.8
Water Temp. (^{o}C)	–	–	28.6	–	29.3
Catch kg (No.)	6.4 (29)	28.3 (236)	1.8 (9)	2.1 (40)	1.4 (34)
Catch per Hour kg (No.)	4.4 (18.3)	2.0 (16.3)	0.7 (3.6)	0.7 (13.3)	0.9 (22.7)
Catch per Hour Per Net kg (No.)	2.2 (9.1)	0.53 (4.3)	0.35 (1.8)	0.08 (1.5)	0.09 (2.3)

Note: 1) The hourly catch was caloulated on the assumption that 4 gill nets for shrimps correspond to 1.75 gill nets for fishes.
2) (A), (B) and (C) denote the types of different gear which are detailed in the Specifications of Fishing Gear.

Fig. 3-4 Illustration and Specifications of Gill Net

Illustration of Gill Net:



(a) Main net
(b) Outer net
(c) Float
(d) Float line
(e) Sinker
(f) Sinker line
(g) Buoy
(h) Buoy line
(i) Anchor line
(j) Anchor

Specifications of Gill Net:

(A) Tangle Net for Spring Lobster

Netting

Name	Material	Thickness	Mesh Size	Breadth Width	Length
Main net	Nylon	210D (2x4) Z 2 ply	85 mm	30.5	71.4 m
Outer net	Nylon	210D (2x6) Z 2 ply	303 mm	7	63.7 m

Ropes

Name	Material	Thickness	Length
Float line	Kuralon (vinylon)	Z (27 x 3 x 3)	38 m
Bolch line	Kuralon (vinylon)	Z (20 x 3)	60 m
Sinker line	Kuralon (vinylon)	Z (33 x 3 x 3)	40 m
Bolch line	Kuralon (vinylon)	S (27 x 3 x 3)	40 m

Others

Name	Material	Size	Quantity
Float	Synthetic float		70 pcs
Sinker	Lead	about 26 g each	210 pcs
Hanging twine	Kuralon (vinylon)	24 pcs	Some

(B) Gill Net for Fishes

Netting

Name	Material	Thickness	Mesh Size	Breadth Width	Length
Main net	Nylon	210D (2x4) Z 2 ply	75.6 mm	40.5	159 m
Outer net	Nylon	210D (2x6) Z 2 ply	303 mm	8	128 m
Hanging twine	Spun nylon	S 3 ply (3x8)			Some

Ropes

Name	Material	Thickness	Length
Float line	Kuralon (vinylon)	Z (27 x 3 x 3)	75 m
Bolch line	Kuralon (vinylon)	Z (20 x 3)	100 m
Sinker line	Kuralon (vinylon)	Z (33 x 3 x 3)	75 m
Bolch line	Kuralon (vinylon)	Z (27 x 3 x 3)	75 m

Others

Name	Material	Size	Quantity
Float	Synthetic float		140 pcs
Sinker	Lead	About 26 g each	420 pcs

3-2-3 Results of Gill Net Fishing Survey

(1) Number and Composition of Species

As is clear in Table 3-7, the number of species collected at the five stations exceeded 29. Station 5 surpassed others with 12 species, followed by Stations 4, 1 and 2. Station 3 marked the smallest number of species of 5.

Table 3-8 shows the weight and percentage of catches of important fishes by station. Small and miscellaneous fishes were disregarded in preparing this table. According to this table, the percentage ratio of species collected by gill net fishing is as follows.

P. pelagicus, Taiwangazami, holds the place over other species with 49%, then comes Amphotistis sp. (Sub-gen. Suguei) of 15%, followed by *Rhinolatos sp.* (Gen. Hirataei) of 10%, *Lutjanus sp.* (Fam. Fuedai) of 6%, *Therapon theraps*, Himekotohiki, of 4%, and *Scolidon corrakowa*, Hiroankozame, and *Tachysurus thalassinus*, Oosaka-hamagigi each marking 3%.

Some common species were collected at Stations 4 and 5; fishes caught at other three stations were hardly common in species and reflected the characteristics of each of the three fishing grounds.

The percentage composition (in weight) of species collected at respective stations is as given below.

Station 1: *Lutjanus sp.* (Fam. Fuedai) occupied the major portion with 39%, followed by rays and skates of 37%. Then came *Chirocentrus*, Saito, and *Thachysurus thalassinus*, Oosakahamagigi, each recording 5%, *Pomadasys hasta*, Hoshimizoisaki, *Pseudorhombus javanicus* (Gen. Ganzobirame) and *Johnius sina* (Gen. Konibe). This composition clearly indicates that the area around Station 1 is suited for offshore fishing and for catching rock fishes.

Station 2: *Portunus pelagicus*, Taiwangazami, accounted for 69%, followed by rays and skates of 24%, *Scoliodon sorrakowah*, Hiroankozame, and *T. thalassinus*, Oosakahamagigi, each marking 3%. Some *Tacypleus tridentatus*, Kabutogani, were also caught. This composition is characteristic of the fishing grounds of *P. pelagicus*, Taiwangazami, along the coast.

Station 3: This station was in the fishing grounds of Plathou at time of the survey. Rays and skates were most abundant with 32%, followed by *Chiloscyllium colax*, Tenjikuzame, of 28%, *Gymnura poecilura*,

Onagatsubakuro, of 22%, and some *P. hasta*, Hoshimizoisaki, and *T. tridentatus*, Kabutogani. Thus, not may useful fishes were found available at this station.

Station 4 & 5: *Therapon theraps*, Himekotohiki, was most abundant with 54 – 36%, then came *Lagocephalus lunaris spadiceus*, Sabafugu, of 18 – 13%. Common species collected at the two stations included *Penaeus semisulcatus*, Kumaebi, and *Metapenaeus mutatus* (a kind of Yoshiebi), which recorded 3 – 4%.

While *P. pelagicus*, Taiwangazami, *Platycephalus indicus*, Kochi, and *Cynoglassus lingua* (Gen. Inumoshita) were found at Station 5, they were not caught at Station 4. In the similar way, *S. sorrakowah*, Hiroankozame, and *T. thalassinus*, Oosakahamagigi, which were caught at Station 4, were not found at Station 5. Thus, there is a minor difference in the specific composition between the two stations, though they are located rather close to each other within the same bay.

(2) Catch

The largest catch of 28.3 kg was attained at Station 2, followed by 6.4 kg of Station 1, 2.1 kg of Station 4, 1.8 kg of Station 3, and 1.4 kg of Station 5. Considering the large differences between stations in the duration of setting, the above grading could be rearranged as follows by the weight of catch per hour given in Table 3-6.

1. 4.4 kg (Station 1)
2. 2 kg (Station 2)
3. 0.9 kg (Station 5)
4. 0.7 kg (Stations 3 and 4)

Further, since different fishing gear were employed at respective stations, comparative study was made on the catches at Stations 1 and 3 where the survey was conducted on bottom fishes. This study, conducted on the assumption that 4 gill nets for shrimps correspond to 1.75 gill nets for fishes, disclosed that the gill net fishing at Station 1 in the relatively offshore area produced the largest catch of 2.2 kg per hour per net, whereas the operation at Stations 2 and 3 located near the coast yielded less than a quarter of this value, ranging from 0.53 to 0.35 kg per hour per net.

Comparing the catches at Stations 4 and 5 where the survey was conducted on shrimps and crabs, there was noticed a slight difference with Station 4 recording 0.08 kg and Station 5, located in the inner area of the bay, marking 0.09 kg.

(3) Full Length and Maturity

As in the case of the trawl net fishing survey, the full length of collected species was measured to give its range and mode. Further, visual inspection of generative organ was conducted to indicate the maturity. Maturity indication given below resorts to the same method as applied for fishes caught by trawl net, i.e., the total number of individuals inspected is taken as denominator and the number of individuals judged to be fully grown or mature taken as numerator. However, the

range and mode of full length and maturity coinciding with or included in the data of fishes collected by trawl net fishing are excluded.

1) *Dasyatis spp.* (Fam. Akaei)

The full length ranged from 4.0 to 22.0 cm. Two groups were observed, one comprising fries measuring 4.0 to 6.0 cm, and the other composed of adult fishes ranging from 19.0 to 22.0 cm.

2) *Leiognathus lineolatus*, Itohiiragi

The range of full length was from 7.0 to 15.5 cm, which is larger than that of fishes caught by trawling operation. The modes, existing in the ranges from 7.0 to 7.5 cm and from 12.5 to 13.0 cm, were also larger than the value obtained by the trawl net fishing survey.

3) *Lutjanus sp.* (Fam. Fuedai)

The full length ranged from 29.5 to 35.0 cm.

4) *Pomadasys hasta*, Hoshimizoisaki

The full length ranged from 25.5 to 28.0 cm.

5) *Therapon theraps*, Himekotohiki

The full length ranged from 0.5 to 16.5 cm, with the mode found in the ranges from 5.0 to 13.0 cm and from 14.5 to 15.0 cm. Maturity: ♀ mature or completed spawning (8/9), ♂ mature or completed spawning (7/9).

6) *Lagocephalus lunaris spadiceus*, Sabafugu

The full length ranged from 15.0 to 21.0 cm.

7) *Pseudorhombus javanicus* (Gen. Ganzobirame)

The full length ranged from 16.0 to 19.5 cm.

8) *Metapenaeus mutatus* (a kind of Yoshiebi)

The carapace length ranged from 2.0 to 3.0 cm. All were immature.

9) *Portunus pelagicus*, Taiwangazami

The carapace width ranged from 7.0 to 17.0 cm. If one individual which measured 17.0 cm is excluded from the specimens, the range of carapace length would be from 7.0 to 12.0 cm, which is the same as obtained by the trawl net fishing survey. The mode ranged from 9.5 to 10.0 cm.
One individual was observed to have eggs on the outside.

Table 3-7 Number and Weight of Fishes by Species and Station

(W = Weight in gr)

Station No.	1	2	3	4	5	Total	Japanese Name
Species	No. (W)	No. (W)	No. (W)	No. (W)	No. (W)	No. (W)	
1. *Chiloscyllius colax*			1 (500)			1 (500)	Tenjikuzame
2. *Scoliodon sorrakowah*		4 (840)		1 (387)		5 (1227)	Hiroankozame
3. *Oasyatis spp.*	5 (1465)	15 (2100)	3 (570)			23 (4135)	(Fam. Akaei)
4. *Amphotistius sp.*	3 (879)	35 (4900)			1 (35)	39 (5814)	(Sub-gen. Suguei)
5. *Gymnura poecilura*			1 (400)			1 (400)	Onagatsubakuro
6. Anodontostoma chacunda				1 (27)		1 (27)	Nanyokonoshiro
7. *Opisthopterus tardooro*					1 (21)	1 (21)	Hiramodoki
8. *Chirocentrus dorab*	1 (320)					1 (320)	Saito
9. *Tachysurus thalassinus*	2 (320)	7 (755)		2 (63)		11 (1138)	Oosakahamagigi
10. *Leiognathus lineolatus*				1 (9)	5 (34)	6 (43)	Itohiiragi

11. *Johnius sina*	1 (232)					1 (232)	(Gen. Konibe)
12. *Johnius dussumieri*					1 (120)	1 (120)	(Fam. Nibe)
13. *Geress sp.*				1 (23)		1 (23)	(Fam. Amagigi) (Fam. Kumasagi)
14. *Lutjanus sp.*	10 (2510)					10 (2510)	(Fam. Fuedai)
15. *Pomadasys nasta*	1 (259)	2 (150)				3 (409)	Hoshimizoisaki
16. *Therapon theraps*				26 (1134)	11 (506)	37 (1640)	Himekotohiki
17. *Lagocehpalus lunaris spadiceus*				1 (370)	1 (185)	2 (555)	(Gen. Sabafugu)
18. *Minous monodactylus*					1 (13)	1 (13)	Himeokoze
19. *Platycephalus indicus*					1 (134)	1 (134)	Kochi
20. *Pseudorhomous javanicus*	5 (250)					5 (250)	(Gen. Ganzobirame)
21. *Cynoglossus lingua*				1 (24)	4 (151)	5 (175)	(Gen. Inunoshita)
22. *Cynoglossus macrolepidotus*	1 (140)					1 (140)	Tenjikuinunoshita
23. *Penaeus semiculcatus*				1 (25)		1 (25)	Kumaebi
24. *Metapenaeus mutatus*				5 (49)	5 (52)	10 (101)	(A kind of Yoshiebi)

25. *Scylla serrata*		1 (150)				1 (150)	Nokogirigazami
26. *Portunus pelagicus*		172 (19400)			1 (144)	173 (19544)	Taiwangazami
27. *Squilla spp.*					2 (23)	2 (23)	(Species resembling Shako)
28. *Tachypleus tridentatus*		2 (200)	2 (150)			4 (350)	Kabutogani
29. *Sea snake*				4		4	(Fam. Umihebi)
Total	29 (6375)	236 (28345)	9 (1770)	44 (2111)	34 (1418)	352 (40019)	

Table 3-8 Weight and Percentage of Catches of Important Species by Station (Gill Net Fishing)

N.B. 1) W = Weight in gr.
2) Values in parentheses indicate percentages

Station	1	2	3	4	5	Total	Japanese Name
1. *Chiloscyllus colax*			500 (28)			500 (1)	Tenjikuzame
2. *Scoliodon sorrakowah*		840 (3)		387 (18)		1227 (3)	Hiroankozame
3. *Dasyatis spp.*	1465 (23)	2100 (43)	570 (32)			4135 (10)	(Fam. Akaei)
4. *Amphotistius sp.*	879 (14)	4900 (17)			35 (2)	5814 (15)	(Gen. Suguei)
5. *Gymnura poccilura*			400 (22)			400 (1)	Onagatsubakuro
6. *Chirocentrus dorab*	320 (5)					320 (1)	Saito
7. *Tachysurus thalassinus*	320 (5)	755 (3)		63 (3)		1138 (3)	Osakahamagigi
8. *Leiognathus lineolatus*				9 (0)	34 (2)	43 (0)	Itohiiragi
9. *Johnius sina*	232 (4)					232 (1)	(Gen. Konibe)
10. *Johnius dussumieri*					120 (8)	120 (0)	(Fam. Nibe)

11. *Lutjanus sp.*	2510 (39)					2510 (6)	(Fam. Fuedai)
12. *Pomadasys hasta*	259 (4)		150 (8)			409 (1)	Hoshimizoisaki
13. *Therapon therpas*				1134 (54)	506 (36)	1640 (4)	Himekotohiki
14. *Lagocephalus lunaris spadiceus*				370 (18)	185 (13)	555 (1)	(Gen. Sabafugu)
15. *Platycephlus indicus*					134 (9)	134 (0)	Kochi
16. *Pseudorhombus javanicus*	250 (4)					250 (1)	(Gen. Ganzobirame)
17. *Cynoglossus lingua*				24 (1)	151 (11)	175 (0)	(Gen. Inunoshita)
18. *Cynoglossus macroleidotus*	140 (2)					140 (0)	Tenjikuinunoshita
19. Shrimps				74 (3)	52 (4)	126 (0)	
20. Crabs		19550 (69)			144 (10)	19694 (49)	
21. *Tachypleus tridentatus*		200 (1)	150 (2)			350 (1)	Kabutogani
22. Other fishes		200 (1)	150 (2)			350 (1)	
Total	6375 (100)	28345 (100)	1770 (100)	2111 (100)	1418 (100)	40019 (100)	

3-3 Comments

Comments given below relate to the outlook of catchable stock in future with reference to the results of trawl and gill net surveys detailed in the preceding paragraph.

The average catch per hour of one trawling operation was as follows. The average catch throughout the entire survey area was 96 kg. In the northwestern area of Koh Kong where fishes were abundant, the average catch was 131 kg, and in the area extending from the southern tip of Koh Kong to the offing of Koh Samit where the catches were rather poor, the value stood at 74 kg. With the entire survey area divided into the northern and southern areas, the former produced an average catch of 84 kg and the latter 107 kg. (See Table 3-9)

Data of fisheries survey conducted in the same area by Mr. Nakada of Nichiro Gyogyo Kaisha, Ltd. (Nichiro Fisheries Co.) during the November-December period of 1968 indicate a catch of 150 kg in the northwestern area of Koh Kong and of 132 kg in the area south of Ream. These values surpass the average catches recorded during the present survey.

Study on the specific composition and full length conducted by the team and by Mr. Nakada reveals that all these catches are predominantly occupied by small and unimportant fishes. Future catches will therefore have to comprise chiefly shrimps and crabs of which large prawns belonging to Penaeus sp. and Metapenaeus sp. may deserve attention.

Table 3-9 indicates that the hourly catch of large prawns by one trawling operation recorded 24 kg at Stations 1, 4 and 5 where the prawns were rather abundant, and 5.4 kg at other stations. The same table also indicates that the northern area produced a catch of 15.5 kg and the southern area 8.8 kg. The catch in the northern area, 15.9 kg, is about 3 times the value recorded by Mr. Nakada (5.4 kg), whereas the total catch of prawns in the same area recorded by the team is smaller than that obtained by Mr. Nakada. (This suggests the necessity for surveys to clarify the outlook of catchable stock before granting approval for trawl net fishing operations)

To discuss further about the Cambodian coastal fisheries, the relative abundance of shrimps and fishes in terms of catch per hour of one trawling operation must be clarified. For comparison of resources, Table 3-9 provides the catches of *Penaeus orientalis*, Koraiebi, by ISEI trawling operation* as well as those of miscellaneous shrimps (with some prawns mixed) by a small one boat trawler operated in Nagasaki Prefecture, Japan.

Data of ISEI trawling operation are given by year, i.e., 1952, 1960 and 1967. 1962 was the year when the largest total catch per trawling operation was attained since the abolition of the MacArthur line[4], 1960 recorded the largest catch of *Penaeus orientalis*, Koraiebi, per operation** (Table 3-9 shows the average catch in March when the largest monthly catch of shrimps was registered), and data for 1967*** are given to indicate the recent situation (Table 3-9 shows the average catch in December when the largest monthly catch was recorded).

As for the small trawler, data of operation in Imari Bay (1966)[5] are given. This is because the data give the results of experimental operation before the trawl net fishing was permitted, and can therefore be compared, in a way, to the survey results in the Cambodian coastal area. Data of Tachibana Bay[6] and Omura Bay[7] are given because these two bays produce a smaller catch of fishes and a comparatively large catch of shrimps and crabs.

Table 3-9 clarifies that the total catch of fishes per hour of one trawling operation was 83 kg and 107 kg respectively in the aforesaid northern and southern areas of Cambodian coastal sea, 300 - 330 kg by ISEI trawler, and 2.0 - 6.8 kg by the small one boat trawler. It also indicates that the catch of shrimps in each of these areas was 15.9 kg, 8.8 kg, 17.8 - 63.3 kg, and 0.8 - 5.6 kg per hour of one operation.

It is quite conceivable that the fishing gear, size and facilities of fishing boat, and fishing techniques which were employed for respective operations shown in the table differed largely from each other. However, since the scale of fishing gear is determined to a considerable extent by that of fishing boat, a comparative study was made only on the scale of fishing gear, assuming that it is the decisive factor for the evaluation of resources and diregarding all other factors. (It is to be added that the comparison was made only for the effective area of fishing gear due to the lack of data on the volumetric capacity of each moving net at time of trawling)

* ISEI trawlers are two boat trawlers operated west of 130°E in China Sea.

, * Courtesy of Dr. Otaki, Saikai District Fisheries Research Inst.

4), 5) & 6) See Par. 3-5.

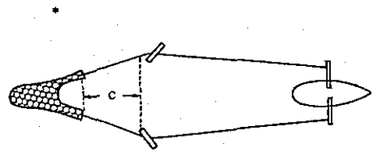
Table 3-9 Relative Abundance of Resources by Area and Fishing Method (Calculated on a trial basis)

Area and Fishing Method / Item			Catch per Hour per One Trawling Operation (kg) (A)		Ratio of Effective Area of Fishing Gear (B)*	A/B	
			Total Catch	Catch of Shrimps		Total Catch	Catch of Shrimps
Trawling Operation in the Cambodian Coastal Area	Present Survey (Feb 1969)	St. 1, 4 & 5 (Area with abundant resources)	131	24.0		131	24.0
		St. 2, 3, 6, 7 & 8 (Area with poor resources)	74	5.4		74	5.4
		St. 1 - 4 (Northern area)	84	15.9	1	84	15.9
		St. 5 - 8 (Southern area)	107	8.8		107	8.8
		Average Catch	96	12.4		96	12.4
	Mr. Nakada's Survey (Nov 1968)	Area west of Koh Kong	150	5.4		150	5.4
		Area south of Ream	132	2.6	1	132	2.6
		Average catch	141	4.0		141	4.0
ISEI Trawling Operation	1952 (Largest total catch recorded)		330	–		16.5	–
	1960 (Largest catch of *Penaeus orientalis*, Koraiebi, recorded)		303	63.3 (Mar)	20	15.1	3.2
	1967 (Recent situation)		300	17.8 (Dec)		15.0	0.9
Small One Boat Trawler Operation in Nagasaki	In and out of Imari Bay (June – July 1966)		6.8	5.6	0.4	17.4	14.0
	Tachibana Bay (June – July 1962)		3.8	1.2	0.4	9.5	3.0
	Omura Bay (June – July 1962)		2.0	0.8	0.1	20.0	8.0

* See Table 3-10 for details.

Table 3-10 Effective Area of Fishing Gear
(Area Covered by Warp Bottoms Set to Sea Bottom and by Ends of Wing Nets)

	Item / Fishing Gear	Tonnage of Fishing Boat (t)	Capacity of Main Engine (hp)	Length of Warp (m)	Length of Seep Line (m)	Length of Head Rope (m)	Distance between Two Boats or Two Sponsom Beams during Trawling Operation (m)	Distance between Otter Boards or Parts Furnished with Sinkers (m) (A)	Horizontal Distance between Frontal Ends of Two Wing Nets (m) (A)	Distance (m) (C)	Effective Area of Fishing Gear $\frac{A+B}{2}$ = Gear used in Cambodia and by ISEI Trawlers B x C = Gear used in Tachibana Bay $\frac{B \times C}{2}$ = Gear used in Omura Bay (m^3)	Ratios of Effective Areas (Cambodia:1)	Remarks
Cambodia	Trawl Net	13	45	135	65	25.0	13.5	49	15	63.0	2,016	1	The ideal form of trawl net found by model tests is such that the line-of-sight of the otter board as viewed from the stern is at an angle of 7.5° with respect to the center line of the boat, and that the line-of-sight of the otter board forms an angle of 15° with respect to the end of the wing net. Calculation was therefore made based on this condition. (Nippon Gyomo Sengu Kaisha, Ltd. (Japan Fishing Gear Co., Ltd.))
Japan	ISEI Trawl Net	100	400	800	400	69.3	400.0	160	42	400.0	40,400	20.0	For the ideal form, the distance between the wing nets should be about 60% of the length of the head line during trawling operation. Calculation was therefore made on this condition (Prof. Hideki Miyamoto of Nihon University)
Japan	Trawl Net Used by Small One-Boat Trawler in Tachibana Bay and Imari Bay	5	10	370		24.0	5.5	11	11	67.0	770	0.4	Small one-boat trawler uses sponsom beams. The sinkers are fitted to the two warps at about 67 m from the wing nets, with an 11 m long bamboo pole used to open the mouth.
Japan	Trawl Net Used by Small One-Boat Trawler in Omura Bay	2	6	45		10.8			6	27.0	81	** 0.1 (0.04)	The two trawl nets are pulled from both sides of a boat. Each warp has two bridles of 30 m at its each end. The mouth net is opened by means of a 6 m long bamboo pole fitted to the frontal ends of the wing net.



*

** 0.04 x 2 ≒ 0.1 because two nets are trawled.

(Calculation by Mr. Takeo Tokunaga, Nagasaki Fisheries Experiment Station)

As previously discussed, it is advisable that the number of nets for trawling operation be determined on the basis of data of experimental operations to be conducted at least 4 times a year both in areas along the coast and in the offing. Such experimental operations are needed not only for data collection but for clarification of wet season resources because of the possible introduction of year-round trawling operation. Fisheries survey of this kind should preferably planned to cover parts of adjoining fishing areas because the fish and shrimp resources in such areas are closely related to those in the Cambodian coastal area. Further, it is recommended that the surveys be conducted using the same types of boats and gear so that the comparative study of resources will be facilitated.

The mesh size is one of the important questions that need careful examination before granting approval for trawling operations in future because it not only bears closely upon preservation and effective utilization of resources, but also is a decisive factor for proper selection of the size of fishing gear, tonnage of boat and capacity of main engine.

The mesh size at the cod end as disclosed by the present survey and Mr. Nakada's survey ranged from 1.5 to 2.0 cm. This is approximately equivalent to the mesh size of small one-boat trawlers in Japan which ranges from 1.2 to 2.5 cm, but far smaller than that of ISEI trawl net which is 5.5 to 5.9 cm.[8] As pointed out by Mr. Nakada, the mesh size is somewhat too small for the size of fishing gear when the tonnage of fishing boat and capacity of main engine are taken into consideration.

Catches during the present survey were composed mostly of small fishes measuring less than 15 cm in full length, and partly of youngs of large shrimps and grown individuals of miscellaneous small shrimps. Shrimps had a carapace length of 1 to 2 cm. Insofar as fishes are concerned, the current mesh size is not likely to present any serious problems in the preservation of resources because fishes were, as already explained, mature though small in size. However, catches of large shrimps, which are hoped to play an important role in the development of coastal fisheries, were noted to include some youngs. Since it is highly probable that the introduction of year-round fishing operation will result in the catching of substantial quantities of these youngs in certain fishing grounds and in certain periods of the year, it is advisable that the mesh size be controlled or suitable measures be taken to control fishing activities in specific seasons and grounds. Such protective measures should naturally be preceded by a close examination of survey data to assure continued production of shrimps.

The catch per hour per net by gill net fishing conducted at stations located outside Kompong Som Bay ranged from 0.35 to 2.2 kg as shown in Table 3-6. Inside the Bay, where nets for shrimps were used, the catch stood at 0.08 to 0.09 kg.

As described in the preceding paragraph (3-2-3), the area along the coast of Khemarak Phouminville can be considered as the fishing ground of *Portunus pelagicus*, Taiwangazami, the offing of Koh Samit as the fishing ground of sharks, rays and skates, Kompong Som Bay as the fishing ground of miscellaneous fishes such as *Therapon theraps*,

Hikotohiki, and *Lunaris spadiceus* (Gen. Sabafugu) (this bay also produces small quantities of *Metapenaus mutatus* (a kind of Yoshiebi) and *Penaeus semisulcatus*, Kumaebi), and the area around Koh Kong Kang as the fishing ground of rays and skates and *Lutjanus sp.* (Fam. Fuedai). This classification of fishing grounds is not a definite one and leaves room for further studies because of the limited number of operations and nets, difference in the time spent for lowering the nets or in the duration of setting the nets to the sea bottom, and other factors. Further, the gill net fishing survey provided only a glimpse of the life history of the species collected, and produced no sufficient data from which to draw a conclusion in some shape or other. However, since it is felt necessary to give some findings of comparative study of catches by gill net, the results obtained during the present survey are compared with Shiokawa's data[9),10)] in table 3-11. Shiokawa's report provides the results of the survey conducted in Amakusa (Kumamoto Prefecture, Japan) using the same type of gill net as employed in the present survey. The comparison is made by converting the catch into the number of fishes caught per hour per 10 m^2 of net.

Table 3-11 indicates that while the catch at respective stations in Cambodia ranged in number from 0.9 (Station 5) to 0.1 (Station 1), the effective annual average catch in Amakusa by species was 1.0 for *Rhinoplagusia japonica*, Kuroushinoshita, *Stephanolepsis cirrhifer*, Kawahagi, and *Panulirus japonica*, Iseebi, 0.7 for *Portunus trituberculatus*, Gazami, 0.3 for *Parapristipoma trilineatus*, Isaki, and 0.2 for *Chrysophrys major*, Madai, and *Sepia esculenta*, Koika. (The catch in Amakusa is the average catch during the fishing season of respective species). Thus, insofar as Table 3-11 indicates, the catch in Cambodia by gill net fishing is not very large. But the comparison in this table should not be construed as fully acceptable because of the aforementioned restrictions on the time and number of operations during the present survey.

Table 3-11 Comparison of Catches by Gill Net Fishing in Cambodia and Japan (per hour per 10 m^2 of net)

Cambodia		*Japan (Amakusa)*	
Station	Total No. *of Catch*	*Species*	Total No. *of Catch*
1	0.5	*Rhinoplagusia japonica*, Kuroushinoshita *Stephanolepsis cirrhifer*, Kawahagi)	1.0
2	0.2	*Panulirus japonicus*, Iseebi	1.0
3	0.1	*Portunus trituberculatus*, Gazami	0.7
4	0.6	*Parapristipoma trilineatum*, Isaki	0.3
5	0.9	*Chrysopherys major*, Madai *Sepia esculenta*, Koika)	0.2

From the results of trawl net fishing survey, it is possible to draw the inference that the fishing grounds along the coast will provide substantial catches of shrimps and crabs by the use of trinal nets and single nets, respectively, and the off-shore areas around Kong Rong, Koh Rong Samlem and Koh Tan will allow, by the use of trinal nets, appreciable catches of rock fishes and large fishes such as rays and skates, *Lutjanidae* (Fam. Fuedai), Lethrinidae (Fam. Fuefukidae), and Pomadasydae (Fam. Isaki).

Needless to say, the development of gill net fishing should be planned based on the studies of actual catchable stock just as in the case of trawl net fishing.

3-4 Summary

(1) Results of eight trawling operations conducted at night for six days from February 5 to 10, 1960 in different fishing areas including the northwestern area of Koh Kong and the offing of Koh Samit (See Fig. 3-2) are summarized below.

(2) The total number of species collected exceeded 71, of which fishes accounted for 82%, crustacea 13% and mollusca 5%. The northern area is richer in the variety of species than the southern area, and the number of species collected at one station ranged from 14 to 36.

The northern and southern areas differ from each other in fish fauna, with Stations 4 and 5 noted to be in the boundary area between them. Station 1 area is rather unique in the northern area, and Stations 3 and 6 are provided with the characteristics of the northern and southern areas, respectively.

(3) Study of a total of 41.6 kg (1,591 individuals) of specimens collected at all stations revealed that the catch was predominantly occupied by *Leiognathus equulus*, Seitakahiiragi (34%), followed by *Pomadasys olivaceus* (Fam. Isaki) (7%), with 7% of *Metapenaeus mutatus* (a kind of Yoshiebi) and 3% of *Penaeus merguiensis* (white), Meruguiebi, forming a part of the catch.

Study of catch by station disclosed that *L. equulus*, Seitakahiiragi, was available at all stations with its percentage ratio standing at 17 to 55%, followed by *P. olivaceus* (Fam. Isaki) that accounted for 0 to 34%. The same study also clarified that Trygonidae (Fam. Akaei) is abundant in the intermediate area with its percentage ranging from 4 to 20%, and that Sciaenidae (Fam. Nibe) occupied 0.3 to 10% of the total catch and was abundant in the northern and intermediate areas.

Large shrimps, chiefly prawns, accounted for 4 to 25% of the total catch, and is more abundant in the north than in the south. In the northern area, *P. merguiensis* (white), Meruguiebi, constituted the major catch of shrimps with some *M. mutatus* (a kind of Yoshiebi) included, while in the southern area, the major species of shrimp was *P. semisulcatus*, Kumaebi.

As for crabs, *P. pelagicus*, Taiwangazami, caught in the northern and western areas of Koh Kong registered 2 to 9% of the total catch.

Besides the species mentioned above, Sepiidae (Fam. Koika), *Anodontostoma chacunda*, Nanyokonoshiro, Sardinella sp. (Gen. Yamatomizun), *P. argenteus*, Managatsuo, and *Scropanidae* (Fam. Minokasabo) may be cited as species peculiar to the northern area, whereas *G. abbreviatus*, Sepparizaki, *H. Bleekeri* (Fam. Itoyoridai), *D. longimana*, Sudaredai, and *A. pleuronectes*, Takasagotsukihi, can be enumerated as a characteristic of the southern area.

