Report
on
The Construction of an Artificial Reef
in Lingayen Gulf
Luzon Island
PHILIPPINES

by Mr. Tokio Kitamado

July, 1984

JAPAN OVERSEAS COOPERATION VOLUNTEERS
(JOCV)

Preface

In October 1979, I was dispatched to the Philippines as the member of Japan Overseas Cooperation Volunteers (JOCV). My host agency in the Philippines was the Bureau of Fisheries and Aquatic Resources (BFAR) and I was assigned to the District Fishery Office in Pangasinan, Region I, that supervises most of the fishing area in Lingayen Gulf.

I worked with coastal fishermen as extension worker. The Regional Director, Mr. Westremundo M. Rosario suggested to me the possibility of constructing an artificial reef with about 1,000 old tires, and installing it somewhere in Lingayen Gulf. He explained that the coastal fishermen in Lingayen Gulf were catching less fish than before because of the use of irregular fishing practices such as dynamiting, poisonning, scooping with fine mesh-nets, and the over use of the fishing areas. Therefore certain measures needed to be taken to preserve an appropriate environment for fish, and thereby enabling the coastal fishermen to get a better harvest and catch.

In June, 1981, one year and half later, after I had completed the basic research work to look for a feasible area for the artificial reef installation and submitted this data and reports to BFAR as well as JOCV, both organizations agreed to fund the project. So, an artificial reef project team was founded in the Extension Division BFAR Regional Office No. 1, in June, 1981.

Our initial team members were Mr. Bernardo Apigo as project leader, Mr. Masashi Nakamura, Mr. Minoru Shinzato, Mr. Akihiko Yatsuzuka and myself with many barangay*1 people in Casantaan, Tobuan and Victoria as our collaborators. We often hired their bancas*2 for research work apart from our own speed boat*3. Those local people sometimes worked as laborers and they were sometimes our teachers. Namely they taught us their experiences of fishing in Lingayen Gulf.

When a scuba diving observation was necessary, we had the assistance of the divers from the Coral Reef Section in Research Division BFAR Central Office who are very skilled in diving and have an in-depth knowledge of fish identification.

While we were conducting the survey, construction and installation of the tire reef etc., a movie concerning an artificial reef was repeatedly shown, followed by a discussion with the coastal people so that they would understand what an artificial reef was and what were the aims of this project.

A bottom type of artificial tire reef was favored from the beginning of the project due to the following factors.

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*1 barangay: village, smallest unit of local government in the Philippines.

*2 banca: small boat usually with outrigger and 10 – 15 h.p. in-board engine.

*3 speed boat: FRP boat with 15 h.p. of out-board engine.

1) Lingayen Gulf is shallow for a long distance from shoreline, therefore we should utilize this horizontal space.

2) Generally a floating type of artificial tire reef is sustained by float, rope (or wire) and sinker. This is less stable than bottom type of tire reef which is sustained by sinker, rope (or wire) and the sea bottom. This factor would make the bottom type artificial reef more durable.

3) A large quantity of bottom type artificial reefs have been installed in Japanese waters, and so many Japanese research workers have reported the fish-gathering effect, durability and other relative factors of the bottom type of artificial reef. Therefore it was easier to study the various cases which bottom type of artificial reefs have been installed and apply these research works to our case.

After all feasible study was done, the tire reef was installed at the site off Port Sual, expanding the small reef that was installed during the inicial study of this area. The structure of the tire reef was improved from that used in the inicial study in order that it could be constructed more easily, installed on the sea bottom more densely so that it would attract more fish, and the ballasting was adjusted so that the rate that it would sink into the bottom would be minimal.

After 400 tires were installed, divers ascertained the positive fish-gathering effect of the installed tire reef, particularly, schools of snappers of 30 – 40 cm in length were swimming around the expanded tire reef. It was observed that the coastal fishermen were beginning to gather to this site to fish with hook & lines, fishing pots or bottom gill nets.

The following report is an analysis of the inicial survey of possible reef sites in Lingayen Gulf, the test installations of small-scale tire reef and payaos in the three sites in the gulf, and after reviewing, all the various factors for installation of the expanded reef in the bay off Port Sual. Although my research data is at times incomplete, I hope that this report can be utilized as a reference by the Bureau of Fisheries and Aquatic Resources (BFAR) of the Philippines as well as by other Japanese volunteers etc., when another artificial reef project is being considered.

This study is based on the Status Report of Establishment of Artificial Fish Shelter in Lingayen Gulf (I) – (V) submitted to the BFAR from September, 1981 to December, 1982. These reports were prepared and submitted by Mr. Bernardo B. Apigo, Mr. Masashi Nakamura, Mr. Minoru Shinzato, Mr. Akihiko Yatsuzuka, Mr. Tatsuo Konno and myself.

Tokio Kitamado
July, 1984
Hyogo, Japan

Acknowledgements

First of all, the writer wishes to express his gratitude to Mr. Bernardo B. Apigo of the project leader, and Mr. Masashi Nakamura, Mr. Minoru Shinzato, Mr. Akihiko Yatsuzuka and Mr. Tatsuo Konno who are members of Japan Overseas Cooperation Volunteers (JOCV). They are all the member of the artificial reef project. They did all necessary work for the project and submitted the status report of the project to the Bureau of Fisheries and Aquatic Resources (BFAR) which forms base of this report.

He is also thankful to Mr. Westremundo M. Rosario, Regional Director of the BFAR, Region I and Mr. Shoji Shinbou, Director of JOCV Manila office for their constant encouragement and support to us. Acknowledgement is also due to the members of the Coral Reef Section of the Research Division in the BFAR, Central Office, especially, Mr. P.G. Castañeda and Mr. R.I. Miclat, who carried out much of the diving activities.

Finally the writer never forget many fishermen and other people in fishing villages, some of who participated out project directly and others indirectly, and all of them gave us their kind attention and hospitality to us. Thank you very much for all.

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CHAPTER I

Survey on Municipal Fishing Areas in Lingayen Gulf

Introduction

Many coastal fishermen live in various fishing villages along the Lingayen Gulf allocated North-West of Luzon Island, Philippines. They operate gill nets, trawl nets, hook & lines, fish pots, etc. depending upon the natural conditions of the environment, e.g., fishing grounds, species of fishes caught, fishing seasons, and the economic resources of fishermen.

But these fishermen have found that the fishery stocks in Lingayen Gulf are declining year by year as compared with a decade ago. This is probably because of the overuse of the fishing areas and the existence of illegal fishing practices like dynamiting. However, this declining tendency in the quantity of fishery stocks seems to be a world wide phenomenon.

An artificial reef is the main technology that can be used to concentrate new marine life and to improve the productivity of a given area. This kind of fishing programs has been implemented during the past decade in many countries and has had a proven positive effect.

This preliminary site survey included a survey of the municipal fishing areas in Lingayen Gulf, a physical environmental survey, and the test installations of a small-scale tire reef and payaos. In order to find a feasible place for the installation of the artificial reef, we had to consider many factors for the site viability. The site, besides attracting fish, must be one that many fishermen can utilize, by being near the fishing villages so that the coastal fishermen can operate their fishing outfits.

Therefore in making the primary survey for setting the artificial reef, we needed to study the details of the fishing activities of the coastal fishermen such as fishing season, fishing grounds, desired species of fish to be caught, disposition of catch, income and expenses from fishing, etc., to envision how the artificial tire reef will help these fishermen.

The following is an explanation of the primary survey.

Material and Methods

To locate the best site for the artificial reef, the Gulf were divided into five areas from east to west namely, off Damortis, off Dagupan City, off Port Sual, off Hundred Islands, and off Bolinao (Fig. 1). However the area off Dagupan City and off Bolinao shall be excluded from the selection of the project site for the following reasons.

First of all the depth of the bottom sediment off Dagupan City is believed to be deep, due to some rivers draining into the gulf near this city, which would cause the artificial reef to sink and to be silted over easily. This area is also used as the fishing grounds for baby trawlers and the placement of the artificial tire reef may bring the breakdown of the fishing grounds used by the baby trawlers.

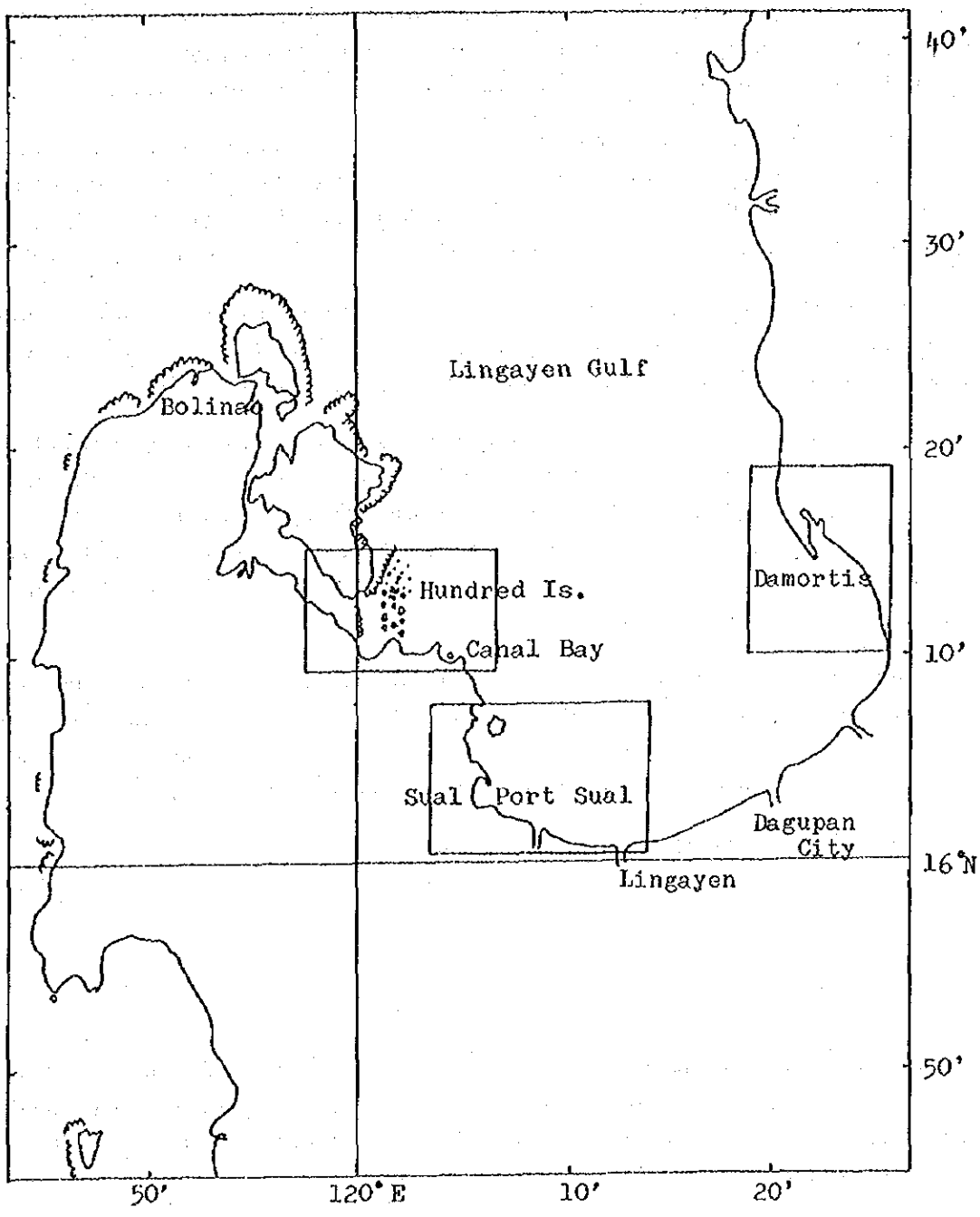


Figure 1. Lingayen Gulf and the three project areas

Secondly there is already an artificial reef installed off Bolinao which has been observed and reported by Murdy. Therefore the preliminary site survey was conducted in the other three areas; off Damortis, off Port Sual and around Hundred Island.

The basic method to gather information for the survey consisted of these two activities;

1. Interviews with the coastal fisherman and observation of their fishing gear.
2. Accompanying the respective fishermen from the fishing villages during their fishing operations.

The numbers of rafts and bancas were counted on the beach, during the day, when the fisherman usually are not fishing and those which were absent from the beach at the time observed could not be counted. These numbers of rafts and bancas were given to show the villages where there is the greatest number of the population is involved in fishing activities. At same time, the fishermen were interviewed and the type of fishing they used was studied.

We chose fishermen operating bottom set gill nets in most cases when accompanying them while they were fishing. The use of this kind of fishing gear is dominant in the Lingayen Gulf and using this as the standard type of fishing method. This makes our data easier to compare the condition of fishery stocks in the three areas that are being evaluated.

Result and Discussion

1. The proposed site off Damortis

The observations for this proposed site were held in the fishing villages of Cupan, Casantaan, Namonitan, Tobud, Damortis, Bani and Rabon which are located in La Union, and Rabon San Fabian which is located in Pangasinan. (Fig. 2)

The major fishing gear for the fishermen in this area are the bottom set gill net and the baby trawl net. (Table 1-1) Fishermen using the bottom set gill nets manipulate their nets with either motorized banca or non-motorized banca. They often catch the less migratory species like moonfish, slipmouths, goatfish, majarras and swimming crabs as well as the highly migratory species like Indian mackerels. (Fig. 5, Table 3)

The fishermen select their fishing ground in accordance with the migration of those species they wish to catch. Their chief fishing grounds are the area to the south and to west of the sand spit which extends south from the village of Cabaroan. The characteristics of this area is the extension to the south of a large sand bar which is located to the south of the sand spit. This bar divides the fishing ground for bottom gill net fishing into two areas. The fishing ground in the area to the east of the sand bar is from 5 to 12 fathoms in depth and often calmer because of the protective function of the shallow portion in breaking waves and the nearness to the shore. Therefore we many envision by placing the artificial reef near this fishing ground, that it would result in a place of sanctuary for fish, a closer site which would be available for

use for a large portion of the population, and hopefully a larger catch with less fuel consumption for their trip.

This area forms also the fishing ground for baby trawlers. The fishermen operate their baby trawl nets with motorized bancas along the coastal area up to 15 fathoms depth. Among the observed fishing villages in this area, fishermen in Namonitan depend on baby trawl fishing the most. When the artificial reef is placed in this area, it is necessary to consider how the reef will influence the fishing ground of the baby trawlers.

In addition to them, the fishermen operating tuna drift gill nets, hand lines and fishing pots were observed in these fishing villages. For instance, ten motorized bancas in Bani, Rosario use tuna drift gill nets (Gear No. 4 in Appendix A), in particular, from December to June (dry season) for catching large size fish such as yellow fin tuna and Spanish mackerels. Their fishing ground is extensive, since it extends up to the area off San Fernando in La Union.

The fishermen using hand lines manipulate two kinds of fishing tackles (Gear No. 9 and 10 in Appendix A). One is tuna hooks for catching large size fish like yellow fin tunas, Spanish mackerels, skipjack tunas and dolpins. The other is small hooks, sometimes with artificial bait, for the small size fish like jacks and mackerels. They operate these fishing gear in the deep sea, sometimes being 20 km west from the shoreline.

Also some fishermen in Casantaan and Tobud use small size fishing pots made of bamboo (Gear No. 14 in Appendix A). They place their fishing pots with bait in the sand bar off Damortis.

The final recommendations for this site will be discussed in the Chapter IV.

How to read Figure 2., Figure 3. and Figure 4.


Fishing ground for bottom set gill net fishing


Fishing ground for surface gill net fishing


Fishing ground for lift net fishing


Fishing ground for baby trawl net fishing


Fishing ground for hand line fishing


Fishing ground for long line fishing

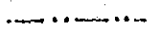

Fishing ground for fish coral fishing


Fishing ground for fish pot fishing


Fishing village


5 fathoms isobath

10 fathoms isobath


20 fathoms isobath


Coral reef

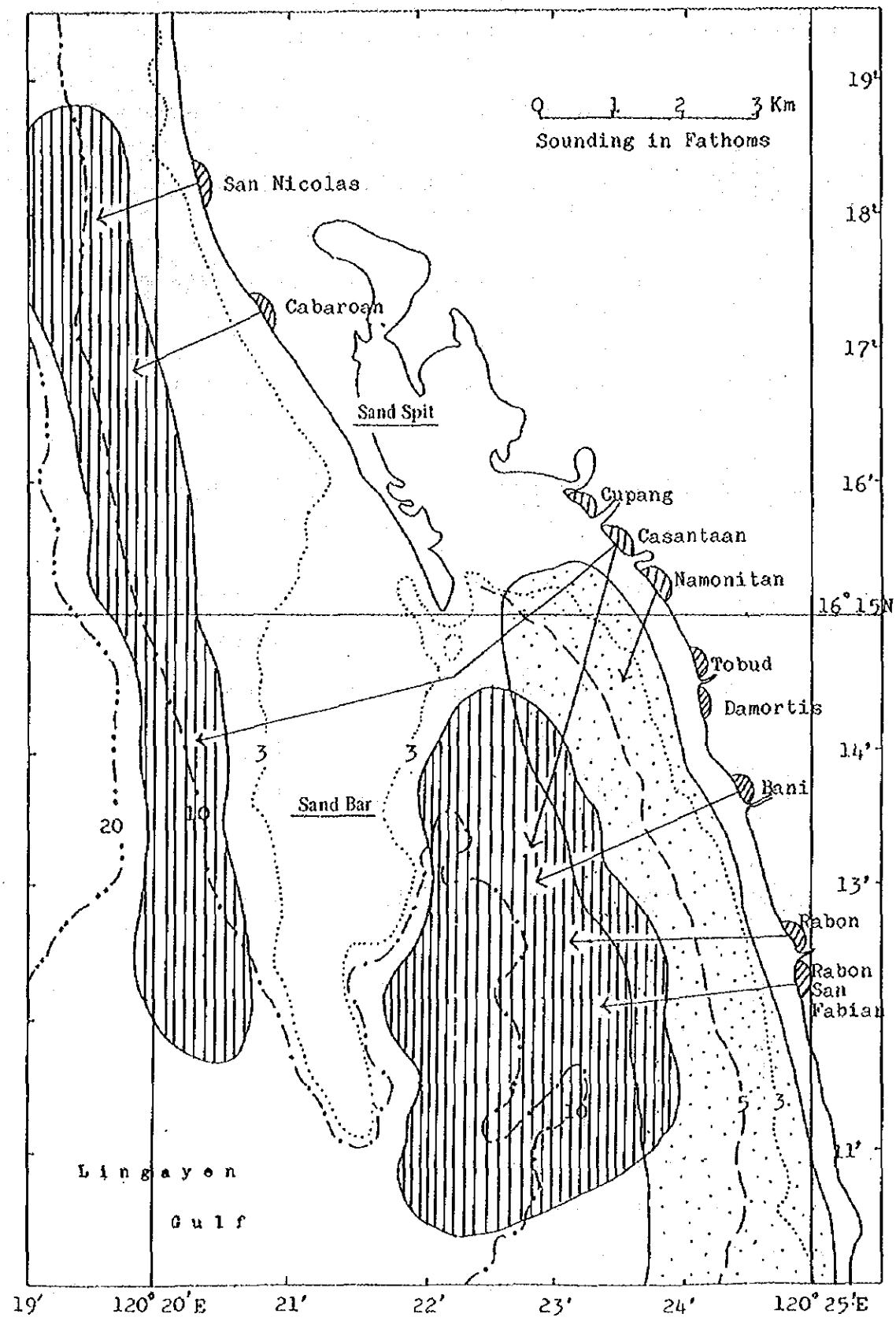


Figure 2. Fishing villages and fishing grounds at the project area off Damortis, Sto. Tomas, La Union

Table 1-1. Fishing gear observed in the fishing villages around the project site off Damortis

Province		La Union							Pangasinan	
Municipality		Santo Tomas				Rosario			San Fabian	Total
Barangay		Cupang	Casantaan	Namonitan	Tobud	Damortis	Bani	Rabon	Rabon San Fabian	
Small Paddle Raft					2			1		3
Non-motorized Banca		9	15		16	3	22	3		67
Motorized Banca		15	21	15	18	16	26	15	17	143
	Bottom Gill Net	-	++		+	+	+	+	+	
	Drift Gill Net						+			
Nets	(Largarite)									
	Baby Trawl Net	-	-	++	+	+			-	
	Lift Net		-						-	
	Beach Seine									
	Cast Net						+		+	
	Push Net	+			+					
Lines	Hand Line	+	-			+			+	
	Long Line	-	-						-	
Others	Pot (large)									
	Pot (small)		+		+					
	Spear Gun	-	-						+	
	Fish Corral								-	

++ Fishing gear often used + Fishing gear sometimes used - Fishing gear not used Blank space: not identified

2. The proposed site off Port Sual

The observations for this proposed area were held in the fishing villages of Uyong, Tobuan, Poblasion and Mangas which are located in Pangasinan. (Fig. 3) The number of motorized bancas and non-motorized bancas in each of the fishing villages are presented in Table 1-2.

Many fishermen in Uyon depend on the lift net for fishing (Gear No. 8 in Appendix A). They use one motorized banca and one non-motorized banca as a unit in their fishing operation. The lift nets are situated in the bay of Port Sual in a water depth of 8 m to 15 m. They catch anchovies and squids at night with the use of two petromax lights to attract the fish.

Most fishermen in Tobuan operate bottom gill nets (Gear No. 1, 2 in Appendix A) with motorized bancas. The fishing grounds where they often use their gill net are;

1) Off two rivers of the Agno River & Limahong Channel, particularly in rainy season.

2) Near Cabalitian Island where there are two natural reefs.

3) The area between those two areas mentioned above in accordance with the migration of certain species of fish such as jacks and mackerels as shown in Fig. 3.

The fishing ground off the two rivers is formed in the boundary between sea water and fresh water from the two rivers sometimes called an estuary. In this fishing ground, cutlassfish are abundant from December to February. Some fishermen believe that they migrate forward the shore in search of alamang paste shrimp. When accompanying the fishermen using bottom gill nets off Agno River in July 1981 (rainy season), gizzard shads were the dominant species in catch (68.0 % of the catch). Also included were slipmouths, mackerels, anchovies, shrimps and prawns (Fig. 5, Table 3). According to our observations, the fishermen in Tobuan also catch the highly migratory species of fish such as jacks and mackerels with their bottom gill nets in various fishing grounds in accordance with the fish's migration.

Common fishing gear used by fishermen in Poblasion is the hand line (Gear No. 11 in Appendix A). They manipulate their hand lines in fishing grounds beyond Port Sual with motorized bancas or off Port Sual with non-motorized bancas. One of the best fishing grounds beyond Port Sual is 1.3 km north from Hundred Islands where large fish are often caught. The other is San Fabian Rock which is situated to the north beside Cabalitian Island (Fig. 3). When accompanying the fishermen using hand line fishing on San Fabian Rock, a large size jack (5.6 kg in weight) was caught. At the same time, other kinds of jacks, barracudas and slipmouths were caught (Fig. 5, Table 3). Some fishermen also manipulate their hand line beside the scaffolds of the lift nets built off Port Sual using non-motorized bancas.

We could observe more non-moterized bancas than moterized in Mangas. Many fishermen in Mangas depend on lift net fishing and they may not need motorized bancas because it is quite a short trip from their living places to the scaffolds of the lift net built off Port Sual. The design of the fishing gear is the same as the one used by fishermen in Uyon.

The coastal water from the estuary of Agno River to the east forms the fishing ground for baby trawlers. The species caught by those trawlers are several kinds of prawns and shrimps. Prawns are caught from May to December and alamang paste shrimps are caught from December to March. The design of the baby trawl net commonly used in this area appears under the heading Gear No. 6 in Appendix A.

After the survey in this area, a site beside the natural reef called Adela Rock was found recommendable for the project site of the artificial reef. Adela Rock is situated about 1 km northeast of Tobuan, Labrador Pangasinan. This place forms a border for the fishing grounds for several kinds of fishing methods such as gill net fishing, lift net fishing and baby trawl fishing. Furthermore, the place is near the great portion of fishermen's population, which makes the utilization of the artificial reef easier for those fishermen. We forsaw the benefits of enlarging the ecological space made by Adela Rock by placing the artificial reef as an extension rock of the natural reef.

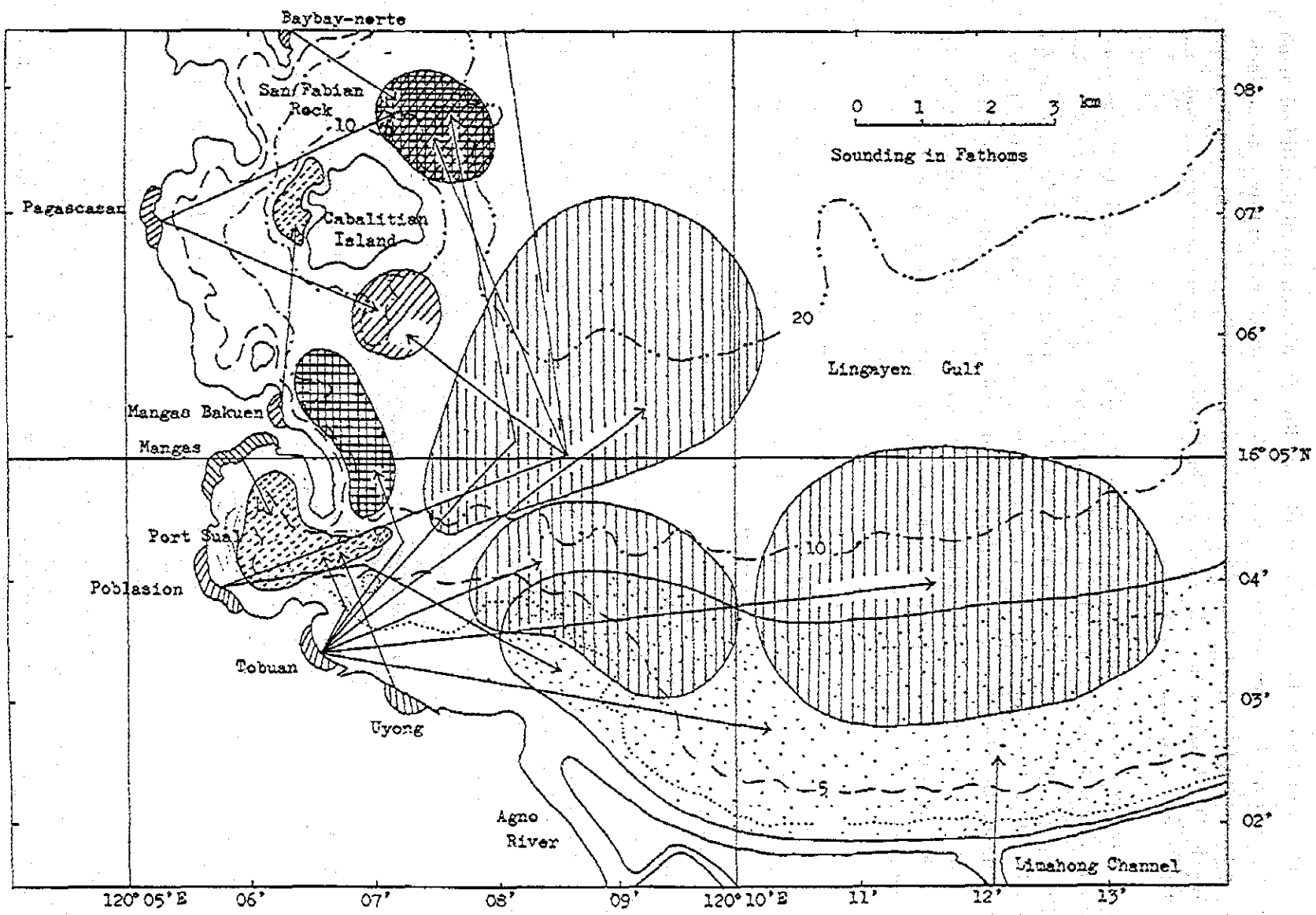


Figure 3. Fishing villages and fishing grounds at the project area off Port Sual, Sual, Pangasinan

Table 1-2. Fishing gear observed in the fishing villages around the project site off Port Sual

Province		Pangasinan				Total
Municipality		Labrador		Sual		
Barangay		Uyong	Tobuan	Poblasion	Mangas	
Small Paddle Raft						
Non-motorized Banca		17	1	32	45	95
Motorized Banca		29	64	53	15	161
Nets	Bottom Gill Net	+	++	+	+	
	Drift Gill Net	+	+	+		
	(Largarite)		+			
	Baby Trawl Net		+	+		
	Lift Net	++	+		++	
	Beach Seine		-			
	Cast Net		-	-	+	
	Push Net					
Lines	Hand Line		+	++		
	Long Line		+	+		
Others	Pot (large)					
	Pot (small)		+		+	
	Spear Gun		-	-		
	Fish Corral		-			

++ Fishing gear often used + Fishing gear sometimes used - Fishing gear not used Blank space: not identified

3. The proposed site around Hundred Islands

The area around Hundred Islands is a noted sanctuary for fish. Various kinds of fishing methods are observed in this area (Fig. 4). One of them is hand line fishing. The obvious fishing ground is 1.3 km north of Hundred Islands where large size fish are often caught. Fishermen who gather at this site with their fishing tackles are coming from various fishing villages, such as Poblasion, Sual or Lucap. The other fishing methods used in this area are kinds of gill net fishing, namely surface gill nets (Gear No. 5 in Appendix A) and bottom set gill nets (Gear No. 1, 2).