(4) The catch per hour of one trawling operation ranged from 43 to 171 kg, averaging 96 kg, and was larger in the northern area.

Study of the hourly catch by species revealed that the catch of shrimps ranged from 1.7 to 34.5 kg, averaging 12.4 kg, and is generally larger in the northern area. *P. pelagicus*, Taiwangazami, registered an average catch of 2.9 kg. Average catches of main species are: 3.2 kg for *L. equulus*, Seitakahiiragi, 9 kg for *P. olivaceus* (Fam. Isaki), 8 - 6 kg for *Scianidae* (Fam. Nibe) and Trygonidae (Fam. Akaei), and 3 kg for *T. thalassinus*, Oosakahamagigi and *P. arsius*, Tenjikugarei.

(5) Measurement of full length and visual inspection of generative organ conducted on about 30 main species clarified that most are small and miscellaneous fishes having a full length ranging from 5 to 18 cm. The only species whose body size exceeded 20 cm were *J. sina* (Fam. Konibe), *P. argenteus*, Managatsuo, *P. arsius*, Tenjikugarei, *S. timbul*, Wanieso, and *O. argenteus*, (Fam. Nibe). Shrimps such as *P. merguiensis* (white), Meruguiebi, *P. semisulcatus*, Kumaebi, *M. mutatus* (a kind of Yoshiebi) were noted to have a carapace length ranging from 1 to 4 cm, *P. pelagicus*, Taiwangazami, had a carapace width of 7 to 11 cm, and *Sepiidae* (Koika) had a carapace length of 4 to 9 cm.

Virtually all these fishes were mature, fully grown or completed spawning with the exception of *S. timbul*, Wanieso, *P. argenteus*, Managatsuo, Suggrundus sp. (Gen. Megochi), *M. Mutatus*, (a kind of Yoshiebi) and *T. hamiltoni*, Chosentarekuchi. It deserves attention that species in the Cambodian coastal area grow quicker than those living in the Japanese waters and fishes caught are mostly mature.

(6) Results of gill net fishing survey conducted on four days (February 2, 7, 13 & 19, 1969) at five stations (See Fig. 3-2) in the northern and southern areas are summarized below.

(7) The total number of species collected exceeded 29, and the number of species caught at one station ranged from 5 to 12. Station 1 (area around Koh Kong Kan) produced a catch whose specific composition points to the suitability of rock-fish and off-shore fishing. Station 2 (area along the coast of Khermarak Phouminville) presented characteristics of fishing grounds of *P. pelagicus*, Taiwan-gazami. Station 3 (area in the offing of Koh Samit), where plathou fishing was conducted during the survey, produced a relatively small catch of important bottom fishes; and rays and stakes, *P. hasta*, Hoshimizoisaki, and *C. colax*, Tenjinzame, were the major species.

Inside Kompong Som Bay, the catch was occupied mostly by miscellaneous fishes such as *T. theraps*, Himekotohiki, and *L. lunaries spadicus*, Sabafugu. The catch in this bay included *P. semisulcatus*, Kumaebi, and *M. mutatus* (a kind of Yoshiebi), indicating that the bay may provide promising fishing grounds of shrimps.

(8) Catch per hour per net was studied by classifying the survey stations into two groups (Stations 1, 2 & 3, and Stations 4 & 5) by the type of gear employed. In the first group of stations, Station 1, located relatively far off the coast for rock fish fishing, registered the largest catch of 2.2 kg, while Stations 2 and 3 along the coast produced less than a quarter of this value, ranging from 0.5 to 0.35 kg. The latter group of stations (Stations 4 & 5) where the operation was intended mainly for catching shrimps and crabs, the catch ranged from 0.08 to 0.09 kg.

(9) Measurement of full length and observation of maturity were conducted also on the catches by gill net fishing, whereby new findings were obtained about such species as *Dasyatis spp.* (Fam. Akaei), *Lutjanus sp.* (Fam. Fuedai), *T. theraps*, Himekotohiki, which were not collected by trawl net, in addition to the fact that *L. lineolaus*, Itohiiragi, was larger than that caught by trawl net.

(10) The catch by gill net was compared with those by three different trawling operations, i.e., the trawl net fishing survey conducted by Mr. Nakada in November 1968, the ISEI trawling operation for *Penaeus orientalis*, Koraiebi, and the small one-boat trawling operation for shrimps fishing in Nagasaki Prefecture. The comparison was made after correcting the respective catches by the effective area of fishing gear used, which revealed that the relative abundance of resources in Cambodia as a whole is six times as large as that of resources disclosed by ISEI trawler and one-boat trawler in Imari Bay (See Fig. 3-9). It is to be added, however, that the catch by gill net was mostly occupied by small and unimportant fishes with the exception of shrimps and crabs.

The resources of shrimps in Cambodia, when expressed in terms of catch, was four times as large as that of *Penaeus orientalis*, Koraiebi, disclosed in March 1960 when the largest monthly catch by ISEI trawler was recorded, and approximately equivalent to the catch in Imari Bay. (Shrimps in Imari Bay are composed of miscellaneous species) The shrimp resources are thus so abundant that the coastal fisheries in Cambodia can be developed for shrimp fishing alone.

The mesh size currently adopted in Cambodia is 1.5 to 2.5 cm at the cod end, which is much smaller than 5.5 to 5.9 cm of trawl net used by ISEI trawlers.

This mesh size is not problematic for the continued utilization of fishes because most of them are mature though small in size (less than 15 cm). However, the catch of youngs of large type prawns witnessed during the survey, if combined with the possible future introduction of year-round fishing operation, is liable to lead to overcatching in specific fishing grounds and in certain periods of the year. It is therefore advisable that special measures be taken in advance either to control

the mesh size or to restrict the fishing operation in such specific fishing grounds and periods.

(11) The catch by gill net was compared with that given in the report on the experimental operation in Amakusa (Kumamoto Prefecture, Japan) by converting the catch into the number of fishes caught per hour per 10 m^2 of net (See Table 3-11). This comparison leads to the conclusion that the resources in Cambodia are about the same or somewhat poorer than those of Amakusa. However, the conclusion derived from this comparison is an assumptive one because the time and method of survey and the number of operations do not fully justify it. The catchable stock by gill net fishing must therefore await further studies and clarification of resources.

If a conclusion must be given, however, one may say that the catches of shrimps and crabs by bottom gill nets (trinal nets for shrimps and single nets for crabs) are rather promising in areas along the coast, and that the off-shore fishing ground around Koh Rong and Koh Tan may produce some rock fishes and larger fishes such as sharks, rays and skates.

3-5 Bibliography

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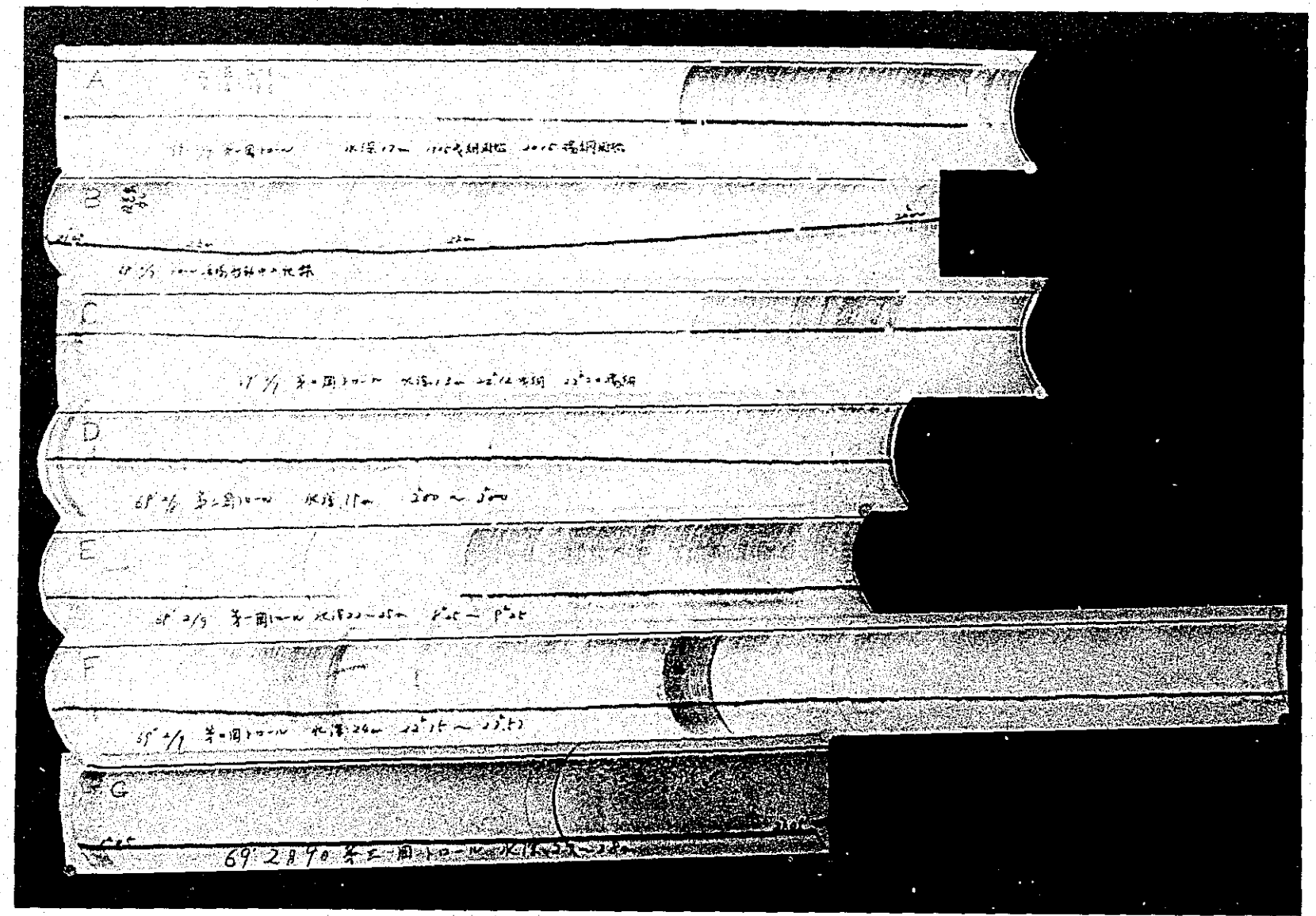


Fig. 3-3 Records of Fish Finder in Experimental Trawling Operation

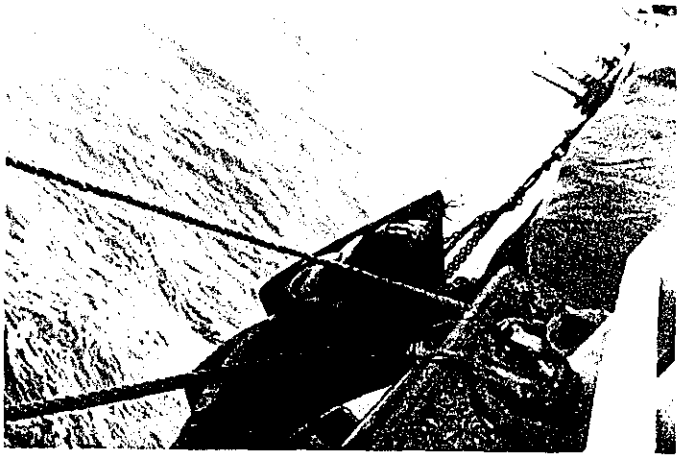


Photo 3-1

Photo 3-2

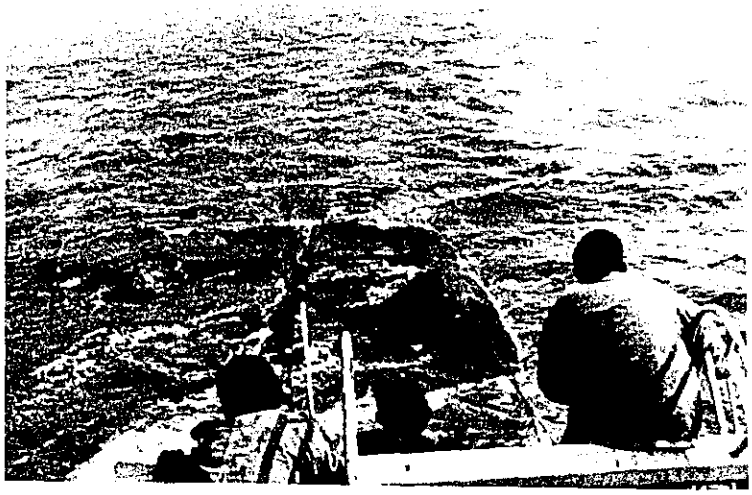


Photo 3-3

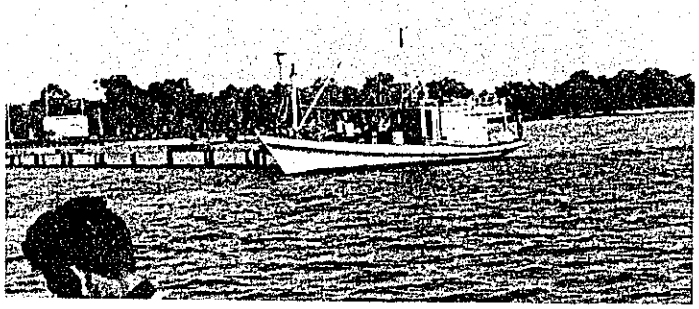


Photo 3-4 Trawl Boat

Photo 3-5 Crews in Operation

Photo 3-6 A Catch by Trawling

Photo 3-7 Experimental Gill Net Fishing

Photo 3-8 Catches by Gill Net Fishing

CHAPTER IV SHRIMPS AND CRABS

Shrimps and crabs rank among the most important catches of the Cambodian coastal fisheries, and they sell at higher prices on the market than other marine products. Among many species of shrimps available, the large prawn is envisaged as an important future export item, and its effective utilization is doubtlessly the key to the desired development of fishing industry. Ecological study of prawns should therefore be made with maximum efforts directed to the preservation of catachable stock so as to assure their continued and effective utilization.

4-1 Shrimp

4-1-1 Distribution of Shrimps

Species collected by trawl net fishing are given in Table 3-1. As discussed in paragraph 3-1, prawns belonging to *Penaeus sp.* and *Metapenaeus sp.* constitute the major portion of shrimps caught by trawl net fishing. However, the beach seine net and dip net fishing conducted in areas along the coast disclosed that the greater part of the catch is occupied by youngs of these large prawns and shrimps of small type.

P. merguiensis, Meruguiebi, which was not collected by the trawl net fishing in the area south of Koh Kong, was found in substantial quantities on the market at both Kampot and Kep. Individuals found on the two markets were all youngs. An appreciably large amount of this species was caught during the previous survey (wet season) by the beach seine fishing on the coast of Kdat and by the small trawler operation in the offing of Kdat - New Kep. From these facts, it is made obvious that this species does not necessarily live only in the northern area.

Adult individuals of *M. mutatus* (a kind of Yoshiebi) were caught in all the off-shore fishing grounds, while small youngs of this species were found in shallow waters close to the coast. This species is caught in large quantities in the estuary of rivers where the effect of fresh water is prominent.

Species other than these two are *Metapenaeopsis stridulans* (species resembling Akaebi), *M. berbeensis* (species resembling Akaebi), *Trachipenaeus poscardoreensis* (species resembling Saruebi), *T. fulvus* (species resembling Saruebi), etc. (See Table 4-1)

4-1-2 Body Length and Ovary Maturation

Of a number of different large prawns collected by trawl and gill net fishing, three species (*P. merguiensis*, *P. semisulcatus* and *M. mutatus*) were selected for indication of their carpace length (C.L.) and ovary maturation. (See Figs. 4-1 – 4-6)

The maturity was judged by visually inspecting the width and colour of the ovary on the dosal side between carapace and abdomen and the conditions of eggs covered by jellyish substance.

(1) *Penaeus merguiensis*, Meruguiebi

The female of this species has a C.L. ranging from 25 to 50 mm, with the mode existing in the range of 40 to 45 mm. About 55% of female individuals were with grown eggs, and the rest was either immature or completed spawning. The male, whose C.L. ranges from 30 to 42 mm, has its mode in the range from 35 to 37 mm. Thus, the male is generally smaller than the female.

The survey disclosed that most of large individuals of this species in the north of Koh Kong had completed spawning, and that the spawning of smaller group would soon follow.

(2) *Penaeus semisulcatus*, Kumaebi

With the mode found at 40 mm, C.L. of this species ranges from 24 to 45 mm. Individuals whose C.L. does not exceed 30 mm were all youngs. 50% of adult individuals were fully grown, and the remaining 50% were either immature or completed spawning.

The male has a C.L. ranging from 22 to 35 mm, with the mode found in the range of 34 to 35 mm.

(3) *Metapenaeus mutatus* (a kind of Yoshiebi)

This species resembles *M. monoceros*, Yoshiebi, which is produced abundantly in every part of Japan.

The female has a C.L. ranging from 13 to 39mm, with the mode existing in the range of 25 to 33 mm. The male is usually smaller, with its C.L. and mode ranging from 10 to 32 mm and 21 to 25 mm, respectively.

Female individuals exceeding 22 mm in C.L. were occasionally found to have eggs, but they were rather few. Mature female individuals were considered to be ready for spawning since most of them were found to have completed copulation.

(4) *Penaeus monodon*, Ushiebi

Throughout the survey period, the catch of this species was limited to a few individuals which were caught by trawl net fishing at Station 1 in the northwest of Koh Kong (See Fig. 3-2). The female individuals were all with eggs. This species is larger than others, ranging in C.L. from 60 to 65 mm, and weighing 60 to 80 g. The male is smaller than the female.

Detailed description on this species is not given here due to the deficiency of data.

(5) Other shrimps

Apart from the above-mentioned species, several other species of small shrimps were caught as shown in Table 4-1, but the trawling operations revealed that their fishing rate is just too small to take them into account.

4-2 Crabs

Important species of crabs in Cambodia are *Scylla serrata*, Nokogirigazami, *Portunus pelagicus*, Taiwangazami and Kdam chor (Cambodian name of a salted crab). The present survey was not conducted on the last one, Kdam chor.

4-2-1 Distribution of Crabs

While *Portunus pelagicus*, Taiwangazami, is widely distributed throughout the entire area along the coast where the salinity is high, *Scylla serrata*, Nokogirigazami, is found in large quantities in the estuary of rivers where mangrove trees grow thickly.

4-2-2 Shell Width, Body Weight and Spawning Activity

(1) *Portunus pelagicus*, Taiwangazami

Individuals caught by trawl net and gill net fishing were all mature without a single exception. This indicates that at the time of survey, mature individuals lived along the coast and in off-shore areas where the water depth exceeded 10 m.

As is clear in Fig. 4-7 showing the shell width of individuals caught by gill net fishing, the female has a shell width ranging from 7 to 10 cm, and the male from 8 to 10 cm. Female individuals constituted one third of total catch, and 24% of them were with eggs. 80% of these eggs were newly held eggs of yellowish colour.

Individuals observed at the market in Sihanoukville on February 19 were mostly female, and 40% of female individuals were with eggs. On inspecting the same market on February 21, it was noticed that male exceeded the female in number, and about 20% of female individuals were with eggs.

Individuals observed at the Kampot market were mostly female, and about 50% of the female crabs were with eggs. Crabs with eggs were rather small, and there were very few large crabs that had eggs.

This species spawns 2 to 3 times after one copulation. The fact that large individuals having eggs were found on very few occastions suggests that their spawning activity, whether initial or successive ones, had drawn to a close, and was to be followed by the spawning of the smaller group.

(2) *Scylla serrata*, Nokogirigazami

One individual caught by gill net was the only catch of this species during the entire survey period. Study on this species had to be made by observing individuals landed at the market in Sihanoukville and Kampot.

At both markets, landed individuals were composed mostly of youngs, with few mature crabs found by close observation. Hence it is probable that 90% of individuals landed in February are youngs which would have grown into adult crabs after one or two exuviations and eventually joined the spawning group.

Individuals observed at the central market in Phnom Penh included a noticeable number of large crabs but no mature female crabs with eggs were found. This suggests that large and older group had not yet entered the spawning season.

4-3 Summary and Conclusion

(1) Large and important shrimps caught by trawl net fishing are *Penaeus merguiensis*, Meruguiebi, *P. semisulcatus*, Kumaebi, *P. monodon*, Ushiebi, Metapenaeus mutatus (a kind of Yoshiebi), and *M. intermedius* (species resembling Moebi). In addition, there are such middle sized species as *Metapenaeopsis stridulans* (species resembling Akaebi) and *M. barbeensis* (species resembling Akaebi).

Species of smaller type were also caught, but their catch was ignorably small.

(2) *P. merguiensis*, Meruguiebi, and *P. semisulcatus*, Kumaebi, were caught by trawl net fishing in the area north and south of Koh Kong, respectively. Youngs of *P. merguiensis* were caught in shallow waters along the coast of Kdat, New Kep, Kampot and Kep.

(3) Majority of shrimps caught in shallow waters close to the coast by beach seine or dip net fishing comprised the youngs of *P. merguiensis*, Meruguiebi, *P. semisulcatus*, Kumaebi, *M. mutatus* (a kind of Yoshiebi) and *M. intermedius* (species resembling Moebi). Mature individuals were hardly found among them.

(4) Only a few individuals of *P. monodon*, Ushiebi, were caught by trawl net fishing at Station 1, though this species is counted as one of the most important species.

(5) Prawns of *Penaeus sp.* caught by trawl net were observed to have either commenced or completed the spawning, implying that their spawning peak is in the period from February to March. However, the catch of youngs of this species in areas close to the southern coast and the reverse calculation based on the body length of these youngs indicate that the concentrated spawning activity took place before December-January period.

(6) Catches at all stations located north of Kompong Som Bay involved many prawns of *Metapenaeus sp.* that had completed copulation. The spawning peak of prawns of this species living north of the bay is therefore considered to be in March-April period.

(7) As for the distribution of crabs, *P. pelagicus*, Taiwangazami, is distributed along the entire coast, but *S. serrata*, Nokogirigazami, lives mostly in the estuary of rivers.

(8) *P. pelagicus* spawns throughout the year, though to a limited extent. The spawning peak of this species is believed to be in February-April period. The spawning of *S. serrata*, on the other hand, is considered to start with the advent of the wet season.

(9) The spawning activity of groups of large and old individuals usually takes place in the earlier period, followed by that of groups of smaller and young individuals. The sea water temperature that remains high throughout the year may be one of incentives to the limited but year-round spawning activity of

shrimps and crabs (though factors other than water temperature are considered more inductive to the spawning). The crabs, in particular, spawn 2 to 3 times after one copulation. A period of at least 30 to 45 days is required in Japan before all two to three spawnings and the hatching are completed. A female individual that has completed the last spawning enters successively into exuviation and copulation stage, which is immediately followed by the spawning stage. Thus the spawning takes place all the year round.

The spawning season of *S. serrata* is believed to be largely affected by the fresh water increase in the wet season since it lives in the estuary of rivers.

(10) It is generally accepted that the life span of shrimps is one year. However, prawns produced in Japan are often found in the second year of their life, and it is quite likely that prawns of Penaeus sp. and Metapenaeus sp. in Combodia also have a life span of more than one year. Fishing operation intended for these two species should therefore be carried out with consideration given to their life span. Consideration for life span is also required in catching crabs.

(11) *S. serrata*, Nokogirigazami, is caught by a simple method using crab nets. Since this species lives within the known and limited area, its body size will naturally decrease if the fishing efforts goes beyond the limit. Hence it is imperative to take such measures as the protection of spawning activity and fishing grounds, operation at suitable intervals, prohibition of catching adult crabs with eggs, stocking of adult crabs with eggs until hatching, etc.

Observation of fish markets at various places revealed that more than 90% of individuals on sale were youngs which had not participated in the propagation of the species. Surveys should therefore be made in future for the preservation of the catchable stock.

(12) In Japan, artificial incubation of prawns and many other fishes and shellfishes is carried out together with the stocking of rivers with fries. Expenses needed for these protective measures are mostly borne by the Government and partially by local public entities and fisheries associations concerned. It may be added that propagation of prawns is undertaken by fishermen themselves in Japan. They produce seeds and discharge them into rivers for themselves, enjoying the expected results in return for their efforts.

It is advisable that similar measures be taken in Cambodia for protection and propagation of shrimps and crabs, with efforts directed to the clarification of their resources.

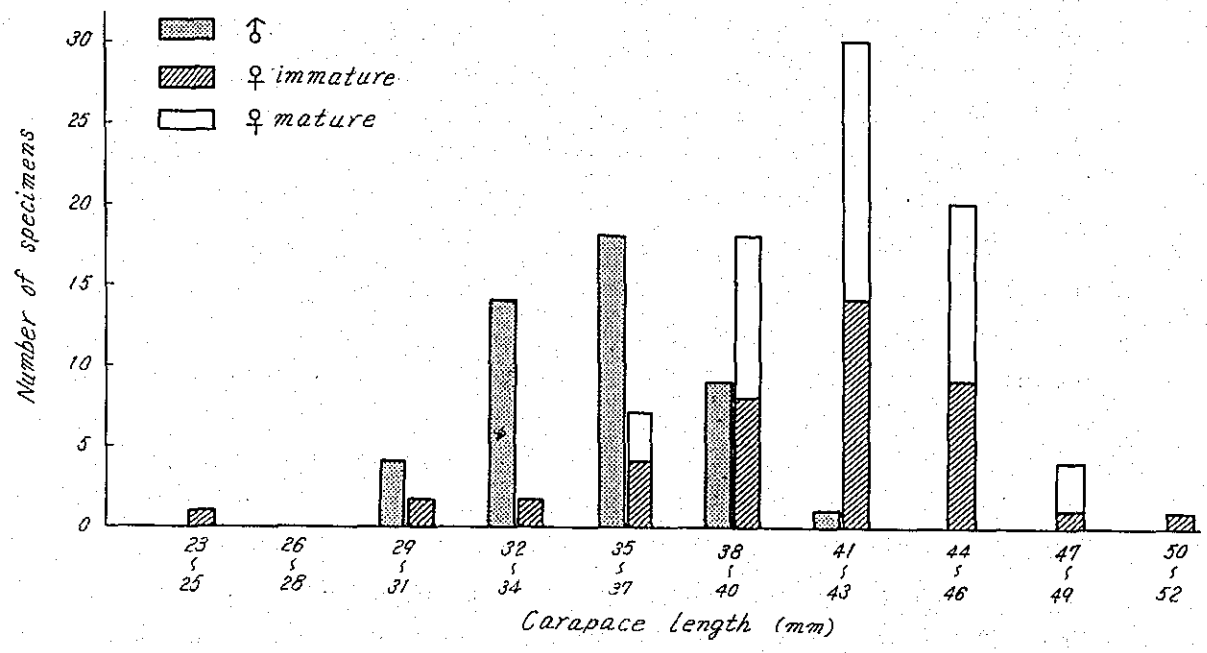


Fig. 4-1 Change of ovary maturation in different carapace length of Penaeus merguiensis

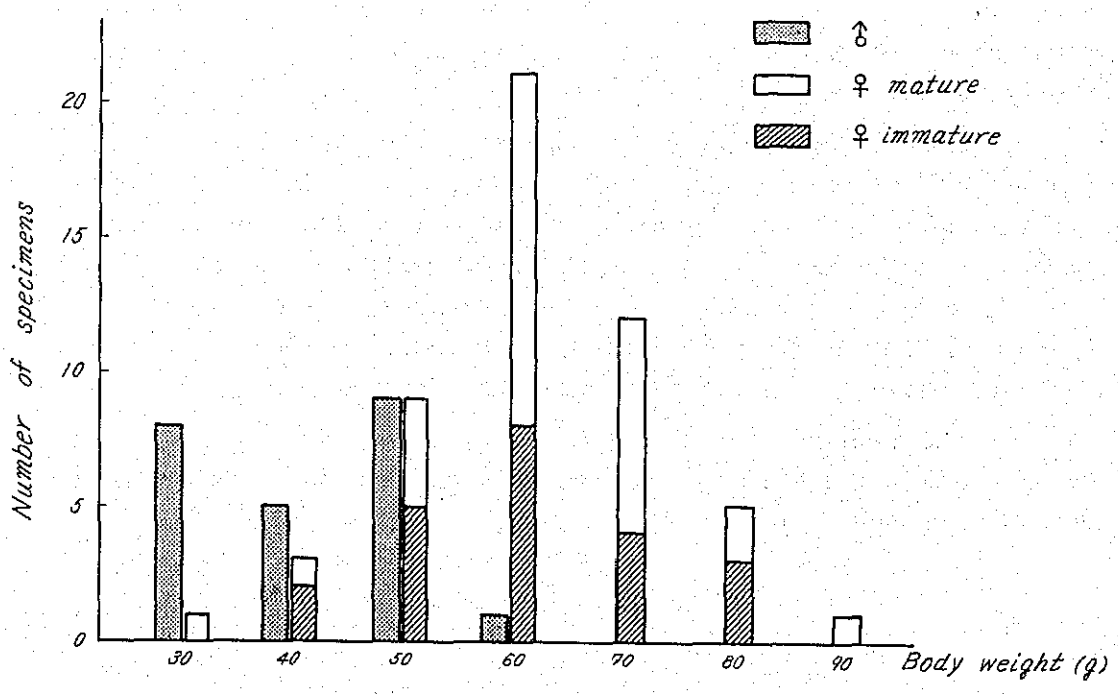


Fig. 4-2 Composition of body weight of Penaeus merguiensis

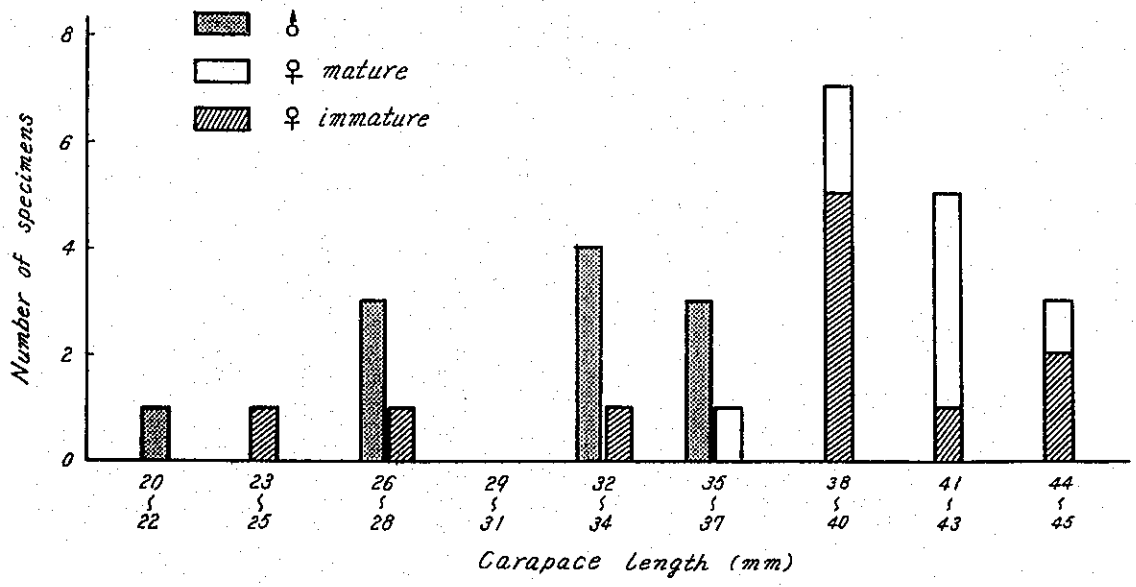


Fig. 4-3 Change of ovary maturation in different carapace length of Penaeus semisulcatus

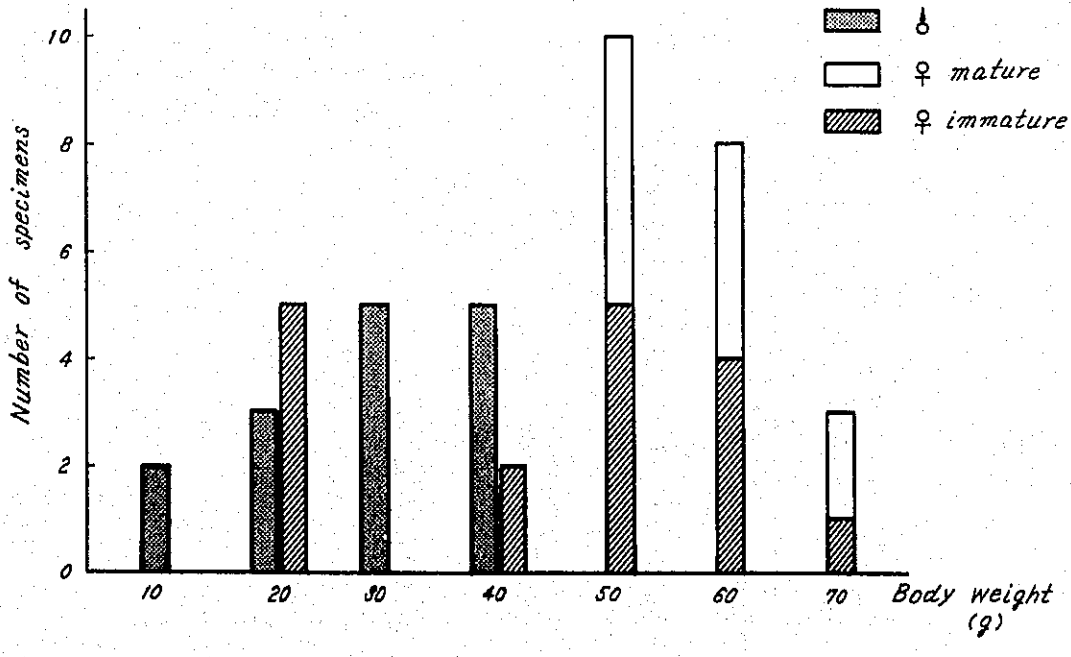


Fig. 4-4 Composition of body weight of Penaeus semisulcatus

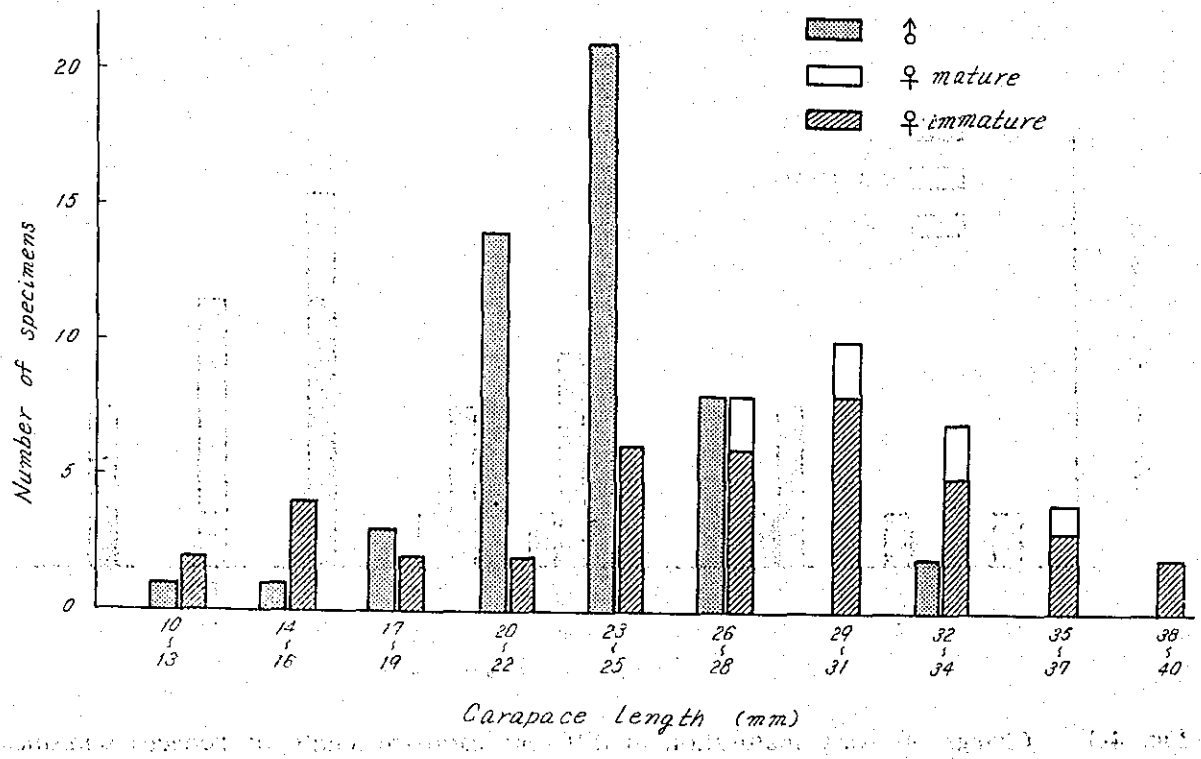


Fig. 4-5 Change of ovary maturation in different carapace length of Metapenaeus mutatus

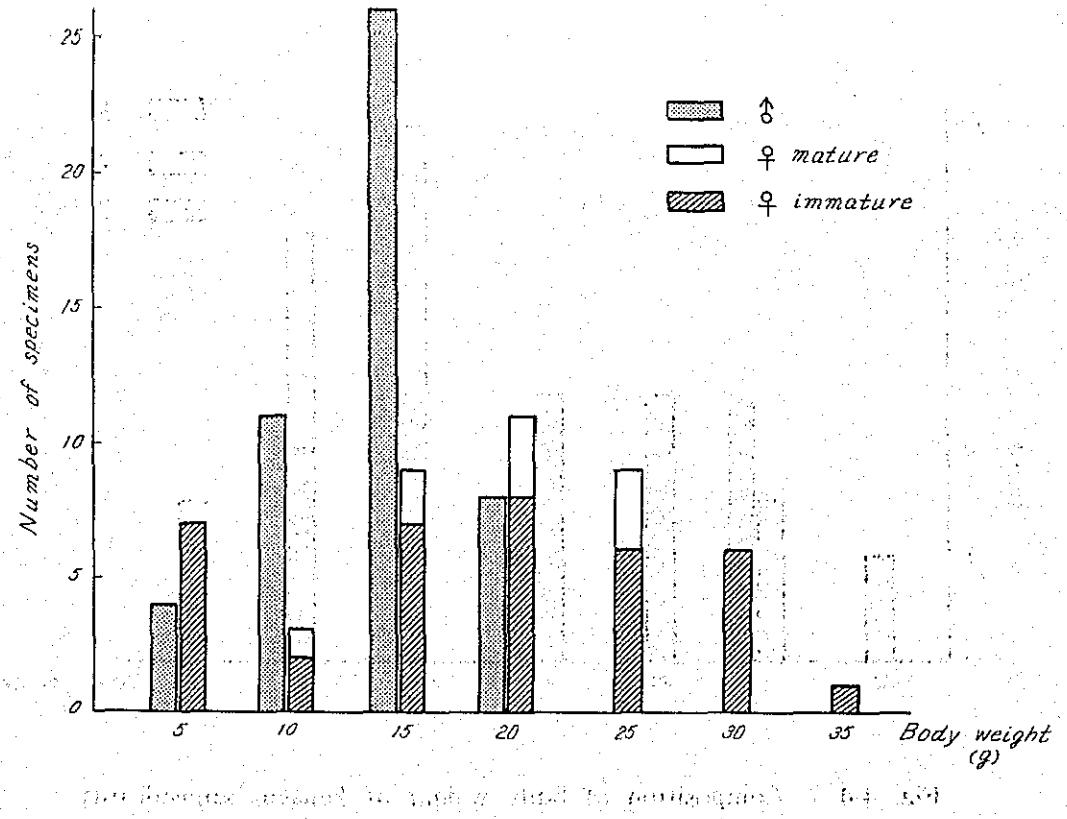


Fig. 4-6 Composition of body weight of Metapenaeus mutatus

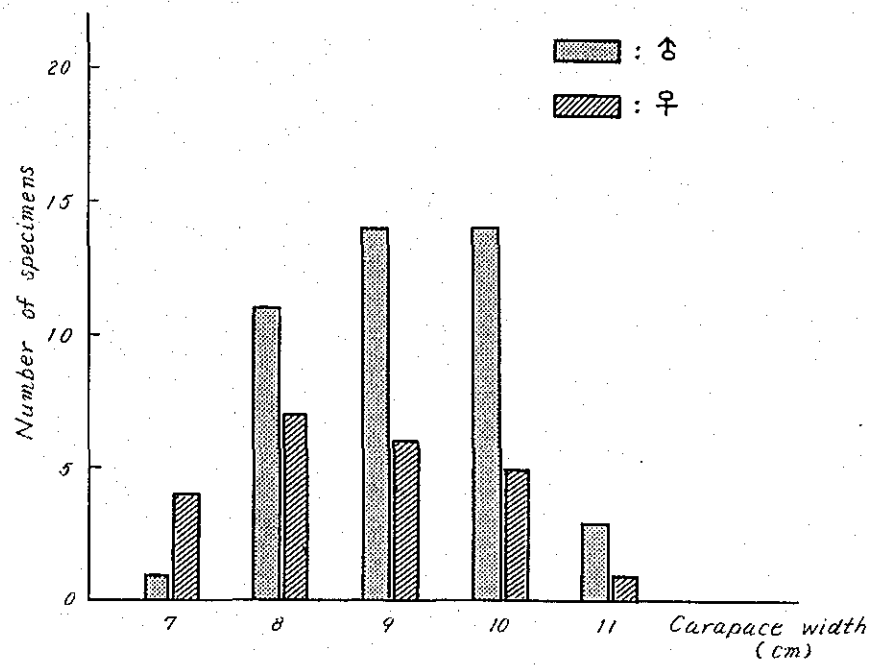


Fig. 4-7 Frequency distribution of the carapace width of Portunus pelagicus.

Table 4-1 Crustacea Collected by Trawl and Gill Net Fishing at Respective Stations

Species		Japanese Name	(Station No.) By Trawl Net Fishing							By Gill Net Fishing		Kampot Market
			1	2	4	5	6	7	8	4	5	
Penaeus semisulcatus	De Haan	Kumaebi	-	-	-	o	o	o	o	o	o	o
Penaeus monodon	Fabricius	Ushiebi	o	-	-	-	-	-	-	-	-	-
Penaeus merguiensis	De Man	Meruguiebi	o	o	o	-	-	-	-	-	-	o
Metapenaeus mutatus	(Lanchester)	A kind of Yoshiebi	o	o	o	o	o	o	o	o	o	o
Metapenaeus intermedius	(Kishinouye)	A species resembling Moebi						o	o			o
Metapenaeus stridulans	(Wood - Masson)	A species resembing Akaebi						o	o			
Metapenaeus barbeensis	Haal	"						o				
Inchypenaeus pescadoreensis	Schmit	A species resembling Saruebi					o	o	o			
Inchypenaeus fulvus	Dall	"					o	o	o			
Solenocera melantho	de Man	A species resembling Kudahigeebi					o		o			
Acetes sp.		A species resembling Akiami										o
Scyllarus sp.		A kind of Semiebi						o	o			
Portunus pelagicus	(Linve)	Taiwangazami	o	o	o	o	o	o	o	o	o	o
Portunus hastatoides	Fabricius	Himegazami						o				
Scylla serrata	(Forskal)	Nokogirigazami										o

Species		Japanese Name	1	2	4	5	6	7	8	4	5	Kampot Market
Podophthalmus vigil	(Fabricius)	*Menagazami*					o					
Charybdis sp.		A kind of Ishi-gani Gen.	o	o	o	o	o	o				
Dorippe japonica	Von Siebold	Heikegani	o	o	o	o	o	o				
Acanthophrys sp.		A kind of Kaimeshigani	o	o	o	o	o	o				
Squilla ovatoria	De Haan	Shako		o	o	o						

CHAPTER V SURVEY BY FISH LAMP

5-1 Purpose

It has long been practised in many countries of the world to lure and gather fishes with a lamp at night and catch them with the dip net, gill net, haul net, blanket net or purse seine. This method is naturally intended for achieving a high fishing efficiency.

The light source for gathering fishes has changed from the torchlight to kerosene lamps, then to carbide lamp. In recent years, electric lamps using a battery or a dynamo are in wide use. In addition, studies on the colour of light have made it possible to select different suitable colours for the intended catches.

Besides the use of the fish lamp which is now the sole means of catching such pelagic fishes as fishes belonging to the jack-mackerel group, mackerels and sardines, application of sonic wave has now come to the stage of practical operation. Thus, efforts are continuously made for achieving a higher fishing efficiency and reducing the time of fishing operation.

Plathou, the most important and abundant fish in Cambodia, used to record an annual catch of as large as 40 thousand tons in the past. Its annual production, however, is said to have much declined of late, due partly to the stagnant export, to about 10 thousand tons which is just enough to satisfy the domestic demand.

This fish is usually caught at night by means of the encircling net (Uon Tith), purse sein (Uon Chhe) or wooden screen pound (Pok). This method is also employed for catching fishes belonging to the jack-mackerel group, mackerels and sardines.

Since Plathou is believed to have the habit of staying away from the fish lamp, lighting fishing lamps during Plathou fishing is considered prohibitive. In the method using the encircling net (Uon Tith), a lamp is used to intimidate, drive and entrap Plathou in the gill net, and in another method using the purse seine (Uon Chhe), a lamp is put on and off at a short interval or the water surface is beat so that Plathou will be intimidated and prevented from escaping through the ends of the net being closed.

Generally, fishes can be classified into two groups by their phototropism. It is known that the intensity of phototropic nature varies by species, and that some species different gathering intensities depending on the duration of lamp operation.

Phototropic fishes usually gather around HIJIRAMI. The term HIJIRAMI denotes the depth beneath which the light suddenly loses its intensity instead of gradually becoming weaker. The distance from the water surface to HIJIRAMI varies by the initial intensity and colour of the light as well as by the transparency of water. The brightness of light at HIJIRAMI suited for gathering fishes differes by species. In order to gather fishes

in such a manner as will assure easy catching, intensity and colour of the light must be controlled on the basis of such factors as the scale of gear, depth of the fishing ground and the intended catch.

In the present survey, fishes gathered around the white underwater fish lamp were identified by reading the record of fish finder and by catching fishes by angling and other means. Quantity and species of fishes were examined by means of purse seine (Uon Chhe) with the cooperation of local fishermen and Koh Kapik Division of the Fishery Service.

The present survey did not clarify the size of fish schools and the method to be applied in future. These are a matter that should await future studies.

5-2 Equipment and Method of Survey

5-2-1 Equipment

Equipment used for the survey are as follows.

a)	Dynamo	100 V, 300 W, AC or DC (Product of Honda)
b)	Fish lamp	White incandescent underwater lamp, 100 V, 100 W, 1 unit
c)	Fish finder	FURUNO Model FG-200

5-2-2 Method of Survey

As a rule, the fish lamp was lit for one hour during which the gathering condition of fishes was recorded by the fish finder at each station. Fish lamp and fish finder were carried on the same boat.

Identification of species was conducted on fishes caught by angling, dip net fishing and purse seine (Uon Chhe) fishing.

The survey also included the study on the difference in the composition of planktons caused by lighting the fish lamp. (See the List of Planktons attached at the end of the report)

The fish finder serves to detect species and quantities of specific kinds of fishes. The survey was not considered to provide accurate information on species and quantities of fishes because no surveys of similar kind had been conducted in the Cambodian coastal area. Consequently, an assumptive conclusion is given below based on the comparison with the records of fish finders relating to fishes belonging to the jack-mackerel group and mackerels in the Japanese waters.

5-2-3 Results of Survey

No. 1

Time and Date : 05:00 - 06:00 hrs, February 2, 1969

Location : Station A near Koh Kong Kang (See Fig. 3-2)

Results : Due to high waves, the boat approached the northern coast of the island and the anchor was cast at a point where the water depth marked 20 - 25 m to lower the fish lamp to a depth of 0.5 m under the water surface.

Schools of small fishes were detected to have gathered around the lamp immediately after it was lit, but identification of species was not possible. In 30 min. after the lamp was lit, it was lowered to a depth of 2.0 m with the light intensity increased. This, however, was followed by a shortcircuit fault caused by the sea water intrusion into the head of the electric bulb. The dynamo was therefore disconnected and the survey discontinued.

No. 2

Time and Date : 20:00 - 23:00 hrs, February 13, 1969

Location : Station B in the north of Koh Samit (See Fig. 3-2, and Fig. 5-1 showing St. B-1 and B-2)

Results : The lamp was lit at 20:10 hrs. and put off at 23:00 hrs. While the lamp was on, collection of planktons and identification of fishes were carried out.

No fishes were caught by angling except *Scolidon sorrokawah*, Hiroankozame, which was probably attracted by the gathered fishes on which it preys.

Planktons collected are listed in the appendix.

Station B area is the fishing ground of Plathou where the water depth recorded 10 m, but the depth becomes deeper towards the offing.

The fish finder, actuated immediately after casting anchor, detected, though not clearly, the existence of a few schools (See point (a) of Station B-1 shown in Fig. 5-1. Points shown in Fig. 5-1 are hereafter referred to as (a), (b), (c) and so on). The lamp was lit one min. after activating the fish finder, whereby a clear record of fish school was obtained in about 30 sec. between 3 and 10 m from the sea bottom (b), and dense dots of fishes were also noticed above the said school (c). In the following 10 min., these dots were integrated into a block which swam up to 5 m below the water surface. Behaviour of

these dots is similar to that of fishes belonging to the jack-mackerel group in Japanese waters (d).

The fish school located between 3 and 10 m from the sea bottom showed itself thickly in the midwater (depth: 8 m) with the elapse of time (e), becoming vague towards the bottom (f), and when the lamp was put off, it disappeared (g), dispersing into dots which were denser in the surface water than in the bottom water (h). When the lamp was lit again, two clearly separated schools, one in the surface water and the other in the mid-bottom water, were detected (i).

In 35 min. after the lamp was lit again (i.e., 80 min. after the test was started), one of these two schools, which was observed in the surface water, became indistinct, and the record indicated the existence of fish school only in the midwater (f, St. B-2).

This fish school swam up about 2 m when the light intensity was decreased (k), but swam down quickly about 4 m when the intensity was increased (l). When the intensity was increased and then gradually decreased to the initial value, the school swam up to the original depth (m).

These observations indicate that the detected fish school apparently formed two groups, the upper and lower, for about 80 min. after the lamp was lit. The upper group disappeared with the elapse of time and the midwater group alone remained on the record.

Fishes swimming in the surface water were small fishes (believed to belong to *Leiognathidae*, Hiiragi group and *Therponiedae*, Shimaisaki group) including few groups of large fishes. Fishes detected in the midwater or at depth closer to the bottom were assumed to be fishes belonging to the jack-mackerel group and mackerels with some large fishes of other species intermixing.

Data of fish finder recorded on the way to Samit Port after completion of survey at St. B are showin in Fig. 5-4.

No. 3

Time and Date : 23:00 - 00:15 hrs, February 14, 1969

Location : Station C located about 40 km west of the northern tip of Koh Kong; water depth - 16 m (See Fig. 3-2, and Fig. 5-1 showing St. C-1)

Results : Survey at Station C was conducted with the cooperation of local fishermen who helped catch the gathered fishes with purse seine (Uon Chhe) for identification of species and determination of quantities. Uon Chhe is a purse seine whose ends are designed to be closed by means of a lead.

In 5 min. after the lamp was lit (at 23:15 hrs), dots of fish schools appeared near the water surface, and the fish finder detected an indistinct fish school between 5 and 6 m from the sea bottom (a). In 20 min. after the lamp was lit, the fish school in the bottom water swam up 1 - 2 m (b), and moved farther upwards close to the water surface in the following 5 min. (c) indicating the similarity to mackerels in the Japanese waters. The fish finder recorded clear dots of fish school around this time. The dots increased with the elapse of time (d). These fish schools disappeared on putting off the lamp (e), and a portion of them swam up to the surface water (f). With the lamp lit again, the same record as obtained before reappeared (g).

With this fact borne in mind, the light intensity was gradually increased 1 hr. after lighting the lamp, with the lamp brought closer to the fish school and a set of Uon Chhe was started to be made (h). However, about 20 min. after making set, the net was fastened around the screw of the netter, and while unfastening it, a large number of fishes fled away.

Major species caught were *Sphyraena picuda*, Onikamasu (about 50 kg), *Trachurops macropthalmus* (Gen. Meaji), *Opisthopterus tradoors*, Hiramodoki, *Leiognathus equulus*, Seitakahiiragi, *Pomadasys hasta*, Hoshimizo-isaki. Species caught by angling while the lamp was lit were *Trachurope macropthalmus* (Gen. Meaji), *Scolidon soorakowah*, Hiroankozame, *Chirocentrus dorab*, Saito, *Pomadasys hasta*, Hoshimizoisaki, *Loligo sp.*

(Fam. Yariika). Species caught on the water surface with spoon nets were *Loligo sp.* (Fam. Yariika), Atherinidae (Fam. Toogoroiwashi), *Hemirhamphus sp.* (Fam. Sayori), Exocoetidae (Fam. Tobiuo), *Shratelloides delicatulus*, Minamikibinago, etc.

Plathou was not included among the fishes caught by the survey. The poor catch of fishes despite the combined use of two boats is attributable to the aforementioned accident of the netter which occurred before setting the net as well as to the lack of skill and coordination in the fishing operation. Such skill and coordination are required in determining the positional relationship between the lamp carrier and the netter which must be based on the direction and velocity of tidal stream, length of the anchor line of lamp carrier, surrounding speed of the netter, water depth and net height. They are also indispensable for determination of optimum net height and light intensity for inducing fishes close to the water surface from HIJIRAMI and for surrounding the fish school with a suitable HIJI.* When these co-related fishing techniques are mastered, the fisheries development using the fish lamp will become much more promising.

* The term HIJI indicates the elbow-shaped peripheries of the circle created by the netter. (See Fig. 5-3)

No. 4

Time and Date : 00:15 - 01:00 hrs, February 15, 1969

Location : Same as No. 3 (See Fig. 3-2, and Fig. 5-2 showing St. C-2)

Results : During the preceding survey (No. 3), the anchor was cast twice and the lamp was lit while Uon Chhe was being hauled to examine the gathering of fishes.

It was noted during this fourth survey that, as in the case of the third survey, the fish school detected in the midwater or at depth closer to the sea bottom becomes clear with the elapse of time (a), and the fish school recorded from the midwater to the surface water is generally indistinct with the

exception of occasional dense dots (b). Dots detected in mid-surface water are considered to indicate the passage of fishes of very large size (c).
All these fish schools swam up to the water surface when the light was put off, indicating that fishes gathered around HIJIRAMI (d).

Since the survey was conducted exactly at the same place as the preceding one, it is probable that the gathered fishes were also composed of the same species. No netter was employed this time.

No. 5

Time and Date : 01:45 - 03:00 hrs, February 15, 1969

Location : Station D located about 2 km northwest of Koh Kong; water depth - 10 m. (See Fig. 3-2, and Fig. 5-2 showing St. D)

Results : In view of the height of the net to be employed, this survey was conducted at a place having a smaller water depth than Station C.

The gathering process of fishes was similar to that noted in the preceding survey, but the record of fish schools was less distinct (a).

The setting of the net was started about 40 min. after the lamp was lit (b), but due to the delay in pulling up the anchor of the netter, the tidal stream caused the net to hang on the anchor. In consequence, the anchor was raised together with the sinker line when the surrounding operation was completed, which allowed the fishes to escape from the outlet created. Therefore, this survey produced no more than several tens of fishes of *Leiognathus sp.* (Hiiragi group) and those belonging to jack-mackerel group.

No. 6

Date : February 19, 1969

Location : Station E in Kompong Som Bay; water depth - 12 m (See Fig. 3-2, and Fig. 5-2 showing St. E)

Results : As in the case of the preceding survey, the gathering of fishes was detected by the fish finder after lighting the lamp.

The fish school first appeared between 4 and 5 m from the sea bottom (a), gradually increasing in thickness until it expanded and reached a depth of 2 - 3 m below the water surface in 20 min. after the lamp was lit (b). In the following 10 - 15 min., this fish school broke into the upper and lower groups (c), and the lower group joined the upper one when the light intensity was decreased (d). When the light was put off, most of fish school dispersed (e). With the lamp lit again 1 min. later, the fish school appeared again with the recurrence of the same process as observed when the lamp was initially put on (f).

5-3 Summary and Comments

Results of the survey by fish lamp are summarized below with some comments and brief description on species identified by the fish finder and angling.

(1) The 100 W white underwater fish lamp displayed and appreciable effect. Fishes gathered by lighting one 100 W lamp could be clearly discrimiated into the upper school and the lower one. The fish school detected in the surface water, believed to comprise small fishes, partly presented the same pattern as that of mackerels in the Japanese waters. On the other hand, the fish school in the bo ttom water presented, though in part, a record which is similar to that of fishes belonging to the jack-mackerel group caught in the Japanese waters.

(2) The fish school in the midwater or at depth closer to the sea bottom is considered to be composed of fishes larger than those gathered in the surface water. Its record on fish finder was also thicker than that recorded in the surface water, and was tinted with dense spots which are believed to have been caused by the intermixture of fishes of different species or of specially large size. Species of these intermixing fishes, however, could not be clarified.

(3) By decreasing, nullifying or increasing the light intensity, the fish school can be induced to swim up, disperse or swim down. This is indicative of the relationship between the phototropic nature of fishes and the light intensity. In other words, fishes gathered around HIJIRAMI moved as HIJIRAMI shifted, whether upwards or downwards, and left HIJIRAMI when the lamp was extinguished. This points to the necessity of studies on the phototropic nature of fishes.

(4) Species gathered around the lamp and identified are as follows. *Sphyraena picuda,* Onikamasu, *Trachurops macropthalmus* (Gen. Meaji), *Opisthopterus tardoore,* Hiramodoki, *Leiognathus equulus,* Seitakahiiragi, *Pomadasys hasta,* Hoshimizoisaki, *Scoliodon sorrakowah,* Hiroankozame, *Chirocentrus dorab,* Saito, *Sillago sihama,* Kisu, *Laligo sp.* (Fam. Yariika),

Atherinidae (Fam. Togoroiwashi), *Hamirhamphus sp.* (Fam. Sayori), *Exocoetidae* (Fam. Tobiuo), *Spratelloides delicatulus,* Minamikibinago, etc.

(5) The purse seine for Plathou (Uon Chhe) which was employed for catching fishes gathered around the lamp did not produce the expected results on account of the unskilled operation, poor coordination between the lamp carrier and the netter and such failures as the fastening of the net around the screw and the hanging of the sinker line on the anchor.

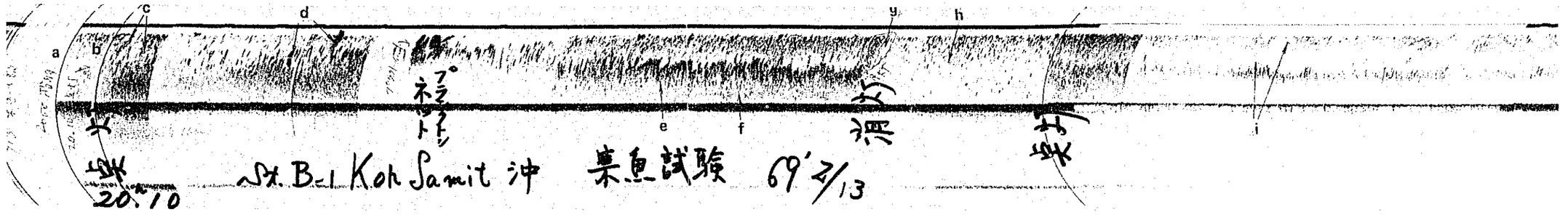
However, the catch can be increased if measures are taken for i) winding up the anchor line of lamp carrier to allow the anchor to be raised simultaneously with the making of a set, ii) using ores and other means to keep the lamp carrier constantly at the centre of the circle of the net, and iii) making a set in such a manner as will provide a sufficient HIJI.

Prior to making a set, the light intensity must be lowered so as to induce the fish school to swim up close to the water surface and form a dense and small block of fishes (See Fig. 5-3).

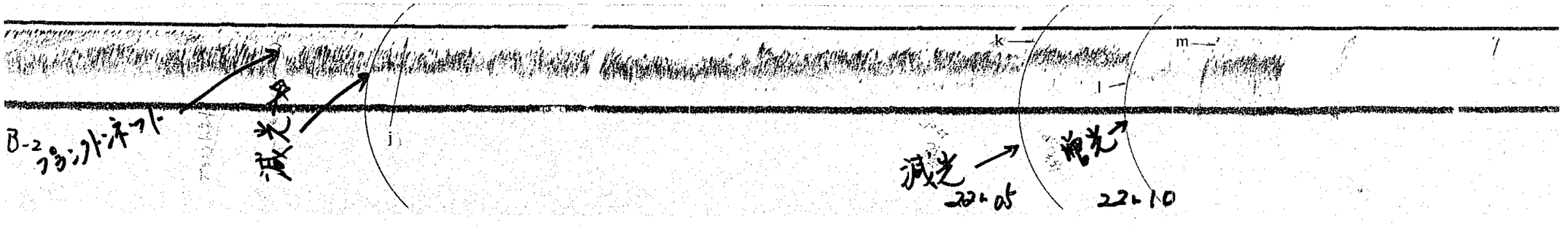
(6) The fish finder employed with the fish lamp will increase the fishing efficiency.