There are many fishermen using small fishing pots made of bamboo placed to catch the reef fish (Gear No. 14). Few fishermen in Lucap, Alaminos also construct big size fishing pots made of bamboo (Gear No. 13) and install them around Hundred Islands at a depth of 7 fathoms to 9 fathoms where the bottom character is muddy. They often catch large size groupers and swimming crabs.

The other fishing gear seen in this area are baby trawl nets (Gear No. 7), bottom set long lines (Gear No. 12), and fish corrals. The fishing ground for the baby trawlers in this area is in Lucap Bay where the bottom character is muddy and has a depth of 2 fathoms to 5 fathoms among the coral reef (Fig. 4). They catch small size fish, shrimps, and crabs from July to September (rainy season).

Other fishermen operate their bottom set long line in the area around Hundred Islands or the area between Hundred Islands and off of Canal Bay, including the fishermen from Victoria. They catch groupers, snappers or threadfin breams generally from 10 cm to 25 cm in body length. Many fish corrals are seen on the edge of coral reef extending from Apo Island as well as in Tanbac Bay in an area as shallow as a few meters (Fig. 4).

As mentioned above, the site around Hundred Islands is a noted fishing ground for various kinds of fishing methods. Therefore it is not necessary to install the artificial reef in this area. The site we approached for setting the artificial reef in this area is in Canal Bay which is situated east of Hundred Islands. The nearest fishing villages are Victoria, Telbang and Magsaysay. The number of non-motorized bancas and raft in these villages is greater than the number of motorized bancas, being necessary a good fishing ground within a short traveling distance from the villages. (Table 1-3)

The common fishing gear in Victoria is the bottom set long line. Those fishermen operate the long lines with motorized bancas in areas out of Canal Bay. Another group of fishermen operate bottom set gill nets in and around Canal Bay with motorized banks, non-motorized bancas or rafts.

The species of fish observed in Canal Bay were barracudas, majarras, goatfish and mackerels. But those fishermen catch relatively poor in spite of many natural reefs. The fishery stock for the gill net fishermen in Canal Bay may not be abundant.

If the artificial reef was placed in Canal Bay, there was the posibility of attracting additional fish from outside of Canal Bay, including such species as threadfin breams, jacks and mackerels as well as fish already in Canal Bay. The project at this site would bring some benefit to the subsistence fishermen living in the area.

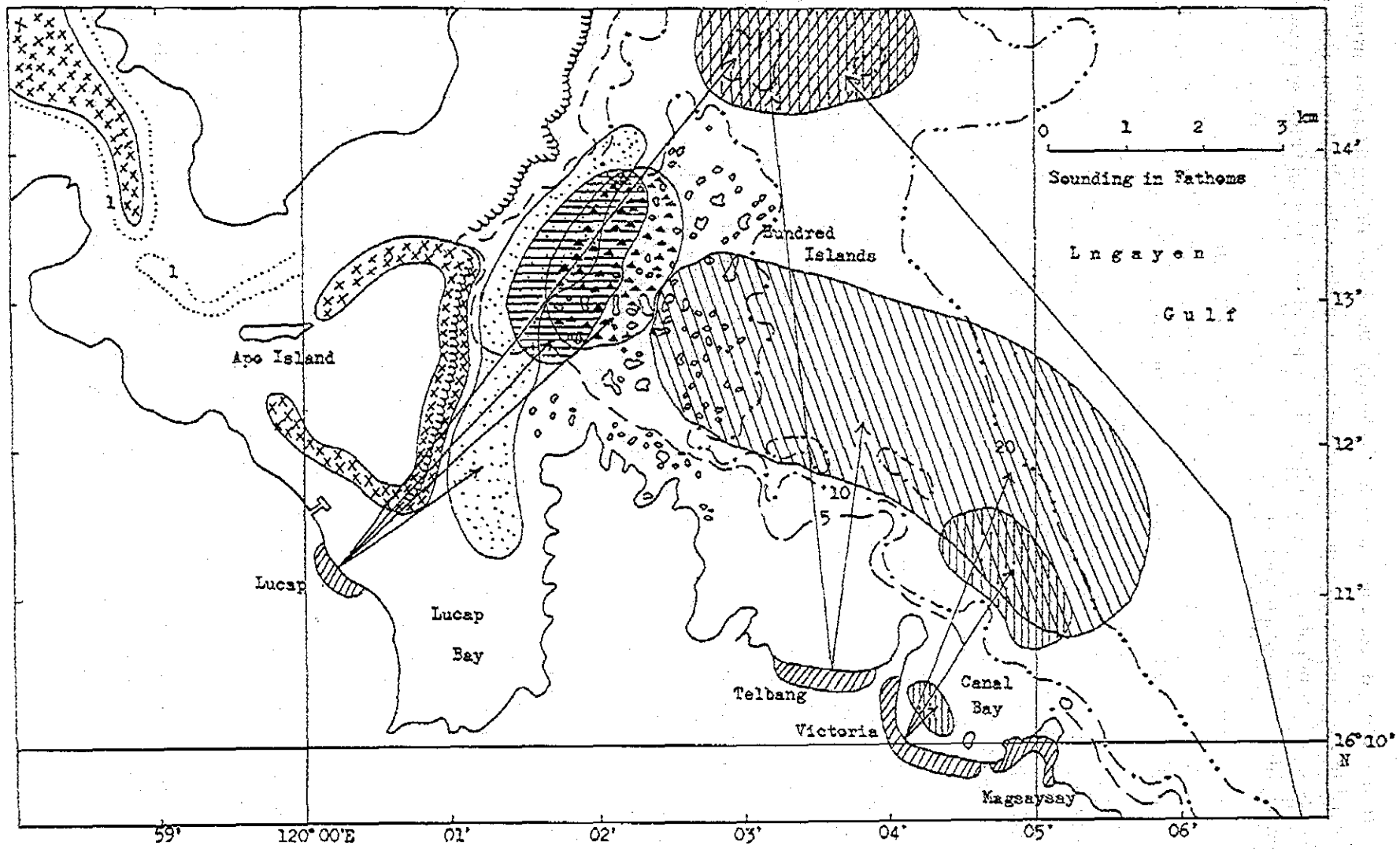


Figure 4. Fishing villages and fishing grounds at the project area around Hundred Islands

Table 1-3. Fishing gear observed in the fishing villages around the project site in Canal Bay

Province	Pangasinan				Total
Municipality	Sual	Alamines			
Barangay	Magsaysay	Victoria	Telbang	Lucap	
Small Paddle Raft	5	13	5	1	24
Non-motorized Banca	2	10	36	3	51
Motorized Banca	3	21	6	38	68
Nets	Bottom Gill Net	+	+	++	++
	Drift Gill Net		-		+
	(Largarite)				
	Baby Trawl Net		-	-	+
	Lift Net		-		-
	Beach Seine		+		-
	Cast Net	+	+	+	-
	Push Net				
Lines	Hand Line		+	+	++
	Long Line		++	+	-
Others	Pot (large)				+
	Pot (small)		+	+	+
	Spear Gun		+	+	+
	Fish Corral		-		+

++ Fishing gear often used + Fishing gear sometimes used - Fishing gear not used Blank space: not identified

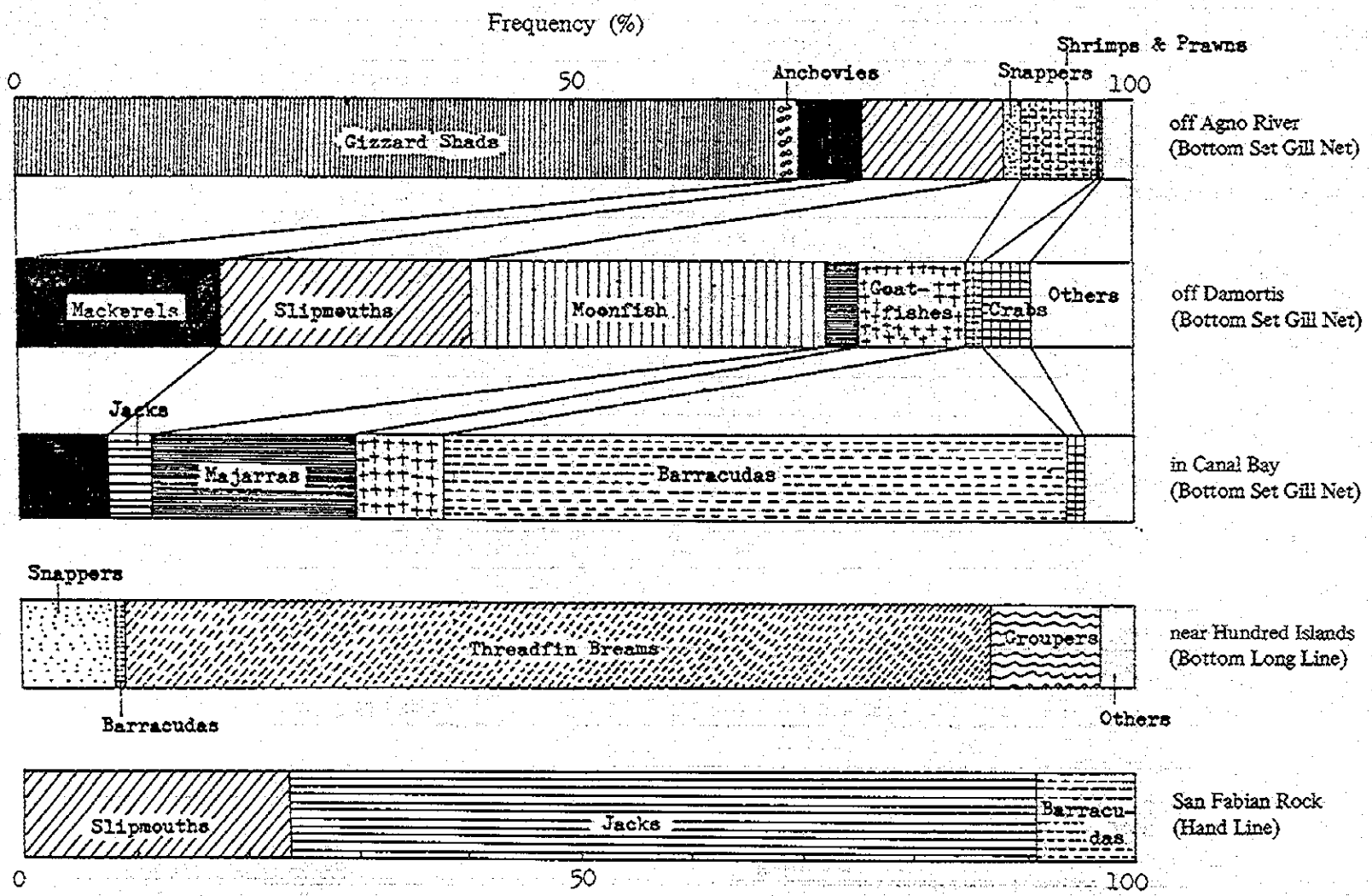


Figure 5. Percentage of the fish caught according to species in the respective fishing grounds

Table 2. Result of the fishing operations held by fishermen in the respective fishing grounds

No.	Date	Fishing Duration (min.)	Mesh Size (Knots)	No. of Units	Catch in Weight (kg)	Location	Depth of Water (m)	Fishing Gear Used
1	1981–07–11	1830–1910 (40)	6, 6.5, 7, 7.5	17	1.3	off Agno River	27	Bottom Set Gill Net
2	1981–07–12	1837–1905 (28)	6, 6.5, 7, 7.5	11	6.5	off Agno River	11	Bottom Set Gill Net
3	1981–07–13	0502–0542 (40)	6, 6.5, 7, 7.5	11	7.0	off Agno River	6 – 11	Bottom Set Gill Net
4	1981–07–13	1825–1903 (38)	6, 6.5, 7, 7.5		7.7	off Agno River	10	Bottom Set Gill Net
5	1981–07–14	1815–1906 (51)	6, 6.5, 7, 7.5	15	6.5	off Agno River	17	Bottom Set Gill Net
6	1981–08–01	1827–1854 (27)	6, 6.5, 7, 7.5	12	(0.8)	off Damortis	14	Bottom Set Gill Net
7	1981–08–01	1838–1857 (19)	7	14	(2.0)	off Damortis		Bottom Set Gill Net
8	1981–08–31	1819–1838 (19)	6, 6.5, 7, 7.5	19	(12.0)	off Damortis	17	Bottom Set Gill Net
9	1981–09–01	1823–1840 (17)	6, 6.5, 7, 7.5		(0.8)	off Damortis		Bottom Set Gill Net
10	1981–09–01	1813–1832 (19)	7	15	(1.0)	off Damortis		Bottom Set Gill Net
11	1981–09–16	0513–0555 (42)	7	10	(1.5)	in Canal Bay	5 – 10	Bottom Set Gill Net
12	1981–09–17	0503–0557 (54)	7	7	(4.0)	in Canal Bay	4 – 5	Bottom Set Gill Net
13	1981–09–18	0515–0545 (30)	7	8		in Canal Bay	5 – 10	Bottom Set Gill Net

No.	Date	Fishing Duration (min.)	No. of Hooks	No. of Units	Catch in Weight (kg)	Catch in Pcs.	Location	Depth of Water (m)	Fishing Gear Used
14	1981–07–15	0545–1127 (342)			9.2	21	San Fabian Rock	29 – 32	Hand Line
15	1981–09–19	0353–	1,540	11	5.0	111	East of Hundred Is.	40	Bottom Long Line
16	1981–09–20	0440–0725 (165)	1,540	11	7.0	53	Around Hundred Is.	1 – 2	Bottom Long Line

Table 3. Compositions of the fish caught by fishermen in the respective fishing grounds

Fishes caught	Catch in pieces									
	off Agno River		off Damortis		in Canal Bay		San Fabian Rock		near Hundred Is.	
	(pcs.)	(%)	(pcs.)	(%)	(pcs.)	(%)	(pcs.)	(%)	(pcs.)	(%)
Gizzard Shads	355	68.0	0	0	0	0	0	0	0	0
Anchovies	12	2.3	0	0	0	0	0	0	0	0
Mackerels	31	5.9	13	18.1	6	7.8	0	0	0	0
Rabbitfishes	2	0.4	0	0	1	1.3	0	0	0	0
Slipmouths	67	12.8	16	22.2	0	0	5	23.8	0	0
Snappers	8	1.5	0	0	0	0	0	0	13	8.0
Grunts	2	0.4	1	1.4	0	0	0	0	1	0.6
Jacks	0	0	0	0	3	3.9	14	66.7	0	0
Mullets	4	0.8	0	0	0	0	0	0	0	0
Moonfish	0	0	23	31.9	0	0	0	0	0	0
Lisardfish	0	0	1	1.4	0	0	0	0	0	0
Majarras	0	0	2	2.8	14	18.2	0	0	0	0
Goatfishes	0	0	7	9.7	6	7.8	0	0	0	0
Murrels	0	0	3	4.2	0	0	0	0	0	0
Goby	0	0	1	1.4	0	0	0	0	0	0
Barracudas	0	0	0	0	43	55.8	2	9.5	1	0.6
Glassyfishes	0	0	0	0	2	2.6	0	0	0	0
Catfishes	0	0	0	0	1	1.3	0	0	1	0.6
Threadfin Breams	0	0	0	0	0	0	0	0	126	77.3
Groupers	0	0	0	0	0	0	0	0	16	9.8
Congereels	1	0.2	0	0	0	0	0	0	5	3.1
Octopus	0	0	1	1.4	0	0	0	0	0	0
Shrimps & Prawns	36	6.9	1	1.4	0	0	0	0	0	0
Crabs	2	0.4	3	4.2	1	1.3	0	0	0	0
Sea Mantis	2	0.4	0	0	0	0	0	0	0	0
	522	100.0	72	100.0	77	100.0	21	100.0	163	100.0

CHAPTER II

Physical Environmental Survey for the Artificial Reef Installation

Introduction

Three proposed sites were recommended for the artificial reef installation in Lingayen Gulf after the survey of the municipal fishing areas. They are the sites off Damortis, off Port Sual, and in Canal Bay.

There are some factors which prevent the stability of the bottom type of artificial reef in the water, one factor is the sinking of the reef into the sea bottom. It is said that the rate of sinking into the bottom is strongly related to the conditions of both bottom sediment and water current. For instance, where the current is strong, an artificial reef installed on a soft bottom will sink into the ground quickly. A bottom character such as gravel and sand is ideal, sand and mud may still be good, but ooze must be avoided in order to prevent the artificial reef from the quickly sinking into the sea bottom.

Another factor is the possibility of the reef changing position by rolling along the bottom. This happens often when the sea bottom is steeply inclined and the current is quite strong, with the artificial reef rolling over the ground easily, in particular, an artificial reef which is small in weight per unit volume is often carried away by current. In order to avoid this, we had to select a site where the sea bottom is flat and the current is calm. The weight of the artificial reef should be considered to avoid both the sinking into the bottom sediment and rolling over the ground.

If there is one present, it is important to survey the existance of a natural reef, its size and shape. This is because the existence of a natural reef near-by sometimes gives a clue to know the variety of fishery stocks in the site where the artificial reef is to be set. There is a possibility of enlarging the ecological space formed by the natural reef by placing the artificial reef beside the natural reef.

These matters mentioned above are taken into consideration in the physical environmental survey of the artificial reef installation as stated in the following pages.

Material and Methods

The physical environmental survey was performed to obtain the data about the bottom topography, bottom slope, depth of water, type of bottom sediment, existence of a natural reef including its shape and size, and water current conditions at each of three project site; off Damortis, off Port Sual and in Canal Bay. These are essential factors for bottom type of artificial reef which govern life term under keeping its function and effectiveness as to gathering economically important fish.

The process to impliment the physical environmental survey is as follows;

1) Look at the relevant charts.

2) In considering depth of water, bottom charactor, natural reef and distance to fishing villages, make stations by placing bouys with flags at regular intervals. How to select the location for the stations depends upon sites which possess many factors as mentioned above.

3) Get a position of each station on the chart with the use of a magnetic compass*1 or a sextant*2.

4) Sound the depth of water by means of echo-sounder and sounding lead at each station.

5) Get bottom sediment by means of bottom samplers (Tanaka's simple bottom sampler, Nauman bottom sampling tube, etc.) at each station.

6) Run from one station to another while sounding continually by means of a echo-sounder keeping the speed of the boat constant. As a result, the record of the echo-sounder shows the bottom topography and slope between each of two stations.

7) If an natural reef is indicated near the stations in the chart, also make stations around the reef and conduct the same process mentioned in the item from (3) to (6) to disclose its size and shape.

8) Measure current velocity & direction on such layers as the sea bottom, mid-water and sea surface at one station which represent all other stations in a project site (or if necessary at more than two stations). This measurement was performed every hour for about 24 hours. Meteorological investigations was done simultaneously to determine the environmental differences at each observation time at each project site.

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*1 By means of magnetic compass (Cross bearings):
It is the way to measure bearings of more than two objects (usually three). The point of intersection made by the acquired bearings is the proposed position.

*2 By means of sextant:
It is the way of measuring both horizontal angles among three objects on the land. The point of intersection made by two loci formed by plotting the points made by the same angle through respective two definite points (objects). This way is more accurate than the above way.

Result and Discussion

1. The proposed site off Damortis

The stations built in the proposed site off Damortis are located about 2.5 Km off southwest (SW) of Damortis, Sto. Tomas, La Union (Fig. 6).

A slight bottom slope (0.1 – 0.4 %) in the direction of east to west was observed and no noted natural reef was ascertained in this area (Fig. 7). From the result of bottom sampling, there is no noted difference in the bottom character among the stations. It is generally of silt and fine sand with little fragments of sea shells and some benthos (Table 4).

It can be said that there is no possibility for the tire reef to roll from the topographical point of view but there may be sinking because of the soft bottom. Although the thickness of the sediment was not measured, it was believed that the sediment might be fairly thick and soft from the recording pictures of echo-sounder.

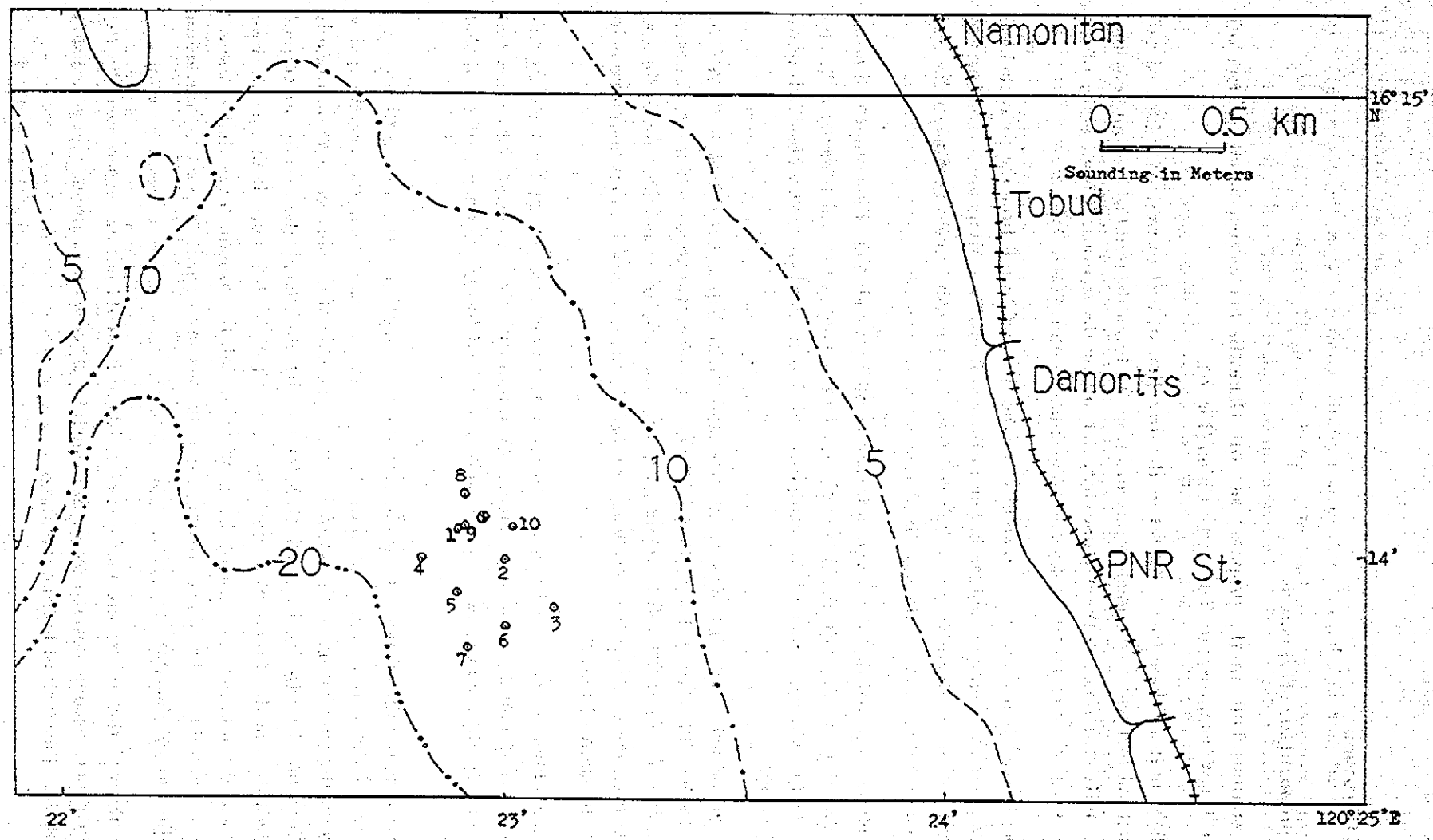
It was also observed that there were few schools of fish within the various depth observed during the day time. In contrast, during the night, a large school of fish which was attracted by a kerosene lamp, which seemed to be composed of Indian mackerels, was observed above the 10 meters layer.

Current velocity and direction were measured from September 13 at 8:30 AM to September 14 at 6:30 AM, 1981 at station 5. The measurement was done every hour, however, it is incomplete for 6:30 PM on September 13, 1981 because of rain. When measuring the current direction, the surface layer only was observed by using a hand bearing compass due to the equipment failure (Table 5).

The maximum current velocity at the surface was 0.39 m/s (0.76 knots) and average was 0.18 m/s (0.35 knots) during the measurements. We found that the current velocity weakened at around 5 m depth rapidly. This fact was also ascertained by the experience of the skilled fishermen.

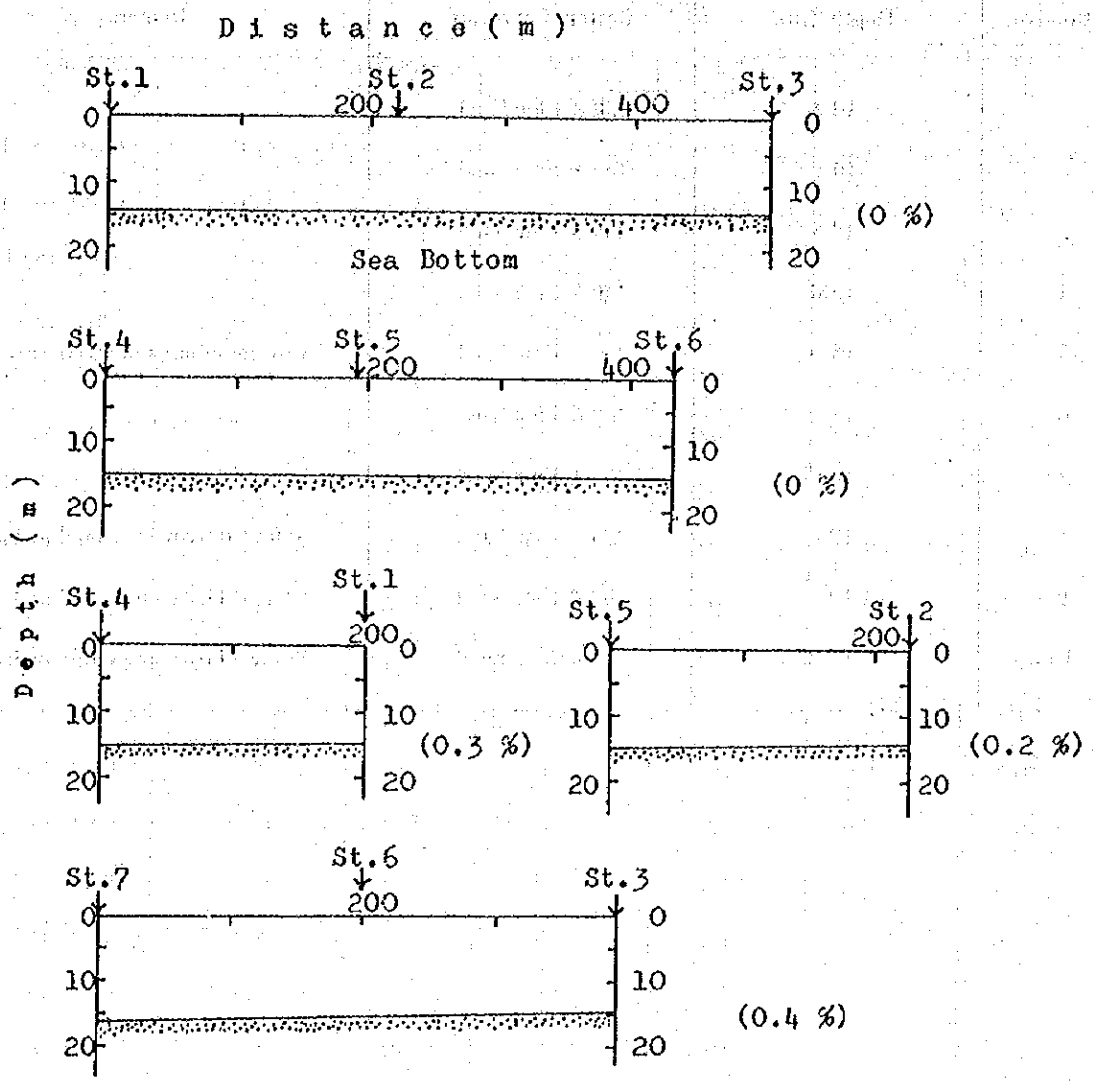
Figure 8 shows the changes of current velocity and direction at the surface (0 m deep). The velocity of the current going southwards seems to be faster than the velocity going northwards on the comparison of the absolute value. The axis of the current going northwards is in the direction of northwest by north (NW/N). On the other hand, the axis of the current going southwards is in the direction of southeast by east (SE/E). It is notable that a clockwise shift is shown in the changes of current direction. Although the fishermen say that the lower stream flows opposite to the upper stream, our data was insufficient to reach a conclusion about the direction of the streams.

It is believed that if the tire reef was placed here it would not be carried away by the current. But it may become covered by the silt which is carried by the current. This conclusion was reached from the result of bottom sampling.



⊙ : Stations ⊗ : Tire reef and payaos were installed on November, 1981.

Figure 6. Stations and the test installation site off Damortis, Santo Tomas, La Union



( ) Bottom slope rate

Figure 7. Bottom topography at the project site off Damortis, Sto Tomas, La Union

Table 4. Depth and bottom character at each station off Damortis, Sto Tomas, La Union

Station No.	Depth (m)	Bottom Character	Remarks
1	14.5	Silt & Fine Sand	
2	14.5	Silt & Fine Sand	
3	14.5	Silt & Fine Sand	
4	15.0	Silt & Fine Sand	
5	15.0	Silt & Fine Sand	Current condition was observed.
6	15.0	Silt & Fine Sand	
7	16.0	Silt & Fine Sand	
8	12.6	Silt & Fine Sand	Sounded by using sounding lead.
9	12.9	Silt & Fine Sand	Sounded by using sounding lead.
10	12.3	Silt & Fine Sand	Sounded by using sounding lead.

Table 5. Current velocity in different layers off Damortis, Sto Tomas, La Union on September 13 to 14, 1981

Time	Depth (m)					
	0	(Direction)	2.5	5	10	15
0834–0900	0.15 (m/s)	0°	– (m/s)	0.01 (m/s)	0.01 (m/s)	0.01 (m/s)
0930–0950	0.14	6°	0.04	0.01	0.01	0.01
1029–1045	0.09	5°	0.08	0.01	0	0.01
1132–1155	0.10	34°	0.09	0.02	0.02	0.01
1230–1258	0.11	62°	0.12	0.01	0.06	0
1329–1353	0.11	86°	0.08	0.01	0.04	0
1429–1451	0.13	110°	0.08	0.01	0.04	0.01
1528–1552	0.17	112°	0.08	0.01	0.03	0.01
1629–1656	0.29	112°	0.13	0.01	0.01	0.06
1728–1752	0.39	114°	0.16	0.02	0.02	0.03
–	–	–	–	–	–	–
1927–1953	0.29	135°	0.18	0.01	0.03	0.01
2030–2102	0.33	118°	0.10	0.01	0.01	0.01
2128–2152	0.26	143°	0.03	0.01	0.01	0
2230–2250	0.16	174°	0.01	0.01	0	0
2328–2349	0.13	184°	0.05	0.01	0.01	0
0036–0057	0.15	195°	0.01	0.01	0.01	0.01
0130–0159	0.14	209°	0.01	0.01	0.01	0.05
0229–0259	0.11	212°	0.01	0.01	0.01	0.01
0329–0353	0.10	245°	0.01	0.01	0.01	–
0429–0452	0.17	335°	0.04	0.02	0.03	–
0530–0554	0.20	355°	0.03	0.03	0.06	–
0624–0646	0.21	344°	0.03	0.06	0.07	–
Average	0.18		0.07	0.01	0.02	0.01

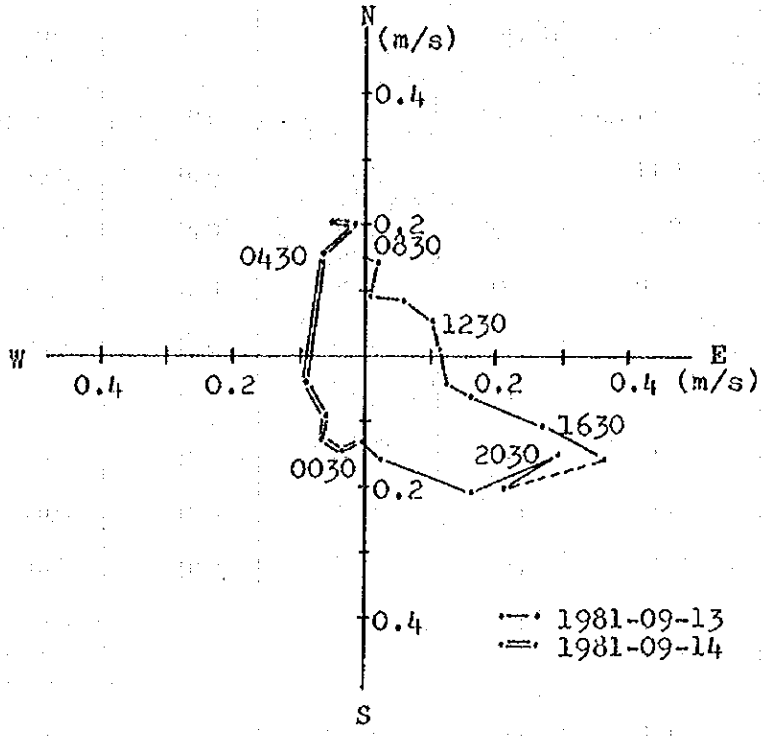


Figure 8. Current velocity and direction in the surface layer (0 m) off Damortis on Sept. 13 to 14, 1981

2. The proposed site off Port Sual

The physical environmental survey in the proposed site off Port Sual was conducted on and near Adela Rock which is situated about 1 Km northeast (NE) of Tobuan, Labrador, Pangasinan (Fig. 9).

Based on the survey, the project site has an almost flat sea bottom which is generally composed of silt and fine sand (Table 6). Deep incline from 0.2 % to 1.4 % is observed toward north (Fig. 10). This area is located 450 m north from Adela Rock and 250 m southeast by south (SE/S) from the nearest scaffold of lift net.

Current velocity and direction were measured every hour from 3:30 PM on July 30 to 2:30 PM on July 31, 1981 at station 11 (Table 7). Maximum current velocity was 0.18 m/s (0.35 knots) on the sea surface, 0.12 m/s (0.23 knots) in the mid-water (4.5 m deep) and 0.15 m/s (0.29 knots) on the sea bottom (9.0 m deep). Average velocity was 0.12 m/s (0.23 knots) on the sea surface and 0.05 m/s (0.10 knots) in the mid-water and on the sea bottom.

Based on the measurement taken, the water current flows mostly northward on the sea surface along Portuguese Pt. that is, 20 of the 24 observations showed the flow going in a direct angle of eighty degrees from northwest by north (NW/N) to northeast (NE). As time goes, a counterclockwise shift is shown in the changes in current direction (Fig. 11).

On the sea bottom (9 m deep), one half of the 24 observations showed a flow going south and one third showed the pause of the flowing and one sixth showed a flow going north. During the observations, a current going south is dominant in flowing duration, but the velocity of the current going north is faster than the one going south (Fig. 11).

It is noted that in the mid-water layer (4.5 m deep), there exists a current flowing into and out of Port Sual. It is believed that if the reef was placed here that it would not be carried away by the current, however, it may be covered by the silt which is carried by the current.

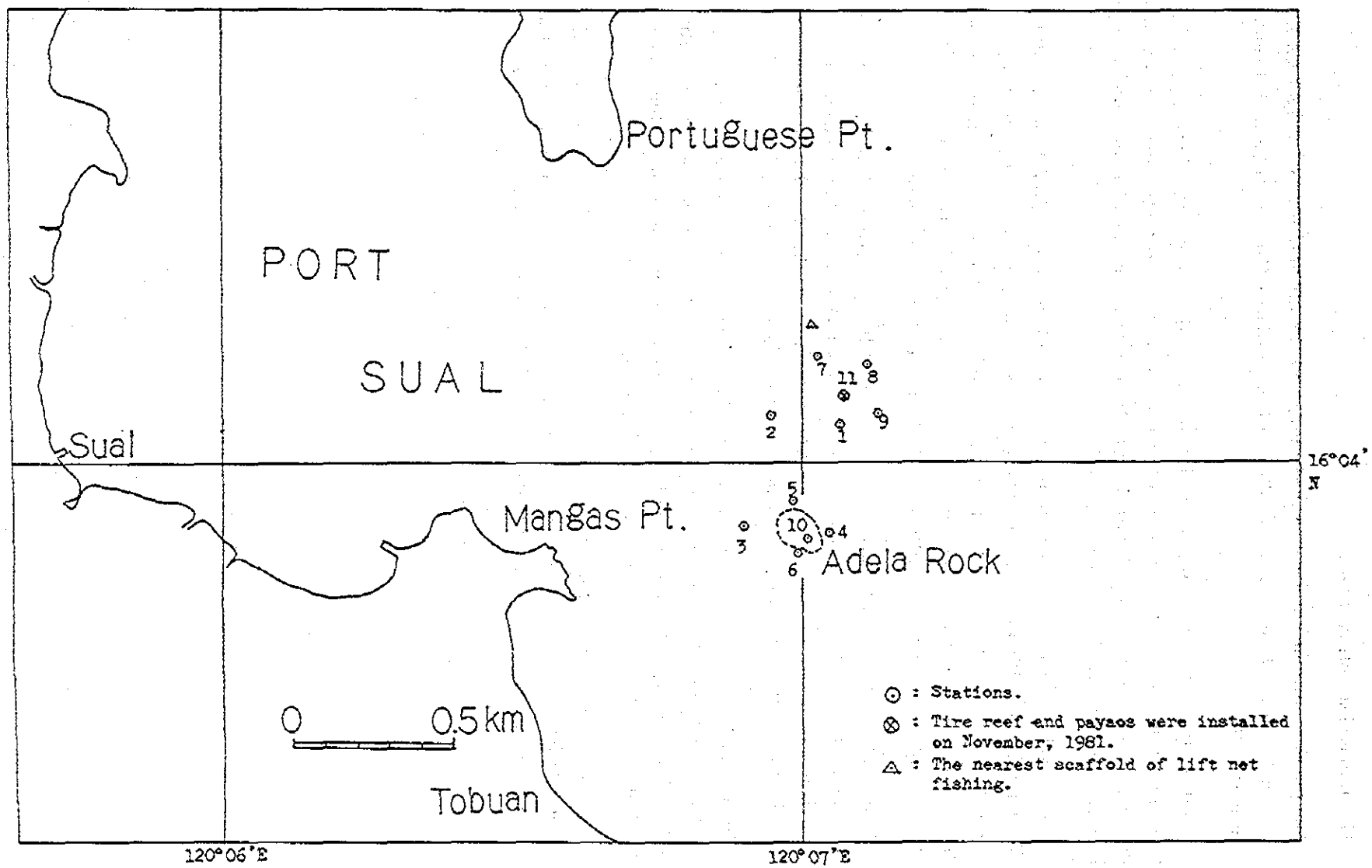


Figure 9. Stations and the test installation site off Port Sual, Sual, Pangasinan

Table 6. Depth and bottom character at each station off Port Sual, Pangasinan

Station No.	Depth (m)	Bottom Character	Remarks
1	9.5	Silt & Fine Sand	
2	11.0	Silt & Fine Sand	
3	6.0	Silt & Fine Sand	
4	7.0	Silt & Fine Sand	
5	8.0	Silt & Fine Sand	
6	6.0	Silt & Fine Sand	
7	12.5	Silt & Fine Sand	
8	11.5	Silt & Fine Sand	
9	9.5	Silt & Fine Sand	
10	3.5	Rock	on Adela Rock
11	9.5	Silt & Fine Sand	Current condition was measured.

Table 7. Current velocity and direction in different layers off Port Sual, Pangasinan on July 30 to 31, 1981

Time	Depth (m)					
	0	(Direction)	4.5	(Direction)	9.0	(Direction)
1530	0.07 (m/s)	–	0.10 (m/s)	–	0.02 (m/s)	–
1630	0.16	120°	0.10	340°	0.02	240°
1730	0.12	90°	0.04	333°	0.03	140°
1830	0.16	45°	0.01	90°	0.05	188°
1930	0.14	43°	0.16	15°	0	–
2030	0.13	38°	0.03	60°	0	–
2130	0.12	10°	0.04	55°	0	–
2230	0.13	353°	0.05	330°	0	–
2330	0.13	–	0.12	–	0.15	–
0030	0.12	340°	0.12	264°	0.11	30°
0130	0.08	5°	0.09	260°	0.15	40°
0230	0.07	10°	0.08	240°	0.10	40°
0330	0.10	15°	0.05	275°	0	–
0430	0.04	342°	0	–	0	–
0530	0.07	15°	0	–	0.04	170°
0630	0.17	12°	0	–	0	–
0730	0.16	27°	0	–	0.08	180°
0830	0.15	–	0	–	0.13	–
0930	0.17	360°	0.06	50°	0.07	220°
1030	0.13	360°	0.04	55°	0.05	190°
1130	0.11	344°	0.02	64°	0.07	210°
1230	0.13	332°	0.05	60°	0.02	210°
1330	0.13	325°	0.06	77°	0	–
1430	0.02	283°	0.05	25°	0.02	250°
Average	0.12		0.07		0.05	

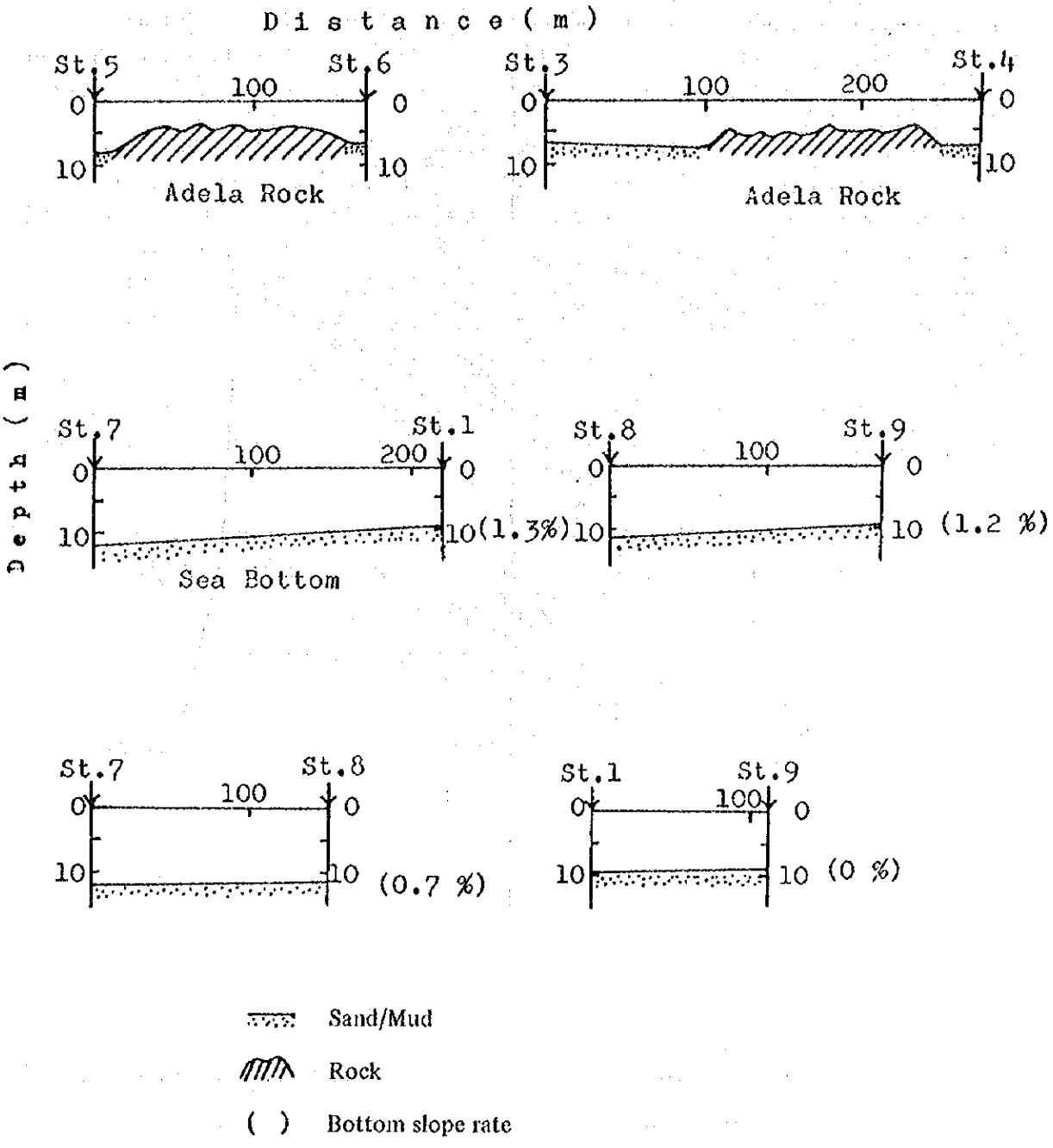
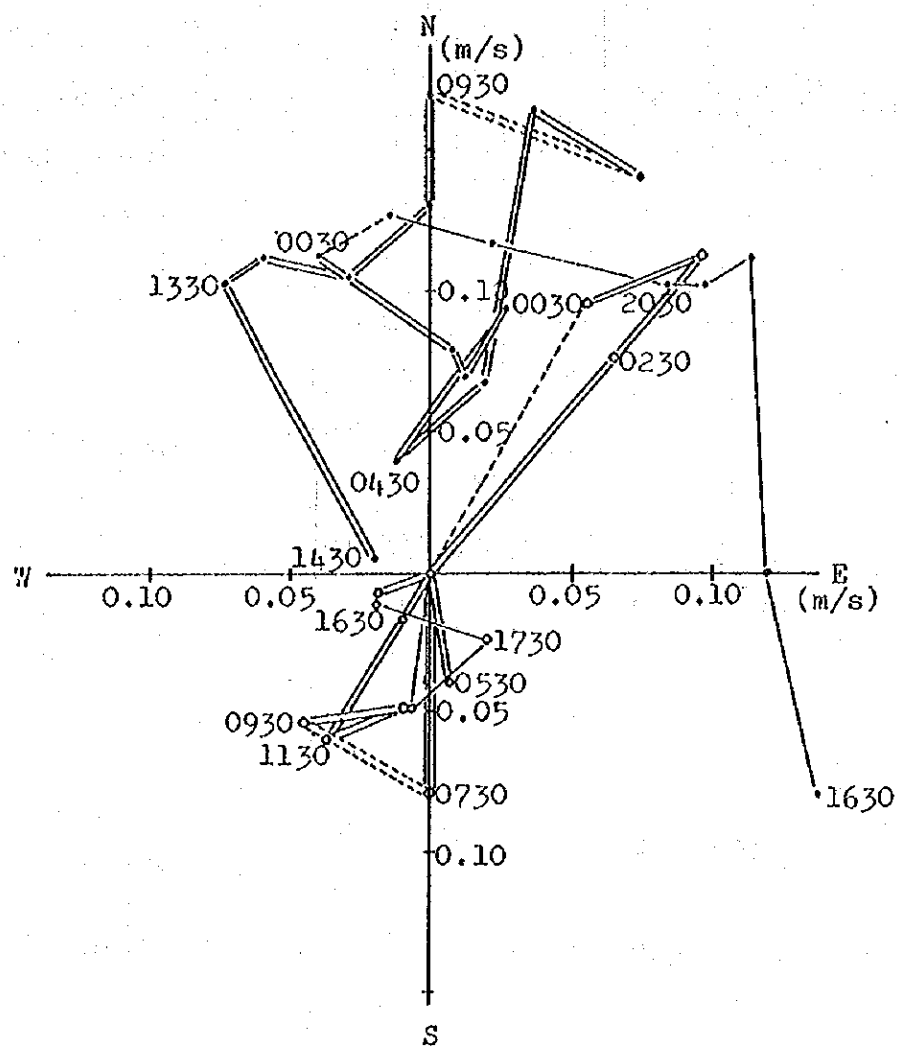


Figure 10. Bottom topography at the project site off Port Sual, Pangasinan



Surface layer(0 m deep)

·——· 1981-07-30

·═══· 1981-07-31

Bottom layer(9 m deep)

∘——∘ 1981-07-30

∘═══∘ 1981-07-31

Figure 11. Current velocity and direction in the surface layer (0 m) and on the bottom layer (9 m) off Port Sual on July 30 to 31, 1981

3. The proposed site in Canal Bay

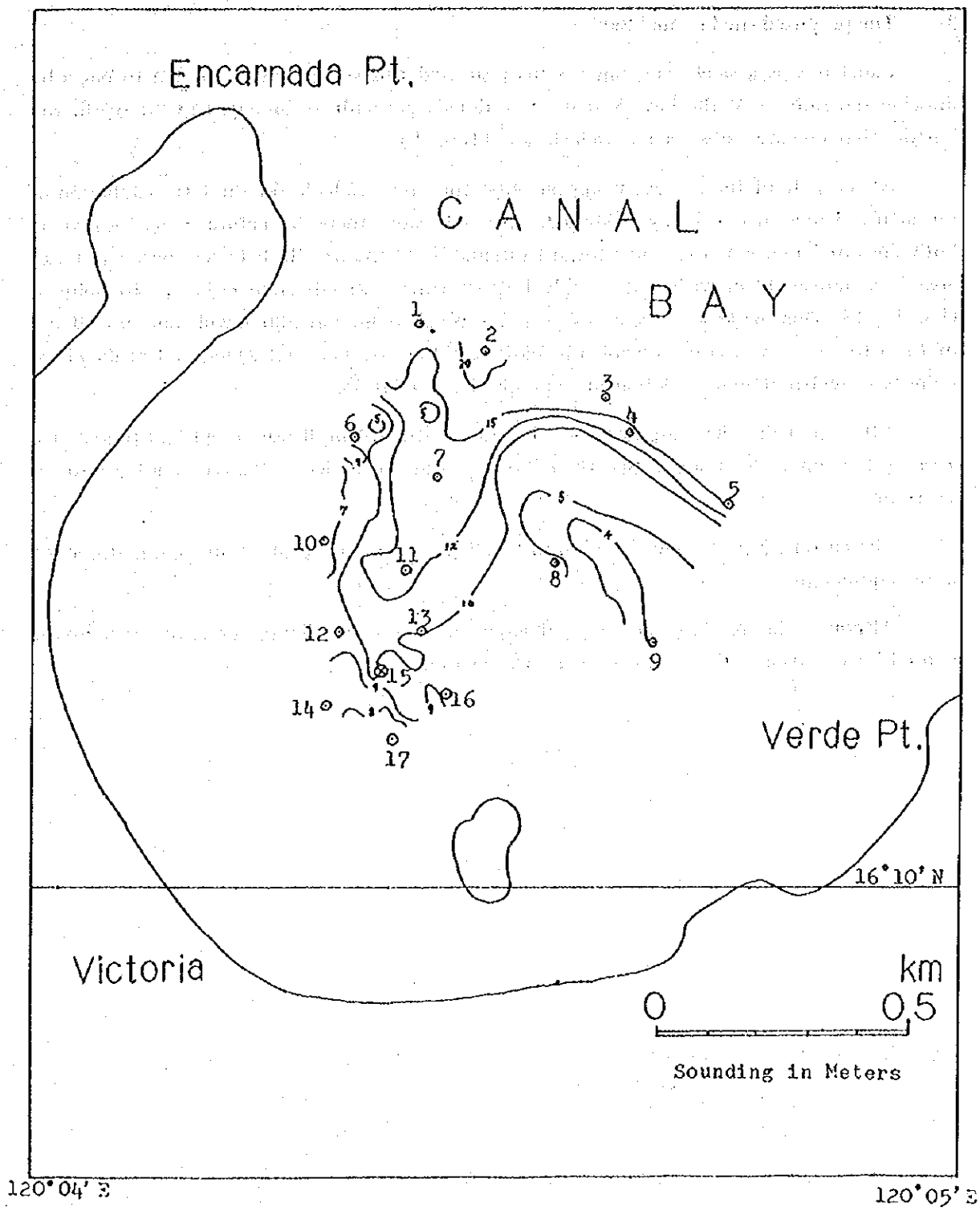
Canal Bay is a small bay, but no chart showed this site in detail. We had to begin by drawing the isobath of the bay. Seventeen stations were built in the bay, and the depth and bottom character were observed at each station (Table 8).

As a result of the survey, it appears that the area available for the test installation of the artificial reef in Canal Bay is limited. This is because there are natural reefs located on both sides of Canal Bay, extending toward the middle of the bay. In between these two locky area is a narrow plain with a flat sandy bottom which extends from point 17 to point 7. (Fig. 12, 13) This flat area, at its narrowest point, is approximately 300 m wide and has a depth of 11 m to 13 m. As you go towards the shore, the flat area becomes wider, and at its widest point has a width of about 1,000 m and a depth of 7 m to 10 m.

After analyzing the samples taken from this narrow plain, it was found that this site has a sandy bottom without silt so that there would be no possibility of the reef sinking into the sea floor.

The current velocity and direction in Canal Bay was not measured due to a malfunction in the equipment.