Fig. 5-1 Fish Finder Record of the Survey by Fish Lamp

St. B–1



St. B–2



St. C–1

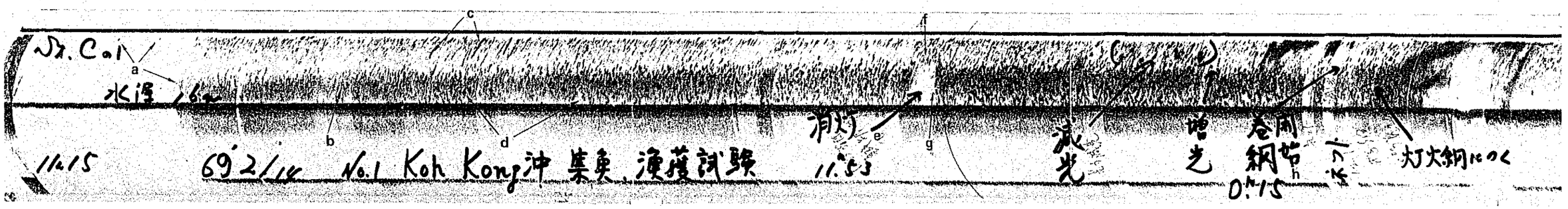
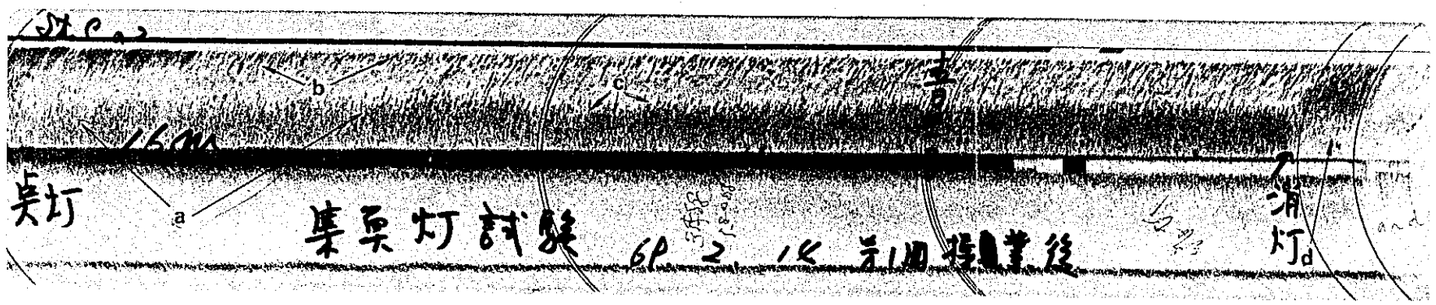
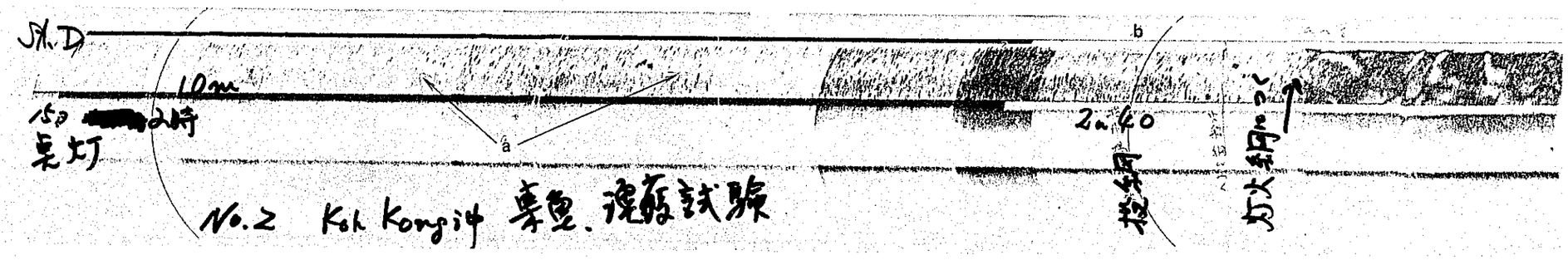


Fig. 5-2 Fish Finder Record of the Survey by Fish Finder

St. C–2



St. D



St. E

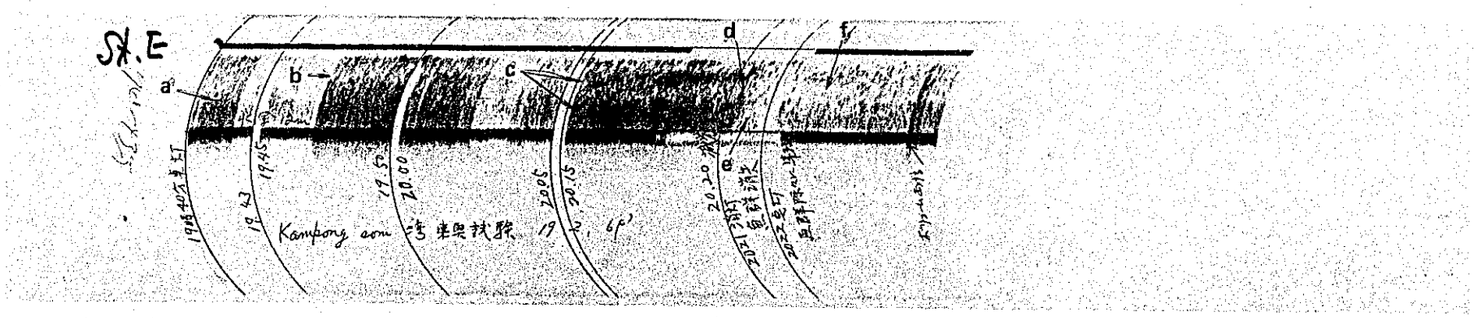


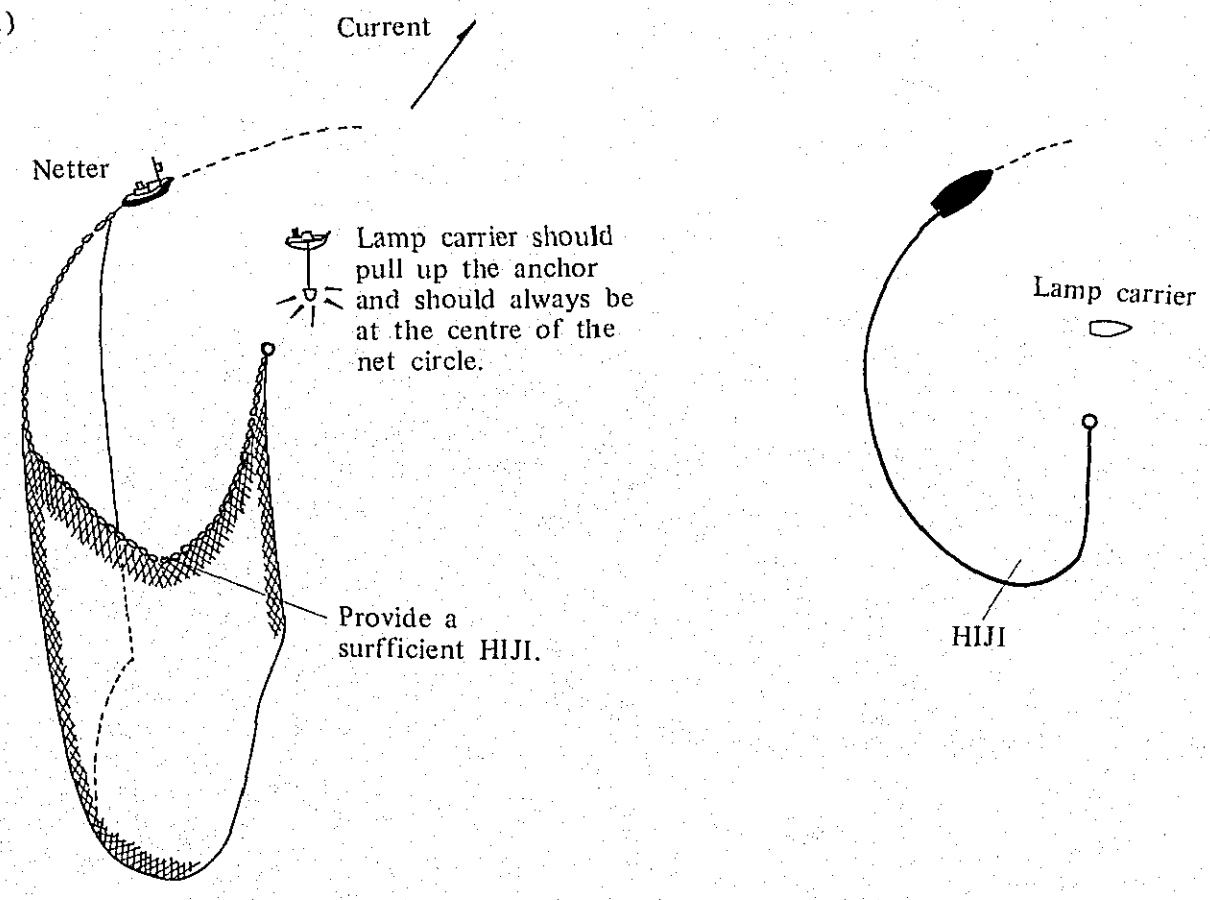
Fig. 5-3 Position of Lamp Carrier and Surrounding Operation

(1) The net is to be lowered so as to encircle the lamp carrier, with attention paid to provide a sufficient HIJI (See par. 5-2-3, No. 3). In time with the lowering operation, the lamp carrier should pull up the anchor, and maintain its position at the centre of the surrounding net.

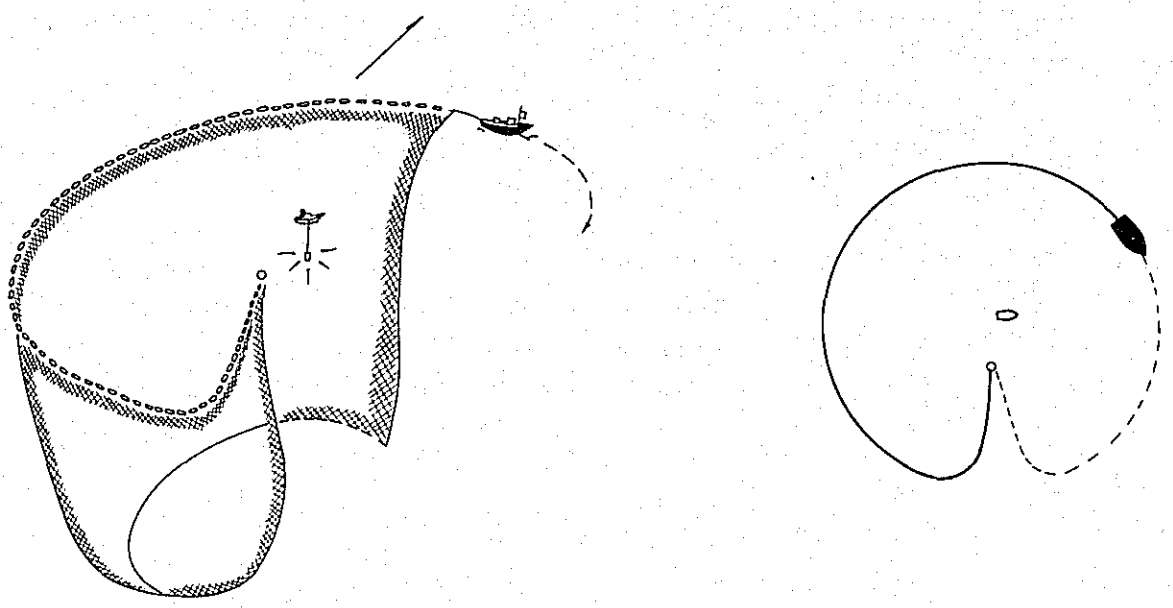
(2) The netter should encircle the lamp carrier and return to its original position in such a way that HIJI will be provided as shown in Fig. 5-3-(2).
While the netter is surrounding the fish school, the lamp carrier should gradually lower the light intensity.

(3) When the netter returns to its original position, the net should be closed by means of a lead. The bottom rople is then to be wound up to start the hauling operation.
The lamp carrier should keep on lowering the light intensity and extinguish the lamp when the net bottom is completely closed, then get out of the circle of net.

(1)



(2) The netter should surround the fish school with a sufficient HIJI provided to the net circle.



(3)

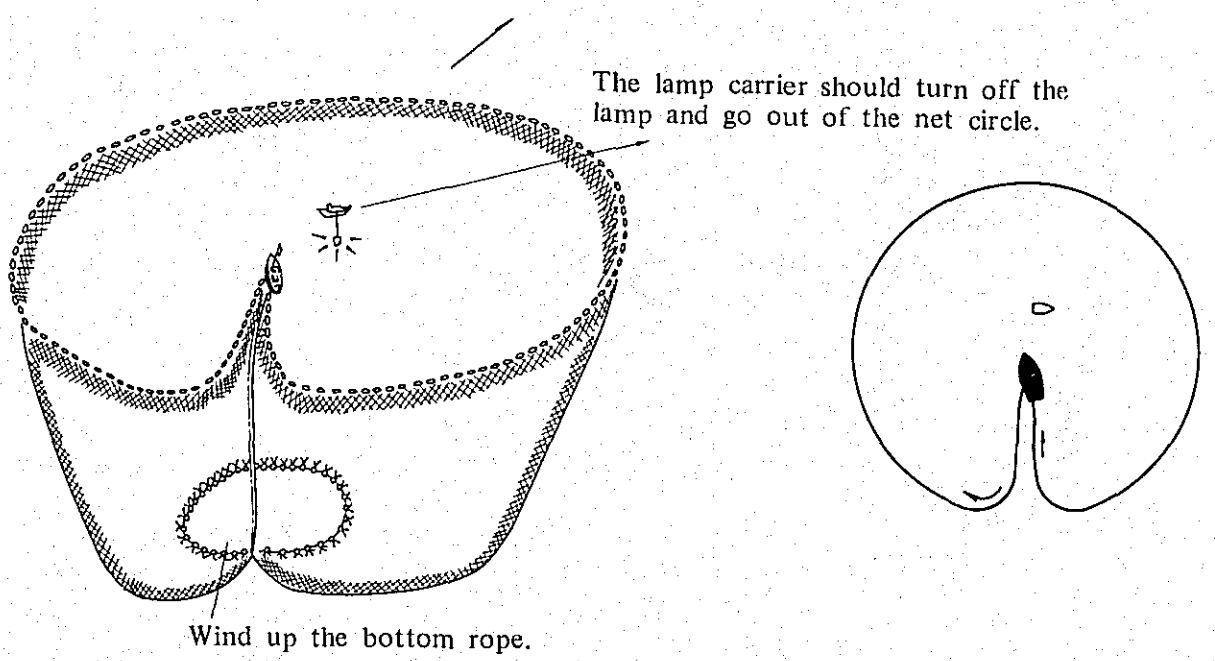


Fig. 5-4 Data of Fish Finder near Samit Port

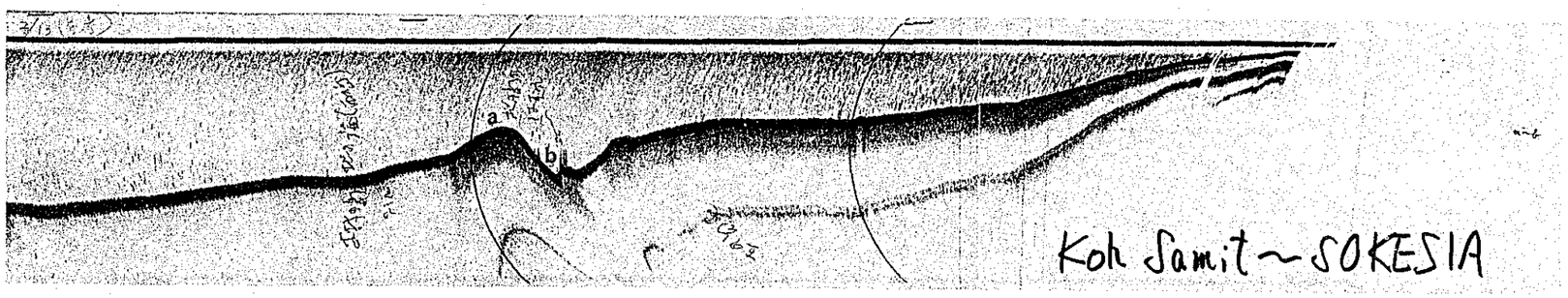


Fig. 5-4 shows the data of fish finder recorded on the way to SOKECIA in Samit after completing the survey in the offing of Koh Samit on February 13, 1969.

Dots appearing close to the sea bottom indicate the small schools of fishes. Portion marked "a" is the top of the rocky upheaval, and that marked "b" is the gully with a small protruvance. Fish schools are recorded along the slope from portions "a" to "b", and also along the slope of the small protruvance. All these fish schools are found on the right side of the slopes, and are considered to shift to the other side if the direction of current changes.

The thickly recorded sea bottom is indicative of hard bottom materials (such as sand and gravels). Such hard bottom causes a duplex record.

As the distance to the coast decreases, the water depth becomes smaller and the seam bottom harder. Immediately before entering the Port of Samit (i.e., before reaching the pier of SOKECIA), the sea bottom gives a triple record, showing that it is composed of hard rock.

Photo 5-1 Pier and Koh Samit as viewed from SOKECIA Office at Samit

Photo 5-2 Pier of Samit Port

CHAPTER VI EXPERIMENTAL OYSTER CULTURE

Introduction

Ancient oystershell heaps are found on the shore along the coast between Plek Kdat and Kampot in Cambodia. This area is supposed to have been a vast haunt of oysters before, for oystershells of a large quantity were dug out several years ago for export to Hong Kong. Even at present, this uncultivated but large type of oyster is caught sometimes in a small quantity. Meanwhile, small uncultivated oysters are found in many areas along the Cambodian coast, and its flesh is found at markets, though in small quantities, all the year round. Under such conditions, the Cambodian Fishery Service has worked out a plan for development of oyster culture and is conducting its own experimental culture by hanging method with piles at Plek Kdat. The Fishery Service has earnestly requested the Japanese Government for a survey for the development of oyster culture.

The previous Survey Team (wet season, 1967) conducted also surveys on oyster. The results of the surveys show that, oysters scatter extensively in various areas along the coast, especially many but small oysters are found in Koh Kong Bay in the north. In Koh Kapik area salinity of the sea water becomes very low in the wet season and many of the small oysters adhered to mangroves (plant of *Rhizophoraceae Family*) are dead, and due attention must therefore be paid to the change in salinity during culture, and around Koh Rong area in Kompong Som Bay some oysters similar to *Crassostrea rivularis*, Suminoegaki, are found and this type is suitable for culture to a comparatively large size.

The aim of the present survey (dry season) was to study the feasibility of developing the oyster culture in Cambodia from both technical and industrial standpoints, with reference to the report of the previous survey (wet season). Accordingly, some observation was made by conducting experiments and surveys on spat collection, culture and impedients with small-scale hanging-type cultivating facilities. Such surveys, however, require a long period of some 2 years at least.

The period for the present survey was so limited that only a part of natural oysters extensively found in Cambodia were employed for experimental culture for test, survey and observation.

6-1 Purpose of Experiment and Survey

6-1-1 Aims for Development

Generally speaking, fundamental conditions required for primary development of oyster culture on the commercial basis are as follows:

(1) Seed oyster of superior species can be easily obtained, both technically and economically. Most desirable is to be able to collect spats near the cultivating grounds.

(2) Oyster must be of a quality which can be fattened by culture to a size larger than natural species and satisfy consumers. (It must be so fat that its internal organs cannot be seen through. More than 8 g. of flesh from every oyster is usually required in Japan, and oysters having more than 10 g. of flesh are most welcomed.)

(3) The yield must be high enough with a minimum loss caused by death or washing away.

(4) Production cost must be low. (In case where oysters do not grow fat enough, expenses for culture and hulling will become quite problematic.)

Intensive production area is required for large-scale oyster culture; for this purpose, the following conditions must be satisfied and promoted:

(1) Suitable and large cultivating ground is available for the increase in production.

(2) Consumer market can be enlarged; for this purpose, long-term preservation of products and their processing for export on the international standard must be assured.

In promoting the development of oyster culture in Cambodia, it must be taken into consideration that when compared with oyster producing countries in the temperate zone, Cambodia has such disadvantageous conditions as the difficulty in transporting live oysters and maintaining their freshness caused by the year-round high atmospheric and water temperatures, and the precocity of generative organs gives rise to quality degradation.

Since even small oysters are put on the market for consumption almost all the year round in Cambodia, demand will be increased, and new markets can be developed by means of appropriate processing method, if the culture proves to contribute to the production of oysters which are larger and fatter than conventional varieties. Therefore, it is first of all necessary to conduct experiments, research and examination of such points as:

(1) If artificial spat-collection enough for culture is possible.

(2) If the oyster is the variety that will grow so fat enough by culture as will increase the consumption.

(3) If the yield is enough for commercial production.

6-1-2 Experiment and Survey Items

Following are the fundamental and minimum works required for studying the feasibility of developing oyster culture and finding a suitable method of development. Testing facilities were accordingly established during the survey period to conduct experiments and surveys given below:

(1) Reconnaisance of haunts of oyster, survey on periods of spawning, experiment of spat-collection, etc. to study "the feasibility of spat collection."

(2) Establishment of cultivating and testing facilities, initial observation and examination of cultivating system suitable for development to study "how oysters grow fat."

(3) Survey on impedients influencing "production and yield by culture" which largely affect the profitability.

(4) Other related surveys.

6-2. Selection of Oysters to be Used for Experiment (Spat Collection, Culture), Experimental Grounds and Cultivating System (Facilities)

6-2-1. Selection of Oysters for Experimental Use.

(1) Cambodian Oyster.

Based on the idea that the development of oyster culture requires that (1) intensive artificial spat collection is possible in the selected area and (2) cultured oysters grow fatter than natural oysters, on-the-spot surveys were conducted on natural oysters in Sihanoukville and Ream areas during the period from Feb. 1 to 3, 1969 and in the north of Koh Kong Bay from Feb. 4 to 7.

Outline of the Survey

Natural oysters scatter extensively along the coast adhering to reefs, piles and prop roots of mangroves (aerial roots from trunks and branches). Around Koh Salour in Koh Kapik area, so many natural oysters adhered to aerial roots of mangroves. This natural oyster adhering to prop roots (hereinafter referred to as mangrove oyster) is the same *Saxostrea parasitica*, Kuroherigaki, (to be mentioned afterwards) as generally found along the coast. Though it is of a small type, it is one of dominance species found in the intertidal zone. Native inhabitants reported that the durability of prop roots (4 - 7 cm in diameter) should be sufficient enough for the use of oyster culture in the sea water. From the above-mentioned viewpoint, the mangrove oyster was selected for the use of hanging culture.

As for the large type of oyster, the previous survey confirmed that some oysters similar to *Crassostrea rivularis*, Suminoegaki, were found in Koh Rong area; however, this was not confirmed during the present activities. Insufficient observations in other areas made it impossible for the Team to obtain oysters of this type suitable for culture.

(a) Living Conditions of Mangrove Oyster.

Oysters of this category adhere to every solid thing suitable such as rocks and stones along the coast (refer to Photo 6-1), wooden screen pound (fish-catching facilities) or wooden supports of fishermen's houses in the sea water, and many of them adhere to prop roots of mangrove trees, thus presenting a very wide-spread distribution.

A vast virgin forest of mangrove trees widely extends in the low marshy area including Koh Kong Bay coast, with many inlets and cannals extending in all directions. In Koh Kapik area, in particular, many natural oysters adhere to prop roots. (refer to Photo 6-2)

The vertical distribution of oyster is within the intertidal zone, and the lower limit of adhesion range seems to be around the low water line of the flood tide. The width of the adhesion range is 60 - 70 cm at places where sunshade is expected, and the width of intense adhesion range is about 40 cm.

Careful observation of oysters adhered to mangrove trees shows that secondary developed oystershells are found over the right shells (shells to form the lids) of the initial shells, next new shells are found over them before they grow up, sometimes overlapping over and over again. In many cases oystershells cling with each other with almost 100 shells sometimes forming a mass. (refer to Photo 6-3)

(b) Varieties and Morphology of Mangrove Oyster.

The mangrove oyster used for experimental culture was *Saxostrea parasitica* (Gmelin, 1971), equal to *Saxostrea mytuloides* Lamarck. It is called also *"Ostrea" cucullata* (Born), which is called Bombeikaki in Japan. This oyster is considered to be of the diminutive type. The largest among those collected from mangrove trees is 43 mm in shell length and 84 mm in shell height, and many are about one-third or two-thirds of the largest size. Some young shells of about 5 to 6 mm at the minimum were found, but none of them was noticed to have just adhered to the mangrove roots.

Oystershells are very solid for their size. A considerable variation was observed on the surface of shells. Some young shells have several vertical stripes of brown or deep purple colors or some pattern in dark color on the half of shell. Old shells are of grayish white without gloss. Many of reef oysters are bluish white and they are usually smaller than mangrove oysters. Because most of the left shells (the one that holds the flesh) adhere closely to mangrove trees or stones, the internal shape of the shell coincides in many cases with the shape of the adhesion base (for example, roundness of prop roots, roughness of stones), and the edge of the shell turn upwards, with solid wave-shaped pleats. Many of oysters in a lump are not uniform in shape and some of them have shell length larger than shell height. When oysters close their shells, the right shell join the left shell, not at the edge but far inside it. The right shell has tens of denticles along the joining portion, in a line parallel to the edge, and the left shells fit each other. The edge of the right shell is covered with elastic, horny and thick cuticle extending upwards along the left shell (as if to prevent the evaporation of moisture); the cuticle, however, remains a little inside the edge. (refer to Photo 6-4)

As mentioned above, most of oysters are not quite shapely. The flesh is not swelling and internal organ can be seen through. The flesh is small for the size of shell

and weighs only one to three grams. Sometimes, however, shapely and oval oysters with large shell width (depth) are found.

(2) Japanese Oyster.

The Japanese oyster was transferred to Cambodia for the purpose of comparison with the Cambodian oyster in experimental culture.

As for transport of Japanese oysters, they were first taken out of fish preserves (water temperature — 9°C) on January 23, 1969. They were then put in wooden boxes after excessive water was removed on Jan. 24 and sealed up to prevent drying, and airborne from Horoshima Airport to Tokyo International Airport. At 10:30 A.M. on Jan. 26 they were exported from Tokyo International Airport, arrived at Phnom Penh at 17:20 (Japanese time) the same date and were hung down from the raft at Sihanoukville (sea water temperature was 28.5°C) at 23:00 of the same day (Cambodian time or 2 hours behind Japanese time). During this period, no oyster was observed dead.

(a) Record of the Japanese Seed Oysters.

Growth of oyster should remarkably vary according to different treatments after spat collection, i.e. process of culture.

The seed oysters were collected during the summer of 1968 and kept in a growth control ground on the dry beach until January 1969 to control their growth by hardening[1] (shell height — 6 - 22 mm) for making them healthy oysters. Two varieties were used, one produced in Hiroshima Prefecture (attaching apparatus is bay scallop shell) and the other produced in Miyagi Prefecture (attaching apparatus is oyster shell). Both are *Crassostrea gigas*, which is called also *Ostrea gigas* Thumbery or *Ostrea laperousei* Schrenk, which is the most popular species of cultured oyster in Japan.

1 Oyster culture in Japan resorts to the hanging method in almost all cases. Seed oysters grow into adult oysters in one year after spat collection, and lay eggs in summer. Oysters cultured by this method are subjected to a high mortality rate during this one year period.

However, if seed oysters that have survived about one month period after the spat collection are placed close together for several months on the hardening race which rises above the low water level 10—13 hours daily, their growth is restrained and health improved. When such hardened oysters are then cultured by the hanging method with rafts arranged an regular intervals, the restraint is removed and the growth accelerated, with an additional merit of decrease in mortality in summer. Seed oysters obtained by this hardening method are also easy to transport and little subjected to damage and death. The hardening method has therefore been one of the indispensable processes in the Japanese oyster culture.

Direct application of this method in Cambodia is not recommendable because of the strong sunlight. Employment of the hardening method in Cambodia would demand some consideration such as the provision of suitable shade or changing of the height of the hardening race.

(b) Japanese Mother Oysters.

They were collected in Hiroshima Prefecture in the summer of 1967. They were hardened until the spring of 1968 and cultured by hanging method with rafts until just before shipment. They were egg-shaped oysters, about 5.3 cm in shell length and 10 cm in shell height. These oysters were employed for the purpose of observing how Japanese mother oysters will change in the tropical zone.

6-2-2. Selection of Suitable Experimental Grounds and Cultivating Methods.

Experimental grounds and cultivating methods were selected on the supreme condition that they must satisfy the aforesaid purpose of experiments as far as possible. Accordingly, the selection had to be made so as to allow the Team to establish the necessary facilities and conduct experiments and surveys during its stay in Cambodia, with consideration given to the convenience of future research work and maintenance of the facilities.

(1) Selection of Experimental Grounds.

The Cambodian Coastal area was first divided into Plek Kdat - Kampot area, Sihanoukville - Ream area and Koh Kong Bay area. Of these areas, Koh Kong Bay area and Sihanoukville - Ream area were selected for the experimental culture after examining all three areas by means of the existing data and hearings to clarify the following conditions:

(1) Possibilities of mass collection and artificial spat collection for experimental use; (2) influence of monsoon; (3) influence of fresh water during flood season; (4) characteristics and abundance of fishing grounds; (5) expanse and applicability of fishing grounds; and (6) maintenance of the facilities. Next, eleven places were investigated on such items as haunts of oysters, depth of water, bottom materials and transparency at fishing grounds, collection of planktons, etc. Consequently the following 4 places were selected for experimental grounds where the experimental facilities were established. (refer to Fig. 6-1 and Table 6-1 (1) — (8))

1) The South-western Front Water of Koh Salour (Koh Karik area) (Station No. 5)

This place is situated outside the magrove forest zone in the northern most part of Koh Kong Bay. Many mangrove oysters observed in adhesion will allow for the spat collection in this area.

Tidal current circulates very well, bottom materials are sandy mud (the inner part of canal is muddy with mold). Planktons are observed in a great quantity. Transparency is 3.6 m. Though the depth of water is 7 m at most, this place is the deepest in the bay. Most of the bay is shallow with a water depth of about 1 m. Facilities provided at this place are bamboo rafts of long-line system and piles for experiments on the growth, yield, influence of flood and spat collection. (refer to Photo 6-5)

2) Northern Front Water of Koh Kong (Station No. 7).

This place is situated near the outlet of Koh Kong Bay and faces Gulf of Thailand. Though some influence may be caused by swell, this place is located in the inlet, not exposed to the south-westerly monsoon. The tidal current circulates well, and it is considered that the influence of flood would be small. Bottom materials are sandy mud. Depth of water is 3 - 4 m. Planktons are observed in a great quantity. Transparency is 2.2 m. Facilities with piles were provided there

for comparative study with those in the inner bay and selection of site for shelter during flood.

3) Front Water of Koh Pos near Sihanoukville (Station No. 10);

This place is located close to the Oceanographic Institute and is in the southeast of Kompong Som Bay, near the outlet to the ocean. It faces extensive Kompong Som Bay in the north, and is free from any intensive influence of wind and waves. The tidal current circulates very well. Bottom materials are sandy mud. Depth of water is 7 m. Volume of plankton is medium. Transparency is 4 m. Facilities provided there are of the long-line system, to be used for general experiments and research on growth, yield, etc.

4) Northern Front Water of Koh Russey in Ream (Station No. 9).

This place is located in the south of Ream Bay, where the adverse effects of monsoon can be avoided. The tidal current mingles with the open sea water and has the highest velocity among the four places. Bottom materials are sandy mud with a large sand content. Depth of water is 3.5 m. Planktons are observed in a great quantity. Transparency is 3.3 m. Facilities provided are piles to be used for experiments on growth, yield, and selection of site for shelter of oysters. (refer to Figures 6-2 (1) and (2))

(2) Selection of Cultivating Facilities.

Oyster cultivating methods generally employed are, (1) raft hanging culture, (2) pile hanging culture and (3) seed sowing culture, each having its own features.

For the present survey the hanging method was used. This method, unlike the seed sowing method, is advantageous in that the spat collection is possible, oysters grow fast, damages by impedients are little and research is easy. For experimental culture, bamboo rafts of the seaworthy long-line system were used, while piles were used for spat collection and culture of seed oysters. (refer to Photo 6-6)

6-2-3. Cultivating Facilities.

(1) Structure and Installing Method of Bamboo Rafts of Long-line System (floating bamboo rafts).

In consideration of seaworthiness against monsoon and increase in weight of suspended oysters, each 2 floating bamboos (thick ones of 12 cm in diameter and 7.5 m in length) are bound together at 5 points with No. 11 wires at an interval of 2.5 m. (see Fig. 6-3)

The rope to moor the rafts is made of chemical fiber with 18 mm diameter in two lines. Two anchors, of cement concrete (30 x 30 x 30 cm) were used to fix a raft at 4 points.

In Koh Kapik area, the experimental rafts (Station No. 5) at Koh Salour are composed of 10 bundles of floating bamboo for every raft, while in Sihanoukville

experimental rafts (Station No. 10) at Koh Pos are made with 8 bundles of bambo for every raft; each raft is provided with a marked buoy.

(2) Structure and Installing Method of Piles.

As shown in Fig. 6-4, thick bamboo or hardwood (about 9 cm in tip diameter and about 7.5 - 8 m in length) were perpendicularly driven in. Thick bamboos (about 8 cm in diameter) were used for bars, to be fixed (with No. 10 wire) at a somewhat higher position between the low and high water lines at neap tide to allow for spat collection and hardening tests.

All the bamboos were unseasoned ones without cracks by drying.

In order to prevent washing away, joints in the 3 m root portion of bamboo piles, to be driven into the sea bottom, were cut through to make air holes, and bottom tips of wooden piles were shaped like tips of harpoons. Bamboo piles were used at 2 experimental grounds, Station No. 5 in Koh Kapik area and Station No. 7 in the northern front water of Koh Kong area. Wooden piles were used at the experimental ground (Station No. 9) on Koh Russey in Ream.

In consideration of possible damages by shipworms, all the materials were made larger than ordinary ones in diameter.

6-3. Methods and Process of Experimental Culture, and Impedients.

6-3-1. Methods and Process of Experimental Culture.

(1) Oysters for Experimental Use and the Hanging Method (Table 6-2).