Although this proposed site is disadvantageous due to the limited area, the area around point 15 was chosen as the test area for the artificial reef.



⊙ Station ⊗ Tire reef and payaos were installed on December, 1981.

Figure 12. Stations and the test installation site in Canal Bay, Alaminos, Pangasinan

Table 8. Depth and bottom character at each station in Canal Bay, Alaminos, Pangasinan

Station No.	Depth (m)	Bottom Character	Remarks
1	17.0	Rough Sand, Shell, Rock	
2	18.0	Fine Sand, Shell	
3	21.0	Sand, Shell	
4	12.7	Sand, Mud	
5	17.0	Shell, Sand	
6	5.5	Shell, Rock, Stone	
7	5.5	Shell, Rock	
8	13.1	Sand, Mud	
9	7.0	Rough Sand, Shell, Rock	
10	11.7		
11	4.5	Coral, Rock, Rough Sand	
12	10.0	Sand	
13	9.5	Fine Sand	
14	10.0	Sand	
15	7.5	Sand	
16	8.0	Sand	
17	9.5	Sand	

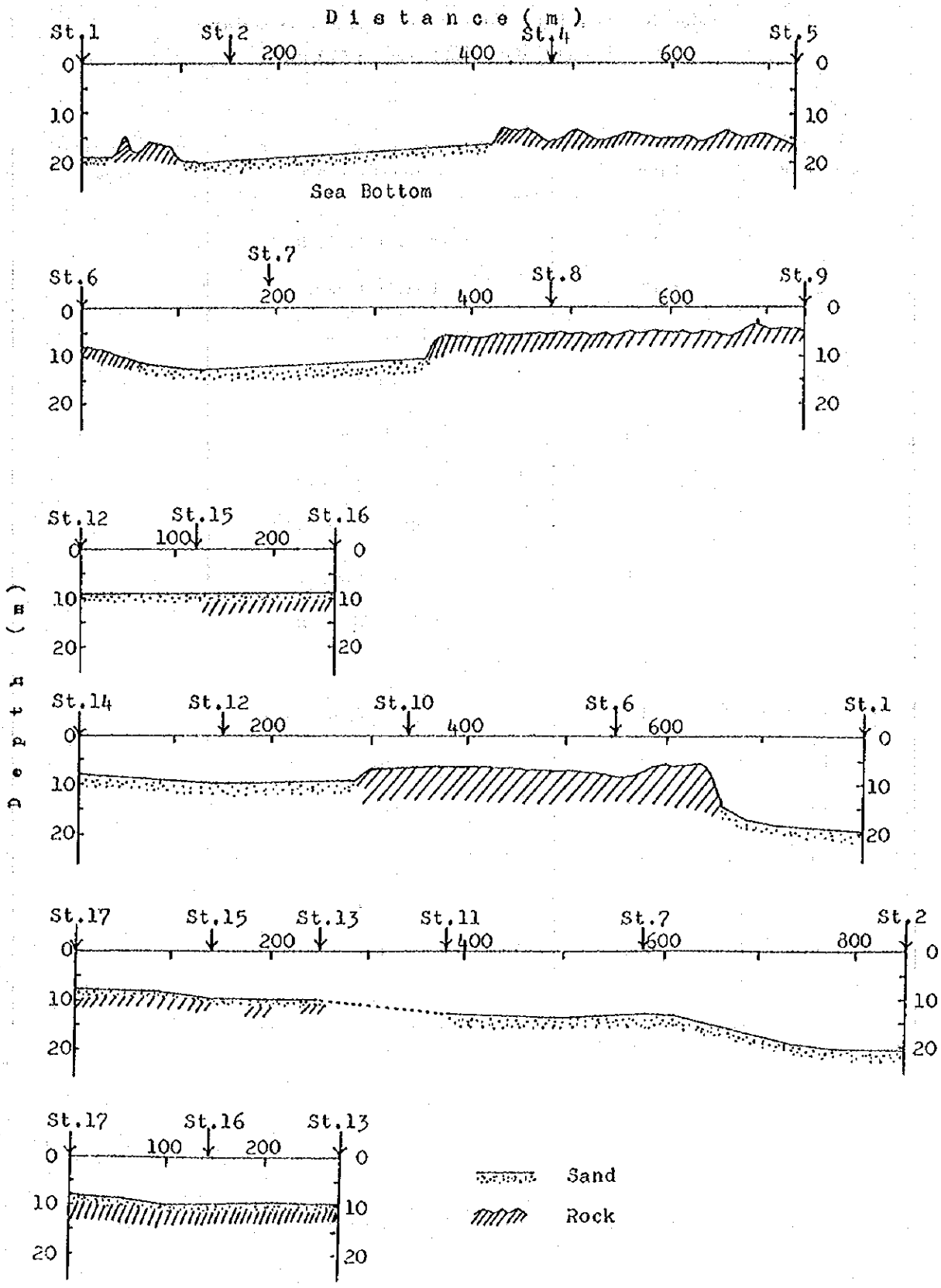


Figure 13. Bottom Topography at the project site in Canal Bay, Alaminos, Pangasinan

CHAPTER III

Test Installations of a Small-Scale Tire Reef and Payaos

Introduction

The ultimate purpose of this project is to establish an ideal artificial reef which will benefit the coastal fishermens' fishing operations. Various essential conditions have been studied by analyzing the study on the municipal finishing areas in Lingayen Gulf. The results from all the proposed sites suggest the possibility that we could establish an effective artificial reef, however, some problems, e.g., sinking of the tire reef into the sea bottom due to a soft bottom . . . off Damortis and off Port Sual, or limited extent of the available area . . . in Canal Bay, remain.

The best suitable site must be chosen for placement of the artificial reef among three proposed sites because of limited funds and time. But it is hard to determine the best site at present because it is not understood which factors are vital and which are not vital ones among the data that has been collected. Therefore it is recommended that a feasibility study is performed by installing a small size artificial reef, experimentally, at each of the three sites and comparing the effectiveness of the reef at each site. This is the best way to realize factors which prevents to establish effective artificial reef, thereby, this is the best way to avoid and minimize the risks.

Materials and Methods

The feasibility study for the artificial reef installation consisted of the test installation of small scale tire reef and payaos*1 at each of the 3 sites and the subsequent evaluation as to which site is the most viable. The evaluation included experimental fishing using a gill net and a diving observation.

1. Test installation of small scale tire reef and payaos

One unit of tire reef was made up of one large size tire (from bus or truck) and three ordinary size tires (from small vehicles). These were lashed together with tire rope and polyethylene rope and ballasted with concrete, which was poured in the sidewall of large size tire. Large holes were punched into the tops of all the ordinary size tires to take out air, as devised by Association for Technology Development on Fisheries and Aquatic Resources in Hokkaido.

One unit of payao was made up of a piece of bamboo about 10 cm in diameter for the float, tire rope, polyethylene rope, shackle and swivel to connect the tire unit with the payao. Four to six coconut leaves were connected to the polyethylene rope. The length of the polyethylene rope varied, depending on the depth of the water. (Fig. 14)

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*1 Payao: Fish gathering apparatus composed of bamboo, coconut leaves, ropes and sinkers. This is popularly used by purse seiners in the Philippines.

Fifteen units of the tire reef including three payaos were installed at each of three proposed sites; off Damortis, off Port Sual and in Canal Bay. Numerous trips were needed to place all of the tire units. At first trip to each site, a tire reef unit with a payao was placed by dropping it overboard. This unit then acted as an anchor for our boat, so that the rest of the tire units could be dropped as closely as possible to the tire unit with the payao. The units were not tied together. To make these small units into a large solid unit under the water is one of the important techniques for these small artificial reef units so that they will attract fish.

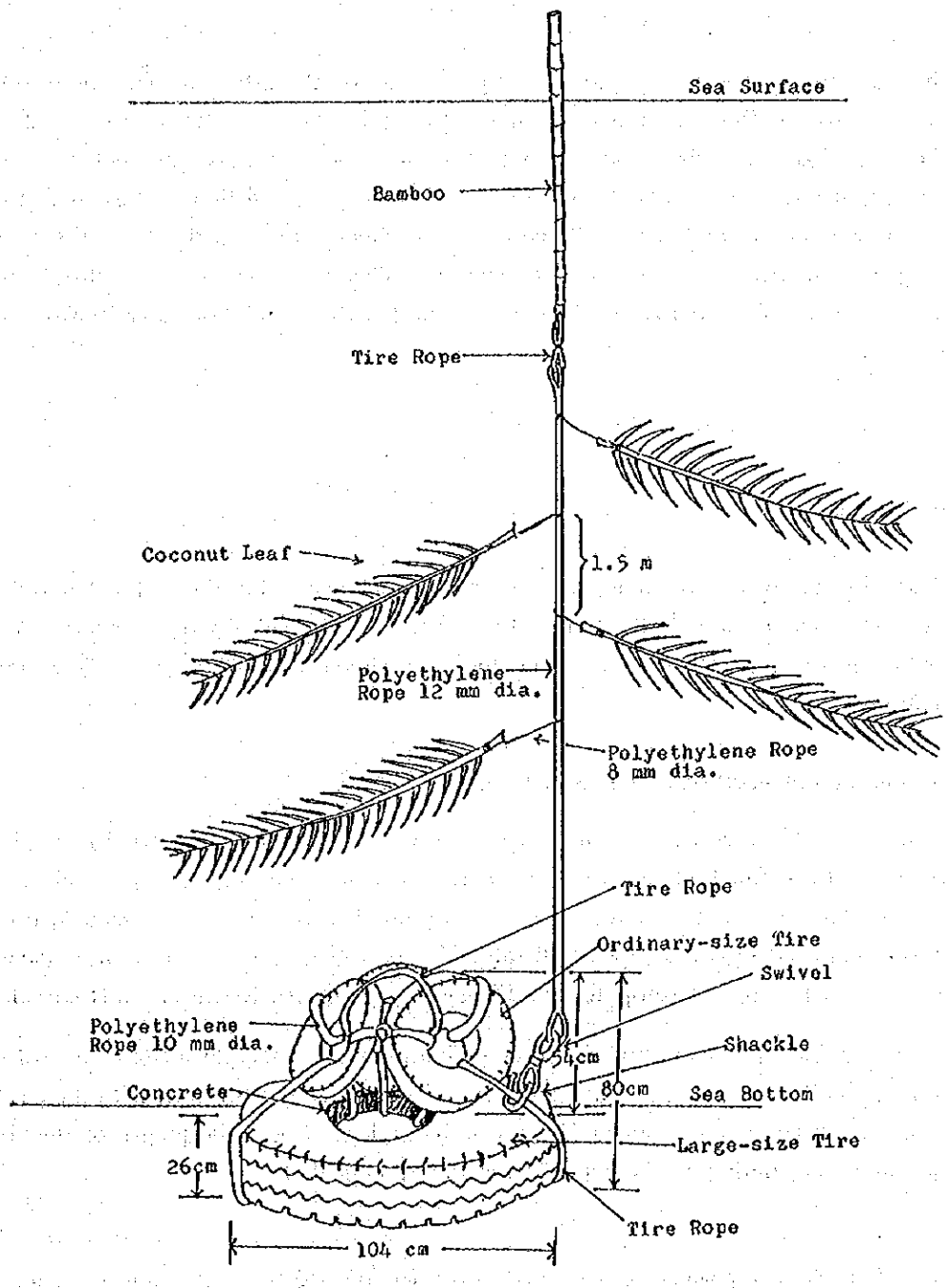


Figure 14. Structure of a unit of tire reef with a payao

2. Evaluation of the test installation

Experimental fishing was conducted to evaluate the effectiveness of the test installations of small-scale tire reef and payaos at the three project areas. This was conducted before and after the test installations were placed with the use of a bottom set gill net. It is possible to discuss the effectiveness of the artificial reef in attracting fish through comparing the result of the experimental fishing, although it is necessary to consider the differences due to the fluctuation of fishery stocks caused by fishing seasons and fish migration etc. During fishing operations, oceanographic and meteorological investigations were done simultaneously to determine the environmental differences in the three project areas.

Scuba diving was used for the underwater observations. The observations made while diving were recorded on plastic writing slates. An underwater camera (Nikonos III) was used for taking pictures of the tire reef, payaos, and fish attracted to the tire reef site. Other instruments used during the diving were a 50-meter tape measure for recording distance between tire units, and a graduated bamboo stick for measuring the depth of the bottom sediment.

The items to be observed were as follows;

1) Underwater formation of the tire reef consisting of fifteen tire units including three payaos.
2) Sinking of the tire reef into the sea bottom.
3) Condition of the payaos.
4) Sessile organisms attached on the tire reef and the payaos.
5) Fish attracted to the tire reef and the payaos.

At the same time, additional oceanographic and meteorological investigations are done.

Result

1. The project site off Damortis

Fifteen units of tire reef and three payaos were installed on November 6, 7 and 10, 1981 in the center of the triangle formed by the three stations No.8, 9, 10 where the water is 13 m deep and the bottom character is silt and fine sand. (Fig. 6)

We went fishing repeatedly before and after the test reefs were installed. This experimental fishing using a gill net was conducted within a 1.5 km radius around the test installation site except experiment No.5 which was conducted beyond the tire reef site. (Table 9) The accurate measurement in weight of catch was not done in the experiment 4 and 5, therefore, these catch were not added to the statistics.

During the experimental fishing, the bottom set gill net was always set from north to south or south to north in the fishing area due to the water current and wind directions. Fish-

ing duration, which starts when the all gill nets are completely cast in the water and then ends when the net is begun to haul up, was 35 minutes on the average before the test installation and 34 minutes after the test installation of fifteen units of tire reef and three payaos. Mesh sizes of the gill nets used were 6, 6.5 and 7 knots, and one unit of gill net was about 50 meters long and 50 meshes deep.

Catch Per Unit Effort (CPUE) in table 9 is computed as follows;
CPUE (g/unit) = Weight of catch in grams ÷ Number of nets used

Average CPUE in the project area off Damortis is 405 g/unit before the test installation (except experiment No.4) and 178 g/unit after the test installation (except experiment No.5).

This CPUE is not modified with the selectivity in catch due to differences in mesh size. This decrease in average CPUE seemed to be caused by seasonal fluctuation of fishery stocks. The experimental fishing before the test installation was conducted during the rainy season and the experimental fishing after the test installation was conducted during dry season. The catch from a bottom set gill net is usually more abundant in rainy season than in dry season according to fishermen's experiences. This result shows that small-scale artificial reef and payaos installed in the site can not compensate for the seasonal density fluctuations of the fishery stocks off Damortis.

Out of the 13 kinds of fishes and crustaceans caught before the test installation of the artificial reef, Indian mackerels, moonfish, crabs and jacks were the dominant species. On the other hand, out of the 22 kinds of fishes and crustaceans caught after the test installation, prawns, shrimps, crabs and slipmouths were the most dominant species in the project area (Fig. 15). The fish caught before the test installation were generally pisivorous and migratory species such as jacks and mackerels, while after the test installation, the fish caught were generally benthic feeders such as prawns, shrimps, crabs and slipmouths.

According to the oceanographic and meteorological investigations during experimental fishing, the sea condition tended to be rough, generally, in the afternoon due to northwest monsoon, with the surface water current going southwards.

The diving observations at the project site off Damortis were held on November 30, and December 1, 1981, 20 days after the installation and on March 17, 1982, four months after the installation.

Underwater formation of all fifteen units of tire reef with three payaos was observed (Fig. 16). The length of distribution/formation of the fifteen tire units was about 44 m from north to south. The width of the area, from east to west, was about 20 m. Thirteen units of tire reef out of fifteen had sunk 15 cm into the ground 20 days after the installation. When the 2nd observation was made on March 17, 1982, (4 months after instilation) one tire reef unit out of five had its base tire completely sunk into the bottom (Fig. 17(B)-II), and the other four tire reef units also had more than two-thirds of their base tires sunk (Fig. 17(B)-I). When divers placed the graduated bamboo stick into the bottom, it measured a silt layer of from 1.8 m to 2.4 m. The surface of the tire units were covered with sponges and filamental algae. All leaflets of the coconut leaves of the payaos were gone except for the midribs of them.

Poor visibility prevented the divers to observe many species of fish. They noted nine species of fish during their observations (Table 10-1, 10-2). Among the fish observed at this site, jacks and slipmouths are important for fishing purposes. School of jacks were swimming, mostly in the mid-water around the payaos. It was observed that some of jacks were pecking the jellyfish around the payao. The sizes of the jacks observed were about 10 cm total length on December 1, 1981 and from 15 to 20 cm total length on March 17, 1982.

Table 9. Results of the gill net experimental fishing in the project area off Damortis

Ex. No.	Date	Fishing Duration (min.)	Mesh Size (knots)	No. of Units of Gill Net Used	Catch in Weight (g)	CPUE (g/unit)	Remarks
1.	1981-10-20	1725-1805(40)	6.5 7.0	5 3) 8	3,630 2,560) 6,190	774	before the installation
2.	1981-10-23	1729-1800(31)	6.5 7.0	5 5) 10	750 1,200) 1,950	195	before the installation
3.	1981-10-25	1710-1745(35)	6.5 7.0	5 13) 18	1,440 3,020) 4,460	248	before the installation
4.	1981-10-26	1745-1815(30)	6.5 7.0	5 6) 11	(2,500)	–	before the installation
		@(35)			Total 12,600*	@405	
5.	1982-01-24	1736-1814(38)	6.0 6.5	15 5) 20	(4,500) approximation	–	after the installation
6.	1982-01-25	0532-0617(45)	6.0 6.5	5 5) 10	1,445	145	after the installation
7.	1982-01-26	0542-0612(30)	6.0 6.5	5 5) 10	2,140	214	after the installation
8.	1982-01-26	1753-1802(27)	6.0 6.5	12 5) 17	1,450	85	after the installation
9.	1982-01-28	0547-0613(26)	6.0 6.5	12 5) 17	2,395	141	after the installation
10.	1982-01-29	0539-0617(38)	6.0 6.5	12 5) 17	5,490	323	after the installation
11.	1982-01-39	0547-0619(32)	6.0 6.5	12 5) 17	2,690	158	after the installation
		@(34)			Total 15,610**	@178	

* : Excluded the catch in Ex. No. 4
** : Excluded the catch in Ex. No. 5

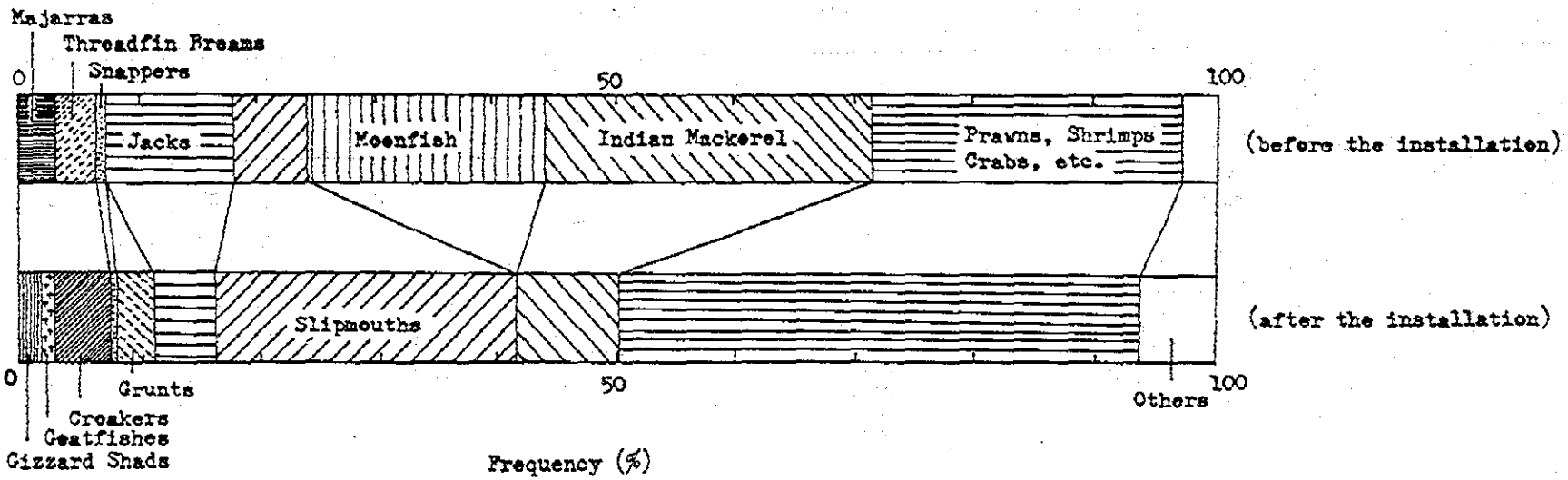


Figure 15. Composition of the fish caught in weight by the gill net experimental fishing conducted before and after the test installation off Damortis, Sto Tomas, La Union

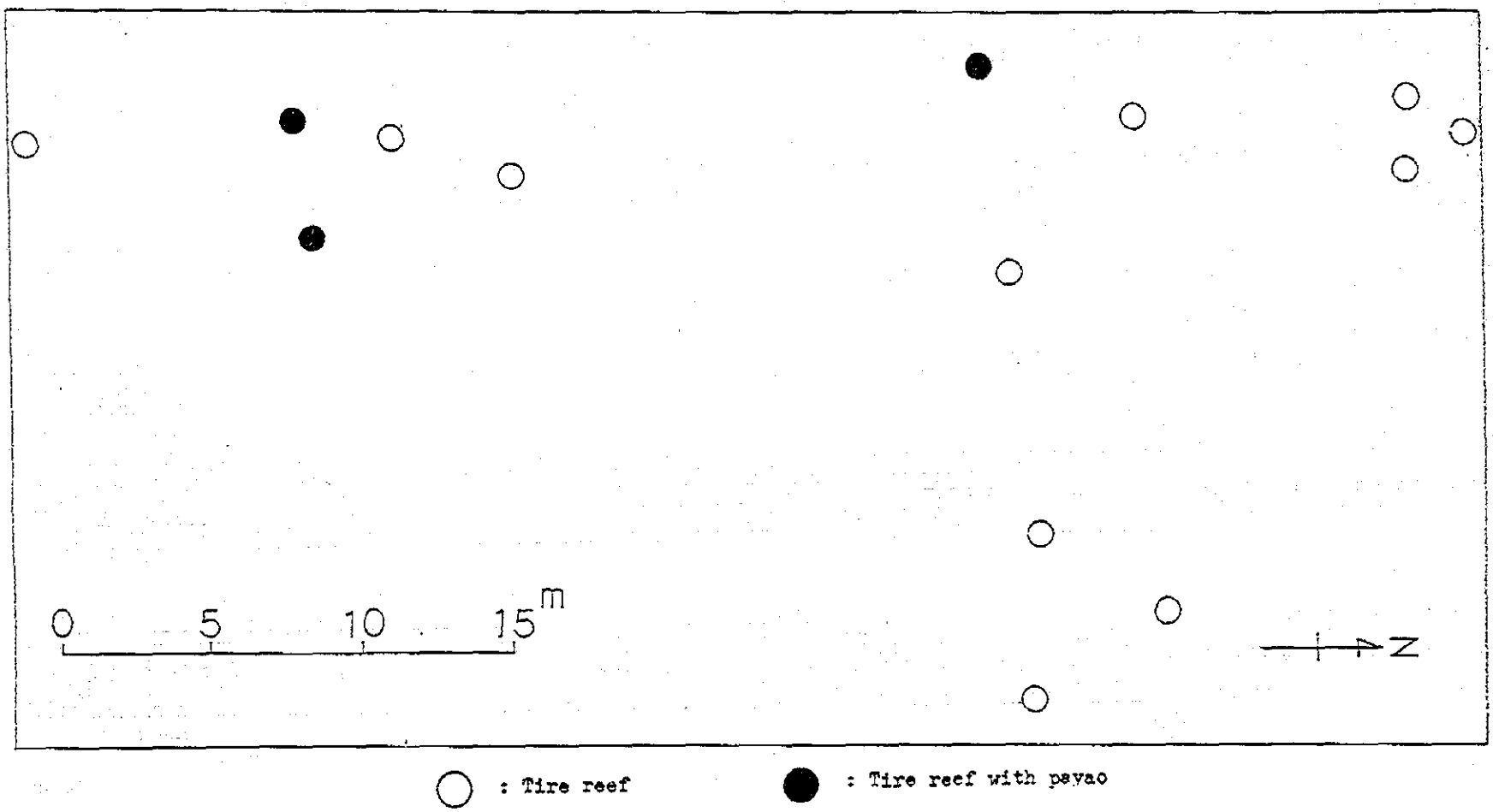
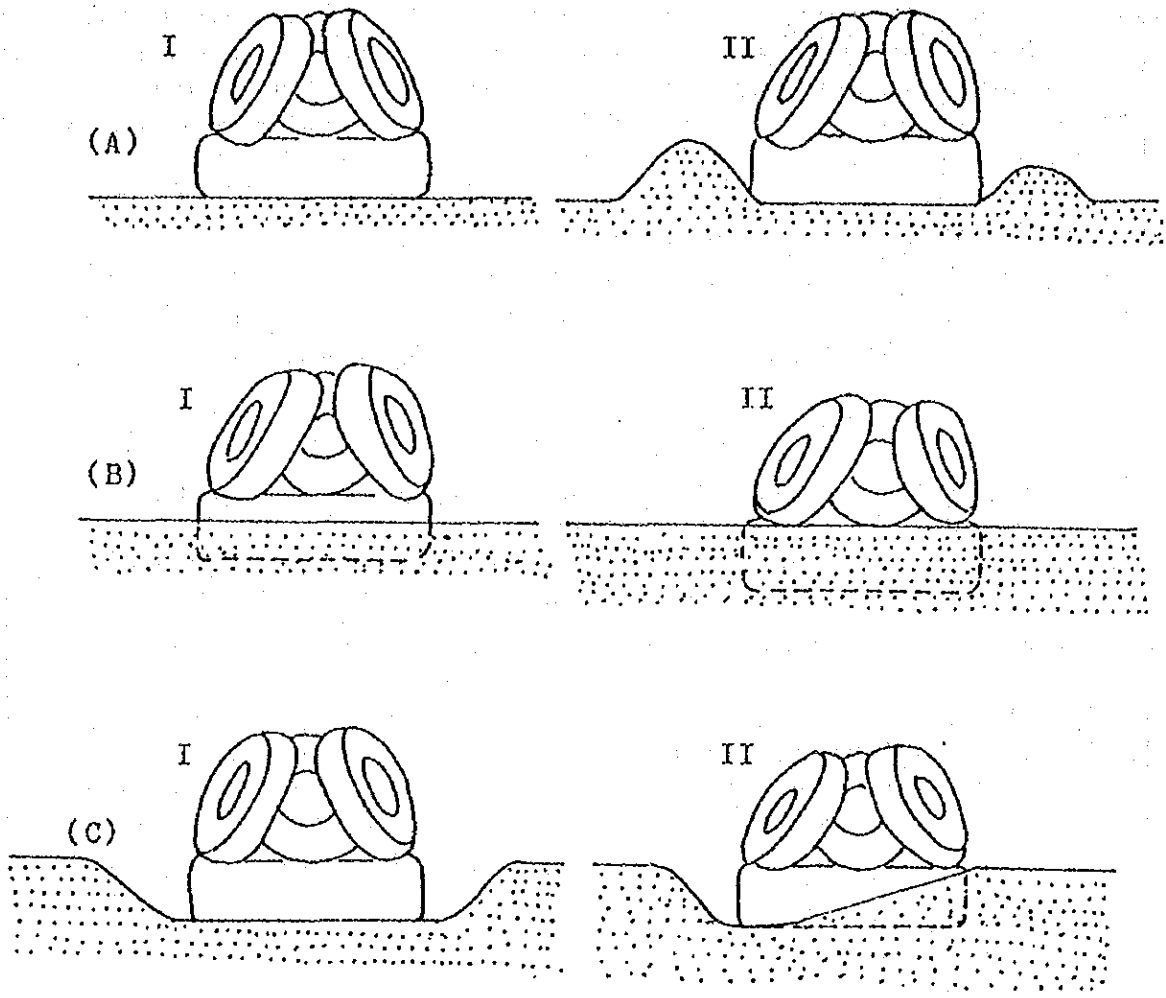


Figure 16. Underwater formation of the tire reef with payaos off Damortis, Santo Tomas, La Union



(A) : No sinking
(B) : Partially sunk
(C) : Base of tire reef was sunk into a depression

Figure 17. Classifications of the sinking conditions of the tire reef

Table 10-1. The fish observed by the divers in the test installation site off Damortis on Nov. 30 and Dec. 1, 1981. (20 days after the reef installation)

English Name	Scientific Name	Quantity*	Size (cm)	Remarks
• Jack	*Caranx* sp.	+++	10	around payao 0–6 m deep
Damselfish	*Abudefduf valgiensis*	+		in the coconut leaves
Cardinalfish	*Apogon amboinensis*	+		in the coconut leaves
• Snapper		–		in the space of the tire reef
Puffer		–		over the tire reef

* : +++ many
++ 20–30 pcs.
+ 5–20 pcs.
– 5> pcs.

• : Economically important fish

Table 10-2. The fish observed by the divers in the test installation site off Damortis on March 17, 1982. (4 months after the reef installation)

English Name	Scientific Name	Quantity*	Size (cm)	Remarks
Cardinalfish	*Apogon amboinensis*	+	3	
• Jack	*Caranx* sp.	+++	10–15	around the payao
• Slipmouth	*Leignathus* sp.	+++	6	below the surface water
Blenny	*Metacanthus grammistes*	–	6	on the payao
Damselfishes	*Abudefduf valgiensis*	+	1	around the bamboo of payao
	Neopomacentrus sp.	–	3	inside of the tire reef
Frogfish	*Antennarius* sp.	–	10	inside of the tire reef

* : +++ many
++ 20–30 pcs.
+ 5–20 pcs.
– 5> pcs.

• : Economically important fish

2. The project site off Port Sual

Fifteen units of tire reef and three payaos were installed at station 11 on November 19 and 20, 1981 (Fig. 9). Experimental fishing with bottom set gill nets was conducted around the test site off Port Sual before and after the test installation, respectively from October 7 to 10, 1981 and from February 8 to 13, 1982 (Table 11).

The experimental fishing using gill nets was done three times before the test installation and nine times after the installation within about a 300 meters radius around the test installation site. During the experimental fishing, a bottom set gill net was always set from north to south or south to north in the fishing area due to the water current and wind directions. Fishing duration on the average was 25 minutes before the test installation and 24 minutes after the test installation. The mesh size of the gill nets used were 6.5 and 7.5 knots, and one unit of the net was about 50 meters long and 50 meshes deep.

Average CPUE resulting from the experimental fishing is 403 g/unit before the test installation and 79 g/unit after the installation. The decrease in CPUE is attributed to the same reason as mentioned in the results of the experimental fishing held off Damortis.

As for the composition of the fish caught during the experimental fishing, out of 12 kinds of fish and crustaceans caught before the test installation, jacks were the most dominant, followed by grunts and snappers as the second dominant species. After the installation, out of 15 kinds of fish and crustaceans caught, jacks and slipmouths were the dominant species, and gizzard shads, grunts, cutlassfishes and crabs were the second dominant species in this area (Fig. 18).

Most of jacks were caught within 50 meters radius around the artificial reef after the installation. However, the relation between the frequency of appearance in catch of fish and the swimming range from the artificial reef was not clear because of incomplete data.

From the result of oceanographic and meteorological investigations, the wind tended to blow from the southeast in the morning and to the north in the afternoon during the experimental fishing held after the test installation. The water current flowed to the north in the morning and to the south in the afternoon during the same testing period.

The diving observations at the project site off Port Sual were held on March 14, 1982, about four months after the tire reef had been installed. Underwater formation of all the fifteen tire units with three payaos was observed (Fig. 19). The length of distribution of the fifteen tire units was about 25 m from east to west. The width from north to south was about 10 m.

The tire reef was divided by two groups (I, II) and four other individually located units. Group (I) consisted of seven tire units including one with a payao, and group (II) consisted of four tire units.

The bases of eleven tire units had sunk into depressions due to their weight and soft bottom. The depressions could be roughly classified into two types. One type is that the tire reef was totally sunk into a depression (Fig. 17 (C)-I). In the other type, it was partly sunk into a depression (Fig. 17(C)-II). Some of the depressions were deeper (15–45 cm deep) than the width of the base tires. Some tire units had partially sunk into the bottom. In these cases, too, the tire units had sunk into depressions and were covered by silt. Bottom sediments in the site had a depth of about 30 cm. The surface of the tire reef was covered by filamental algae. Sponges and hydroids were also observed on the tire reef.

All leaflets of coconut leaves of the payaos were gone except for their midribs. Filamental algae covered the bamboo, rope and midribs of the coconut leaves of the payaos. Many hydroids were attached on the bamboo and ropes of the payaos.

Divers recorded twenty species of fish during the observation (Table 12). Among them, snappers were the most useful species for fishing purposes in their number and size. The average size was about 15 cm in total length. Schools of snappers were mostly seen around two groups (I, II) of the tire units. They were swimming over and inside tire units.

The biggest fish recorded was a grouper reaching approximately 60 cm in total length which was swimming beside the tire units. However, most of the groupers recorded were juveniles and a number of them were not very large. Schools of jacks were observed swimming around the payaos. These were not yet suitable size for harvesting since their size was 5 to 8 cm in total length.

Other notable fish recorded in this site were parrotfish, batfish, scat and rabbitfish, but they were small in number. Damselfish and cardinalfish which were dominant in number, were seen swimming over the tire reef.

Table 11. Results of the gill net experimental fishing in the project area off Port Sual

Ex. No.	Date	Fishing Duration (min.)	Mesh Size (knots)	No. of Units of Gill Net Used	Catch in Weight (g)	CPUE (g/unit)	Remarks
1.	1981-10-07	1844-1858(14)	6.5	5	900	180	before the installation
2.	1981-10-08	1815-1835(20)	65.	5	1,750	350	before the installation
3.	1981-10-09	1803-1845(42)	6.5	5	3,390	678	before the installation
		@(25)			Total 6,040	@403	
4.	1982-02-08	1802-1826(24)	6.5 7.5	5 2) 7	455 160) 615	88	after the installation
5.	1982-02-09	0623-0642(19)	6.5 7.5	5 2) 7	370 20) 390	56	after the installation
6.	1982-02-09	1808-1840(32)	6.5 7.5	5 2) 7	530 0) 530	76	after the installation
7.	1982-02-10	0555-0617(22)	6.5 7.5	5 2) 7	750 530) 1,280	183	after the installation
8.	1982-02-10	1735-1817(23)	6.5 7.5	5 2) 7	10 260) 270	39	after the installation
8. 9.	1982-02-11	0542-0607(25)	6.5 7.5	5 2) 7	270 55) 325	46	after the installation
10.	1982-02-12	0559-0623(24)	6.5 7.5	5 2) 7	450 120) 570	81	after the installation
11.	1982-02-12	1753-1816(23)	6.5 7.5	5 2) 7	175 185) 360	51	after the installation
12.	1982-02-13	0549-0612(23)	6.5 7.5	5 2) 7	50 610) 660	94	after the installation
		@(24)			Total 5,000	@79	

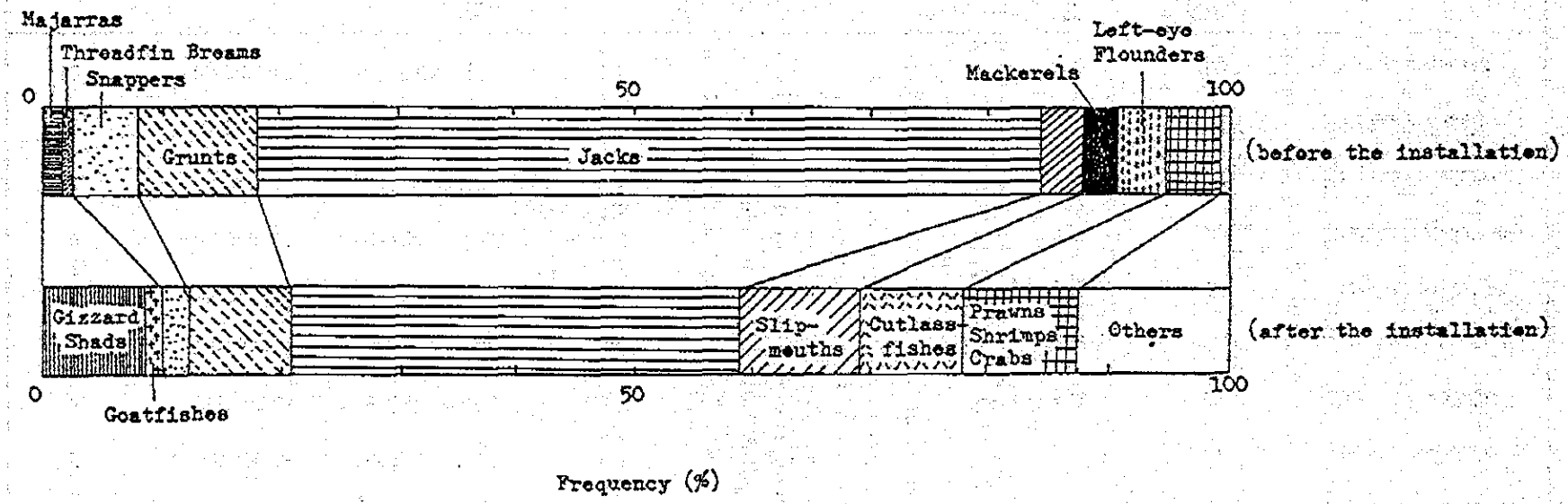
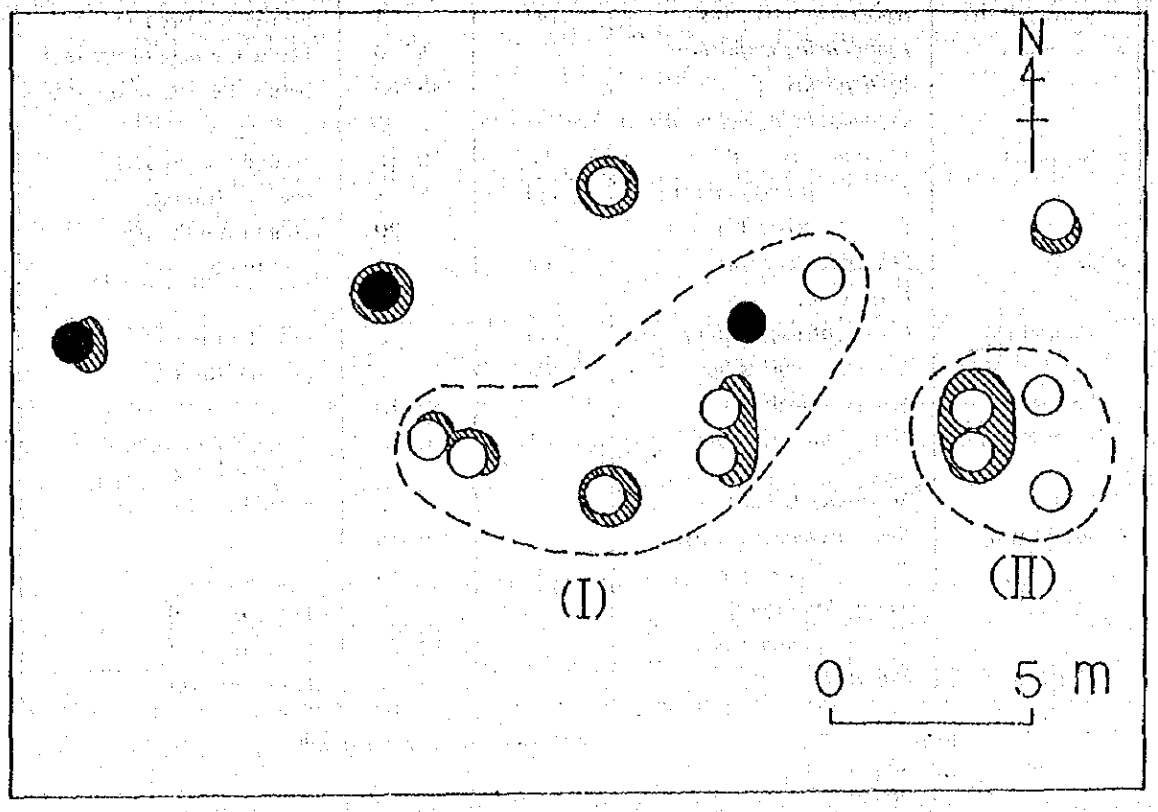


Figure 18. Composition of the fish caught in weight by the gill net experimental fishing conducted before and after the test installation off Port Sual, Sual, Pangasinan



○ : Tire reef

● : Tire reef with payao

◌ : Group of tire reef

▨ : Base of tire reef is sunk into depression.

Figure 19. Underwater formation of the tire reef with payaos off Port Sual

Table 12. The fish observed by the divers in the test installation site off Port Sual on March 14, 1982.

English Name	Scientific Name	Quantity*	Size (cm)	Remarks
• Goatfish	*Upeneus tragula*	+	10	
Cardinalfish	*Apogon amboinensis*	+++	3	in/over the tire reef
• Groupers	*Epinephelus sexfasciatus*	+	5–10	beside the base of tire reef
	Epinephelus sp.	–	30–60	beside the base of tire reef
	Cephalopholis pachycentron	+	5	
• Snappers	*Lutjanus ruselli* (?)	++	10–15	around the tire reef
	L. lineolatus (?)	+++	5– 8	over the tire reef
	L. sebae (?)	–	20	around the tire reef
• Jacks	*Selaroides leptolepis*	++	5	over the tire reef
	Caranx sp.	–	8	
Damselfish	*Pomacentrus philippinus*	+++	3	over the tire reef
	Neopomacentrus sp.	++	2	over the tire reef
Parrotfish	*Scarus gobban*	–	10	
• Batfish	*Platx teira*	–	15	beside the minribs of coconut leaves
• Scat	*Scatophagus argus*	–	15	around the tire reef
• Rabbitfish	*Siganus canaliculatus*	–	10–15	
	S. javus	–	15	
Puffers	*Tetraodon hispidus*	–	10	in the tire reef
	T. immaculatus	–	10–20	in the tire reef
Frogfish	*Antennarius* sp.	–	5– 8	in the tire reef

*: +++ many
++ 20–30 pcs.
+ 5–20 pcs.
– 5>

• : Economically important fish

3. The project site in Canal Bay

Fifteen units of tire reef and three payaos were installed at station 15 on December 11 and 12, 1981 (Fig. 12). Experimental fishing with gill nets was conducted around the test installation site 3 times before the test installation and 5 times after the test installation.

Fishing duration on the average was 37 minutes before the test installation and 25 minutes after the test installation. The mesh size of the gill net used was 6.5 knots, and one unit of the net was about 50 meters long and 50 meshes deep.

Average CPUE of experimental fishing before the test installation was not computed because accurate catch in weight was not measured. It is sure, however, that it can hardly reach to 100 g/unit. Average CPUE after the test installation was 368 g/unit. This is an obvious increase in catch of fish after the test reef was installed (Table 13).

In the result of the experimental fishing conducted five times after the test installation, CPUE suddenly increased in experiment Number 8 after the gradual decrease from Number 4 to the Number 7 experiment. Although the differences in the setting of the gill net in each experiment and small sample size (i.e. number of experiment) should be considered, it is

assumed that there were some supplemental schools of jacks coming from other areas to the project site.

Based on the experiments conducted after the installation, out of 5 kinds of fish and one kind of crab caught, about 90% of the catch was composed of jacks (Fig. 20) which were caught, mostly within a 30 m radius of the artificial tire reef. This strongly proves the relation between the schools of jacks and the artificial reef. Rabbitfish and snappers were also caught within a relatively close range of artificial tire reef.

The water current flowed to north in the norming and south in the afternoon during the experiment 4, 5, 6, 7 and 8.

The diving observations were held twice about 3 months after the test reef was installed. During the diving observations, the water was rather clear. Transparency was 9.4 m on March 15, while the sea depth of this site was around 9.5 m. Therefore, the divers were able to look out over the tire reef from a mid-water position. Fifteen units of the tire reef were placed rather densely at this site, as compared with the other two sites (Fig. 21). Length of fifteen units of the tire reef was about 13 m from east to west. Length from north to south was about 10 m.

The depth of bottom sediments in this site is less than 20 cm. Sand mounds made by burrowing organisms were distributed over the area and made the floor uneven. Indeed, the tire units had not sunk into the sea floor, but the sand mounds were found around the tire reef (Fig. 17(A)-II). The surface of the tire reef was covered all over by filamental algae, which in turn was covered with a film of silt.

The coconut leaves of the payaos had kept their form but they were starting to deteriorate. The coconut leaves gave their shade to small fish, and with so much algae attached to the leaves of the payaos. This became food for the fish. We observed rabbitfish grazing on the algae. Other sessile organisms observed on the payaos were barnacles, oysters and hydroids.

Twenty six species of fish were observed in this site during the diving (Table 14). Among the fish observed, jacks were the most commercially important. About fifty jacks whose average length was about 35 cm were observed swimming around the tire reef site.

Snappers were also observed swimming over and inside the tire units. Schools of many small fish such as cardinalfish, butterflyfish and juveniles of fusiliers were swimming around the payao and under the shade made by the coconut leaves. It seems that the payao serves not only as shelter for small fish but also as a nursery for the juveniles of some species.

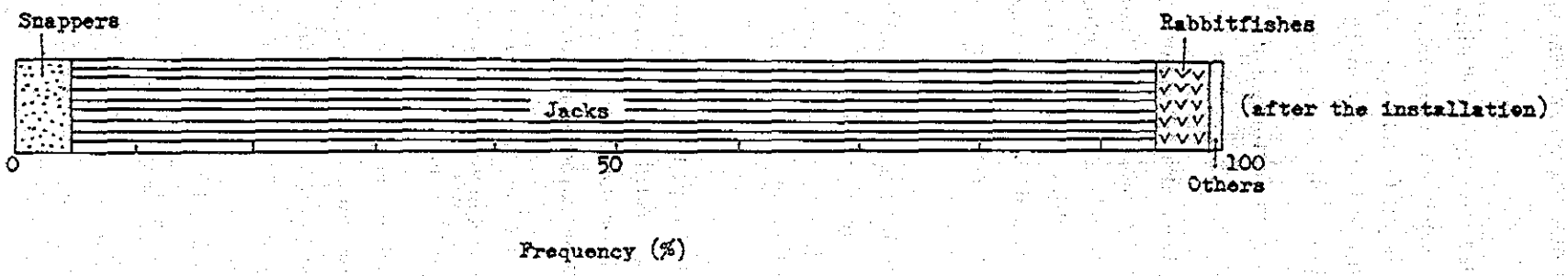
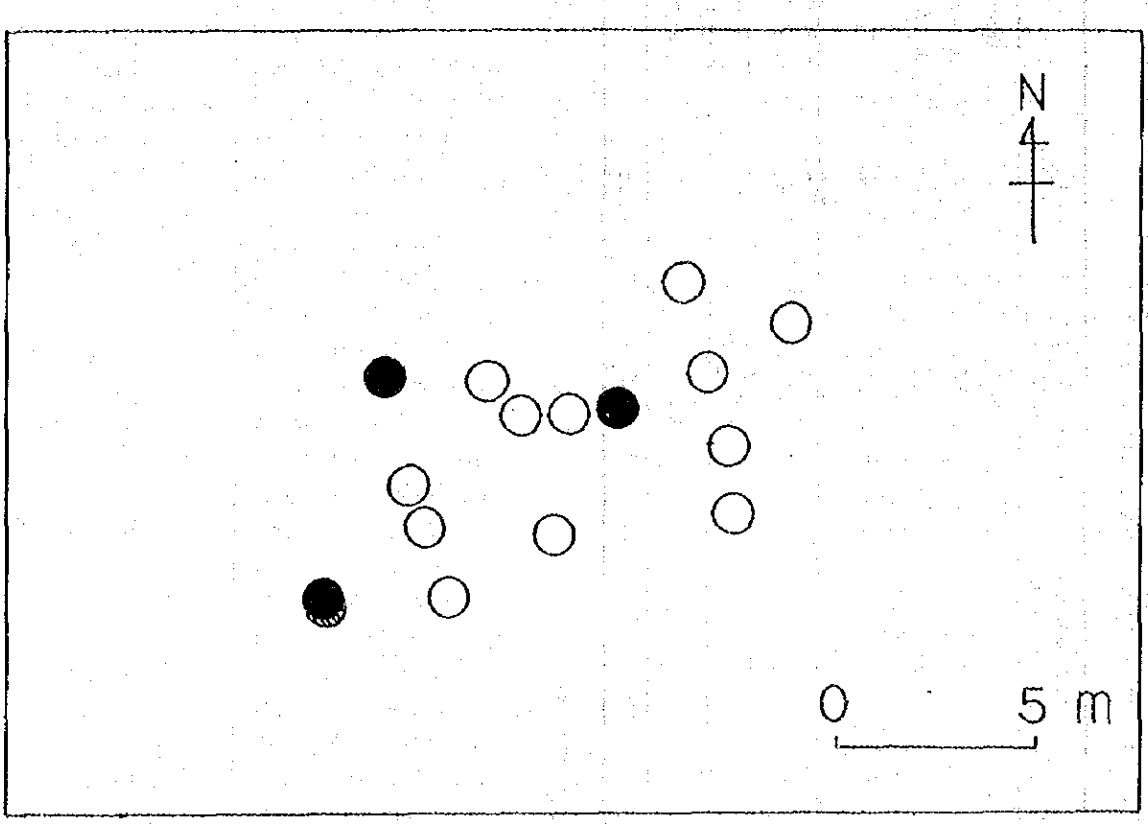


Figure 20. Composition of the fish caught, in weight, by the gill net experimental fishing conducted after the test installation in Canal Bay, Alaminos, Pangasinan



○ : Tire reef

● : Tiré reef with payao

▨ : Base of tire reef is sunk into depression.

Figure 21. Underwater formation of the tire reef with payaos in Canal Bay

Table 13. Results of the gill net experimental fishing in the project area in Canal Bay

Ex. No.	Date	Fishing Duration (min.)	Mesh Size (knots)	No. of Units of Gill Net Used	Catch in Weight (g)	CPUE (g/unit)	Remarks
1.	1981-10-13	1752-1822(30)	6.5	5	(700)	–	before the installation
2.	1981-10-15	1758-1838(40)	6.5	5	(50)	–	before the installation
3.	1981-10-16	1804-1844(40)	6.5	5	(50)	–	before the installation
		@(37)			Total (800)*	–	
4.	1982-02-16	0603-0654(24)	6.5	5	3,510	702	after the installation
5.	1982-02-17	0605-0631(26)	6.5	5	1,835	367	after the installation
6.	1982-02-18	0606-0630(24)	6.5	5	300	60	after the installation
7.	1982-02-18	1804-1828(24)	6.5	5	135	27	after the installation
8.	1982-02-19	0602-0628(26)	6.5	5	3,410	682	after the installation
		@(25)			Total 9,190	@368	

* Catch in weight before the installation is indicated approximately.

Table 14. The fish observed by the divers in the test installation site in Canal Bay on March, 15, 16, 1982.

English Name	Scientific Name	Quantity*	Size (cm)	Remarks
Cardinalfishes	*Cheilodipterus quinquelineatus*	–	4	by the coconut leaves
	Apogon sp.	+++	4– 5	by the coconut leaves
• Grouper	*Epinephelus areolatus* (?)			
• Threadfin Bream	*Scolopsis cancellatus* (?)	–	5	between the tire reefs
• Snappers	*Lutjanus biguttatus*			
	L. lineolatus (?)	+++	9	around the tire reef
	L. sp.			
Fusiliers	*Caesio diagramma*	++	6– 7	by the coconut leaves
	C. caerulaureus	++	6– 7	by the coconut leaves
	C. erythrogster	+	6– 7	by the coconut leaves
• Jacks	*Caranx ignobilis* (?)	+++	30–35	10 m around the tire reef
	Gnathanodon speciosus	+	30	10 m around the tire reef
Triplefin	*Tripterygion* sp.	+	2– 3	on the bamboo of payao
Blennies	*Melacanthus grammistes*	+	6	on the payao
	Plagiotremus rhinorhynchos			
Damselfishes	*Pomacentrus Philippinus*	+++	3	around the coconut leaves
	P. burrohi			
	Neopomacentrus sp.	+++	3	around the coconut leaves
	Chromis weberi (?)	–	7	in the tire reef
Wrasses	*Thalassoma lunare*	–		
	Pteragogus flagellifera	–		
	Labroides dimidiatus	+	6– 7	
Butterflyfish	*Heniochus acuminatus*	+	8	around the coconut leaves
• Surgeonfish	*Acanthurus mata*	–		
• Rabbitfish	*Siganus canaliculatus*	+	10–15	eating algae on the coconut leaf
Puffer	*Canthigaster valentini*	–	3	

* : +++ many
++ 20–30 pcs.
+ 5–20 pcs.
– 5 pcs.

• : Economically important fish

Discussion

Table 15 shows the difference in composition of the fish caught after the test installation of the artificial reef in the three project areas. The frequency of appearance of the fish in the catch is dependent on environmental conditions such as bottom character, water turbidity, water current, fish migration patterns and month of year, etc.

Fish caught more than 5% off Damortis is 6 items of slipmouths (25.1%), Prawns & Shrimps (24.1%), Crabs (13.5%), Mantis Shrimps (5.6%) and Jacks (5.2%) in the same table. Fish caught more than 5% off Port Sual is also 6 items, namely, Jacks (37.9%), Slipmouths (10.2%), Glzzard Shads (8.6%), Grunt (8.6%), Cutlassfishes (8.5%) and Crabs (8.2%). On the other hand, fish caught more than 5% in Canal Bay is only one item that is Jacks (89.9%).

The project sites off Damortis and Port Sual are often influenced by the turbid water from the rivers, so that the bottom sediments in both areas are relatively organically rich. The sea bottom in Canal Bay is composed of corals and sands and there is no river flowing into the bay. Therefore it can be said that the areas off Port Sual and off Damortis include more species of bottom feeder than the area in Canal Bay.

However, gill net fishing method has selectivity of catch in species of fish and their sizes. And it is not clear to find well the relation between fish caught by the nets and the aritificial reef. Therefore, scuba diving observation is required.

The fish attracted around the tire reef and payaos could be roughly classified into various types according to their behavior.

1) The fish swim in schools around the payaos and/or swim around the reef. They have good swimming ability as, for example jacks and mackerels.

2) The fish swim mostly in schools over and/or inside of the tire reef. They often go from one tire unit to other units, but don't go far away from the tire reef as, for example snappers.

3) The fish gather as a school over or inside of the tire reef, don't go actively from one tire reef unit to other units. These fish swim also around the payaos, but don't go far away from the payaos as, for example damselfish and cardinalfish.

4) The fish stay individually beside or underneath the tire reef as, for example groupers.