Oysters used for experimental culture were Cambodian mangrove oysters, Japanese seed oysters and Japanese mother oysters.

1) Mangrove Oyster (refer to Photo 6-7).

Oysters for experimental use: Those are natural oysters attaching to prop roots of mangrove trees on Koh Salour (Koh Kapik area). Some prop roots with 20 - 50 oysters attaching were selected and cut short to 30 - 40 cm for use. Of 49 oysters adhering to one attaching apparatus, 18% were 10 mm or less in shell length, 43% were 10 to 20 mm, 16% were 20 to 30 mm and 22% were 30 to 40 mm. Mangrove oysters of less than 10 mm in shell length, very small type, were, on an average, 9.0 mm in shell length and 13.2 mm in shell height (measured from the hinge for the convenience of measurement). Smaller young oysters of about 5 - 6 mm were very rate, and no smaller ones were found. Large oysters of more than 30 mm in shell length were very few, and averaged 37.0 mm in shell length and 52.4 mm in shell height (up to the hinge). Those over 40 mm in shell length were very few.

Hanging of oysters: There are 2 kinds of materials to which oysters are hung, No. 11 wire (galvanized steel wire) and synthetic fiber rope (Kuremona, 8 mm in diameter).

In the hanging method employed, steel wire or rope was hung down from the raft with prop roots (attaching apparatus) tied to at regular intervals, each of such wire on rope is called "Ren" in Japanese.

Each Ren was suspended from floating bamboo rafts or from ledges of the pile system. Intervals of attaching apparatus were in principle 80 cm in the long-line system and 50 cm in the pile system; length of a Ren is about 6 m in the long-line system, and about 3 m in the pile system.

2) Japanese Seed Oysters (refer to Photo 6-8).

Oysters for experimental use: Japanese seed oysters (300 each from Hiroshima and Miyagi Prefectures) were temporarily transferred in baskets to the rafts under the sea near Sihanoukville on Jan. 26. Most of them were washed away or damaged by a storm on Feb. 2. Moreover, damage caused by the poor skill of workers was so heavy that oysters of only 7 Ren (65 attaching apparatuses) could be prepared for culture. At the beginning of experimental culture, the size of seed oysters was 5 - 23 mm, 13.2 mm on the average. On an average, thirteen seed oysters attached to one attaching apparatus.

Hanging of oysters: As the number of attaching apparatus decreased, 9 of them were used to form one Ren, namely, 3 attaching apparatuses were used for upper, medium and lower portion of each Ren. 25 cm bamboo pipes were employed to maintain an equal interval between 3 apparatuses tied to each portion of Ren, and with an interval of 50 cm between the three portions. Each Ren was made with No. 11 wire of 3 m. long.

3) Japanese Mother Oysters.

These oysters were not damaged by the storm on Feb. 2. Fifty-three oysters were equally divided into 4 bamboo baskets and hung from the rafts temporarily set in front of Koh Pos on the opposite side of Sihanoukville on Feb. 3. They were hung at a depth of 3.5 m under the water surface, about the middle of the depth of sea water.

Bamboo baskets: Two round flat baskets of 50 cm in diameter and 10 cm in depth were joined to make one. The flat baskets were made of split bamboo of 1 cm in width, pleated crosswise at intervals of 1 cm.

Many of the oysters died during the period from 15 to 21 February, and the rest was transferred into 4 small net-baskets and hung at four depths of 0.5, 1.0, 1.5 and 2.0 m in the sea water.

(2) No. of Ren Hung Down at Experimental Grounds.

Table 6-2 shows the numbers of Ren hung down at experimental grounds and the dates. Many barnacles attached to the surfaces of mangrove oysters and Japanese seed oysters which were hung at Koh Pos ground on Feb. 15. It was therefore tried to remove them from about half of Ren on Feb. 22. As for the Japanese seed Oysters, however, barnacles could not be removed because these oysters were too young and small.

(3) Process of Experimental Oyster Culture.

1) Japanese Seed Oysters.

Growth: As for the Japanese seed oysters hung from the rafts near Koh Pos on Feb. 3, it was observed on Feb. 17 that new thin shells of 3 - 5 mm were growing around the shells; this was a favorable growth.

Yield: Many of the Japanese seed oysters were observed dead on the way of growth. The motality during the period from the arrival in Cambodia on Jan. 26 (when no death was observed) to Feb. 17 was about two-thirds. It is considered that this was caused mainly by some mechanical reason such as jostling with each other among the oysters. Some of the dead oysters indicated a certain extent of growth, though the reason was not investigated. Thirteen Japanese seed oysters per attaching apparatus were observed alive on Feb. 17.

Though many barnacles were observed attached on Feb. 21, Japanese seed oysters were left as they are for comparison with mangrove oysters.

2) Japanese Mother Oysters.

Growth: These are single oysters removed one by one from attaching apparatus. No shell growth was observed on both Feb. 15 and 21. (Usually shells do not grow much during the maturation of generative organ.)

Death: It was observed that many oysters (39 among 53 oysters) died during the period from 15 to 21 February. It was observed on Feb. 21 that many were just after death; some of them had their flesh left complete, some others' flesh collapsed and began to melt, and some ones left only ligaments.
These oysters were about 60 - 70% of the dead ones. Two oysters were very much weakened among the 14 found alive.

The 2 weakened oysters and other 4 healthy oysters were put in a container filled with sea water on Feb. 21, but one of the two weakened died next day, Feb. 22.

Generative Organ: About these 6 mother oysters, their generative organ grew very well and soft, and genital pipes in arborescence were clearly observed by human eyes. Microscopic observation revealed that sperms were moving, eggs had grown in a slim triangular shape, and their maturation seemed to require a short period of time. During the survey, the temperature of sea water was 28.5° - 29.6°C and the specific gravity of sea water (δ15) was 23.7 - 24.0.

3) Cambodian Mangrove Oysters. (refer to Photo 6-9)

Growth: At Koh Pos (Sihanoukville area), growth of shells of mangrove oysters was investigated 10 days after transfer and at Koh Pos (Sihanoukville), 11 days after transfer. New thin shells were formed over the cuts around edges of transferred oysters, and some new shells were also observed along other edges. Remarkable growth like Japanese seed oysters was not observed. Unlike Japanese seed oysters, their edges were rather solid. There was no death during the survey and they grew

up very well. Surveys on growth and yield of mangrove oysters were left to be conducted in the future.

Generative Organ: In many of them, flesh was not fat and digestive organ was seen through. During the observation of a few oysters, there was no matured generative organ. Well matured sperms, however, were observed in oysters of the same varieties (*Saxostrea parasitica*, Kuroherigaki) attached to reefs. It was not confirmed if this was due to the maturation of new spermary or the undischarged sperms.

The period of the present survey was not the spawning period of mangrove oysters. Therefore, survey must be conducted in the future to find out when mangrove oysters spawn.

6-3-2. Impedients to Oyster Culture.

As for impedients during the period of growth of oysters, kinds of creatures and conditions of damages must be different by the culture conditions, i.e., natural growth, seed sowing culture and hanging culture. Accordingly, some survey was conducted to study the outline of impedients which are considered to hamper the development of oyster culture.

(1) Main Impedients.

1) Barnacle (*Balanus* spp.)

This type of creature attaches mainly to rocks and piles inside bays, and is the dominance species together with oysters. Not much influence upon natural oysters was observed except mere concurrence of attaching. Insertion of barnacles was not much in mangrove forests inside bays, and no influence upon oysters was supposed. Heavy damage by barnacles was observed in the case of hanging culture, which shall be mentioned afterwards.

2) *Polychaeta*

Polychaeta are impedient to oysters when attached to the surface of shells or between rocks and oysters, or intruding into the shells. They were observed to be about 100 individuals in 200 liters of sea water. (Table 6-3)

3) Shipworm (*Teledo sp.*)

Though shipworms do not influence oyster itself, they are considered to give some adverse effect on such facilities as bamboos and wooden materials of hanging facilities. Accordingly, rough survey was conducted on the conditions of floating larvae. Forty larvae were observed in 200 liters of sea water on Feb. 6 in the northern part of Koh Kong Bay. (refer to Table 6-3)

4) Roll-shells (*Gastropoda*)

Though spiral shellfishes of many varieties are found in the coastal sea, few oystershells were observed to have died by the effect of spiral shellfishes. No

serious effect is considered to be afflicted upon oysters in culture by hanging method. Though it is considered that spiral shellfishes are in close relation to oysters cultured by seed sowing method, no investigation was made on the sea bottom during the present survey.

5) Flagellates (*Dinoflagellata*)

Plankton survey was conducted specifically on flagellates which was assumed to represent all creatures causing red water. Flagellates were observed in considerably great amounts at various places during the survey. (refer to Table 6-3)
About 1,000 - 6,000 individuals of dinoflagellata were collected by vertical hauling of plankton net from a depth of 4 m, and many of them were *Ceratium* spp. and *Peridinium* spp.

6) Starfishes (*Asteroidea*)

It is considered that many of Asteroidea like starfishes and others give bad influence upon oyster culture by seed sowing method. However, no starfish was found on the dry beach and survey must be made on the sea bottom in future.

(2) Barnacles attaching to Suspended Oysters.

During the period of 3 days from 10 to 13 February, it was observed that 9.5 barnacles per cm^2 attached to marked piles from near the water surface down to a depth close to the sea bottom (4 m deep) around Koh Russey in Ream area. During 11 days from 10 to 21 February, mangrove oysters suspended from rafts suffered from many barnacles which numbered 8 - 13 per cm^2 of oystershell around Koh Pos near Sihanoukville. It seemed that the whole surface of oystershell was covered by barnacles. Barnacles were removed from half of "Ren" and these "Ren" cleared of barnacles were used again for experimental culture for the purpose of comparative study on survival of barnacles and their damage to oysters. Attached barnacles were those similar to *Balanus Amphitrite Communis* Darwin, Sarasafujitsubo, or *Balanus Amaryllis* Darwin, Sakurafujitsubo (or *Balanus tintinnabulumrosa* Pilsbry, Akafujitsubo), and those belonging to a few other species but no minute investigation was made.

6-3-3. Surveys on Generation and Attaching Season of Oysters and Barnacles.

(1) Survey on Hatching Season of Oysters and Barnacles by Means of Plankton Survey. (refer to Photos. 6-10 and 6-11)

Planktons were collected by double vertical hauling from a depth of 4 m with xx 16 plankton net in Koh Kong Bay, Kompong Som Bay and Ream areas, and put to microscopic examination. (refer to Table 6-3)
The results of microscopic observation show that there are so many species of planktons. Though the survey was made in the dry season when the effect of fresh water need not be considered, the transparency was rather low ranging from 2.2 to 4.0 m. This transparency is equal to that in the propagation season of planktons in Hiroshima Bay (Japan).

As for varieties of plankton, phytoplanktons, especially Diatoms, were in a greatest number, and those of Copepods were dominant in number among zooplanktons. Bivalbes (Pelecypod) and roll-shells were observed in great numbers. Planktons were observed in large numbers along the coast of Koh Kong, followed by Ream and then Koh Pos (Sihanoukville).

1) Oyster Larvae: Only one large larva very similar to oyster larva was found; it was not the hatching season of oyster. (refer to Photo 6-12)

2) Larva Similar to Oyster: A small number of larvae similar in shape to oyster was observed. Survey must be conducted during the season when such larvae are found in large numbers.

3) Lavae of Other Bivalbes: Many varieties of bivalbes were observed in great quantities. Larvae of such many varieties are not found in the same season in Hiroshima Bay (Japan).

Thus, the survey period coincided with the hatching season of bivalbes, but it was not confirmed if it was the peak of hatching in the present survey.

4) Barnacle Larvae: Many barnacle larvae were observed during the present survey. In most cases, more than 100 individuals of *nauplius* (converted into value by 4-m vertical hauling; hereinafter the same) and more than 10 individuals of *cypris* were observed. This condition is approximately the same as that in the hatching peak in Hiroshima Bay. Judging from the quantity of these larvae, oysters suspended cannot be saved from the attaching of barnacles. With the limited period allowed for the present survey, however, it was impossible to confirm how long the hatching season of barnacle larvae will last. (refer to Photo 6-13)

(2) Experiment on Attaching of Oysters and Barnacles.

The survey was conducted to investigate the period, number and range of depth of attaching of oysters and barnacles, and also their growth after attaching.

Bay scallop shells were used as attaching apparatus. In pile system the top of the attaching apparatus was set at a depth 1.0 m higher than the low waterline and the bottom of the apparatus at a depth of 1 m lower than the low waterline. For rafts, the apparatus was set at a depth of 0.2 - 2.0 m under the sea level.

Results of the experiment are shown in Table 6-4(1) and 6-4(2).

1) Oysters: Only one young shell very similar to oyster was observed, for it was not the attaching season of oysters. This coincides with the result of plankton survey.

2) Barnacle: In pile system in Koh Kong Bay, many barnacles attached under the low water line; they were found attached in the largest quantity around Koh Salour (Koh Kapik), 1,200 for 12 days (15.7/cm^2/12 days), that is, 1.3 barnacles per cm^2 a day. Around Koh Pos near Sihanoukville, all barnacles were found constantly submerged, attaching at a depth ranging from 1 to 2 m under the sea level, 600 barnacles for 6 days (8.0/cm^2/6 days), that is, 1.3 per cm^2 a day.

This agrees very well with the results of the afore-mentioned plankton survey. This also coincides with the number of attached ones in Hiroshima Bay (oyster culture ground with many barnacles) during the best season for hatching peak of barnacles. Among the barnacles attached, those similar to *Balanus Amphitrite Communis* Darwin, Sarasafujitsubo, grew up best of all, showing a growth of 8 mm/13 days. Those similar to *Balanus Amaryllis* Darwin, Sakurafujitsubo, showed a growth rate of 7 mm/13 days.

Attaching apparatus were set at each experimental ground to carry out experiments on survival and growth of these barnacles. (refer to Photo 6-14)

6-4. Comments.

In order to study the feasibility of developing oyster culture along the Cambodian coast, surveys were commenced with investigations on distribution of natural oysters and conditions of fishing grounds, and experiments and research were conducted on spat collection, culture and yield of mangrove oysters. Some comments are made herewith on the basis of experiments and survey.

(1) On Oysters As The Objective Of Development.

The dominance species of oyster found in areas along the Cambodian coast is *Saxostrea parasitica*, (Gmelin), Kuroherigaki (so-called "*Ostrea*" *cucullata*, Bombei gaki). Especially, many natural oysters attach to prop roots of mangrove trees in the forest of the northern shore of Koh Kong Bay, and sometimes 100 oysters make one lump. As for the composition by size of a lump of such oysters, about 60% was those less than 20 mm in shell length, as mentioned in Para. 6-3-1. Composition by age of mangrove oysters is not clear; even if there should be many oysters over 2 years old, it is considered that the number of young and newly attached oysters is not less than one-third of the total number of attached oysters, and attaching apparatus (shells) will collect more oysters than prop roots.

In the case of Hiroshima Bay in Japan, about 200 million shells are set in the sea for spat collection. This number of shell makes 2.6 million "Ren" (about 75 shells per "Ren") and the length of spat collecting shelf will be about 400 km. This will be so enormous that a fishing ground of 1 km^2 is filled with shelves even in the most effective spat collection. In this way of spat collection, the number of young shell (about 0.3 mm) just attached is 200 - 500 per attaching apparatus. 40 or 50 for one apparatus are observed when oysters grew up to about 1 cm, and 20 - 30 will survive at the time of harvest. Survey and observation are made on the season when oysters attach in a great quantity so that seed oysters may be collected and transferred to bamboo rafts. Thus, more than 20,000 tons of oysters (weight of flesh) is produced by utilizing the fishing ground to the maximum extent. In a rough comparison of the density of oysters attaching to wooden piles and rocks in Hiroshima Bay and that of natural oysters attaching to prop roots of mangrove trees around Koh Salour, the latter does not seem to be lower than the former. And distribution was very extensive in both areas.

The difference between them is that, in Cambodia prop roots of mangrove trees are the haunts for mother oysters and also attaching apparatus for young oysters, while in Hiroshima Bay attaching apparatus of a great number are artificially prepared during the hatching season for commercial purposes. This system is naturally affected by the varieties of oysters and different surroundings.

Though *Crassostrea belcheri* Sowerby, Kokegoromo, of huge type was not collected and no experiment could be made, it is desirable to conduct experiments for its development like the case of *Saxostrea parasitica*. The key factor of such a survey is a study on the feasibility of intensive spat collection.

Fundamental problems for development seem to be if *Saxostrea parasitica* will grow up, and if *Crassostrea belcheri* Sowerby can be collected in an intensive way. Accordingly, emphasis must be placed on these points in surveys, experiments and technical improvement.

(2) Transfer.

Japanese seed oysters were transferred and in culture for the purpose of comparison with Cambodian oysters. The period of transfer was the coldest season in Japan with the sea water temperature of 9° - 10°C. The temperature rapidly changed up to about 28°C in Cambodia, and then up to 30°C during the next one month. Seed oysters were therefore exposed to a temperature difference of as large as 20°C in a short period. During such a change in temperature, the Japanese seed oysters grew very well until the middle of the survey, but some dead ones were found afterwards. These transfered mother oysters had generative organs well grown up to show a very early maturity in a period of less than one month after transfer. Such conditions of maturity are usually observed in May (Sea water temperature is 8° - 20°C) or afterwards in Japan.
It is already admitted that the rise of temperature promotes maturity of generative organs and spawning, and it is believed that the generative organs grew quicker by the transfer to a warmer sea water.

(3) Growth of Oysters.

Japanese seed oysters grew up to shells of 3 - 5 mm in 2 or 3 weeks after the transfer. Generally speaking, seed oysters whose growth is controlled by hardening grow quicker after transferred for hanging culture. The above-mentioned growth is almost equal to the growth speed of oysters released from hardening in Japan.

However, because of problems such as early maturity as mentioned above and death of oysters as will be described later, surveys must be conducted on the growth and yield in the future.

Meanwhile, as for *Saxostrea parasitica* attaching to mangrove trees, only a few new shells were observed during a 10-day period. It is necessary to continue long-term observation on growth by hanging culture of this small type of oysters.

Judging from commercial point of view, this oyster is of small size as mentioned in Para. 6-2-1. It has a strong habit to attach to an apparatus, and its figure is much influenced by the shape of the attaching apparatus. For example, as it grows up closely

adhering to the cylindrical prop roots of mangrove trees, the inside of the left shell (the attaching side) becomes convex. Oysters fight each other to form some deformation and its flesh does not grow so fat, and most of the internal organs are seen through from the surface. It was observed that many young shells were attaching one after another to the surface of older shells in every spawning and attaching season. This must be the main reason for poor growth or deformation of oysters. Lumps of oyster around mangrove trees are caused mainly by such consecutive attaching, and it was observed that many shells were fighting each other and growth of many large oysters attached in the earlier stage was impeded.

Accordingly, invention of a new culture technique for accelerating growth and producing better flesh and also measures for preventing new young shells from attaching consecutively are important problems to be solved in the future.

No experiment was conducted about seed sowing method during the present survey due to shortage of time and labor. In this method, not many oysters attach in deep water and not many new young shells attach to oysters cultured in seed sowing method at the bottom of shallow sea, and oysters grow well into a round shape. Though a little longer period may be required for culture by the method, it is necessary to make efforts in applying this method for culture. (Oysters of a great quantity are required for the experiment of this method.) In this case, it is important to invent culture methods in consideration of environmental conditions such as climate (monsoon), sea conditions (effect of fresh water) and bottom materials. It is also important to obtain materials for the purpose of studying problems and countermeasures for future development of culture technique by surveys on the growth of *Saxostrea parasitica* of mangrove trees, the existence of impedients and the outline of their damages.

(4) Death of Oysters.

As mentioned in Para. 6-3-1, generative organs of Japanese mother oysters grew so abnormally 3 - 4 weeks after transfer that many of them died before spawning. It was not considered that current of sea water was moving abnormally during the period, nor was sea water observed to have been subjected to red water or hydrogen sulfide. Rapid rise of water temperature and high salinity were pointed out as remarkable changes after the transfer.

The relation between the rise of sea water temperature and the maturity of generative organs was already mentioned.

It is admitted that physiological disorder of oyster is caused by the excessive rise in the sea water temperature. Even if the disorder is not the direct cause of death, it is considered to be closely related to death of oysters, and high temperature and high salinity are considered to be the cause for the disorder. In Japan also, it is pointed out that oysters become weaker with the rise of sea water temperature if it exceeds 25°C.

(5) Impedients.

As stated in Para. 6-3-2, many barnacles were born consecutively and observed attaching in the range from the surface down to the 4-m deep sea bottom during the survey.

Then the surface of suspended oysters was covered with barnacles; the extent of damages by such attaching of barnacles will depend upon their growth. This is one of the points to be made clear by future investigations. The quantity of barnacle larvae and that of attached barnacle larvae are almost the same as those in the peak season of occurence and attaching in Hiroshima Bay. If oysters are very young they are seriously damaged and attaching of oysters is very much obstructed after the attaching of barnacles. Therefore, in Hiroshima Bay collection of oyster seeds is conducted only during the season when the number of barnacles decreases.

The condition of occurence of oysters and barnacles along the Cambodian coast is not clear. If barnacles are born in great quantities all the year round, it is necessary to develop new techniques for spat collection and culture.

(6) Marketability.

Meat of small oysters is sold almost every day at the central market in Phnom Penh at a price of 40 - 50 Riels per kilogram (one Riel is equal to about ¥6). This price is considered reasonable in comparison with those of other marine products in Cambodia, and is almost the same as the market price in Japan. Because of the small size of meat, however, the labour cost for shuckling the shells occupies a large portion in the overall production cost, yielding a relatively low profit rate. In this sense, it is important to develop oysters of large type; and if its commercial production proves successful, it will bring forth an increase in the production, demand, market price, and producers' profit.

The above-mentioned are observations of the Survey Team and suggestions for the future development. The most important point at present is to clarify how *Saxostrea parasitica* of mangrove trees (mangrove oysters), which are considered to be available for spat collection along the Cambodian coast, will grow in the future. According to the results, it would be necessary to design a secondary step or technique. Facilities prepared during the present survey should therefore be maintained with continued surveys and observations until the completion of the experiments.

Items not investigated among the data collected will be replenished at an opportunity in the future.

Fig. 6-1 Locations of Selected Experimental Oyster Culture Grounds

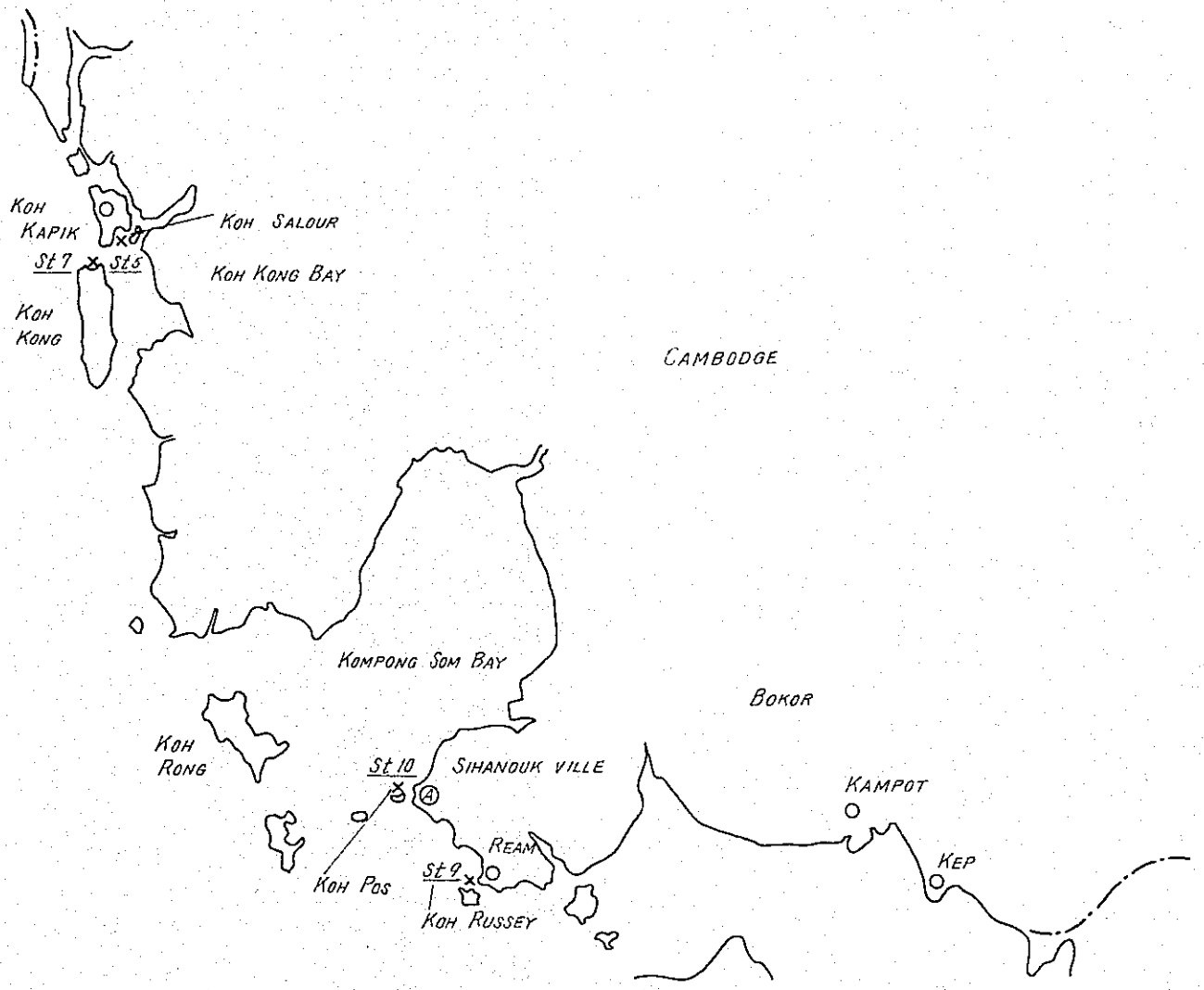


Fig. 6-2-(1) Oceanographic Observation Stations and Experimental Culture Facilities (Koh Kapik Area)

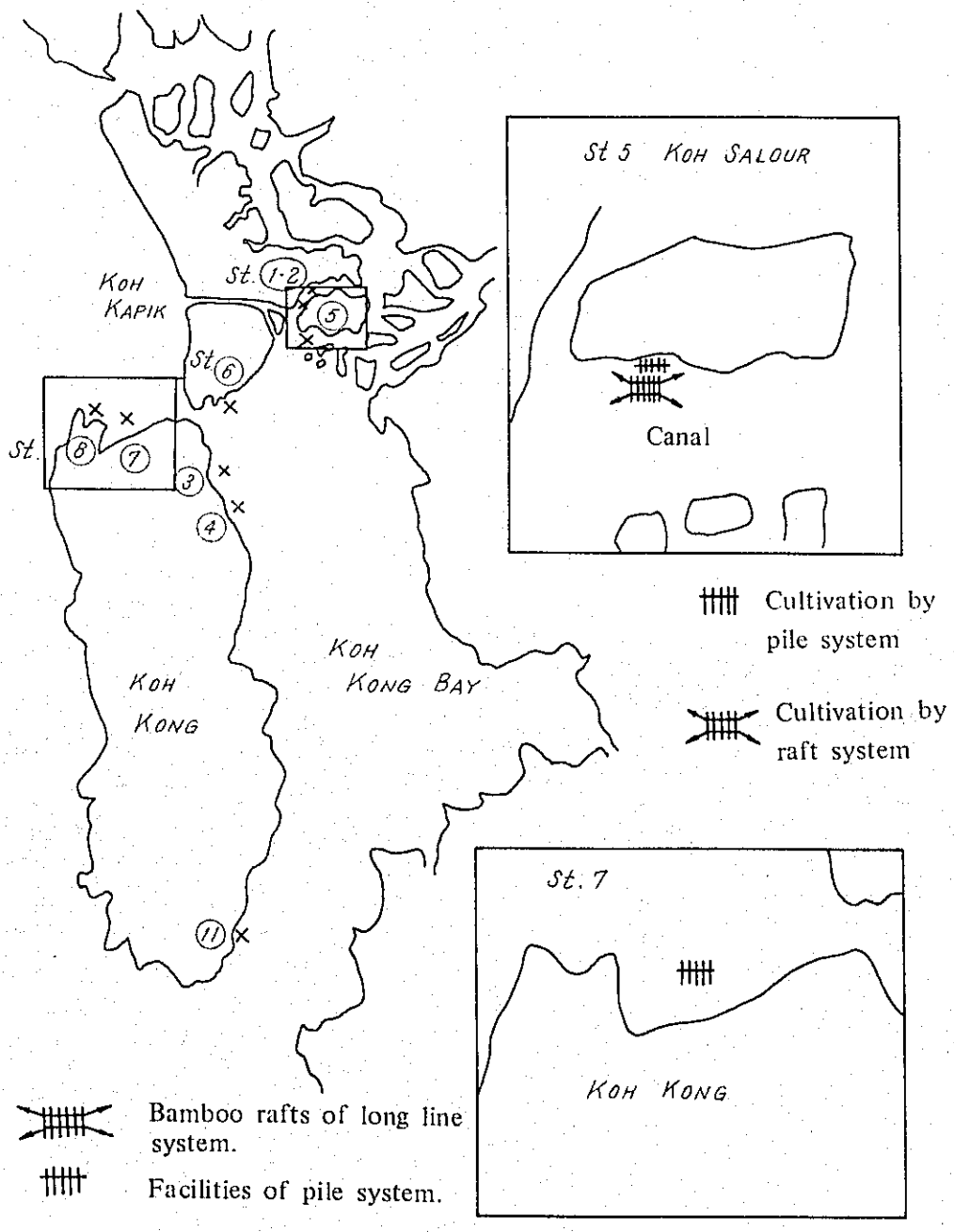


Fig. 6-2-(2) Oceanographic Observation Stations and Selected Experimental Oyster Culture Grounds (Sihanoukville and Ream Areas)

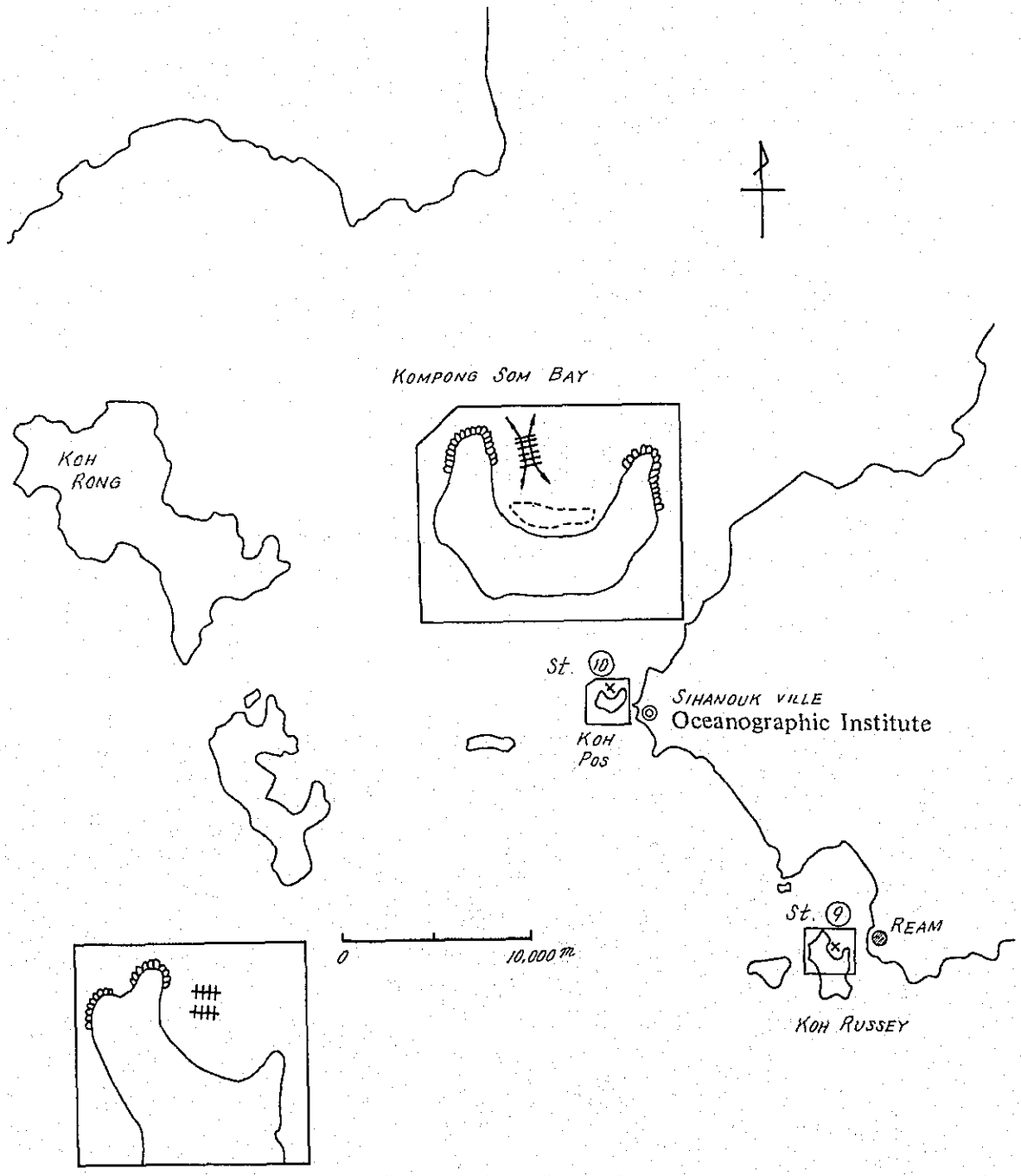


Fig. 6-3 Bamboo Rafts of Long Line System for Experimental Oyster Culture

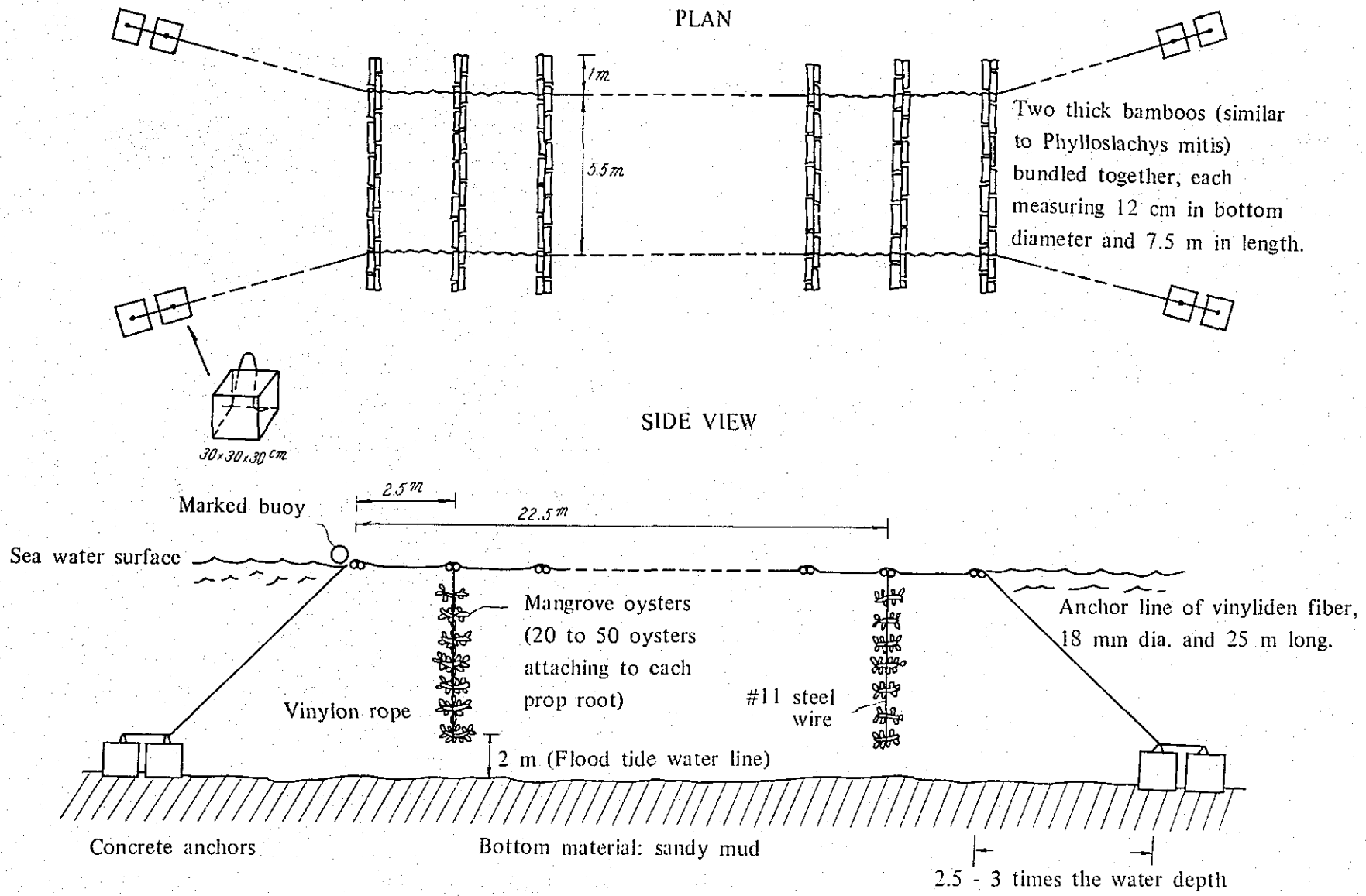
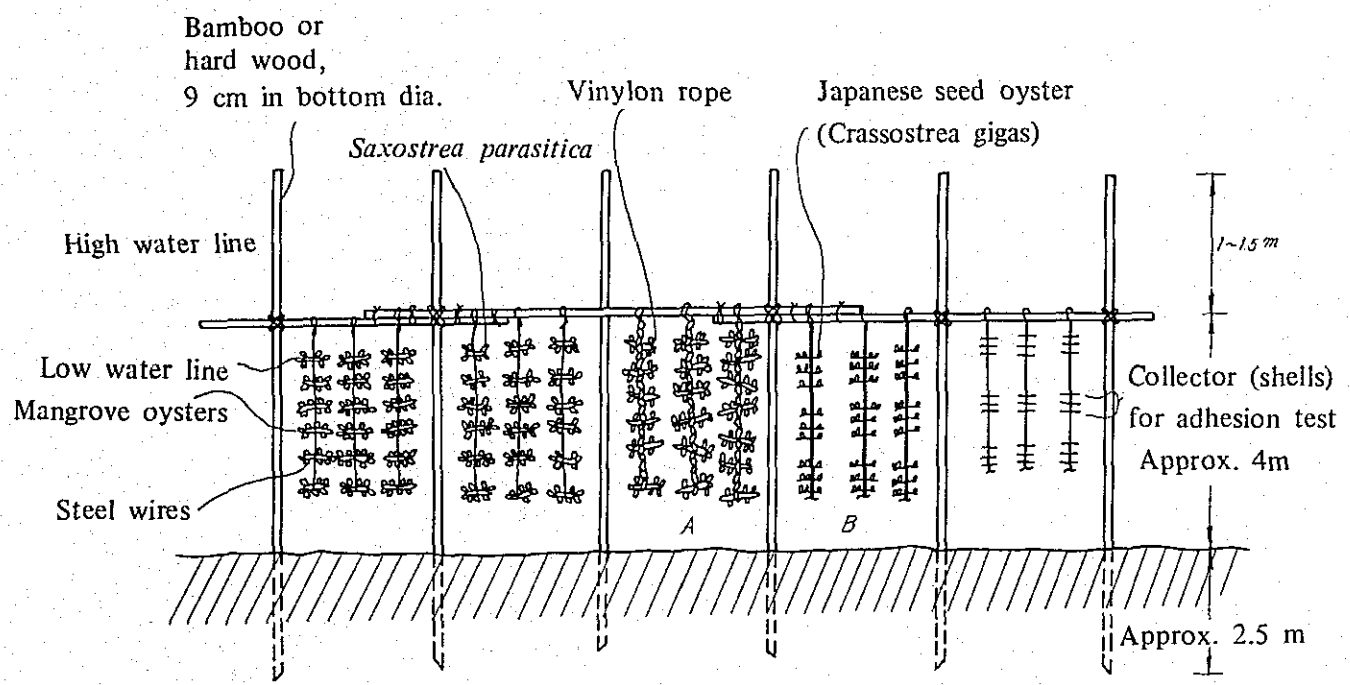
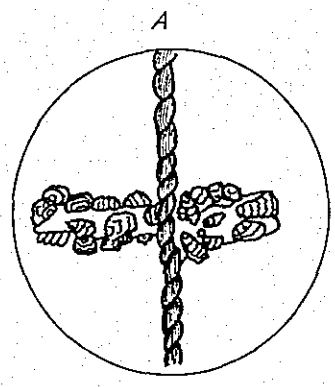
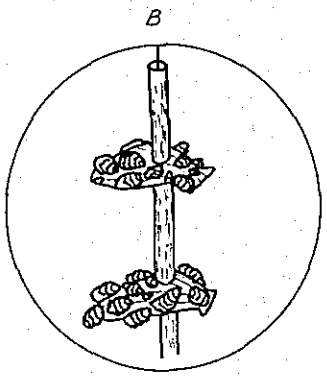


Fig. 6-4 Pile Facilities for Experimental Oyster Culture





Oysters attached to mangrove prop roots: *Saxostrea parasitica* (Gmelin), Kuroherigaki (also called Bombay gaki)



Japanese seed oysters: *Crassostrea gigas* Thumbery, Magaki

Table 6-1-(1)～(8) Data of Oceanographic Observations (1969)

(1) Stations 1 & 2, Canal of Koh Kapik (Charcoal Collecting Yard)

Water depth	Feb 6, 9:30 Fair		Feb 6, 10:30, Fair		Feb 6, 13:30, Fair, Temp. 30.5°C		Feb 19, 13:30, Fair, Temp. 31.6°C	
	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15
0	27.7	23.8	27.4	23.8	29.1	23.7	30.2	23.7
1	27.4	23.8						
2			27.7	23.9	28.1	23.8	29.9	23.7
4			27.7	23.9			29.8	23.8
	Atmospheric temp. 28.0°C Bottom material: Muddy with the smell of H_2S		Transparency: 3.1 m Bottom material: Muddy with the smell of H_2S		Atmospheric temp. 30.5°C Bottom material: Muddy with the smell of H_2S		Observation omitted	

(2) Stations 3 & 4 in front of Koh Kong

Water depth	Feb 6, 14:30, Fair		Feb 17, 14:00, Fair	
	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15
0	28.6	24.2	29.7	24.0
1			29.7	24.0
2	28.2	24.1		
3			29.6	24.2
4	28.1	24.1		
	Transparency: 2.6 m Water depth: 3.8 m		Water depth: 2.5 m	

(3) Station 5 in front of the southwestern coast of Koh Salour (Koh Kapik Area)

Water depth	Feb 7, 14:20, Fair		Feb 18, 14:30, Fair		Feb 19, 12:30, Fair	
	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15
0	28.4	23.5	30.2	23.7	30.0	23.7
1	28.4	23.6	30.0	23.8	30.0	23.7
2	28.0	23.7	29.6	23.8	30.0	23.8
3						
4	28.0	23.8	29.5	23.8	30.0	23.8
5						
6						
7	27.9	23.9	29.5	23.8		
	Transparency: 3.7 m Water depth: 7.0 m				Water depth: 6.0 m	

(4) Station 6 in front of the southeastern coast of Koh Kapik

Water depth	Feb 7, 17:30, Fair Wind force - 13		Feb 19, 11:00 Fair	
	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15
0	28.8	23.7	29.8	23.9
1	28.8	23.9		
2	28.0	24.1	29.6	24.0
4	27.9	24.0	29.6	24.0
	Transparency: 3.3 m Water depth: 4 m		Water depth: 5 m	

(5) Stations 7 & 8 in front of the northern coast of Koh Kong

Water depth	Feb 7, 17:30, Fair, Wind force 3		Feb 19, 10:00, Fair	
	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15
0	28.7	24.2	29.5	24.2
1			29.5	24.2
2			29.5	24.2
3	28.5	24.3	29.5	24.3
	Transparency: 2.2 m Water depth: 3 m		Water depth: 3 m	

(6) Station 9 in front of the coast of Koh Russey (Ream)

Water depth	Feb 10, 11:30, Fair		Feb 13, 11:00, Fair	
	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15
0	28.5	23.6	28.4	–
1				
2	28.5	23.7		
3	28.5	23.8		
4			28.3	–
	Transparency: 3.3 m Water depth: 3.5 m		Transparency: 4.0 m Water depth: 4.0 m	

(7) Station 10 in front of the northern coast of Koh Pos (Sihanoukville)

Water depth	Feb 15, 15:30, Fair		Feb 22, 10:00, Fair	
	Water temp.	Specific gravity σ 15	Water temp.	Specific gravity σ 15
0	28.6	23.7	29.6	23.9
1	28.6	23.9		
2	28.6	23.9	29.4	23.9
4	28.6	23.9	29.3	24.0
6				
7.5	28.5	23.8		
	Transparency: 4 m Water depth: 7.5 m		Water depth: 7 m	

(8) Station 11 at the southeastern tip of Koh Kong (Check Point)

Water depth	Feb 17, 13:00, Fair, Atomospheric temp. 31.0	
	Water temp.	Specific gravity σ 15
0	29.6	24.2
2	29.4	24.4
4	29.3	24.6
	Water depth: 4 m	

Table 6-2 Facilities at Respective Experimental Oyster Culture Grounds (Feb 23, 1969)

Item \ Location of Ground	Koh Salour (Koh Kapik), St. 5		Northern Coast of Koh Kong, St. 7	Koh Pos (Sihanoukville), St. 10	Koh Russey (Ream), St. 9	Remarks
Kind of Facilities	Bamboo Rafts (long line system)	Pile System	Bamboo Rafts (long line system)	Bamboo Rafts (long line system)	Pile System	
Total Q'ty of Facilities	7.5mx10 bundles	10m x 1 row	7.5m x 2 rows	7.5m x 8 bundles	14 m x 2 rows	Length of one row of piles is that of the cross-bar.
Mangrove Oyster:						No death of mangrove oysters was observed during the survey period. The prop root measured 30 - 40 cm in length and 4 - 7 cm in diameter. Oysters attaching to one prop root numbered 20 - 50. (Oysters were dissected for observation on Feb. 22).
Date of installation (Date of commencing experiments)	18/2/69 (18/2/69)	7/2/69 (8/2/69)	18/2/69 (18/2/69)	15/2/69 (10/2/69 & 21/2/69)	13/2/69 (13/2/69)	
Kind of attaching apparatus	Proproot	Ditto	Ditto	Ditto	Ditto	
Length of Ren	6 m	3 m	3 m	6 m	3 m	
No. of apparatus per Ren	7 pcs.	5 pcs.	5 pcs.	9 pcs.	6 pcs.	
No. of Ren	16 (ropes)	6 (ropes & wires)	10(ropes & wires)	8(ropes & wires)	8(wires)	
Japanese Seed Oyster:						*Some oysters died during their growth.* Size of attaching apparatus: 50 cm^2. No. and length of seed oysters attached to one apparatus were 13 individuals and 13.1 mm, respectively as of Feb. 17.
Date of installation (Date of commencing experiments)	18/2/69 (3/2/69)	18/2/69 (3/2/69)		15/2/69 (3/2/69)	13/2/69 (3/2/69)	
Kind of attaching apparatus	Shell			Shell	Shell	
Length of Ren	3 m			3 m	3 m	
No. of apparatus per Ren	7			9	10	
No. of Ren	2			2	3	
Japanese Mother Oyster:						Experiments commenced as from Feb. 3. A sizable quantity of oysters died during the period from Feb. 15 to Feb. 21. Oysters were transferred from bamboo baskets to net containers. Oysters were dissected for observation on Feb 22.
Date of installation (Date of commencing experiments)				15/2/69 (26/1/69)		
Kind of container				Net basket		
No. of containers				4		
No. of oysters per container				2		
Spat Collector (for spat collection test):						Adhesion of barnacles was noted active. *Adhesion of one shell resembling oyster* was noticed during the survey period. The generative organ of Japanese mother oysters was noted to have grown nearly mature on Feb. 22.
Date of installation (Date of commencing experiments)		7/2/69 (7/2/69 & 18/2/69)		15/2/69 (15/2/69 & 21/2/69)	13/2/69 (3/2/69)	
Kind of attaching apparatus	Bay scallop shell			Ditto	Ditto	
Length of Ren	2 m			2.5 m	2.5 m	
No. of apparatus per Ren	12			15	15	
No. of Ren	3			5	5	
Remarks				Barnacles removed from about half of oysters on Feb. 22		

Table 6-3 Plankton Survey By Means Of Plankton Net (xx 16)

(by double 4-m vertical haulings; only at Station No. 3, sea water of 400 liters was sampled from the surface layer)

Planktons examined on microscope / Water sampling date / Quantity	Larvae similar to oysters		Total of other bivalbe larvae			Shipworm larvae		Barnacle larvae		Phytoplanktons	Zooplanktons	Dinoflagellata	Shrimps (including Mysis)	Crabs	Others
	U	F	D	U	F	U	F	N	C	Diatomaceae (only serial substance)	Copepods	Peridium, Ceratium			
St. 3 Feb. 6 (sea water of 200 liters was sampled	(30)	0	100	200	30	40	5	100	30				20	5	*Porikiita* (?) (100)
St. 5 Feb. 7 Converted into 4-m vertical hauling	(40)	0	200	400	a few			200	30	89,000	22,000	2,000	50	20	
St. 9 Feb. 10 " " "	(1)	0	300	700				300	20	32,000	6,000	3,000	100	200	
St. 9 Feb. 13 " " "	0	0	200	300	10			100	30	61,000	8,000	2,000	0	1	
St. 10 Feb. 15 " " "	(2)	0	60	300				100	10	11,000	3,000	2,000	0	1	
St. 4 Feb. 17 Converted into 2.5-m vertical hauling	0	0	200	500				300	50	90,000	9,000	6,000	100	100	
St. 11 Feb. 17 Converted to 4-m vertical hauling	(1)	0	400	800	a few			900	100	41,000	5,000	2,000	0	0	
St. 5 Feb. 18 " " "	(10)	1	300	200	Very a few			300	20	110,000	12,000	6,000	50	0	
St. 5 Feb. 19 " " "	(2)	0	400	400	10			500	30	258,000	8,000	3,000	50	30	Rollshell 7,500
St. 7 Feb. 19 " " "	0	0	320	200	0			100	10	41,000	2,000	1,000	0	40	
St. 10 Feb. 22 " " "	0	0	200	100	0			50	0	22,000	4,000	1,000	0	0	

(Note) D: D-type larvae U: larvae of *Ampo* (?) period F: matured larvae
N: larvae of nauplius period C: Cypris larvae

: Not measured

The barnacle includes some of other *Mankyaku-rui.* (?)

Table 6-4-(1) Adhesion Test of Oysters and Barnacles

Station		St. 2 - Koh Kapik Charcoal Collecting Yard			St. 4 - in front of Kong Kong			St. 5 - in front of Koh Salour		
Test Period		13 days from Feb 6 to Feb 19, 1969			11 days from Feb 6 to Feb 17, 1969			12 days from Feb 7 to Feb 19, 1969		
Test Method		Pile System			Pile System			Pile System		
Kind of Shell		Oyster	Barnacle	Other shells	Oyster	Barnacle	Other shells	Oyster	Barnacle	Other shells
(1) (+1.0m) At a level approx. 1.0 above low water line	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day	0/13 days	0/13 0 0	0	0	0/11	0	0	2/12 0.03/12 0.00	0
(2) (+0.5m) At a level approx. 0.5 above low water line	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day	0	370/13 4.9/13 0.38	0	0	70/11 0.9/11 0.08	0	?	290/12 3.8/12 0.32	0
(3) approx. 0 m, around low water level	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day	0	980/13 12.9/13 0.99	8/13 0.11/13	0	330/11 4.3/11 0.39	10/11 0.13/11	0	760/12 10.0/12 0.83	0
(4) (-0.5m) At a level approx. 0.5m below low water line	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day	0	1,110/13 14.6/13 1.12	6/13 0.08/13	0	490/11 6.41/11 0.58	18/11 0.28/11	0	1,200/12 15.7/12 1.31	6/12 0.08/12
(5) (-1.0m) At a level approx. 1m below low water line	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day				0	210/11 2.8/11 0.25	100/11 1.31/11	0	1.100/12 14.5/12 1.21	4/12 0.05/12
Remarks	Attached area on collector: 76 cm^2 (38 cm^2 on one side). Collectors above low water line emerge from water surface at low tide, and those beneath it were constantly immersed.	Maximum diameter: *Balanus amphitrite communis darium*, Sarasa Fujitsubo - 8 mm *Balanus amaryllis* Darium, Sakura Fujitsubo - 7 mm						*Balanus amphitrite communis*, Darium, Sarasa Fujitsubo, was dominant, followed by shells resembling *Balanus amaryllis* Darium, Sakura Fujitsubo. Max. dia. 6 mm		

Table 6-4-(2) Adhesion Test of Oystersand Bernacles

Station		St. 10 - in front of Koh Pos					
Test Period		6 days from Feb 15 to Feb 21, 1969			1 day from Feb 21 to Feb 22, 1969		
Test Method		Bamboo Raft (Hanging System)			Bamboo Raft (Hanging System)		
Kind of Shell		Oyster	Barnacle	Other shells	Oyster	Barnacle	Other shells
(1) (-0.2m) At a depth about 0.2 m below the water surface	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day	0	34/6 days 0.4/6 0.07	0	0	2/1 day 0.03/day 0.03	0
(2) (-0.8)	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day	0	610/6 8.0/6 1.33	0	0	1/day 0.01/day 0.01	0
(3) (-1.4m)	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day	0	580/6 7.6/6 1.27	0	0	1/day 0.01/day 0.01	0
(4) (-2.0m)	No. of shells per collector No. of shells per cm^2 No. of shells per cm^2 /day	0	590/6 7.8/6 1.30	0	0	1/day 0.01/day 0.01	0
Remarks	Attached area of collector: 76 cm^2 in average (38 cm^2 on one side). All collectors are immersed below water level.						

Photo 6-1 Oysters adhering to rock's along the coast of Koh Kapik

Photo 6-2 Oysters adhering to the mangrove roots at Koh Salour (Koh Kapik area)

Photo 6-3 Oysters (crassostrea rivularis) clinging with each other

Photo 6-4 Natural oysters adhering to the mangrove.

Photo 6-5 Koh Salour Station (Koh Kapik area)
(Bamboo rafts of long line system)

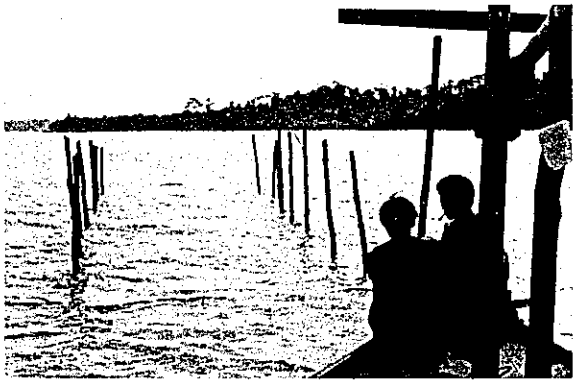


Photo 6-6 Koh Russey Station (Ream)
(Pile hanging system)

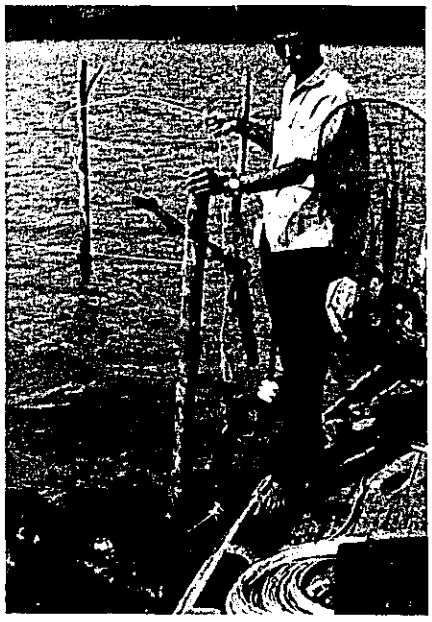


Photo 6-7 Mangrove oyster, Saxostrea parasitica (Gmelin)

Photo 6-8 Japanese seed oyster, Crassostrea gigas

Photo 6-9 Lift: Cambodian Mangrove oyster
Right: Japanese adult oyster

Photo 6-10 Observation of temperature and specific gravity of sea water

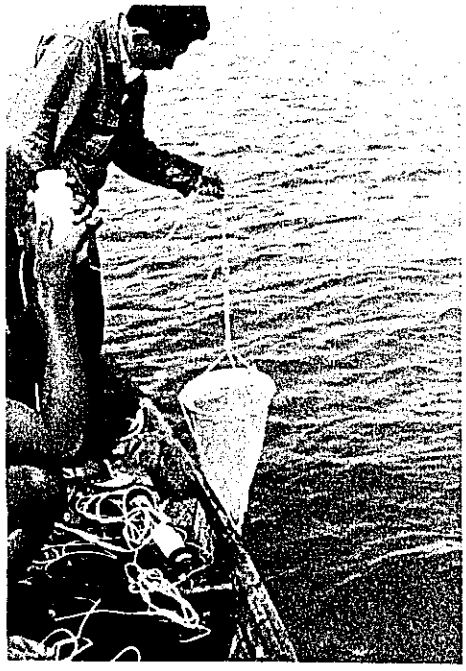


Photo 6-11 Plankton survey
(xx16, mouth diameter 30 cm)

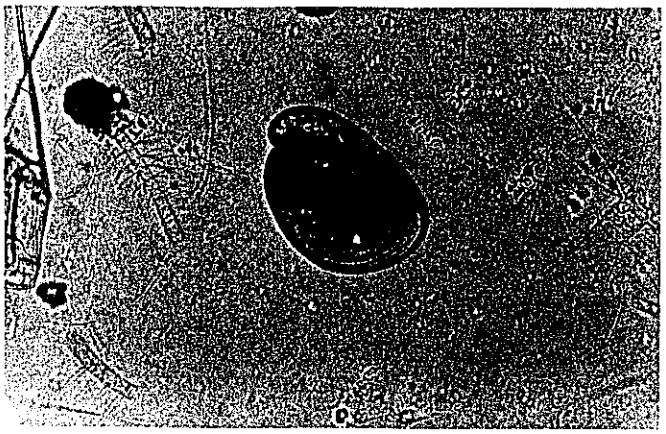


Photo 6-12 A shell resembling the oyster larva in the transition from the latter Umbo-stage larva to the full grown larva 250μ (shell length) x 280μ (shell height)

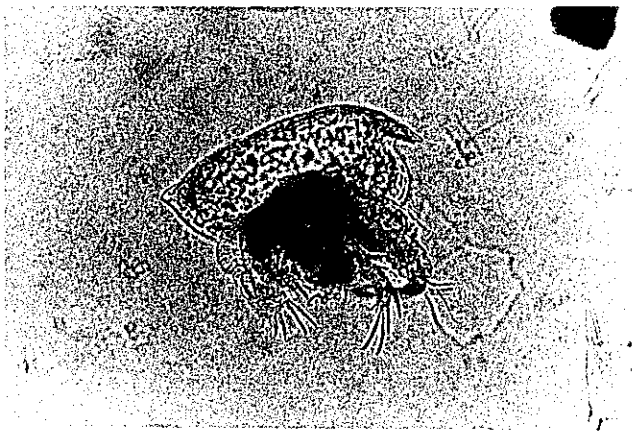


Photo 6-13 Excuviation of nauplius of polychaeta

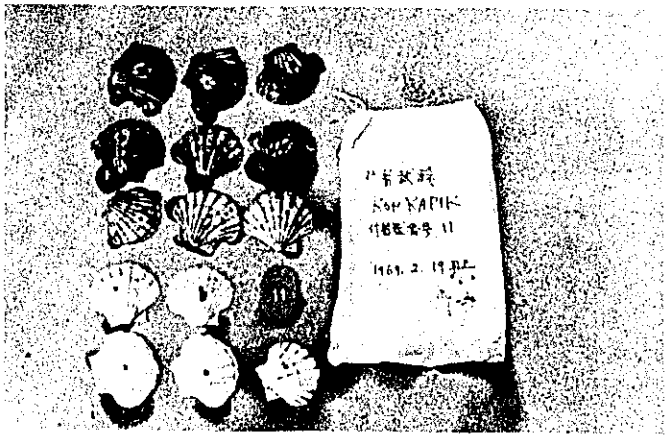


Photo 6-14 Adhesion of barnacles
Uppermost row: Barnacles collected at a depth of about 1.0 m below the low water level
Third row: Barnacles collected at the low water level
The lowermost row:
Barnacles collected at a depth of about 1.0 m above the low water level

Experimental oyster culture station installed by the Cambodian Government (Kdat)

Photo 6-15

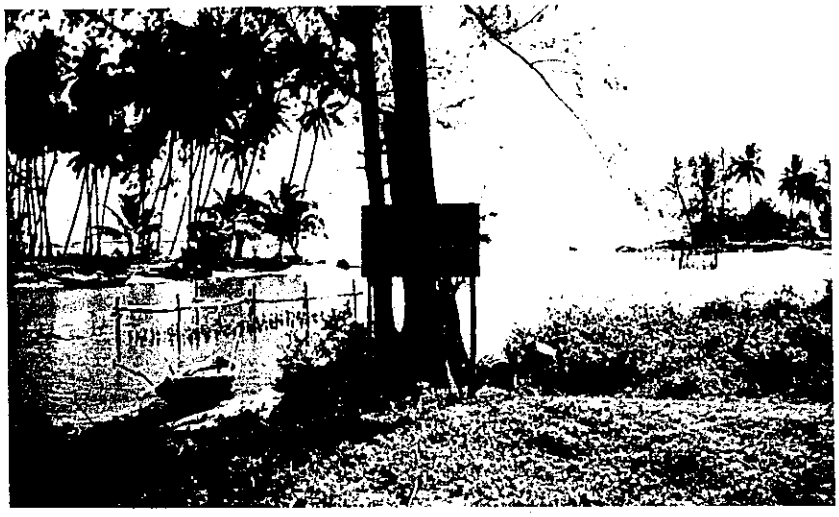


Photo 6-16

Photo 6-17

Setting of rafts for preservation of Japanese seed oyster in the sea water near the Oceanographic Institute