5) The fish occupy the inside of the tire units individually or as a pair as, for example puffers and frogfish.

Among these fish classified into five types, the fish of type 1), 2), and 4) are commercially important.

The information from the diving observations could suggest the ideal formation in this type of tire reef and payaos, and also could suggest the most effective fishing methods or gear to be used in the area of the tire reef, as follows;

1) The ideal formation of tire reef with payao, as habitats of these commercially important fish is that the tire units should be placed densely, and more payaos connected with the tire units.

2) For the fish of type 1), bottom set gill nets could be recommended first. From the result of the experimental fishing, bottom set gill nets were effective in catching jacks in Canal Bay, as mentioned in the earlier part of this chapter. Hook and line, using artificial bait,

could also be suggested for this type of fish. For the fish of type 2) and 4), hook and line, bottom long line and fish trap could be suggested. These fish could also be caught by bottom set gill net. It is, however, not strongly recommended that the bottom set gill net be operated on top of the tire reef with payao, even though a good fish catch is to be expected, because the gill net might become entangled with payao.

3) The problem, which should be considered, are about the life expectancy of the tire reef with the payaos themselves as the habitats of the fish. The coconut leaves of the payaos were gone, except for their midribs, in the four months since the tire reef with payaos were installed in two test sites, off Port Sual and Damorits. In the other test site in Canal Bay, the coconut leaves of payaos were starting to deteriorate in the three months since the tire reef with payaos were installed. Instead of coconut leaves, other materials should be tried. Another problem regarding the life expectancy of the tire reef is the sinking of the tire reef. As mentioned in an earlier part of this chapter, it should be observed and be considered over a long time period. Nevertheless, it is advisable that this type of tire reef should be avoided in a muddy bottomed place like the test site off Damortis, or other types of tire reef could be modified to such an area.

Table 15. Compositions of the fish caught by the gill net experimental fishing in the three project areas held after the test installations.

Fishes Caught	Catch in Weight					
	Damortis		Sual		Canal Bay	
	(g)	(%)	(g)	(%)	(g)	(%)
Gizzard Shads	335	2.1	430	8.6	0	0
Sardines	0	0	0	0	55	0.6
Anchovies	20	0.1	195	3.9	20	0.2
Wolf Herring	100	0.6	85	1.7	0	0
Lizardfishes	80	0.5	0	0	0	0
Threadfin	150	1.0	0	0	0	0
Goatfishes	190	1.2	85	1.7	0	0
Croakers	740	4.7	0	0	0	0
Majarras	30	0.2	110	2.2	0	0
Threadfin Breams	230	1.5	0	0	0	0
Snappers	70	0.4	115	2.3	410	4.4
Grunts	475	3.1	430	8.6	0	0
False Trevally	0	0	230	4.6	0	0
Jacks	810	5.2	1,895	37.9	8,260	89.9
Slipmouths	3,920	25.1	510	10.2	0	0
Moonfish	130	0.8	0	0	0	0
Indian Mackerels	1,340	8.6	0	0	0	0
Spanish Mackerels	75	0.5	0	0	0	0
Cutlassfishes	0	0	425	8.5	0	0
Sicklefishes	50	0.3	0	0	0	0
Rabbitfishes	0	0	0	0	420	4.6
Filefishes	45	0.3	0	0	0	0
Flatheads	90	0.6	0	0	0	0
Soles	0	0	5	0.1	0	0
Prawns & Shrimps	3,760	24.1	50	1.0	0	0
Crabs	2,100	13.5	410	8.2	25	0.3
Mantis Shrimps	870	5.6	25	0.5	0	0
Total	15,610	100.0	5,000	100.0	9,190	100.0

Table 16. Oceanographic and meteorological data during experimental fishing from Jan. 24 to Feb. 19, 1982.

Ex. No.	Date	Time	Weather	Wind *1		Cloud *2	*3	*4	Current	Surface Water	Sea Depth	Location
				Direction	Force	Quantity	Wave	Swell	Direction	Temperature (°C)	(m)	
1.	1932-01-24	1610-2040	fine	NNW	4	3	4	1	S	—	35–40	off Damortis (8 km)
2.	1982-01-25	0446-0730	fine	N	1	2	1	0	N	— Time	15–16	off Damortis
3.	1982-01-26	0452-0736	fine	NEW	1	4	1	0	N	26.0(0720)	14–16	off Damoritis
4.	1982-01-26	1720-1945	fine	NNW	3	5	3	0	S	26.2(1800)	14–16	off Damortis
5.	1982-01-28	0446-0812	fine	S	2	1	2	1	N	25.8(0801)	14–16	off Damortis
6.	1982-01-29	0449-0845	fine	S	2	1	2	1	N	25.9(0834)	12–15	off Damortis
7.	1982-01-30	0458-0805	fine	S	3	3	3	1	N	25.9(0747)	14–16	off Damortis
8.	1982-02-08	1737-1900	fine	N	2	7	2	1	S	26.0(1748)	6–10	off Port Sual
9.	1982-02-09	0610-0724	fine	N	2	7	2	1	N	25.5(0628)	6–10	off Port Sual
10.	1982-02-09	1753-1916	fine	SE	3	5	3	1	S	26.0(1810)	6–10	off Port Sual
11.	1982-02-10	0528-0717	fine	SE	3	1	3	1	N	25.5(0558)	6–10	off Port Sual
12.	1982-02-10	1735-1852	fine	N	1	7	2	1	S	26.1(1757)	6–10	off Port Sual
13.	1982-02-11	0521-0656	fine	SE	3	5	3	1	N	25.8(0548)	6–10	off Port Sual
14.	1982-02-12	0543-0656	cloudy	SE	2	8	2	0	N	25.9(0605)	6–10	off Port Sual
15.	1982-02-12	1733-1851	cloudy	N	2	8	2	1	S	26.6(1756)	6–10	off Port Sual
16.	1982-02-13	0527-0654	clear	ESE	3	0	3	1	N	26.1(0555)	6–10	off Port Sual
17.	1982-02-16	0530-0654	fine	W	1	6	2	1	N	26.8(0608)	10	Canal Bay
18.	1982-02-17	0535-0701	cloudy	NE	2	9	2	1	N	26.8(0612)	10	Canal Bay
19.	1982-02-18	0530-0702	fine	SE	3	3	3	0	N	26.8(0612)	10	Canal Bay
20.	1982-02-18	1716-1854	fine	N	3	6	3	1	S	27.5(1810)	10	Canal Bay
21.	1982-02-19	0526-0700	fine	NE	1	3	2	0	N	26.8(0609)	10	Canal Bay

*1 : Beaufort's wind scale (0–12)
*2 : Scale range (0–10)
*3 : Scale range (0– 9)
*4 : Scale range (0– 9)] WMO Code 3700, S–state of sea

Table 17. Oceanographic and meteorological data during SCUBA diving observations from March 14 to 17, 1982.

Ex.	Date	Time*	Weather	Wind**		Cloud***	Current	Water	Transpar-	Sea Depth	Surface Water	Bottom	Location
				Direction	Force	Quantity	Direction	Color	ency (m)	(m)	Temperature(°C)	Charcter	
1.	1981-11-30		fine		1	7		6	3.7	13.0	27.9 Time	Silt	off Damortis
2.	1981-12-01	1030-1200	fine		0	1		7	2.6	13.0	27.5(1030)	Silt	off Damortis
3.	1981-12-02	1030-1130	fine		3	3	N			8.5		Sand+Silt	off Port Sual
4.	1981-12-02	1500-1600	fine	N	1	4	N	9	0.7	8.5	28.7(1530)	Sand+Silt	off Port Sual
5.	1982-03-14	0846-1127	fine	SE	5	1	N	5	5.3	8.5	27.5(0925)	Sand+Silt	off Port Sual
6.	1982-03-14	1403-1650	fine	SE	2	1	S	5	8.0	8.7	27.8(1439)	Sand+Silt	off Port Sual
7.	1982-03-15	1630-1805	fine	NW	2	1	S	5	9.4	9.7	27.6(1653)	Sand+Coral	Canal Bay
8.	1982-03-16	0825-0950	fine	SES	4	3	N	5	7.0	9.5	27.1(0855)	Sand+Coral	Canal Bay
9.	1982-03-17	0913-1148	fine	S	2	3	N	6	4.2	13.0	28.6(1132)	Silt	off Damortis

* : Time (Departure – Arrival)
** : Beaufort's wind scale (0–12)
*** : Scale range (0–10)

CHAPTER IV

Analysis of Data that Led to the Determination of the Expansion Site for the Artificial Reef Project

The following analysis is based on the Chapters I, II and III, and it gives a general description of the three sites e.g., off Damortis, off Port Sual and in Canal Bay. This analysis will discuss the advantages and disadvantages of the three sites which led to choosing the site where the expansion project was placed.

1. Off Damortis

This site is located about 2.5 km southwest (SW) of Damortis, Sto Tomas, La Union. Barangays Cupang, Namonitan, Tubod, Casantaan, Damortis, Bani and Rabon are the nearest fishing villages to the site. These barangays have a large population of subsistence fishermen with Casantaan having the largest.

These seven barangays have a total 67 non-motorized bancas (sibid-sibid), 143 motorized bancas and 3 rafts as of June 15, 1981 according to the survey. The project site has a depth of about 13 meters and is accessible only to the fishermen using motorized bancas because of distance from the shore line. Since the site is quite spacious it can easily accommodate the 143 motorized bancas from the 7 fishing villages in the area.

The fishing gear used in this area are as follows; bottom set gill net, baby trawl net, (these are the main gear used), along with drift gill net, fish pots, and long lines.

The characteristics of this site is the extension of a shallow portion toward the south from the sand bar which divides the fishing ground for bottom set gill net into two areas (Fig. 2). The inner area has a relatively calm sea surface which makes it more accessible to the fishermen because that can have a smoother and faster ride. The observations show that the fishermen using bottom set gill nets, operate this gear either in the outer area or in the inner area depending on the location of the migratory fish like jacks, mackerels and slipmouths. By placing the artificial reef in the inner area, the migratory schools will be lured to the site which would allow the fishermen to fish in the nearer site, thus saving fuel and travel time.

The results of the experimental fishing with the bottom set gill net before and after the test installation of small-scale tire reef and payaos are as follows; the average Catch Per Unit Effort (CPUE) decreased at this site after the test installation based on computation, however, the average CPUE is affected by the data from a small sample size and data from only one season of sampling which showed a seasonal fluctuation of fishing stock, etc. Therefore, it is difficult to analyze the changes of CPUE. During the diving observation, schools of fish such as jacks and slipmouths were observed around the site.

This site has some disadvantages to establish the expansion project. It is the bottom condition that is very unsatisfactory to place bottom type of artificial reef due to a soft layer of mud. Among 15 units of the tire reef, almost all the base tires had already sunk into the sea floor four months after the installation. Even if we devised a tire reef to widen its bottom area and lighten its weight per unit volume, the sinking would still continue. This fact could not be avoided due to the depth of the bottom sediment in this area which is composed of silt & mud. It is recommended that only payaos or a mid-water type of artificial reef should be placed in areas that have this kind of bottom character.

2. In Canal Bay

This site is located east of the Hundred Islands. Victoria, Telbang and Magsaysay are the closest fishing villages to the site. These villages have a total of 23 bamboo rafts, 40 non-motorized (sibid-sibid), 30 motorized bancas and 8 sail bancas as of April 5, 1981, according to the survey.

The fishing gear used are: multiple long line, fish pots, bottom set gill net, cast net, spear gun and beach seine. The multiple long line is mainly used by the fishermen with motorized bancas. They must use this gear beyond Canal Bay because there is not sufficient space to manipulate this gear within the bay.

This project would then benefit the fishermen who use the 23 bamboo rafts, 40 non-motorized bancas (sibid-sibid) and the 8 sail bancas in Canal Bay. The result of the physical environmental survey showed a limited space in this bay, from a bottom topographical point of view, in order to operate the multiple long line. The bottom topography in this bay includes three shelves. The first shelf has a depth of one meter while the second shelf has a depth ranging from 7 to 15 meters and the third shelf has a depth of more than 20 meters. The second shelf has a width of about 300 m having natural reefs as if cliff on its both sides. This area is almost flat in bottom with bottom character of sand. The fishermen operate the bottom set gill net in this area. Therefore, the test installation of tire reef and payao was done at this area.

The diving observation at this site showed that the migratory fish of jacks were observed swimming around and over the tire reef with payaos, likewise, small sized damselfish and cardinalfish were seen also in schools together with juvenile *Caesio* sp.

The result of the experimental fishing, with the use of bottom set gill net before and after the test installation, definitely improved, with the average Catch Per Unit Effort (CPUE) increasing after the installation.

Even though an increase of fish is achieved in the given area, the multiple long line, that is a dominant fishing gear in this area, can not be used because there is not space to manipulate this gear in the bay. This means that, the test installation brought nice effect in attracting fish in this area but space is insufficient. If we institute the expansion project at this site, the precious area of flat sea bottom with sand becomes smaller and even fishing operation with bottom set gill nets becomes harder. We would say the expansion of artificial reef is not suitable in this area.

3. Off Port Sual

The proposed site is located about 1 km northeast (NE) of Tobuan. Mangas, Poblacion, Tobuan and Uyong are the nearest fishing villages to the site. These four fishing villages have 95 non-motorized bancas and 161 motorized bancas as of April 6, 1981 according to the survey.

The main fishing gear used by the subsistence fishermen at this site is the bottom set gill net, with the other fishing gear being lift nets, fish pots, baby trawl nets, hook & line and multiple long line. The sea bottom is generally flat and sandy, which brings no problem to install the bottom type of artificial reef against the sinking of artificial reef into the bottom and possible rolling over the bottom.

Migratory fish, e.g., majarras, cutlassfish, jacks, and mackerels are swimming to this area in accordance with their own fish stock fluctuation and seasonal migration. There is also such fish stock as anchovies and squids which can be caught by lift nets along the Portuguese Pt. The result of the experimental fishing, with the use of bottom set gill net, before and after the test installation, brought the decrease of average CPUE after the experimental fishing. It is considered that this decline of CPUE seemed to be caused by the seasonal density fluctuation of fishery stocks. On the other hand, many fish swimming around and over the tire reef and payaos were observed by divers. These fish are snappers, jacks, juvenile groupers, damselfish and cardinalfishes.

Bottom sediments consisted of soft layers of mud in this site are not deeper than the one off Damortis. And spacious area of flat sea bottom in this site is much wider than the one in the Canal Bay.

4. Conclusion

The most important factors in the selection of a suitable site is a place where the artificial reef will concentrate marine animals well, where the artificial reef can have long life span and where the largest number of people can benefit from the project.

The results of the preliminary site survey at the three proposed sites could be compared and the best choice made for the expansion of this project. All three proposed sites showed an effectiveness in attracting marine animals, as observed during scuba diving, although average CPUE declined after the test installation at the two sites, off Damortis and off Port Sual. This decline was probably due to seasonal density fluctuations of fishery stocks. We have encountered problems at two of the sites, off Damortis and in Canal Bay, which do not make them a suitable site for the expansion of the artificial reef project.

a) off Damortis ..... The bottom sediments, composed of soft layers of mud, are very thick. Divers observed that most tire reef units had already sunk 15 cm into the sea floor only 20 days after the installation. It is believed that this submergence will continue. A mid-water type of artificial reef, as reported by Hammond et al., Yoshiwara et al. and Ogawa, would be more suitable in this site.

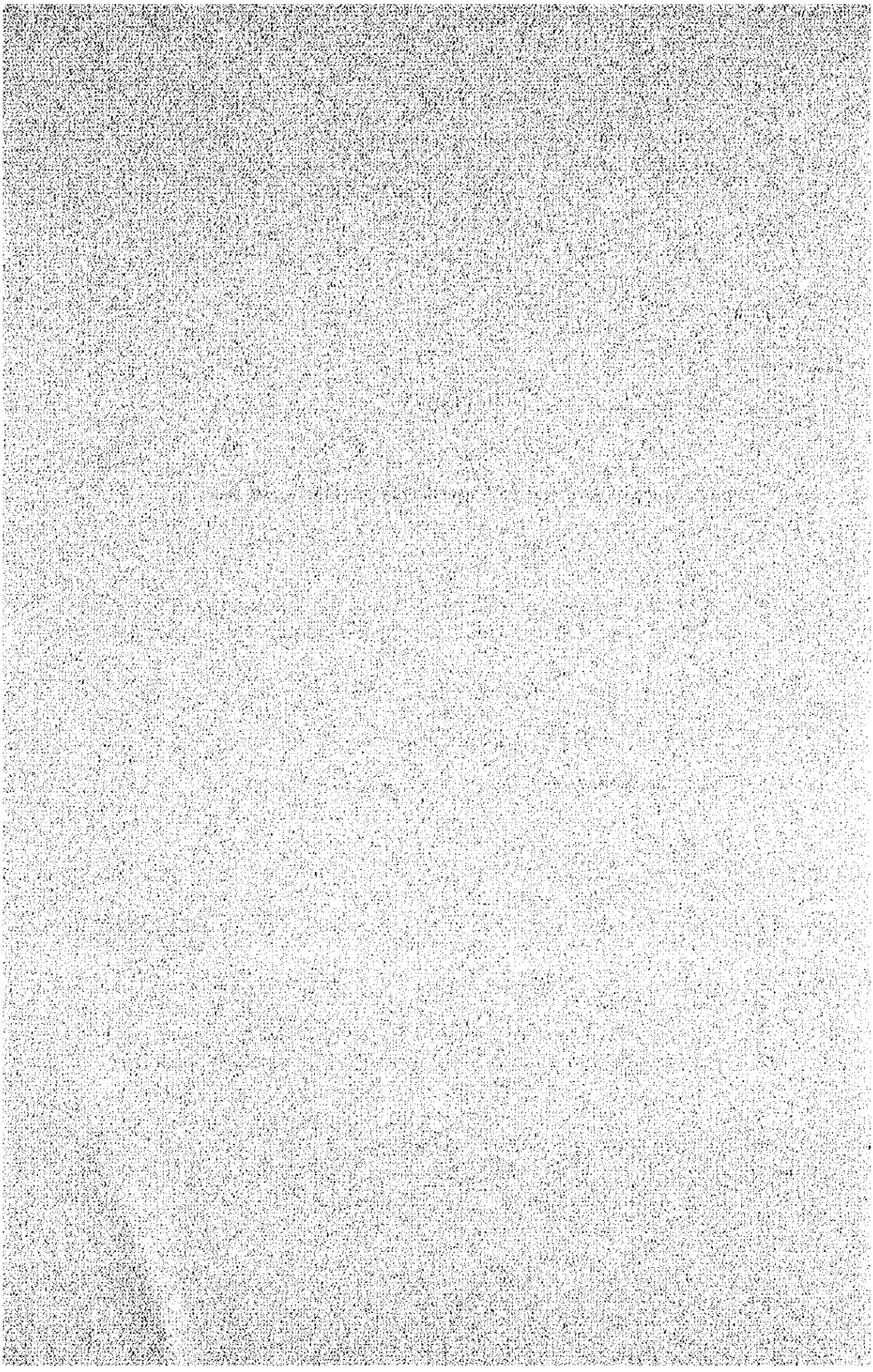
b) in Canal Bay ..... The test installation of fifteen units of tire reef and three payaos had the best effect in attracting fish in comparison with the other two project sites. The physical environmental survey showed, however, that the area available for setting the artificial reef is limited because of so many natural reefs and lack of even bottom area.

c) off Port Sual ..... The bottom sediments are relatively shallow with sandy and muddy bottom character and this area can accommodate a number of fishermen, with their fishing outfits to use and so benefit from the artificial reef.

After comparison of the three sites, the area off Port Sual was chosen as the productive and suitable site for the expansion of the bottom type of artificial reef.

CHAPTER V

Expansion of the Tire Reef Project at Port Sual in Lingayen Gulf



Introduction

For the procedure and the results of the preliminary survey used for the site selection for artificial reef in the Lingayen Gulf, see the preceding chapters. Based on the results, an expansion project was carried out at the project site in the sea off Port Sual. The results of this inicial survey recommended that the tire reef structure should have a wider base and that the weight per unit volume be made as light as enabling to avoid the sinking of the tire reef, due to soft bottom sediments.

Also, needless to say, the proper weight per unit volume of the tire reef must be considered to avoid movement along the sea bottom due to strong waves, in particular, during stormy weather. Another factor is the need to heighten the tire reef, in the view that the higher the artificial reef, the better it is in attracting migratory fish such as jacks and mackerels.

Artificial reefs are classified into two types, in accordance with their purpose. One is for the purpose of propagation. The primary productivity of the sea increases as the water gets shallower and nearer the shoreline, so that the proper depth that the artificial reef is installed for propagation purposes would be from 0 m to 30 m. The other type is for the purpose of capture after concentrating marine animals by means of the artificial reef. For this purpose, installation of the artificial reef can be done from 4 m to 130 m in depth, with the most common depth range being from 20 m to 40 m. On this bases, the artificial reef installation in Lingayen Gulf was planed at the site at about 20 m deep. We would have liked to place the reef at a deeper location, but since Lingayen Gulf is shallow for a long distance from the shore, the site where the expansion project is to be set was determined by the point of compromise between depth of water and distance to fishing villages. Because the final site is not too far from the shore, this site is accessible to all the fishermen because of the small amount of gasoline consumption.

Another physical environmental survey was carried out at the site off Port Sual where the expansion project of the artificial reef was located.

Materials & Methods for Expanded Reef

The following changes and improvements were made on the construction of the expanded artificial reef, based on our experience from the test installation of the small-scale tire reef.

1. We had to reconsider the proper weight per unit volume of the tire reef to avoid its rolling along the sea bottom as well as to avoid its sinking into the sea floor. A sinker unit was filled with cement, tied with polyethylene rope (18 mm dia.) and then installed on the sea bottom as either end of one set of tire reef (this consists of about 200 tires.) The regular tire reef units were filled with stones put into the sidewall. Then several holes were punched on top of the tires with a hot iron bar (to take out the air). (Fig. 22-1)

2. The basic structure of the tire reef was redesigned to bind the tire units more closely together and to allow the reef to have certain areas built up in height, so that more fish would be attracted. This was done by making one unit of tire reef which consissts of 2 tires bound together by means of polyethylene rope. Stones were put in the sidewall, etc. as explained above. These regular tire reef units were then either placed on the bottom directly by feeding the main rope (attached to the sinker unit which had been placed on the sea floor) through the center of the tire unit and dumping it into the ocean, where it would sink to the bottom next to the sinker unit (Process A) or splicing a branch rope around the main rope and connecting it to the tire unit, allowing this unit to sink to the bottom (Process B). The process B was easier to build up in height than the process A. But the process B might bring less durability of concentrated tire reef units because each tire reef unit was connected to the main rope by the branch rope. And this branch rope is of much smaller size than the main rope. Please refer the figure 22-2 as to how to install the expanded tire reef.

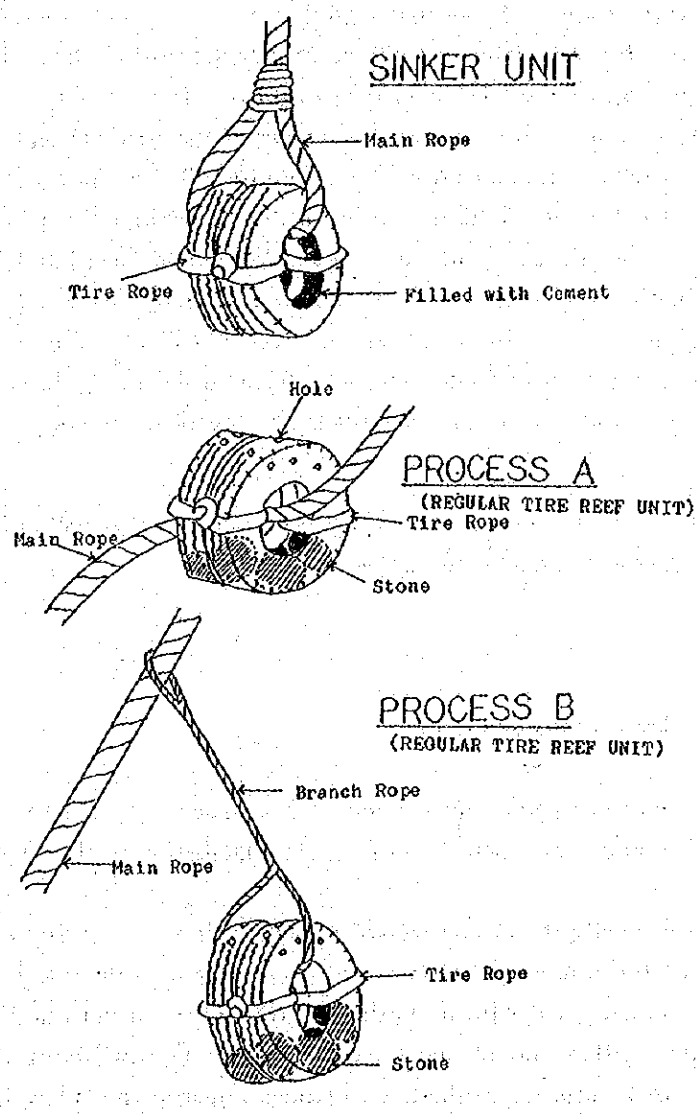
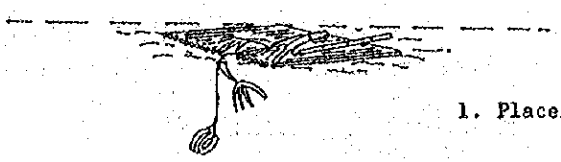
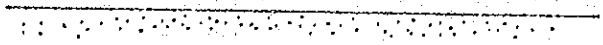
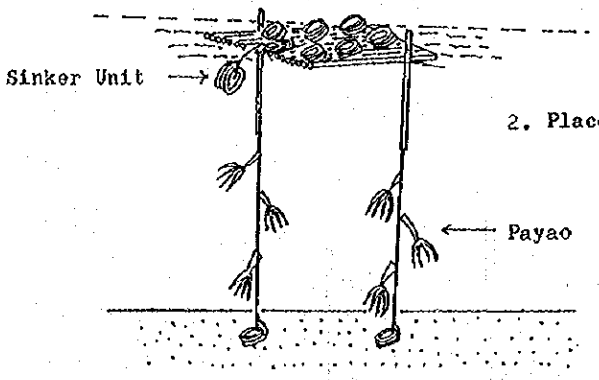


Figure 22-1. Sinker unit and regular tire reef units in process A and B

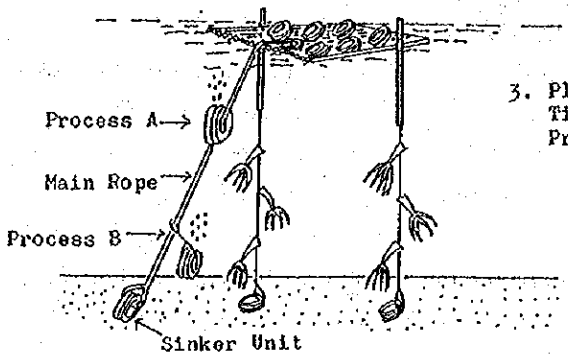


1. Placement of Payao.





2. Placement of Sinker Unit.



3. Placement of Regular Tire Reef Units in Process A and B.

– continued –

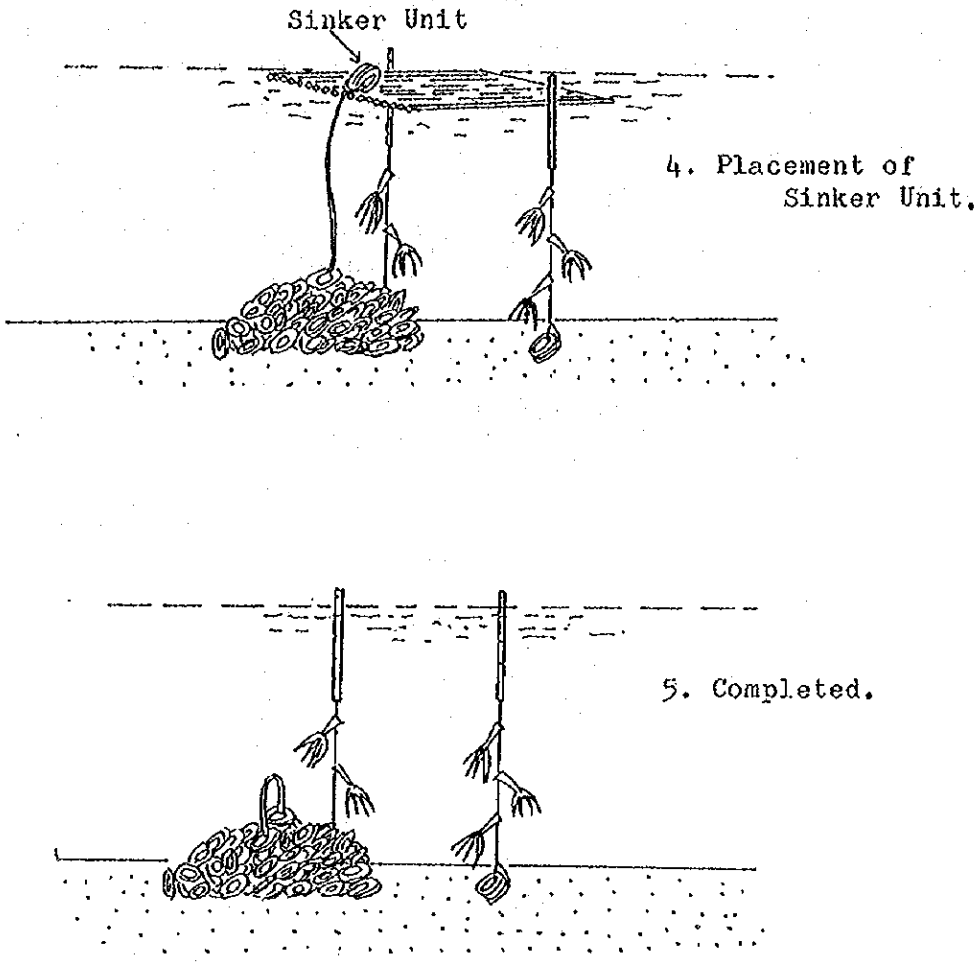


Figure 22-2. Process for the installation of the expanded artificial tire reef

3. Four small scale payaos were designed the same as the one used in the test installation (Fig. 14) except that boli leaves were used instead of coconut leaves because of its better durability.

4. Large size of bamboo raft (3 mtr x 4 mtr) was constructed and attended for loading about 10 tire reef units per trip to be installed. This raft was towed from shore by the speed boat.

5. Experimental fishing by gill net was operated for one of evaluation of the expanded tire reef. The net was casted around the tire reef and far from the tire reef so that we may compare the difference of Catch Per Unit Effort (CPUE) and kinds of fish to be caught.

6. Diving observations were held to observe underwater formation of the installed tire reef and fish attracted around the tire reef.

Result

Physical Environmental Survey

The expansion project site is located 2.8 km northeast of Tobuan, Labrador, Pangasinan (Fig. 23). This site is from 11.5 m to 18.0 m deep and has an almost flat sea bottom (Fig. 24) which is generally composed of silt, sand, and clay (Table 18). Bottom sediments have accumulated from 0.6 m to 1.7 m depending on the stations observed, generally, the deeper the water, the deeper the accumulated bottom sediments. There is a gradual slope (0% – 1.3%) toward the north.

Current velocity and direction were measured every hour from June 22 at 09:30 AM to June 23 at 09:30 AM, 1982 at station 7 where the tire reef was installed (Table 20-1, 20-2). At that time, one set of the tire reef had been installed. Maximum current velocity was 0.15 m/s (0.29 knots) on the sea surface and 0.10 m/s (0.19 knots) on the sea bottom and at mid-layer (7.5 m deep). Average velocity was 0.08 m/s (0.16 knots) on the sea surface, 0.05 m/s (0.10 knots) at mid-layer (7.5 m deep) and 0.04 m/s (0.08 knots) on the sea bottom. The current velocity on the sea surface is generally greater than that at mid-layer and on the sea bottom.

Based on the measurements taken, water current often flows north (along Portuguese Pt.) on the sea surface with 29% occurrence (Fig. 25-1).

On the sea bottom, 32% of 25 observations showed no current found. The current direction scattered in various directions during the observations. Among them, the current from north (N) to northeast by north (NE/N) is most obvious in occurrence (20%) (Fig. 25-2). It is thought that the bottom current was disrupted at the site due to the installation of one set (200 tires) of the artificial reef.

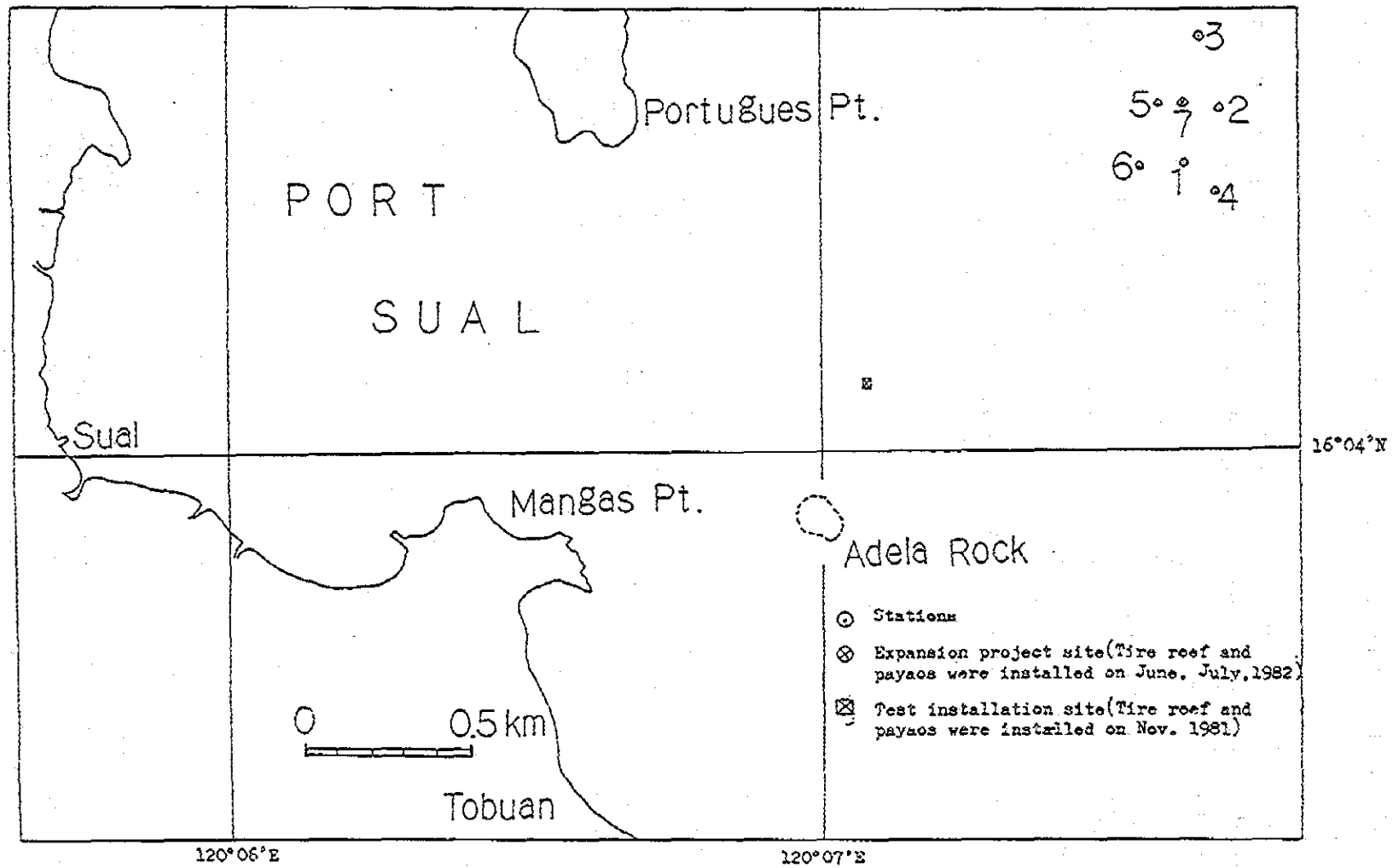
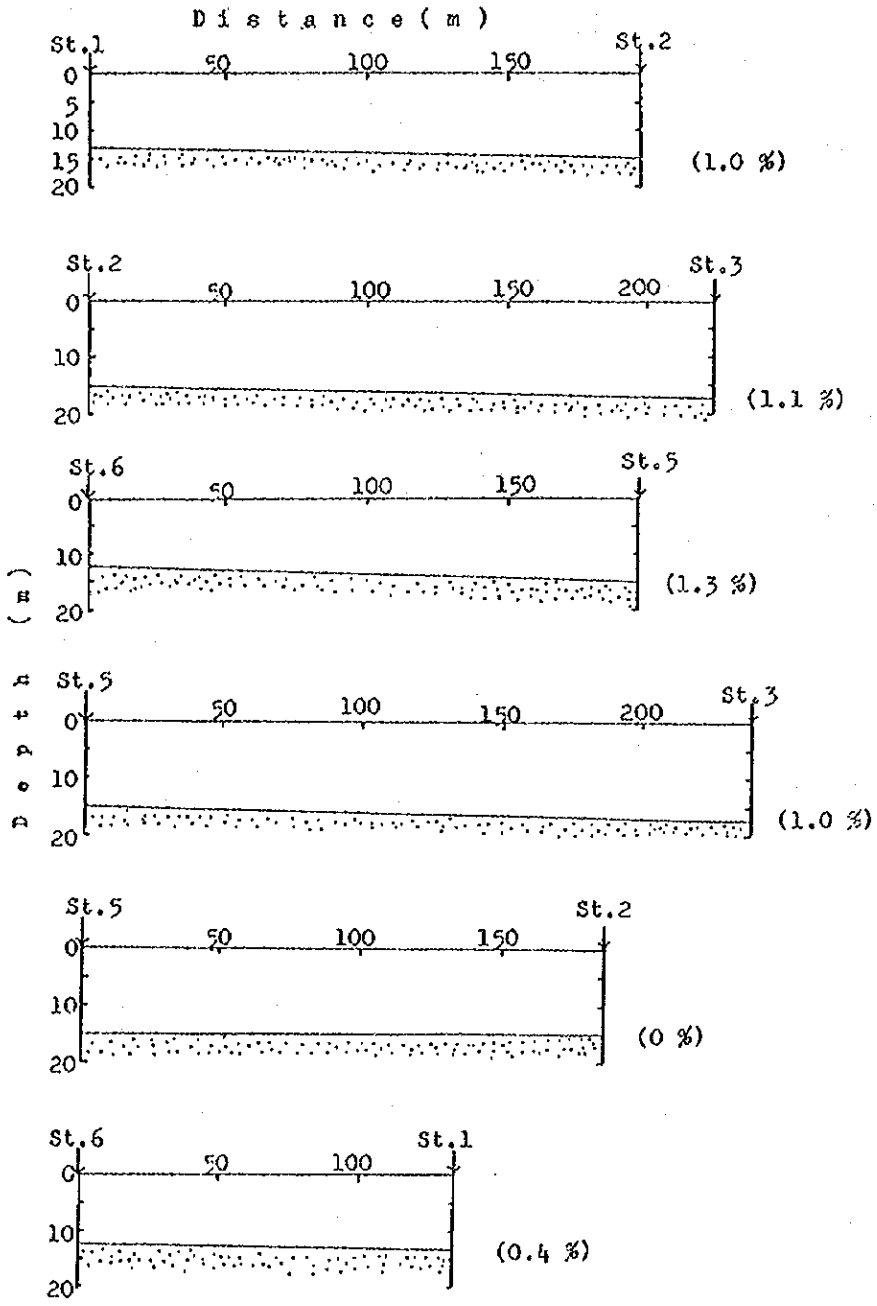


Figure 23. Stations and expansion project site off Port Sual, Sual, Pangasinan



( ) Bottom slope rate

Figure 24. Bottom topography at the expansion project site off Port Sual, Sual, Pangasinan

Table 18. Result of the physical environmental survey in the area of the expansion project off Port Sual, Sual, Pangasinan.

St. No.	Date	Depth of Water echo-sounding lead-sounding	Bottom Character	Depth of Bottom Sediments (m)	Current Velocity (m/s) Current Direction (°)			Trans-parency (m)	Water Color	Surface Water Temperature (°) Time	Remarks
					Surface	Mid-water	Bottom				
1.	1982-05-22	13.0 (m) 13.4	Sand+Silt							30.5 (1000)	
	1982-05-25	13.5	Silt	1.1	(0 m) 0.15 325°	(7.0 m) 0.10 350°	(13.5 m) 0.10 70°	7.2	3		Diving investigation
2.	1982-05-22	15.0 15.5	Silt								
	1982-05-25	15.0	Clay	0.6	(0 m) 0.15 325°	(7.0 m) 0.10 350°	(13.9 m) 0.10 70°	8.0	4		Diving investigation
3.	1982-05-22	17.0 18.2	Silt								
	1982-05-25	18.0	Clay	1.7	(0 m) 0.20 305°	(9.0 m) 0.10 3°	(18.0 m) 0.05 38°	7.7	4		
4.	1982-05-22	11.5 12.2	Sand							30.6 (1110)	
5.	1982-05-22	15.0 15.5	Silt+Sand								
	1982-05-25	15.0	Clay	0.8	(0 m) 0.15 310°	(7.8 m) 0.10 350°	(15.0 m) 0.05 15°	6.8	3		Diving investigation
6.	1982-05-22	12.5 13.1	Sand+Silt								
7.	1982-06-08	15.0	Clay	0.8	(0 m) 0.20 25°	(7.0 m) 0.25 45°	(15.0 m) 0.25 20°		3		Diving investigation
	1982-06-21	15.5 15.5	Silt+Sand						3	31.0 (1325)	

Table 19. Oceanographic and meteorological data during the physical environmental survey from May 22 to June 21, 1982.

Date	Weather	Cloud amount *1	Wind *2 Direction	Wind *2 Force	Wave *3 Direction	Wave *3 Scale	Swell *4	Remarks
1982-05-22	fine	3	N	2	N	2	1	
1982-05-25	fine	3	SE/E	2	SE/E	2	0	Diving investigation
1982-06-08	fine		E		E			Diving investigation
1982-06-21	fine	6	NE/N	2	NE/N	2	0	

*1 : Scale range (0–10)
*2 : Beaufort's wind scale (0–12)
*3 : Scale range (0– 9) WMO Code 3700, S–state of sea
*4 : Scale range (0– 9)

Table 20-1. Current velocity & direction in different layers at the tire reef installation site on June 22 to 23, 1982.

Time	Depth (m) 0 m (Direction)°		7.5 m (Direction)°		15.0 m (Direction)°	
0930	0.15 m/s	350°	0.10 m/s	40°	0.05 m/s	70°
1030	0.10	350	0.05	160	0.03	10
1130	0.10	280	0.03	160	0.05	10
1230	0.05	310	0	–	0.05	0
1330	0.05	350	0	–	0	–
1430	0.05	320	0.05	270	0	–
1530	0.05	25	0.05	330	0.10	10
1630	0.05	40	0.05	340	0	–
1730	0.10	15	0.05	270	0.03	225
1830	0.05	110	0.03	220	0.01	100
1930	0.05	90	0.05	280	0.01	0
2030	0.05	70	0.03	250	0	–
2130	0	–	0	–	0	–
2230	0	–	0	–	0	–
2330	0	–	0	–	0	–
0030	0	–	0	–	0	–
0130	0.05	350	0.05	10	0.03	80
0230	0.15	240	0.05	260	0.03	90
0330	0.10	300	0.05	30	0.05	90
0430	0.05	310	0.03	50	0.01	170
0530	0.15	330	0.10	90	0.10	200
0630	0.05	350	0.05	80	0.03	200
0730	0.05	350	0.05	45	0.05	230
0830	0.10	10	0	–	0.03	280
0930	0.10	340	0.01	70	0.03	250
Average Velocity	0.08 m/s		0.05 m/s		0.04 m/s	

Table 20-2. Frequency of current direction and the average current velocity in the surface and the bottom layers at the tire reef installation site on June 22 to 23, 1982.

Direction range (°)	Surface layer		Bottom layer	
	Frequency* (%)	Average vel (m/s)	Frequency* (%)	Average vel. (m/s)
0 – 22.5	8%	0.10m/s	20%	0.05m/s
22.5 – 45.0	8	0.05	0	0
45.0 – 67.5	0	0	0	0
67.5 – 90.0	4	0.05	8	0.04
90.0 – 112.5	8	0.05	12	0.03
112.5 – 135.0	0	0	0	0
135.0 – 157.5	0	0	0	0
157.5 – 180.0	0	0	4	0.01
180.0 – 202.5	0	0	8	0.07
202.5 – 225.0	0	0	0	0
225.0 – 247.5	4	0.15	8	0.04
247.5 – 270.0	0	0	4	0.03
270.0 – 292.5	4	0.10	4	0.03
292.5 – 315.0	12	0.07	0	0
315.0 – 337.5	8	0.10	0	0
337.5 – 360.0	28	0.08	0	0
No current found	16		32	
	100%		100%	

*25 time observations = 100%

How to read Figure 25.

Length of arrows ..... Frequency of current directions flowed during 25 observations

0 10 20 30 %

Numbers in the circles ..... Frequency of non-current

(16) .... %

(100% = 25 times)

Width of arrows ..... Average current velocity

0 < ⟶ ≧ 0.05 m/s

0.05 < ⟹ ≧ 0.10 m/s

0.10 < ➡ ≧ 0.15 m/s

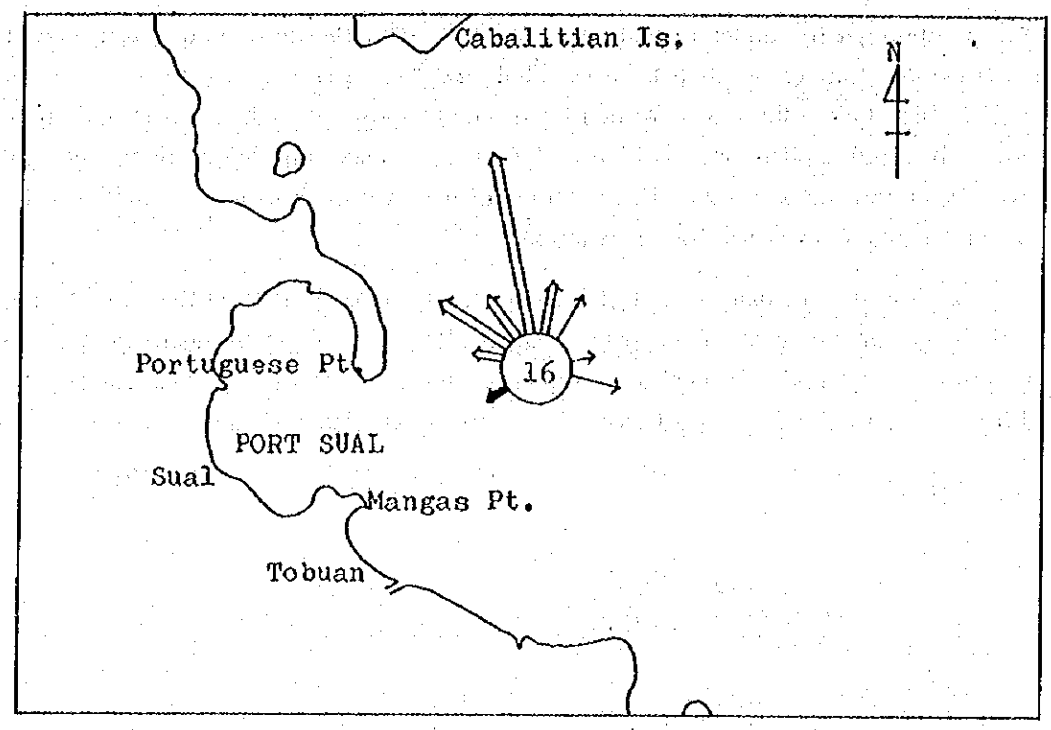


Figure 25-1. Current velocity and direction in the surface layer (0 m) at the tire reef installation site on June 22 to 23, 1982

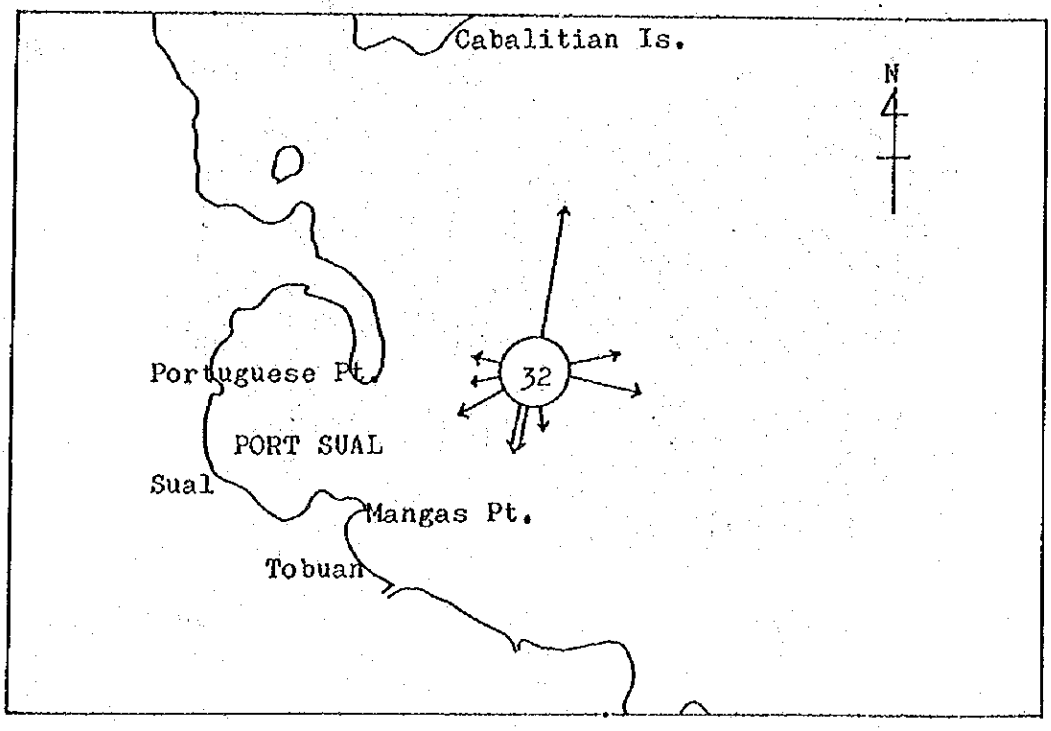


Figure 25-2. Current velocity and direction in the bottom layer (15.0 m) at tire reef installation site on June 22 to 23, 1982

Underwater Formation of Two Sets of the Tire Reef

Divers observed the under formation of the reef, after the two sets of the tire reef (four hundred tires) and four payaos had been installed, and they ascertained it to be a two hillock shaped (Fig. 26). One hillock was formed by triple-piled tires as high as 2.3 m and the other was formed by double-piled tires as high as 1.8 m. The maximum length of the two hillock shape was 14 m and the width was 12 m. Submergence into the bottom sediments was from 9 cm to 25 cm at two months after the installation.

Divers noticed that many pieces of branch rope were dangling from the reef which could lead to the easy entanglement of the fishing gears to the tire reef. Three small-scale payaos out of four were observed and their positions in relation to the tire reef was noted. The two hillock shaped tire reef is situated in the northerly portion from the triangle made by the three payaos.

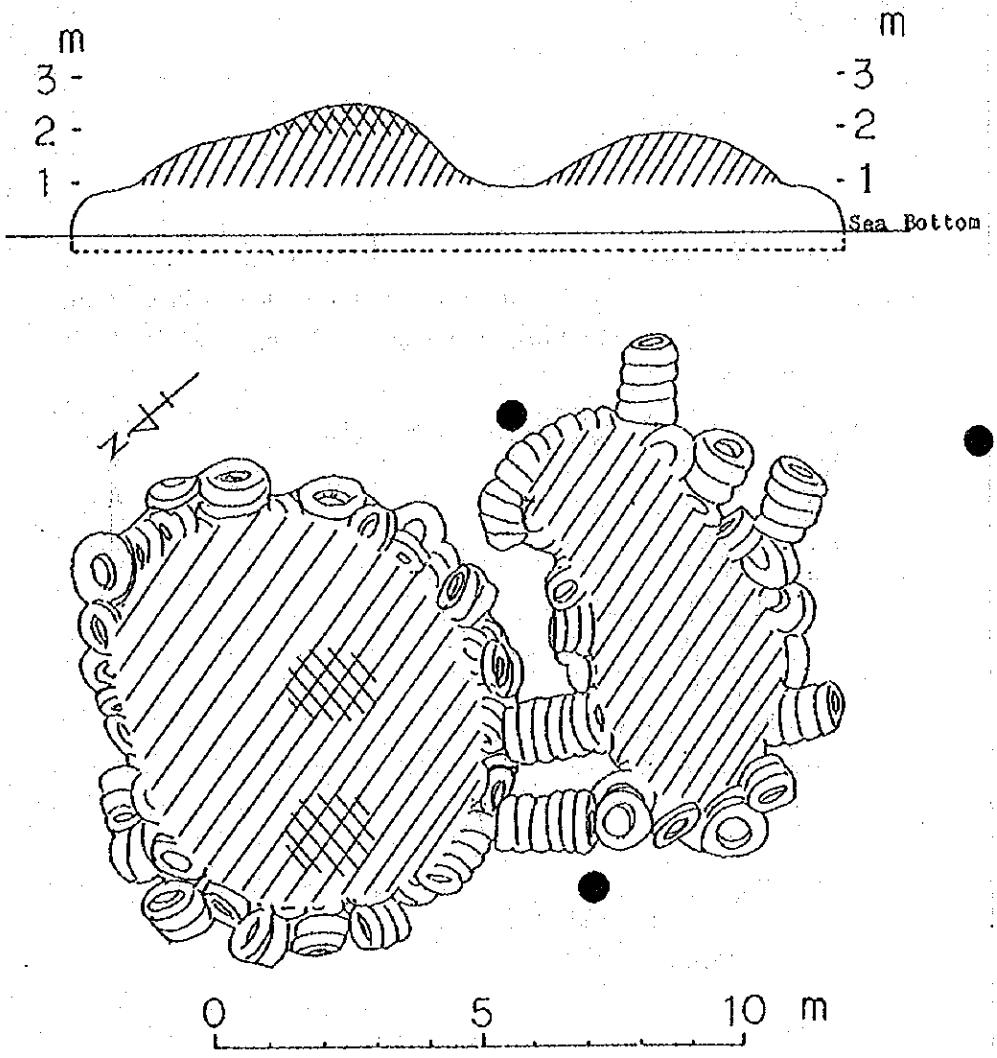


Figure 26. Underwater formation of two sets of the tire reef with payaos

Single-piled tires
Double-piled tires
Triple-piled tires
Payao

Gathering Fish at the Tire Reef Installation Site

Divers noted 30 species of fish at the tire reef installation site during the 4 observations (Table 21-1 – 21-4). Among those species, snappers are the most important economically in their sizes and numbers. These snappers seem to have stayed at this tire reef site and they swim just around the reef in schools.