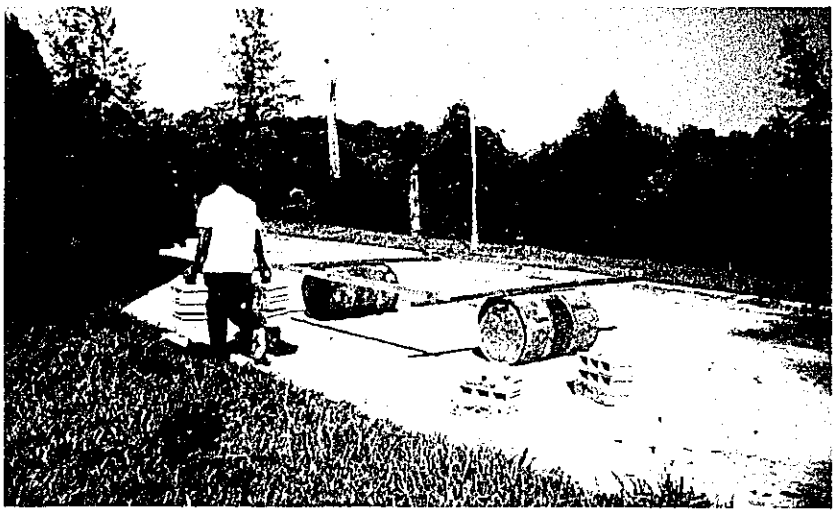


Photo 6-18

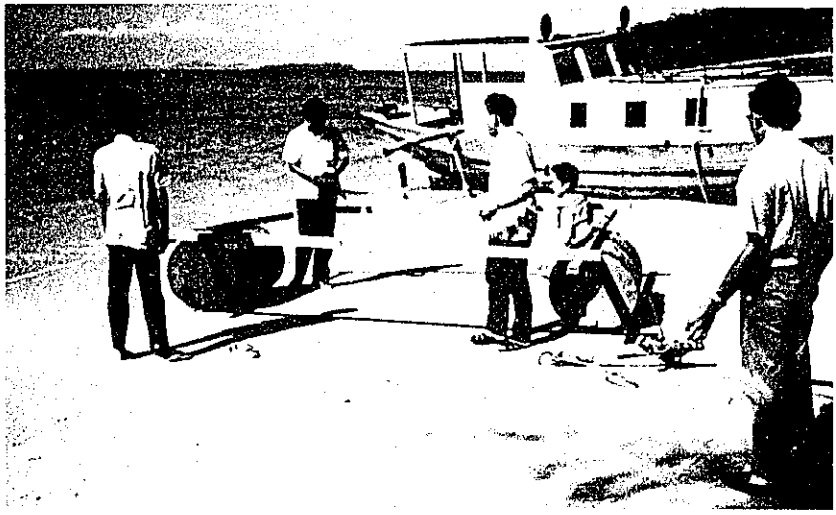


Photo 6-19

Photo 6-20

Setting of experimental pile system at Koh Salour (St. 5) (I)
Piling operation of bamboo posts

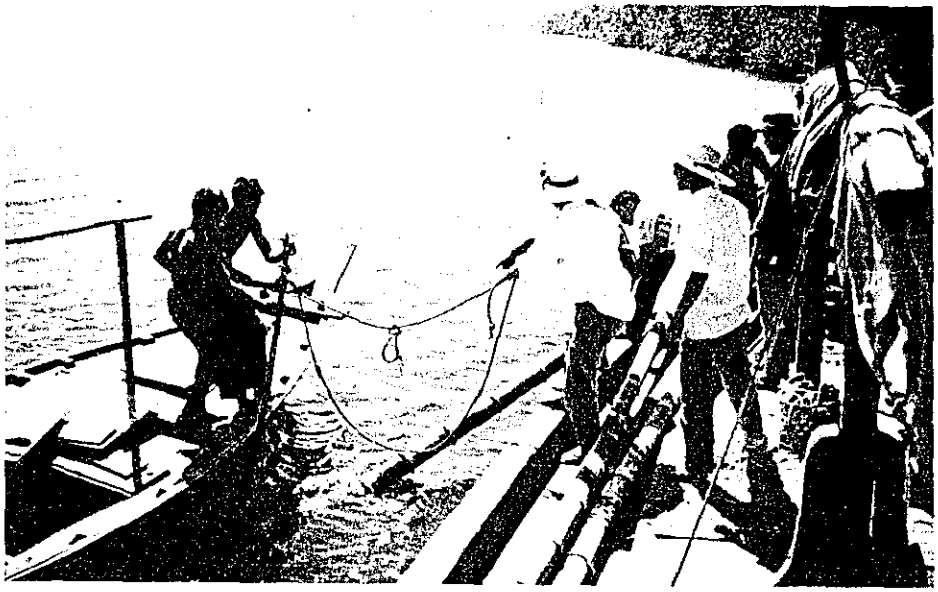


Photo 6-21

Photo 6-22

Setting of experimental pile system at Koh Salour (St. 5) (II)

Photo 6-23 Hanging of spat collector

Photo 6-24 Hanging of mangrove oyster

Photo 6-25 Cambodian oyster adhering to mangrove prop roots.
(Called "Mangrove oyster")

Mangrove trees at Koh Salour (St. 5)

Photo 6-26

Photo 6-27 Oysters adhering to mangrove prop roots above the water surface

Experimental long line system in the front waters of Koh Pos (St. 10)

Photo 6-28

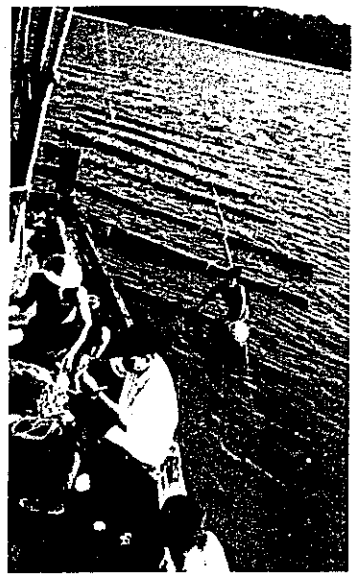


Photo 6-29

Photo 6-30

CHAPTER VII PLANKTON SURVEY

7-1 Purpose of Survey

For the purpose of observing the change in the composition of planktons between the survey in the wet season of June 1967 and the present survey, surveys on plankton were conducted at the mouth of Kampot River and at few other places where fish lamp surveys were conducted. The state of zooplanktons (especially feed planktons) before and after lighting the fishlamp was also examined. (refer to Fig. 7-1)

7-2 Method of Survey

Horizontal hauling was conducted for 3 minutes at every point in the mouth of Kampot River. At places where surveys were conducted with fish lamps, one vertical hauling from the sea bottom was made before (at 20:25 hours) and 65 minutes after (at 21:30 hours) the lighting in the offing of Koh Samit (Station B), before (at 23:10 hours) and 65 minutes after (at 0:15 hours) the lighting in the offing of the coast of Koh Kapik (Station C) and before (at 19:30 hours) the lighting in Kompong Som Bay (Station E).

For plankton net, Kitahara Net with a mouth diameter of 45 cm was used.

7-3 Results of Survey

The survey found 141 species of plankton; of them 61 were phytoplanktons and 80 were zooplanktons. In comparison with the results of the wet season survey of 1967, the number of species was smaller by 11 in total, 2 in phytoplanktons and 9 in zooplanktons. (refer to the List of Plankton in the Appendix.)

Though zooplanktons predominate in the number of species, phytoplanktons are in an overwhelmingly large quantity. This trend coincides with the results of the previous survey.

Dominance species of phytoplanktons were Rhizosolenia alata, Rhiz. alata f. indica, Rhiz. calca-avis, Rhiz. habetata f. semispina, followed by Rhiz. robusta and Rhiz. imbricata. It may be added that the survey was conducted during the propagation season of Rhizozolenia.

Species generally observed were Coscinodiscus granii, Thalassio thrix frauenfeldii Thal. *longissima*, *Biddulphia Sinensis*, *Ditzlium sol*, *Tricerdium favus*, *Chaetoceros curvisetus*, Eucampia zoodiacus, Stephanopyxis parmeriana. Observation of very small quantities of inland-sea planktons such as Bellerochea malleus and Streptotheca india and fresh-water planktons such as Nitzschia paradoxa, Synidra spp., Grammatophora sp. showed some influence of fresh water from rivers.

Though very few, such species as Hemidiseus Cuneiformis, Thalassionema nitzschiodes were also observed in each area.

As for zooplanktons, there were very few dominance species, and only Conchoecia noctilluca, Allanta spp. and Copepoda nauplii were observed. Also, some planktons with eggs of such genera as Oithona and Corycaeus were found.
Larvae of shrimps and crabs especially *Portunus pelagicus* were found universally at various places, for it was their spawning season. (refer to 4-2-2-(1))

Of the planktons collected, those identified were; among phytoplanktons, 7 species of Rhizosolenia genus, each 5 of Coscinodiscus, Chaetoceros and Bacteriastrum genera, 4 of Nitzschia genus, 3 of Hrmiaulus genus and each 2 of Eucampia and Biddulphia genera. Among zooplanktons, 10 species of Corycaeus genus, 8 of Ceratium genus, 5 of Oithona genus, 3 of Acartia genus and 2 of Lucicutia genus. Species collected are almost identical to those obtained during the wet season survey of June 1967. The survey was conducted during the best season for propagation of planktons of Rhizosolenia genus of phytoplankton, and planktons newly collected were such zooplanktons as Conchoecia noctilluca, Ceratium sumetranum, Cerat. extensum, Cerat. dens, etc.

Prey planktons of Copepoda genus were mostly in nauplius season, and no adults of such genera as Labidocera, Pontella, Pontellopsis, Centropages, Calanus, Eucalanus, Gactanus and Aetidius were found in the present survey. It is considered they are found in March or April after the propagation of phytoplanktons.

7-4 Summary of Results.

1. Though the number of species collected are almost equal to that of the previous survey, phytoplanktons, especially those of Rhizosolenia genus, were in the propagation season.

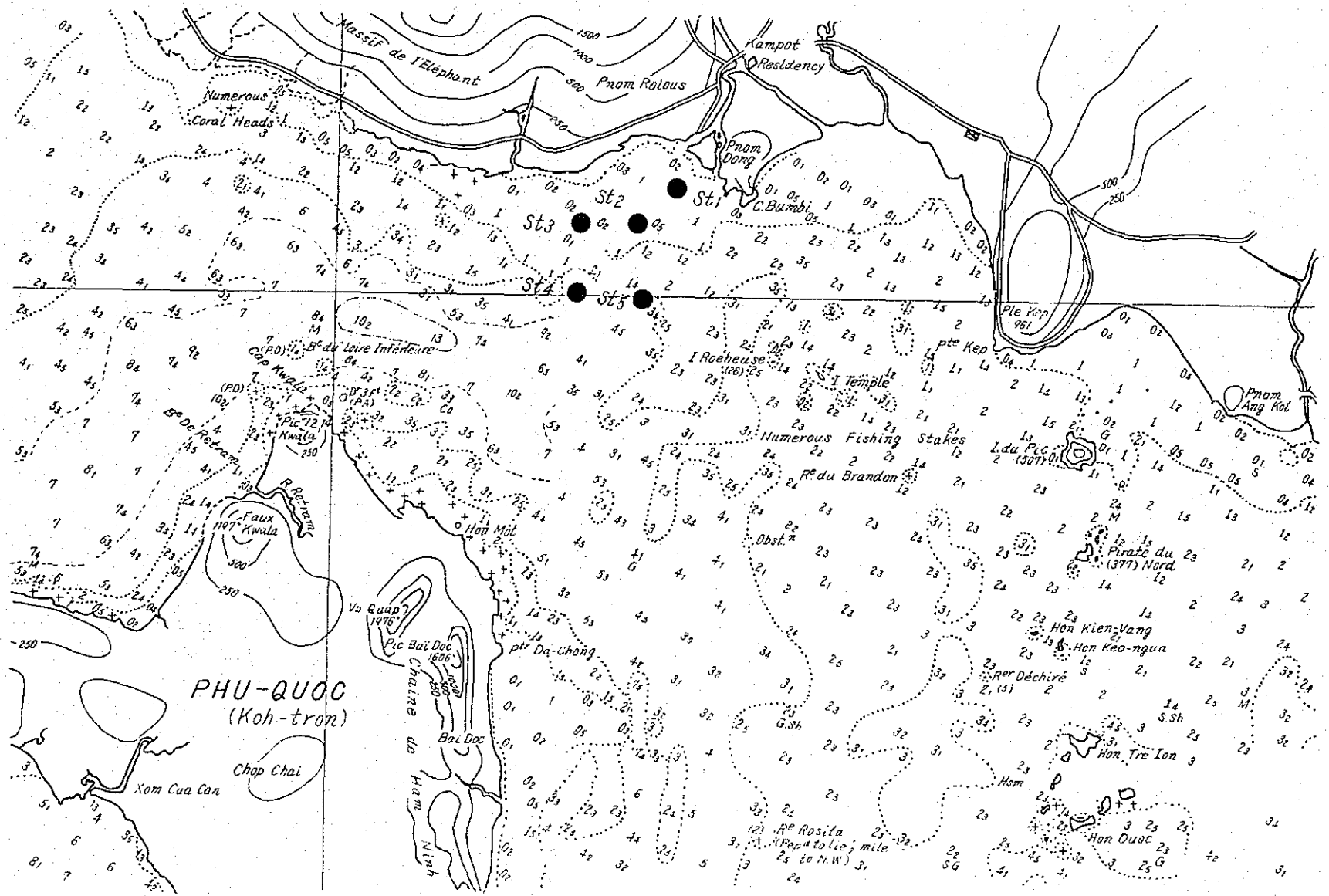
2. Among zooplanktons, Copepoda, prey for fish, was not in the real season for propagation. It is considered that it will be found in larger quantities as phytoplanktons increase in the future.

3. Many larvae of shrimps and crabs, especially Taiwangazami, were found, and this conforms to the fact that about half of Taiwangazami were spawning. (refer to 4-2-2-(1))

4. The mode of movements of zooplanktons by means of fish lamps varies by species. Many of them increased by the lighting of fish lamp.

5. Balanus nauplii, found in a very small quantity at the mouth of Kampot River, was not observed at any other places.

Fig. 7-1 Stations of Plankton Survey



Processing.

The Survey Team visited places such as Koh Kapik, Sre Ambel, Sihanoukville, Ream, Kampot and Kep to conduct surveys on the present state of fishing industry, processing of fish catches and distribution of the products in cooperation with many Divisions of the Fishery Service.

At Phnom Penh, surveys were also conducted on the fisheries administration policies of the country, export of marine products and the present state of SONACOP; and data and materials of fishing industry were collected.

8-1 Fishery Administration

8-1-1 Fundamental Principle of Fisheries Administration Policy

Fundamental principle of fisheries administration adopted by the Cambodian Government is to promote the development of sea fisheries for stabilization and development of the national economy by means of sufficient supply of animal protein to the people, full exploitation of untouched marine resources and the obtaining of foreign currencies by export, coping with the ever-increasing national population and the tendency of decrease in fish catches caused by the degradation of conditions of fresh water fishing grounds.

In relation to protection, regulation and development of fisheries, an item of agenda taken up at the 7th National Economic and Financial Reconstruction Commission meeting on Feb. 7, 1969, it was stated that the future of Cambodia must be an age of sea fisheries like Japan and the following policies must be adopted for development of sea fisheries.

1) to seek cooperation of large foreign capitals,
2) to enlighten the people with the advantage of consumption of seafish,
3) to protect and regulate fisheries in rivers and lakes,
4) laws and regulations must be reviewed and made perfect for protection of flooded forests and control of fishing,
5) export of fresh-water fishes should not be banned.

The Commission has also discussed systematization and regulation of fisheries in Thai Gulf for promoting the production at SONACOP at Khemarak Phouminville and extension of export of fresh and salted fishes to Singapore.

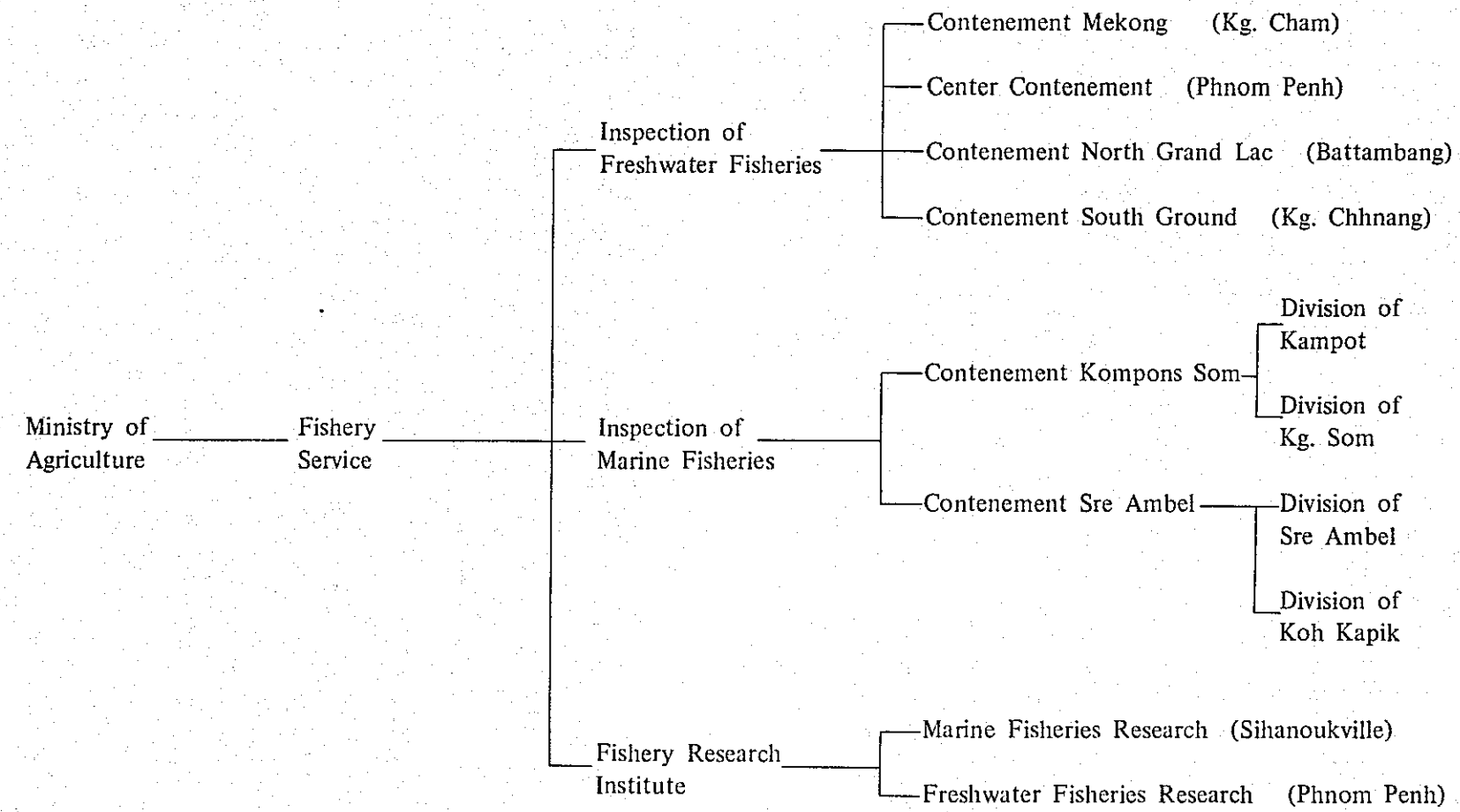
8-1-2 Administrative Organization

Fishery administration is executed by the Fishery Service belonging to the Ministry of Agriculture. Its structure is shown in Table 8-1.

The instructional progress made in connection with sea fisheries since the time of previous survey is as follows: while the Inspection of Marine Fisheries had the only Marine Fisheries Section with 4 local branch offices, it is now split into two Contenements of Kompong Som and Sre Ambel, and Divisions of Kampot and Kg. Som (called Chamlang Kour before) are newly set up under the former and Divisions of Sre Ambel and Koh Kapik under the latter.

Though the organization was remodelled with the view to strengthening it for development of sea fisheries, it seems that no actual result is obtained partly because of the insufficient period of time elapsed after the change.

Table 8-1. Fishery Administrative Organization.



8-1-3 Fisheries Law

The fisheries law enacted in 1957 for regulating the fisheries of the country. Under the provisions of this law, restrictions are imposed on fishing industry for the protection of marine resources. The law provides for the types of fishing operations, and stipulates that no other fishing operations are allowed without special approval by competent authorities.

The law also stipulates the period of prohibition of fishing operation; from January 15 to March 31 for plathou and from December 1 to May 31 for turtles. Special approval by the competent authorities is required for operation of trawling; and special approval for trial operation is at present given to SONACOP to operate 3 trawlers for the purposes of developing sea fisheries and providing SONACOP's fish processing plant with raw materials for canning. This special approval for trial operation is given on condition that no operation be made in areas south of the line between Ream and the southern tip of Koh Tan and areas of less than 20-meter depth for protection of coastal fishermen and resources.

8-1-4 Revision of Fisheries Law

In regard to the period of prohibition of plathou fishing, the Fishery Service of Cambodia is of the opinion that, since plathou is the most important fish in the country, it is required to study protective measures on the basis of ecological study of plathou with a view to achieving permanent and sound development of the fishery.

As for the provisions for bottom trawl net fishing, trial operation is approved under certain special terms, as mentioned in the previous Paragraph, for the purpose of promoting the fishery by means of developing the untouched fishing grounds and resources; and it was observed that some practical measures should be taken in keeping abreast of full-fledged promotion of this fishery.

8-2 Outline of Fishery Conditions

8-2-1 Fishing Population

According to the data complied by the Oceanographic Institute in 1966, the fishing population was 2,911. Of them 1,845 persons were engaged only in fishery all the year round, and the remaining 1,066 worked also for other trades like farming and so on.

Breakdown of the fishing population by area is as follows: 1,147 in Koh Kapik, 602 in Ream, 464 in Kompong Som, 454 in Kampot and 244 in Chamlang Kour.

This breakdown also shows that Ream area has a larger fishing population despite of its shorter coast line, and Kompong Som and Kampot also have larger fishing populations engaging only in fishing industry.

It is understood that fishermen's dependency upon fishery varies in different areas according to topography, weather, fishing grounds and other conditions. Examination of status and conditions of fishery production as well as those three conditions will clarify fundamental terms required for establishing various measures for fostering fishermen's cooperative associations which aim at improving fishery production and fishermen's welfare.

Table 8-2. Fishing Population (1966, by Oceanographic Institute)

	Kompong Som	Kampot	Ream	Koh Kapik	Chamlang Kour	Total
Full-time	369	300	421	606	149	1,845
Part-time	70	100	150	234	47	601
Temporary	25	54	31	307	48	465
Total	464	454	602	1,147	244	2,911

(Note) This data differ from the results of the previous survey in 1967 because of the different sources of statistics.

8-2-2 Number of Fishing Boats

Statistics complied by the Fishery Service show that the total number of fishing boats both for sea fishery and freshwater fishery was 21,928 in 1966, and the number increased every year during the period from 1964 to 1966. (Table 8-3) Particularly, the number of powered boats remarkably increased. It was impossible, however, to know the number of fishing boats used only for sea fishery.

Table 8-3. Number Of Fishing Boats (Total No. of sea-fishing & freshwater fishing boats, by Fishery Service)

	1964	1965	1966
Boats with inboard engine	550	1,000	1,280
Boats with outboard engine	350	1,116	1,475
Sail-boats	1,700	2,150	2,050
Rowing Boats	15,100	15,600	15,600
Others	1,200	1,500	1,523
Total	18,900	21,416	21,928

While some data obtained by the Team tell that, among the fishing boats used for sea fishery, the number of powered boats was 416 in 1968, this is a remarkable increase from 283 in 1966. The real number, however, must be more than this number if judged from actual numbers of boats at various fishing bases and tendency of purchase of engines.

Table 8-4-1. Number Of Powered Boats By Tonnage & Areas (1968, by Oceanographic Institute)

	Tons 1-3	Tons 3-5	Tons 5-7	Tons 7-9	Tons 9-12	Tons 12-15	Tons 15-20	Total
Kampot	48	4	3	2	5	1	1	64
Kg. Som	23	53	27	3	-	1	-	107
Sre Ambel	48	13	19	18	3	-	-	101
Koh Kapik	42	30	28	34	4	6	-	144
Total	161	100	77	57	12	8	1	416

Table 8-4-2. Number Of Powered Boats By Horsepower & Areas (1968, by Oceanographic Institute)

	HP 1-5	HP 5-10	HP 10-15	HP 15-20	HP 20-25	HP 25-30	HP 30-50	Total
Kampot	44	10	6	-	2	1	1	64
Kg. Som	27	34	16	19	6	4	1	107
Sre Ambel	42	24	8	15	12	-	-	101
Koh Kapik	37	32	19	15	33	2	6	144
Total	150	100	49	49	53	7	8	416

8-2-3 Fishery Production and Principal Fisheries

According to the statistics compiled by the Fishery Service, the total fishery production of both sea and freshwater fisheries is about 170,000 tons annually, and this has hardly changed for the past several years. The production of sea fishery has also hardly changed.

Table 8-5. Annual Fish Catches (by Fishery Service)

Unit: 1,000 tons

	Sea Fishing	Freshwater Fishing	Total
1966	44	124	168
1967	44	125	169
1968	45	124	169

Divisions of the Fishery Service are striving for collecting data of fish catches by month and varieties in areas under their administration. (refer to Appendix) Research works and data collection are made based upon fishermen's reports.

The Oceanographic Institute also is finding the total of monthly catches of Trey Plathou and T. Beka as main varieties. (refer to Appendix) Though it may be difficult to figure out actual value from catches obtained by those reports, rough trend can be understood. Outline of a few fishings summarized from those reports is as follows:

a. **Plathou Fishing**

Koh Kapik area is the center of Plathou fishing which is started in September. The catch of Plathou is made in rather a considerable amount through the peak period lasting from November and December till March. In Kompong Som Bay, Koh Rong and Koh Rong Sam Lem areas, Plathou fishing is started in October and conducted through the peak period of November and December till February.
Further in southern areas, though actual value of catch is far less than that in northern area, there are catches in Ream area in March-April period and September-October period. These phenomena are largely connected with migration of fish schools.

According to fishermen in Sihanoukville and Ream areas, Plathou is of about 8 - 15 cm length in August and September, and will grow up to 15 - 20 cm length in December. Thus, its catch will increase in volume.
As for incubation, it was reported that in Sihanoukville area Plathou holds eggs in January through March and spawns in April; in Ream area Plathou mostly holds eggs in November and December and many of them spawn by the middle of February.
Purse seine is mainly used for catching Plathou, while encircling gillnet is used in the period when fish schools are not rich. Besides, Plathou is caught mixed with other varieties by small gillnet used along the coast.

There are more than 100 fishing boats with purse seiners for Plathou fishing. It is natural that the number of such boats registered at fishing bases is in proportion to the volumes of catches. Ream area, however, is an exception. Plathou catch in Ream area is smaller when compared to the number of fishing boats registered,

because the boats of this area mostly go out to other areas for fishing and only a part of their catch is landed in Ream area.

b. Beka Fishing

Data compiled by the Oceanographic Institute for 1968 show that the catch of Beka is the largest in December and comparatively stabilized in other months except April, July and August. In Ream area, the fishing starts in September and lasts through the peak period of December till April. In Sihanoukville area, the catch is small in the period from August to November; in Koh Kapik area north to Sihanoukville the catch is small during the period from May to August like Sihanoukville. Most of Beka catch is done mainly with gillnets at farmost off-shore fishing grounds. Shipowners in Ream area reported that the main fishing ground of Beka was the area of 2 - 4 hour sailing from Ream in the direction of Koh Tan.

Catch of Beka is only about 10% of that of Plathou. However, as its price is usually two or three times that of Plathou, it is highly evaluated in terms of profit and Beka fishing is considered to be the most important next to Plathou fishing.

c. Shrimp Fishing

Data obtained are not sufficient for the Survey Team to analyze the present status of shrimp fishing.

Generally speaking, it is considered that such areas in the sea to which much fresh water flows in are suitable for shirmps' spawning and growth. Judging from the data only, there are shrimp catches in the period from January to August, with large catches in April, May and June in Sre Ambel area.
Actually, however, shrimp fishing by dip net, bag net, and gillnet is operated in many areas along the coast of the country, and it was observed during the survey that a considerable volume of shrimp catches is landed at Phnom Pehn every day. It is considered that there must be some particular circumstances which obstruct such large and year-round shrimp catches from being listed in the data.

8-3 Distribution and Processing

8-3-1 Distribution

Processing technique and consolidation of distribution system for preservation of fish catches are very important problems for Cambodia which is located at a low latitude with high temperature all the year round. For example, in the case of Plathou which is the most important variety among the country's sea fishes, catch is concentrated in a certain season of the year; it is important to preserve large catches obtained within a short period for the off-shore use, and to prevent its price from declining in the season of large catches in the aspect of fishery economy.
It is also pointed out there are problems of treating and processing shrimp catches in off-shore fishing which is hoped to be developed in the future for export purpose. Problems pertaining to shrimps will be detailed in the next paragraph

Views of Mr. Suon, Chief of Oceanographic Institute, on the problems involved in the distribution of Plathou are as summarized hereunder.

1. To prevent deterioration of freshness and increase the consumption of sea fish by means of reduction of the time required for transport and improvement of transport method.

2. To aim at increasing the producers' income by means of improvement of distribution system.

3. To enlarge the market for Plathou, "a large-catch-type variety", by improving the processing method and expanding its export, and to establish countermeasures for price stabilization of fishes for the benefit of producers.

4. To foster organizations for collection, preservation and sales by the fishermen themselves with a view to improving their economic status.

5. As mentioned above, comprehensive measures are required for improving the producers' economic status and for supplying the consumers with fishes of high freshness and low prices.

(Note) 1. "Trey Plathou" Etude de la Peche et de Ecologie
2. Fresh Fish Distribution in Cambodia

Results of the survey on prices of marine products at retail markets are shown in the Table 8-6.

Table 8-6. Retail Prices Of Marine Products

Unit : Riel/kg.

Cambodian Name	English Name	Ream Feb. 13	Sihanouk-ville Feb. 14	Sre Ambel Feb. 15	Kampot Feb. 21	Kep Feb. 22	Phnom Penh Jan. 28	Phnom Penh March 1
T. Plathou	Mackerel	10	10					15
T. Kantuy Rung	Jack mackerel						15	12
T. Beka	Spanish mackerel		20		25	30	30	30
T. Sbayka	Marlin							
T. Sonpon	Dolphin							
T. Kalaing	Silvery moon fish		25					
T. Koun	(Chacoessus) punctatus					12		
T. Srom Ddo	Dorab, Chirocen-tridae		10		10 - 15	10		20
T. Khabak Sar	Gray mullet		large-35 medium-20	medium-18	medium-20	small-15		
	Gruper		25				20	
T. Prabel	Ray		10			14		
T. Chap	Pomtrets						50	50 - 70
	Sole, Cynoglossus						35	20
	Trigger-fish							25
T. Caoc	Cat-fish		6 - 10			4		
Mik Bandeng	Cuttle fish				50	large-50 small-25	60	medium-40
Mik Slos	Common squid		medium-30					
Kdam Ses	Blue crab	medium-12 small-10	15		medium-12	medium-20 small-15	25	
Kdam Thomar			25		70	medium-30-35 Small-25	25 - 40	
Bang Kea	Prawn		medium-80 small-60	small-35	70	medium-60 small-50	large-70 medium-60	large-70
	Hard clam		30/100 in-dividuals					
	Corbicula	2/can			5/kg		2/can	
	China fish	40				40	25	
	Eel	25						
	Cat fish		35					
	Oyster						small-50	small-40
	Dried fish, freshwater	50						
	Dried fish, dolphin		30	30				
	Dried fish, Spanish mackerel			28	24	40		
	Dried fish, China fish						45	
	Pork	best-60 poor-45			best-60			
	Beef	best-55 average-50		best-50 average-40	best-50 average-40			

8-3-2 Freezing Process Of Shrimp

As both atmospheric and water temperatures are rather high in and around Cambodia, shrimps caught must be cooled down as soon as possible for preservation of freshness and quality. Therefore, the ideal processing method is to treat and process shrimps on boats just after they are caught to the condition required at the markets.

Following is processing methods required for shrimp export under the present conditions of sizes of fishing boats, facilities on board and fishing grounds.

(1) Processing On Boats

Fishes caught must be assorted by varieties at every net-hauling. As for shrimps, heads must be cut off; then washed with water and stored with ice prepared in advance in a heat-proof fish-hold. The temperature in the hold must be kept at $0^{\circ}C$. Awning must be employed for preventing direct sunshine for the processing work during daytime.

Freshness, degraded in boats, cannot be restored by any treatment or processing afterwards.

(2) Landing

Number of days between boats' departure from and entry into ports must be determined according to such conditions as fuel, clean water and foodstuff to be loaded on board, number of days for which freshness of fish can be preserved, crew's recreation and supply of raw materials for smooth operation of fish preserving factory.* From the viewpoint of operating cost of fishing boats, however, it is desirable to increase the number of days for boats' stay at fishing grounds by reducing sailing time for both ways.

Freshness of shrimp can be preserved for 2 or 3 days in boats by cold storage with ice, if conditions are favorable.

Shrimps must be landed quickly at the time when the atmospheric temperature is low in the day; and attention must be paid so that shrimps may not be damaged during transport and other stages.

* It is the same as the case of employing cold storage vessels equipped with freezing or refrigerating facilities, instead of fish preserving factory.

(3) Freezing Process and Storage

Shrimps brought into the fish preserving factory are assorted into varieties and different sizes*, and after washing with water, put into quick freezers by five pounds on freezing plates. (In case of washing, it is effective for preserving its commercial value to dip into solution of $NaHSO_3$ or others for prevention of discoloration into black; however, careful attention must be paid to such treatment, because some countries impose restrictions on imported fishes thus treated in compliance with food sanitation law.)

* Shrimps are classified into following classes usually by the number of individuals per pound:

10 or less,
11 or more and 15 or less,
16 or more and 20 or less,
21 or more and 25 or less,
26 or more and 30 or less,
31 or more and 35 or less,
36 or more and 40 or less,
41 or more and 50 or less,
51 or more and 60 or less,

Freezing temperature must be kept at -30°C or under.
After freezing, glazing must be applied for preventing evaporation of moisture from shrimps.

After processing, shrimps are put by five pounds in carton boxes marked with size, and ten cartoon boxes are put in one master cartoon box and kept in refrigerators at a temperature of -30°C or under untill shipment.

(4) Factors Influencing On Commercial Value Of Frozen Shrimps.

- Discoloration
- Size
- Damage on body, tail or legs
- Taste
- Flavor
- Hardness of Meat
- Weight and size

(5) Conditions Of Location Of Fish Preserving Factory

- To be near fishing grounds
- To be convenient for fishing boats' access to wharf, mooring and landing of fish catch
- To be convenient for supply of commodities and equipment required for operation of boats and factory
- To be near repairing facilities of fishing boats
- To be easy to obtain site for factory, water and electric power
- To be easy to secure cheap labor in a greater quantity
- To be convenient for transport and export of products
- To be convenient for employees' life

8-3-3 Study On Economic Feasibility Of Export Of Frozen Shrimps

(1) Method of Study

Market price of frozen shrimps is determined for different varieties, quantities and sizes by the balance between demand and supply.

Production cost per unit weight varies according to the volume of production. Therefore, without detailed data about the price and the cost, it is difficult to make an economic study on the feasibility of exporting frozen shrimps in a correct way.

A tentative study at the present stage, however, is considered to be necessary and effective for entering into detailed examination of future export. Therefore, a fundamental study is tried herewith, in the following sequence and method:

i) Price of fresh shrimp in Cambodia (present producer price of shrimp caught by coastal fishermen)

ii) International market price of frozen shrimp (average unit value of shrimps imported to Japan in 1968)

iii) The price of the item i) is subtracted from the price of the item ii); if the expenses for freezing, processing and freight charges can be paid from the balance of the subtraction, export is considered to be profitable.

(2) Price Of Fresh Shrimp In Cambodia *1

In comparison of the producer price with the standard consumer price in Phnom Penh *2 of shrimps caught along the Cambodian coast in the wet season and the dry season, the producer price is 35 - 45 Riels with a little change by seasons, and the consumer price is 70 - 80 Riels in the wet season and 60 - 70 Riels in the dry season; it is a little higher in the wet season than in the dry season.

(Note)

*1. In Cambodia, shrimps are sold with heads in fresh condition except dried ones.

*2. The consumer price at Phnom Penh which is the largest consumer area influences largely upon the producer price.

Table 8-7. Price Standard Of Fresh Shrimp In Cambodia

Unit: Riel/kg.

	Producer price	Consumer price
Wet season (June 1967)	35 - 45	70 - 80
Dry season (Jan. - March 1969)	35 - 40	60 - 70

* Survey on the price standard must be made on such factors composing the price as varieties, sizes and freshness under the same conditions; such a strict survey was not conducted.

(3) International Market Price Of Frozen Shrimp

Shrimp is one of high-class marine products favoured in every part of the world. Its international price is largely influenced by the market of the USA which

has the largest demand. Japan imports recently 30 - 40 thousand tons of fresh and frozen shrimps*1 annually, and the import price is influenced by the market price in the USA.

In this sense, the international market price of shrimp as expressed in terms of import price in Japan was US$2,217 *3 per ton *2 in 1968.

*1. Most of the imported shrimps are frozen after cutting heads off.

*2. Total import value of shrimps of various sizes from different countries are divided by the total import volume.

*3. Though the imported quantity in 1968 was far less than that of the previous year, the import value was not so much different;

Table 8-8. Import Record of Fresh & Frozen Shrimps in Japan
(Statistics on Customs Clearance)

	Quantity	Amount	Price per ton
	tons	US$1,000	US$
1965	21,011	35,938	1,710
1966	36,156	60,085	1,661
1967	44,466	79,732	1,793
1968	35,204	78,079	2,217

(4) Examination

As shrimps cannot be caught in a large quantity at a time like other fishes, it is necessary to collect a sizable amount (for example, 20 or 30 tons) which is sufficient for negotiation for export; and for the number of days required for transport and sales to the consumers in importing countries, it is necessary to apply freezing processing to maintain the quality during those days.

Unit production cost of frozen shrimp is determined by also the price of fresh shrimp and the freezing method.

Now at this stage, on the basis of only the recent producer price in Cambodia the price per ton of fresh shrimp without heads is converted into US dollars under following conditions.

(Conditions)

1) Yield after cutting the head off shall be 55%.
2) The official conversion rate of 55.65 Riels per US$1.00 is adopted.
3) Shrimps caught in Cambodia are supposed to be the same in average size and quality as those imported into Japan.

Producer price (with heads)	in case of 35 Riels/kg	in case of 40 Riels/kg	in case of 45 Riels/kg
Converted Value (without heads)	63.6 Riels/kg	72.7 Riels/kg	81.8 Riels/kg
Converted value in US$ (per ton)	US$1,142/ton	US$1,306/ton	US$1,469/ton

Then, export shall be profitable if all the expenses including costs for processing and delivery to importing countries are within US$1,075/ton in case of 35 Riels/kg of producer price with heads, US$911/ton in case of 40 Riels/kg and US$748/ton in case of 45 Riels/kg.

(Note) US$2,217 - US$1,142 = US$1,075
US$2,217 - US$1,306 = US$911
US$2,217 - US$1,469 = US$748

8-4 Export of Marine Products

The whole export to foreign countries is taken case of by SONEXIM, which was established in 1964 with some private capitals included; at present the whole capital is paid by the Government.

The Government is eager to promote the export of marine products (refer to 8-1-1). Table 8-8 shows the record of export. The export contract concluded with Singapore for 1969 includes 2,500 tons of Plathou and 400 tons of other varieties to be exported for the total amount of 3,500,000 Riels.

Cambodia does not import any marine products.

Table 8-9. Export Volume & Value of Marine Products. (SONEXIM)

Unit: Volume in kg.
Value in Riels

	Plathou (fresh)		Plathou (boiled, salted)		Others (fresh)		Total	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
1965	19,000	10,853	-	-	53,370	175,090	72,370	185,944
1966	17,500	9,975	847,897	679,515	294,248	961,210	1,159,645	1,650,701
1967	263,000	150,041	898,600	716,744	101,270	328,137	1,262,870	1,194,923
1968	1,347,582	768,874	197,141	159,704	29,600	98,444	1,574,323	1,027,028

(Note) All exported to Singapore.

8-5 SONACOP.

SONACOP was established at Khemarak Phouminville in 1967 for the purpose of promotion of fisheries and full utilization of marine products. Its capital was initially 15 million Riels, and increased to 24 million Riels at present with a capital increase by 9 million Riels in 1968. The whole capital was invested by the Government.

SONACOP has 7 Directors and its President is Mr. Sao Leang, former Director of the Fishery Service.

Main facilities of SONACOP are ice manufactory of 5 tons per day, cold storage for 100 tons, fish meal facilities of 3 tons per day, canning facility and 3 trawlers. Employees are, 10 for clerical work (3 of them for the head office at Phnom Penh), 40 for the factory and 30 for the trawlers.

Its actual records of operation as of January 1969 are, 400 tons of ice (to be used for SONACOP's trawlers and sold to local fishing boats at the price of 1 Riel/kg), 50 tons of fish-meal; canning is still at experimental and preparatory stage; trawling was started in November 1968.

The Report submitted by the Minister of Agriculture about the status of SONACOP is included in the Appendix.

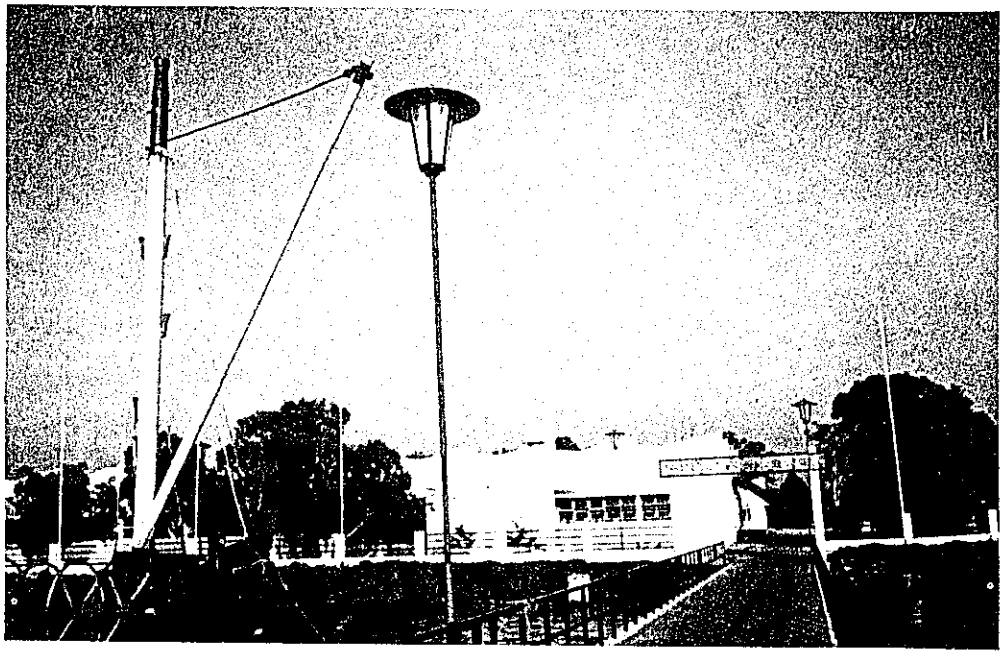


Photo 8-1 SONACOP factory and its pier

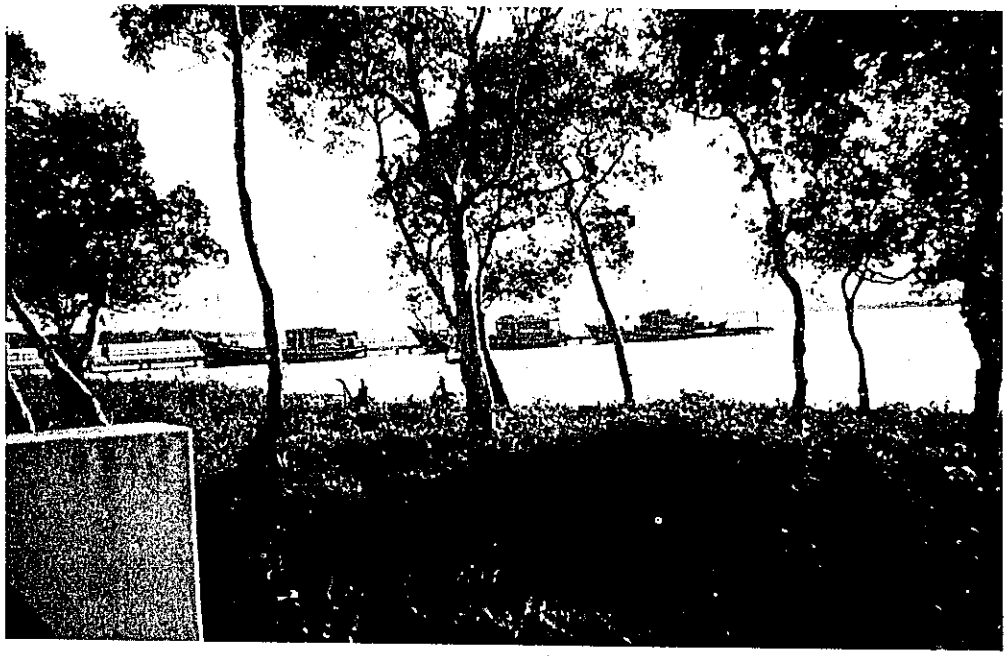


Photo 8-2 Pier and trawl boats as viewed from within the premises of SONACOP

LIST OF MARINE ANIMALS

sampled during the Second Phase
Survey (dry season), Jan.- March, 1969

(A – D)

A. **Phylum Chordata**
Class Chondrichthyes
Order Lamnida
Suborder Lamnina
Family Orectolobidae

1. Chiloscyllium colax (Meushchen)
2. Chiliscyllium sp.

Family Carcharinidae

3. Eulamia sp.
4. Carcharhinus sp.
5. Carcharhinus sp.
6. Scoliodon sorrakowah (Cuvier)

Order Rajida
Suborder Rajina
Family Rhinobatidae

7. Rhina ancylostoma Bloch & Schneider
8. Rhinobatos sp.
9. Rhinobatos sp.

Family Trygonidae (Dasyatidae)

10. Dasyatis sephen (Forskål)
11. Dasyatis sp.
12. Dasyatis sp.
13. Dasyatis sp.
14. Himantura sp.
15. Amphotistius sp.
16. Urolophus sp.
17. Gymnura poecilura (Shaw)
18. Gymnura sp.
19. Taeniura meyeni Müller & Henle

Family Myliobatidae

20. Aetobatus narinari (Euphrasen)

Class Osteichthyes
Order Clupeida
Suborder Clupenia
Family Dorosomatidae

21. Anodontostoma chacunda (Hamilton-Buchanan)

Family Dussumieridae

22. Dussumieria acuta C. & V.
23. Dussumieria hasselti Bleeker
24. Spratelloides delicatulus (Bennett)

Family Clupeidae

25. Pellona ditchela Valenciennes
26. Sardinella sp.
27. Opisthopterus tardoore (Cuvier)
28. Sardinella jussieu (Lacépéde)

Family Engraulidae

29. Thrissa hamiltoni (Gray)
30. Thrissa mystax (Bloch & Schneider)

Family Chirocentridae

31. Chirocentrus dorab (Forskål)
32. Chirocentrus nudus Swanison

Order Myctophida
Suborder Myctophina
Family Synodontidae

33. Saurida tumbil (Block)

Order Cyprinida
Suborder Silurina
Family Tachyduridae

34. Tachysurus thalassinus (Rüppell)

Order Anguillida
Suborder Anguillina
Family Muraenesocidae

35. Muraenesox cinereus (Forskål)

Order Belonida
Belonidae

36. Ablennes sp.
37. Tylosurus sp.

Suborder Exocoetina
Family Hemirhamphidae

38. Hyporhamphus (Valenciennes)
39. Hemirhamphus georgi (C. V.)
40. Hemirhampus marginatus (Forskål)

Family Exocoetidae

41. Cypselurus comatus (Mitchill)
(Cypselurus bahiensis (Ranzani))
42. Parexocoetus mento (C. V.)

Order Syngnathida
Suborder Aulostomina
Family Fistulariidae

43. Fistularia villosa Klunzinger

Order Percida
Suborder Mugilina
Family Atherinidae

44. Allanetta forskali (Rüppell)
45. Pranesus duodecimalis (C. V.)

Family Mugilidae

46. Mugil sp.

Family Sphyraenidae

47. Sphyraena picuda Bloch & Schneider

Suborder Polynemina
Family Polynemidae

48. Eleutheronema tetradactylum (Shaw)

Suborder Channina
Family Channidae

49. Canna atriatus (Bloch)

Suborder Scrombirna
Family Scrombridae

50. Rastelliger brachysoma (Bleeker)
51. Rastelliger kanagurta (Cuvier)
52. Euthynnus affinid affinis (Cantor)

Family Teichiuridae

53. Trichiurus haemula (Forskål)

Suborder Carangina
Family Carangidae

54. Megalaspis cordyla (Linnaeus)
55. Caranx malabaricus (Forskål)
56. Trachurops macrophthalmus (Rüppell)
57. Gnathanodon speciosus (Forskål)
58. Selaroides sp.
59. Selaroides leptolepis (C. V.)
60. Selaroides sp.
61. Atropus atropus (Bloch & Schneider)
62. Caranx sp.
63. Chorinemus laysan (Forskål)

Family Formionidae (Formiidae, Apolectidae)

64. Formio niger (Bloch)
(Apolectus niger)
(Parastromateus niger)

Family Leiognathidae

65. Leiognathus equulus (Forskal)
66. Leiognathus lineolatus (C. V.)

Family Lacteriidae

67. Lactarius lactarius (Bloch & Schneider)

Suborder Stromateina
Family Pampidae

68. Pampus argenteus (Euphrasen)

Suborder Anabantina
Family Anabantidae

69. Anabas testudineus (Bloch)

Suborder Rercina
Family Mullidae

70. Upeneus tragula Richardson
71. Pseudupeneus cinnabarinus (Cuvier)
72. Upeneus sulphureus C. V.
73. Upeneus sp.

Family Apogonidae

74. Apogon quadrifasciatus C. V.
75. Apogon sp.

Family Priacanthidae

76. Priacanthus tayenus Richardson

Family Serranidae

77. Epinephelus sonnerati (C.V.)
78. Epinephelus sexfasciatus (C. V.)
79. Epinephelus malabaricus (Bloch & Schneider)
80. Epinephelus amblycephalus (Bleeder)

Family Sciaenidae

81. Johnius sina (C. V.)
82. Johnius dussumieri (Cuvier)
83. Otolithes argenteus (C. V.)
84. Argyrosomus sp.
85. Sciaena dissumieri (C. V.)

Family Sillanginidae

86. Sillago sihama (Forskål)

Family Gerridae

87. Gerres abbreviatus Bleeker
88. Gerres oyena (Forskal)
89. Gerres sp.

Family Lethrinidae

90. Lethrinus mahsenoides (C. V.)
91. Lethrinus sp.

Family Lutjanidae

92. Lutjanus decussatus (C. V.)
93. Lutjanus malabaricus (Bloch & Schneider)
94. Lutjanus johni (Bloch)
95. Lutjanus sebae (Cuvier et Valenciennes)

Family Nemipteridae

96. Scolopsis ciliatus (Lacépéde)
97. Scolopdid taeniopterus C. V.
98. Nemipterus sp.
99. Nemipterus bleekeri (Day)

Family Pomadasyidae

100. Pomadasys maculatus (Bloch)
101. Pomadasys hasta (Bloch)
102. Pomadasys olivaceus (Day)
103. Pomadasys argenteus (C. V.)

Family Theraponidae

104. Therapon puta (C. V.)
105. Therapon theraps C. V.
106. Authisthes puta (C. V.)

Suborder Gobiina
Family Eleotridae

107. Butis butis (Hamilton)

Family Gobiidae

108. Rhinogobius criniger (C. V.)
109. Acanthogobius iridi punctatus (Valencien)

Suborder Pomacentrina
Family Pomacentridae

110. Abudefduf saxatilis vaigiensis (Quoy & Giamard)

Suborder Labrina
Family Labridae

111. Cheilinus chlorurus (Bloch)

Suborder Chaetodontina
Family Monodactylidae

112. Monodactylus argenteus (Linńe)

Family Ephippidae

113. Ephippus orbis (Bloch)

Family Drepanidae

114. Drepane longimana (Bloch & Schneider)

Family Platacidae

115. Platax orbicularis (Forskål)

Family Scatophagidae

116. Scatophagus argus (Linnaeus)

Suborder Siganina
Family Siganidae

117. Siganus oramin (Bloch & Schneider)
118. Siganus vermiculatus (C. V.)

Order Tetraodontida
Suborder Balistina
Family Triacanthidae

119. Triacanthus brevirostris Temminck & Schlegel

Family Monacanthidae (Aluteridae)

120. Stephanolepis sp.
121. Aluterus monoceros (Linnaeus)
122. Amanses pardalis (Rüppell)

Suborder Ostraciontina
Family Ostraciontidae

123. Rhynchostracion nasus (Bloch)

Suborder Tetraodontina
Family Tetraodontidae

124. Lagocephalus lunaris spadiceus (Richardson)
125. Lagocephalus lunaris lunaris (Bloch & Schneider)

Order Cottida
Suborder Cottina
Family Scorpaenidae

126. Pterois russelli Bennett
127. Vespicula trachionoides

Family Synancejidae

128. Minous monodactylus (Bloch & Schneider)

Family Platycephalidae

129. Grammoplites scaver (Linnaeus)
130. Suggrundus sp.
131. Platycephalus indicus (Linnaeus)
132. Elates thompsoni (Jordan & Seale)

Order Pleuronectida
Suborder Psettodidae
Family Psettodidae

133. Psettodes erumei (Schneider)

Suborder Pleuronectina
Family Pleuronectidae (Bothidae)

134. Pseudorhombus arsius (Hamilton-Buchanan)
135. Pseudorhombus javanicus (Bleeker)

Suborder Soleina
Family Soleidae

136. Aseraggodes sp.
137. Zebrias quagga (Kaup)
138. Synaptura sp.
139. Synaptura orientalis (Bloch & Schneider)

Family Cynoglossidae

140. Cynoglossus lingua Hamilton-Buchanan
141. Cynoglossus macrolepidotus (Bleeker)
142. Cynoglossus sp.

Order Symbranchida
Suborder Symbranchina
Family Symbranchidae

143. Symbranchus bengalensis (McClelland)

Class Reptilia
Family Elapidae

144. Sea snake

Phylum Mollusca
Class Bivalvia
Order Pteriomorphia
Family Codakiidae

145. Amusium pleuronectes (Linnaeus)

Class Cephalopoda
Order Decapoda
Family Sepiidae

146. Sepia esculenta Hoyle
147. Sepiella inermis (Férussac & d'Orbigny)

Family Loliginidae

148. Loligo duvauceli d'Orbigni
149. Loligo edulis Hoyle
150. Sepioteuthis lessoniana Lesson

Order Octopoda
Family Polypodidae

151. Octopus macropus Risso
152. Octopus sp.

B. **Phylum Arthropoda**

Crustacea

Decapoda

Macrura

Sergestidae

Acetes

1. Acetes sp.

Penaeidae

Solenocera

2. Solenocera melantho de Man

Penaeus

3. Penaeus semisulcatus de Haan
4. Penaeus monodon Fabricus
5. Penaeus merguiensis de Man

Metapenaeus

6. Metapenaeus mutatus (Lanchester)
7. Metapenaeus intermedius (Kishinouye)

Trachypenaeus

8. Trachypenaeus pescadoreensis Smith
9. Trachypenaeus fulvus Dall

Metapenaeopsis

10. Metapenaeopsis stridulans (Wood-Manson)
11. Metapenaeopsis barbeensis Hall

Scyllaridae

Scyllarus

12. Scyllarus sp.

Brachyura

Leucosiidae

Leuosia

13. Leuosia langifrons de Haan

Majidae

Acanthophrys

14. Acanthophrys sp.

Portunidae

Portunus

15. Portunus pelagicus (Linné)
16. Portunus hastatoides Fabricius
17. Portunus gladiator Fabricius
18. Scylla serrata (Forskål)

Charybdis

19. Charybdis sp. A
20. Charybdis sp. B
21. Charybdis sp. C
22. Charybdis cruciata (Herbst)

Podophthalmus

23. Podophthalmus vigil (Fabricus)

Stomatopoda

Squillidal

24. Squilla oratoria de Haan

Harpiosquilla

25. Harpiosquilla raphidae (Fubricius)

C. **Arthropoda**

- Crustacea
  - Cirripedia
    - Thoracia
      - Lepadomorpha
      - Balanomorpha
        - Balanus spp.
  - Copepoda
  - Decapoda
    - Macrura
    - Brachyura
    - Anomura

Mollusca

- Gastropoda
- Bivalvia
- Adapedonta
  - Teredinidae

Annelida

- Chaetopoda
  - Polychaeta

Echinodermata

- Asteroidea
- Ophiuroidea

Protozoa

- Flagellata
  - Dinoflagellata
    - Peridinium spp.
    - Ceratium spp.

D. List of Plankton

Species	Mouth of Kampot River					Survey by Fish Lamp				
						Offing of Koh Samit		Offing of Koh Kong		Kg. Som Bay
	St. 1	St. 2	St. 3	St. 4	St. 5	Before lighting	After lighting	Before lighting	After lighting	Before lighting
Phytoplankton										
Coscinodiscus asteromphalus			R	R		+				
Cos. granii	R			+	+	+	+	+	+	+
Cos. gigas	+	R	R	R	+	+	R	+	+	+
Cos. oculus-iridis	++	+	R			+		R		
Cos. radiatus						C		+		
Rhizosolenid alata	C	C	CC	CCC	CC	C	CC	CC	CC	C
Rhiz. alata f. indica			CC	CC	CC					
Rhiz. hebetata f. semispina			C	+	+	+	C	C	+	+
Rhiz. calca-avis	CC	C	CC	CC	CC	CC	C	C	C	CC
Rhiz. robusta			+	C	+	+	+	C	+	+
Rhiz. stoltherfothii			+	+	+	+	+	+	+	+
Rhiz. imbricata	+	C	+	+	+	C	C	C	C	C
Guinardia flaccida	R			R		+	+	+		+
Cerataulina Bergonii				R			R			
Hemiaulus indicus			R	+			+		+	
Hem. membraceus				R						
Hem. hauckii				R		R			R	
Hemidiscus cuneiformis			RR	R	RR	R	R	+	R	R
Lauderia borealis				R		+	R	+	R	
Stephanopyxis palmeriana	RR	RR	R	RR	RR	R	R	R	R	RR
Chaetoceros curvisetus	+	+	+	+	+	+	+	+	+	+
Chaet. decipiens				R					R	
Chaet. brevis										R
Chaet. denticulatum										R
Chaet. pervianus			+	+	+					R
Bacteridstrum elegans	+	R		R		C	+	+		+
Bact. minus								+		
Bact. rarians	+		+		R	+	R	+		R
Bact. varians var. hispida										R
Bact. hyalinum				R	R					
Thalassiothrix frauenfeldii	+	+	C	+	+	+	+	C	+	+
Thal. longissima	R	+	+	+	+	+	+	+	R	+
Thalassionema nitzschioides	R	R	R	+	+	+	R	+	+	+
Thalassiosira subtilis						R		R		
Eucampia zoodiacus			RR	R	R	R	+	+	R	+
Euc. cornuta						RR				R
Nitzschia longissima		R	RR							
Nitz. longissima var. reversa	RR	R								
Nitz. paradoxa		R								
Nitz. seriata				+	R	R			R	
Bellerochea malleus						RR		R		
Biddulphia sinnensis	+	+	R	+	+	+	+	+	+	+
Bidd. pulchella				RR	RR					
Pyrophacus horologicum							R	R	R	
Climacodium frauenfeldianum	RR		RR	R	R				R	
Triceratium favus	+	+	RR	R	R	RR	RR	RR	RR	R
Ditylium sol	+	+	R	+	+	+	C	+	+	+
Pleurosigma normanii		+							R	
Pleuro. angulatum	+	R	R	R	R	R	R	+	+	R
Pleuro. spp.						R	+	+	+	R
Cosinosira oestrupi				RR	RR			RR		
Streptotheca indica		RR						RR		
Climacosphenia moniligera	R	RR								
Melosira sp.				R						
Navicula spp.		+	+	+						
Campylosira cymbelliformis	RR									
Diatoma sp.	R		RR							
Synedra spp.		RR								
Grammatophora sp.	RR									
Rhabdonema sp.	RR									
Tricodesmium thiebauti	RR					RR	R			

Species	Mouth of Kampot River					Survey by Fish Lamp				
						Offing of Koh Samit		Offing of Koh Kong		Kg. Som Bay
	St. 1	St. 2	St. 3	St. 4	St. 5	Before lighting	After lighting	Before lighting	After lighting	Before lighting
Zooplankton										
Globigerina sp.	RR									
Acanthometron pellucidium							RR	R		
Tintinnopsis aperta									R	
Tint. spp.									RR	
Ceratium massiliens	+	R	+	R						
Cera. macroceros	+	+				+	+			+
Cera. macroceros var. gallicum		R	R	+					+	
Cera. gibberum							+	+	R	
Cera. dens				+		+		+		
Cera. extensum	+	R	+		+	R		+	+	
Cera. sumatranum	+	R	R	+	+	+	+	+	+	+
Cera. tripos								R	R	R
Peridinium oceanicum								R	R	R
Phabdonella sp.	RR						RR			
Pyrocystis lunula	R	R	R	+	R	+	+	+	R	+
Dinophysis sp.						RR			R	
Noctiluca scintillans							+	+	+	
Clausocalanus arcuicornis	RR							R	R	
Clau. pergens		RR						R	RR	
Scolecithricella minor							R		RR	
Paracalanus parvus						+				
Para. aculeatus						+				
Acrocalanus gracilis									R	
Labidocera pavo							R			
Clytemnestra rostrata						R				
Macrusetella gracilis	R			R		+	+	+	R	R
Microsetella rosea	R	R	R	+	+	+	+	R	+	R
Euterpina acutifrons	RR	R	R				R	R		
Tortanus forcipatus								RR	RR	
Calanopia thompsoni									RR	
Temora discaudata		RR	RR				R			
Tem. stylifera							RR			
Lucicutia scutellata									R	
Luci. ovalis									RR	
Acartia danae							+			
Acar. erythrea	+	+	+		R	+	+	+	R	RR
Acar. clausi	R					+				
Candacia aethiopica										RR
Cand. catula										R
Oithona nana					+	+				
Oit. gibbulus	ZR	R	R	R						
Oit. rigida									R	
Oit. fallax	+				+					
Oit. robusta		+	+		+					
Corycaeus speciosus					RR			RR		
Cory. gibbulus					+	R				
Cory. dahli		R	R							
Cory. crassiusculus				R	+		+			
Cory. catus				R	R	+			R	
Cory. lautus					R					
Cory. carinatus								+	+	
Cory. robustus	+			R	+				+	
Cory. agilis						+				
Cory. longistylis							+			
Oncaea venusta	R			R	+		+	+	+	
Onc. robusta	R			R	+					
Onc. media					+					
Onc. mediteranea							+			
Penilia schmackeri							R	+	+	
Copepoda nauplii	+	+	+	+	+	+	C	+	C	C
Fish eggs		+	+	R	+	R	+	R		
Fish larva		R	R	R			R		R	
Macruran larva	+	R	R	+	+	+	+	+	+	+
Brachyura larva	+	R	R	+	R	+	+	+	+	+
Polychaeta larva							+	R	R	
Appendicularia						RR			RR	
Sagitta spp.						+	+	+	+	
Oikopleura spp.										
Balanus nauplı	R									
Veliger	C			R	+	+	+	+	+	
Atlanta spp.	+					C		+	R	

Species		Mouth of Kampot River					Survey by Fish Lamp				
							Offing of Koh Samit		Offing of Koh Kong		Kg. Som Bay
		St. 1	St. 2	St. 3	St. 4	St. 5	Before lighting	After lighting	Before lighting	After lighting	Before lighting
Polydora	*ciliata*		RR	RR						R	
Pelngonia	*sp.*						RR	RR			
Limacina	*sp.*	C									
Globrotalis	*spp.*	R									
Rhabdonella	*sp.*	RR									
Conchoesia	*noctilluca*		R	R	+	+	+	+	C	C	+
Conc.	*imbricata*							R			
Cyphonautus	*larva*							RR			
Nematoda						RR					

Remarks: The quantity of plankton is shown by the following signs :
CC: very "common", C: "common", ++: between "common" and "present"
+: "present", R: "rare", RR: very "rare"