Lutjanus lineolatus is the most dominant species in number swimming over the tire reef and around the payaos. *Lutjanus russelli* is one of the most expected species for capturing purpose in this artificial reef. These are growing in their number and size month by month. Divers noted that this species were eating organisms attached to the rope floating from the reef. *Lutjanus sanguineus* is the other species expected to be caught by fishermen. Divers often observed large size fish with a length of about 40 cm. At the third observation, it was noted that fusiliers were rapidly increasing in number, compared with the first and the second observations.

Table 21-1. The fish observed by the divers in the installation site off Port Sual on June 25, 1982.

	English Name	Scientific Name	Quantity*	Size (cm)	Remarks
•	Filefishes	*Aluteres scriptus*	–	25	around payao
		(not identified)	–	10–15	around payao
	Blennies	*Meiacanthus grammistes*	–	5–10	around payao
		(not identified)	–	3– 5	around payao
•	Slipmouth	*Leiognathus* sp.	+++	10	around payao
•	Snappers	*Lutjanus lineolatus*	+++	10–15	around payao
		L. russelli	++	20–25	around tires
		L. gibbus	–	20–25	over tire reef
		L. g. (juv.)	+	15	over tire reef
•	Fusiliers	*Caesio cunning* (juv.)	+++	10	around payao
		C. pisang	+	10	around payao
•	Barracuda	*Sphyraena* sp. (juv.)	++	10–15	around payao
•	Jacks	*Selaroides leptolepis* (juv.)	+++	5	around payao
		Caranx sp. (juv.)	+++	15	around payao & over tire reef
•	Groupers	*Epinephelus sexfasciatus*	+	15	beside tires
		Cephalopholis pachycentron	+	10	beside tires
	Puffer	*Tetraodon immaculatus*	+	5–10	in tire reef
	Damselfish	*Pomacentrus Philippinus* (juv.)	+++	5	over tire reef
	Butterflyfish	*Heniochus acuminatus* (juv.)	+	5	over tire reef
	Cardinalfish	*Apogon kiensis*	+++	5	inbetween tire reef
		A. amboinensis	+++	5	inbetween tire reef

* : +++ many
++ 20–30 pcs.
+ 5–20 pcs.
– 5 pcs.

• : Economically important fish

Table 21-2. The fish observed by the divers in the installation site off Port Sual on July 6, 1982.

English Name	Scientific Name	Quantity*	Size (cm)	Remarks
• Filefishes	*Aluteres scriptus*	--	35	around payao
	A. sp.	--	15--20	around payao
	Stephanolepis sp.	+	5-- 8	around payao
Blennies	*Plagiotrema rhinorhynchos*	--	4	over tire reef
	Melacanthus grammistes	+++	4-- 5	along payao
• Snappers	*Lutjanus russelli*	+++	25--30	over the tires
	L. gibbus	+	30--45	over the tires
	L. lineolatus	+++	4-- 5	around payao
• Fusilier	*Caesio* sp.	+++	3-- 4	over the tires
• Jacks	*Caranx* sp.	+++	10	over the tires & around the payao
	Selaroides leptolepis	+++	7-- 8	around the payao
• Grouper	*(not identified)*	--	50	on the tire
Puffers	*Tetraodon stellatus*	--	40	inbetween tires
	T. immaculatus	+	5--10	inbetween tires
Damselfishes	*Pomacentrus Phlippinus*	++	2-- 3	around payao
	Abudefduf vaigiensis	--	3	around payao
• Butterflyfish	*Heniochus acuminatus*	+	4-- 8	inbetween tires & on the tires
Cardinalfishes	*Apogon klensis*	+	3-- 4	inbetween tires
	A. amboinensis	+	3-- 4	inbetween tires
• Rabbitfish	*Siganus* sp.	--	3	beside the tires

* : +++ many
++ 20--30 pcs.
+ 5--20 pcs.
-- 5 pcs.

• : Economically important fish

Table 21-3. The fish observed by the divers in the installation site off Port Sual on August 18, 1982.

English Name	Scientific Name	Quantity*	Size (cm)	Remarks
Blenny	*Melacanthus grammistes*	++	5-- 6	around payao
• Slipmouth	*Leiognathus* sp.	++++	3-- 4	around payao
• Snappers	*Lutjanus russelli*	+++	20--40	around tires
	L. lineolatus	++++	5-- 6	around payao
	L. gibbus			
• Fusilier	*Caeclo erythrogaster*	+++	10--12	around payao
• Barracuda	*Sphyraena* sp.	+	20	around payao
• Jacks	*Selaroides leptolepis*	+++	10--12	around payao
	Caranx sp.		--	
• Grouper	*Epinephelus sexfasciatus*		--	5 beside tires
Damselfish	*Pomacentrus philippinus*	++	3-- 4	over tire reef
• Butterflyfish	*Henichus acuminatus*	+		over tire reef
Cardinalfish	*Apogon amboinensis*		4	inbetween tires
• Tigerfish	*Therapon jarbua*	--	15	
• Surgeonfish	*Acanthrus* sp.	--		

* : +++ many
++ 20--30 pcs.
+ 5--20 pcs.
-- 5 pcs.

• : Economically important fish

Table 21·4. The fish observed by the divers in the test installation site off Port Sual on Sept. 8, 1982.

English Name	Scientific Name	Quantity*	Size (cm)	Remarks
Blenny	*Melacanthus grammistes*	+++	10	over the tires
• Slipmouth	*Lelognathus* sp.	++++	5	over the tires
• Snappers	*Lutjanus russelli*	+++	15–25	around tire reef
	L. sanguineus sp.	++	10–40	around tire reef
	L. lineolatus sp.	++++	5–13	around tire reef
	L.	+++	30–40	around tire reef
	L.	+	15–20	around tire reef
• Fusiliers	*Caesio cunning*	++++	5–15	around payao
	C. ptsang	–	5	around payao
• Barracuda	*Sphyraena* sp.	+++	20–25	over the tires
• Jacks	*Selaroides leptolepis*	++++	3–15	at 10 m radius of the tire reef
	Caranx sp.	+++	20–25	at 10 m radius of the tire reef
Puffer	*Tetraodon immaculatus*	+	10–15	on the tire reef & around payao
Damselfish	*Neopomacentrus taeniurus*	+++	2– 5	over the tires
• Butterflyfish	*Heniochus acuminatus*	+	5–10	over the tires & around payao
Cardinalfishes	*Apogon amboinensis*	+++	3– 6	between tires
	A. sp.	++	2– 5	between tires

* : +++ many
++ 20–30 pcs.
+ 5–20 pcs.
– 5 pcs.

• : Economically important fish

Other economically important fish observed during the diving observations were slipmouths, barracudas and jacks which were swimming in schools over the tire reef and around payaos. Groupers were also seen swimming on the sea bottom beside the tire reef and filefish were around the payaos.

The surface of the tires was covered by silt, filamental algae, sponges and hydroids. Filamental algae covered the surface of the bamboo, rope and leaves of the payaos. The leaflets of boli leaves used for the payaos were still attached three months after the installation according to the diving observations.

Gill Net Experimental Fishing

Experimental fishing at the site around the tire reef was conducted six times within 370 m radius around the project site. Experimental fishing at a site away from the tire reef was conducted five times from 520 m to 1,400 m radius southeast of the project site (Fig. 27-1, 27-2).

Fishing duration on the average was 33 minutes around the tire reef and 32 minutes beyond the reef. Average Catch Per Unit Effort (CPUE)* resulting from the experimental fishing conducted around the tire reef was 281 g/unit in total catch. The weight of the fish alone was 250 g/unit in the catch (the remaining weight was composed of various crustaceans). Average CPUE resulting from the experimental fishing conducted beyond the tire reef was 426 g/unit in total catch. The weight of the fish alone was 245 g/unit in the catch (the remaining weight was composed of various crustaceans) (Table 22).

Out of the 18 kinds of fish and crustaceans caught at the site around the tire reef, jacks were the most dominant species and slipmouths, Indian mackerels and crabs were the second most dominant species. Out of 20 kinds of fish and crustaceans caught at the site beyond the tire reef site, crabs were the most dominant species (Table 24, Fig. 28).

This experimental fishing was conducted in the middle of rainy season when, fishermen say, the better catch is obtained. The weather was always either rainy or cloudy during the fishing and a better catch was recorded than the catch in February 1982 conducted at the test installation site in the sea of Port Sual.

*CPUE (g/unit) = Weight of Catch in Grams ÷ Numbers of Fishing Gears Used

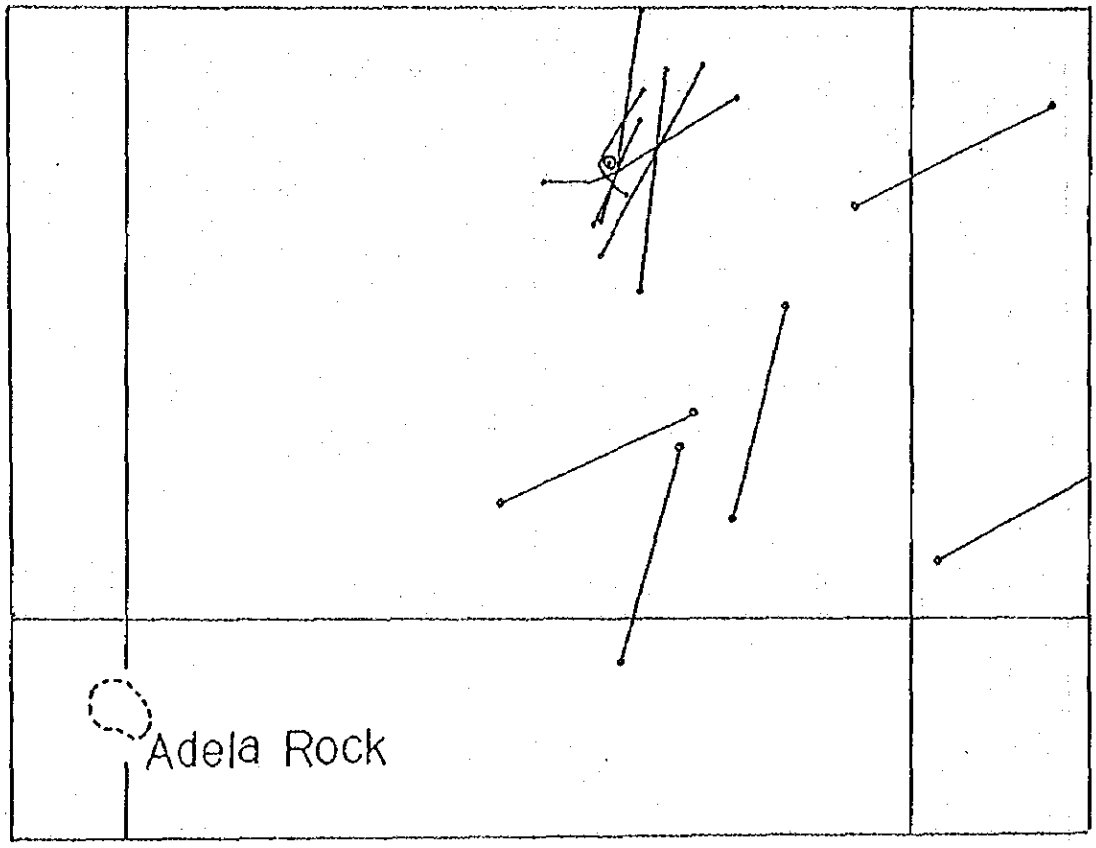


Figure 27-1. Experimental fishing area at the project site in the sea of Port Sual

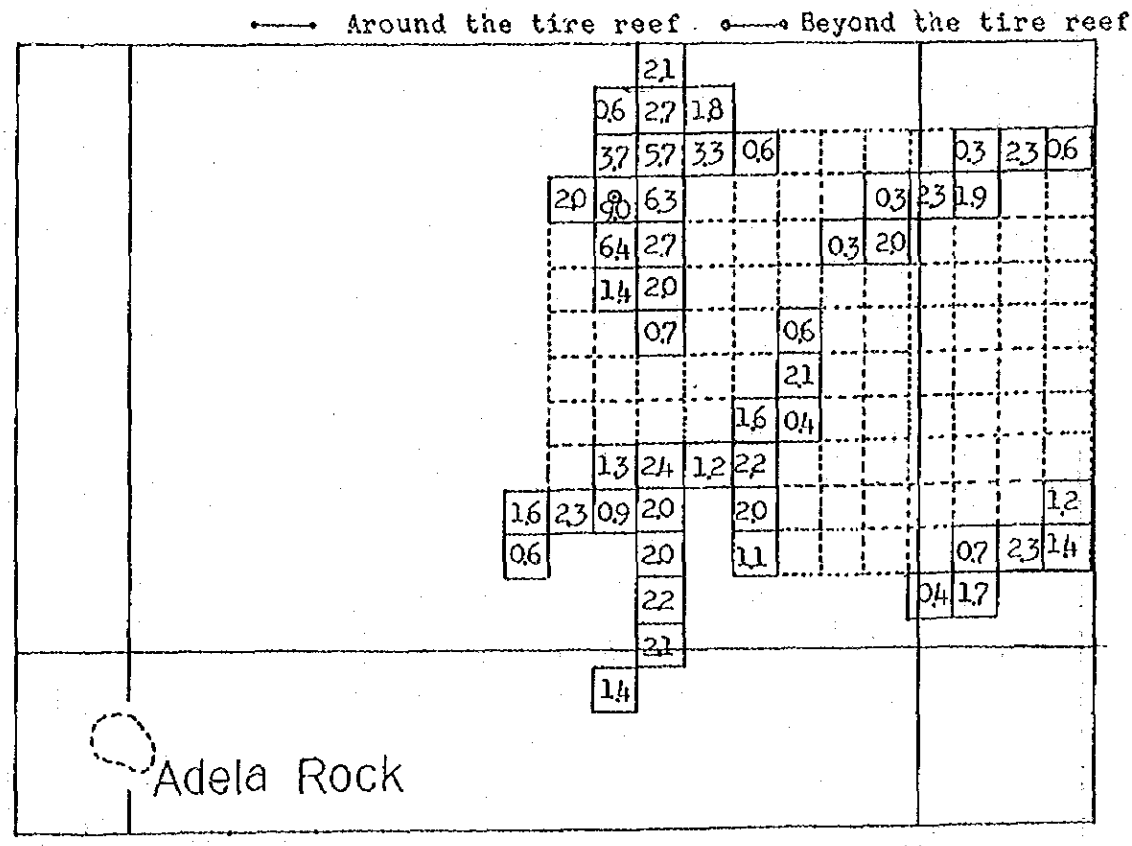


Figure 27-2. Unit number of bottom set gill nets scattered in each 100 m square during the experimental fishing

Table 22. Result of the gill net experimental fishing in the expansion project area off Port Sual, Sual, Pangasinan.

Ex. No.	Date	Time	Fishing Duration (min.)	Mesh Size (knots)	No. of Units of Gill Net Used	Catch in Weight (g) (except crastacians)	CPUE (g/unit) (except crastacians)	Location
1.	1982-07-21	1805-2015	1824-1900(36)	6.5 7.5	5 5) 10	3,299 (3,299)	330 (330)	beside tire reef site
2.	1982-07-23	1759-2005	1825-1845(20)	6.5 7.5	3 3) 6	1,184 (1,164)	197 (194)	beside tire reef site
3.	1982-07-27	1740-2015	1806-1847(41)	6.5 7.5	5 5) 10	1,638 (925)	164 (93)	beside tire reef site
4.	1982-07-30	1810-2010	1840-1910(30)	6.5	5	1,455 (1,230)	291 (246)	beside tire reef site
5.	1982-08-10	1758-2015	1820-1848(28)	6.5 7.5	5 5) 10	5,098 (4,918)	510 (492)	beside tire reef site
6.	1982-08-13	1745-2002	1807-1849(42)	6.5 7.5	5 5) 10	1,675 (1,225)	168 (123)	beside tire reef site
			@(33)		Total	14,349 (12,761)	@281 @(250)	
7.	1982-07-22	1740-1950	1802-1850(48)	6.5 7.5	5 5) 10	2,885 (1,310)	289 (131)	beyond tire reef site
8.	1982-07-26	1815-2125	1855-1925(30)	6.5 7.5	5 5) 10	2,840 (1,935)	284 (194)	beyond tire reef site
9.	1982-07-28	1800-2135	1820-1840(20)	6.5 7.5	5 5) 10	3,895 (1,165)	390 (117)	beyond tire reef site
10.	1982-08-11	1845-2140	1815-1852(37)	6.5 7.5	5 5) 10	8,090 (5,640)	809 (564)	beyond tire reef site
11.	1982-08-14	1810-2020	1825-1850(25)	6.5 7.5	5 5) 10	3,605 (2,195)	361 (220)	beyond tire reef site
			@(32)		Total	21,315 (12,245)	@426 @(245)	

Table 23. Oceanographic and meteorological data during the gill net experimental fishing from July 21 to August 14, 1982.

Ex. No.	Date	Time	Weather	Cloud *1 Amount	Wind *2		*3 Wave	*4 Swell	Sea Depth (m)	Remarks
					Direction	Force				
1.	1982-07-21	1805-2010	rain	10	NW/W	2	2	0	13–20	beside tire reef site
2.	1982-07-23	1759-2005	cloudy	8	W	2	2	0	14–17	beside tire reef site
3.	1982-07-27	1740-2015	rain	10	W	3	3	0	14–21	beside tire reef site
4.	1982-07-30	1810-2010	cloudy	10	SW	2	2	0	14–17	beside tire reef site
5.	1982-08-10	1758-2015	rain	10	NE	1	1	0	12–17	beside tire reef site
6.	1982-08-13	1745-2002	cloudy	10	SW/W	2	2	0	12–17	beside tire reef site
7.	1982-07-22	1740-1950	rain	10	SW	2	2	0		beyond tire reef site
8.	1982-07-26	1815-2125	cloudy	10	SW/W	2	2	0	14–20	beyond tire reef site
9.	1982-07-28	1800-2155	cloudy	10	W	3	3	0	14	beyond tire reef site
10.	1982-08-11	1845-2130	cloudy	10	E	1	1	0	9–10	beyond tire reef site
11.	1982-08-14	1810-2020	rain	10	SW	2	2	0	9–12	beyond tire reef site

*1 : Scale range (0–10)
*2 : Beaufort's wind scale (0–12)
*3 : Scale range (0– 9)] WMO Code 3700, S–state of sea
*4 : Scale range (0– 9)

Table 24. Composition of the fish caught by the gill net experimental fishing in the project area.

Fish Caught	Catch in Weight			
	Around Tire Reef Site		Beyond Tire Reef Site	
	(g)	(%)	(g)	(%)
Jacks	4,277	29.8	405	1.9
Lizardfish	410	2.9	205	1.0
Tigarfish	638	4.4	650	3.0
Grunts	478	3.3	1,860	8.7
Snappers	720	5.5	95	0.4
Goatfish	181	1.3	555	2.6
Slipmouths	1,875	13.1	1,605	7.5
Indian Mackerels	2,400	16.7	4,615	21.7
Mackerels	730	5.1	0	0
Majarras	170	1.2	400	1.9
Filefish	0	0	310	1.5
Cutlassfish	0	0	195	0.9
Threadfin Breams	0	0	145	0.7
Soles	0	0	300	1.4
Anchovy	17	0.1	5	0.0
Croakers	0	0	50	0.3
Left-eyed Flounders	130	0.9	0	0
Big eyes	70	0.5	0	0
Gizzard Shads	565	3.9	820	3.8
Rabbitfish	100	0.7	0	0
Wolf Herrings	0	0	30	0.1
sub total	12,761		12,515	
Crabs	1,465	10.2	8,880	41.7
Shrimps & Prawns	85	0.6	40	0.2
Mantis Shrimps	38	0.3	150	0.7
Total	14,340	100.0	21,315	100.0

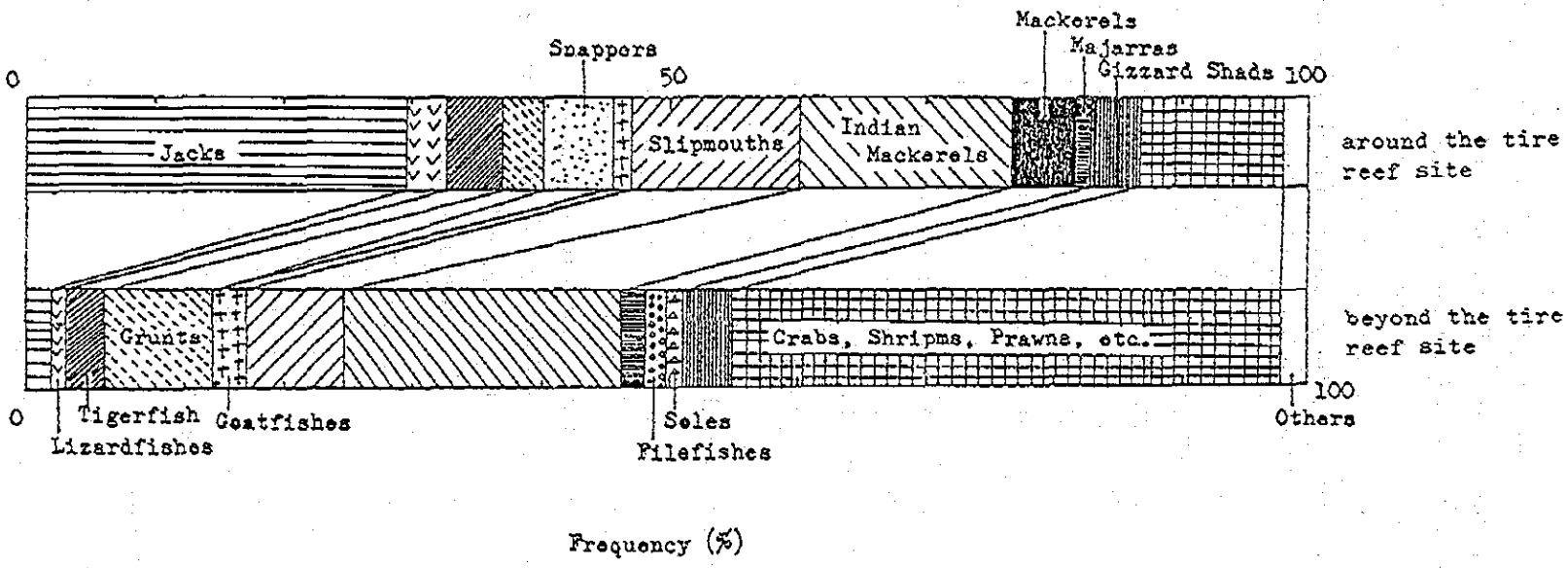


Figure 28. Composition of the fish caught, in weight, by the gill net experimental fishing conducted around the tire reef site and beyond the site off Port Sual

Discussion

We satisfy an underwater formation of the expanded tire reef that was installed as per we designed in respect to its height and form. Perhaps the combination of the process A and B helped to make it. In this type of artificial reef, however, a problem that exists is that the many pieces of the branch rope dangling from the tire reef could cause the entanglement of the fishing gear with the tire reef. Other possible problem is, " will the rope deteriorate in the water and if so, what is the rate of deterioration?" These matters must be taken into consideration and perhaps certain improvements should be made on further projects.

In comparing the former two diving observation held after one set of the tire reef (200 tires) had been installed and the latter two diving observation held after two sets of the tire reef (400 tires) had been installed, several kinds of snappers and fusiliers greatly increased in number. This might mean that quantity of fish attracted to the site is proportional to the size of the tire reef. If this is true, by continuing to enlarge the tire reef in area as well as in height, it is possible to attract as many fish as to correspond size of the artificial reef.

As of this moment, two sets of tire reef composed of 400 tires have been installed together with some payaos. We confirmed good effect in attracting fish, however, in order to accommodate more number of fishermen the tire reef installation shall be continued as long as gathering fish in quantity is proportional to the size of the reef.

According to the result of the gill net experimental fishing the schools of snappers were not easily caught in spite of their existence around the tire reef, while schools of jacks which were also observed during the dive were the most dominant species caught by the gill nets.

This difference may be attributed to the different swimming ranges of snappers and jacks. Snappers stay and swim in small area and jacks usually swim in a wide area. The bottom gill net is more efficient in catching school of jacks rather than in catching snappers. Fishing tackles and fishing pots might be more suitable and effective in catching snappers since these gear can be utilized on and beside the tire reef. Fishing gear and method should be developed for the reef site in order that the artificial reef can be utilized more effectively.

It is necessary to carry out a follow up study to determine durability of the tire reef and ability to attract fish, etc. For example, the recent experimental fishing was performed in the rainy season when, fishermen say, many fish is coming to the shore. If the ability to attract fish is observed even in dry season when, fishermen say, fish is going away, fish gathering effect of the tire reef is really proved. We should also keep on observing durability of the reef, particularly, the rope deterioration and sinking ratio of the reef into the bottom.

This project was instituted as joint project between Bureau of Fisheries and Aquatic Resources (BFAR) and Japan Overseas Cooperation Volunteer (JOCV) inicially. However, in order that this kind of project can obtain deeper understanding in local areas, the participation of JOCV should lessen in the form of transferring its function to such organizations as local government, Fishermen's association, the Lion's club or the Rotary club etc. in the respective

area. It is our pleasure to hear that after our project, the local government of Illocos Sur in Region I began an artificial reef project. We are glad if our project stimulates people in other areas and contribute to certain kind of development.

After all, it is noticed through the execution of our project that nothing is born without people's mutual understanding.

REFERENCES

Aichi Fisheries Experimental Station. 1971. Report on studies of the synthetic aid project in 1970. 23 p. (in Japanese)

Bridgestone Inc. 1979. BS-system on artificial tire reef. Ocen Age. 11 (8): 58–59 pp. (in Japanese)

Chawandani, H. (ed.) 1978. Collection of 110 practical examples on fishing gears and methods. Hokkai Suisan Sinbun. Hokkaido. 351 p. (in Japanese)

Funakoshi, S. 1974. Result of the survey on the tire reef installed off Miyazaki, Japan – I. Reports on the trust research of artificial reefs by Musashi Inc. 17 p. (in Japanese)

_____. 1974. Result of the survey on the tire reef installed off Miyazaki, Japan – II. Reports on the trust research of artificial reefs by Musashi Inc. 17 p. (kn Japanese)

_____. 1975. Result of the survey on the tire reef installed off Miyazaki, Japan. Reports on the trust research of artificial reefs by Musashi Inc. 16 p. (in Japanese)

Gomez, E.D. 1982. Growth of some corals in an artificial reef off Dumaguete, Central Visayas, Philippines. Kalikasan, Philipp. Biol. 11 (1): 148–157 pp.

Hammond, D.L., D.O. Myatt, D.M. Cupka. 1977. Evaluation of midwater structures as a potential tool in the management of the fisheries on South Carolina's artificial fishing reefs. South Carolina Marine Resources Center Technical Report Series Number 15. 19 p.

Higo, N. 1974. On the fish gathering effect of the artificial reefs ascertained by the diving observation – I. Mem. Fac. Fish., Kagoshima Univ. (28): 19–28 pp. (in Japanese)

_____and M. Nagashima. 1978. On the fish gathering effect of the artificial reefs ascertained by the diving observation – II. Mem. Fac., Kagoshima Univ. (27): 117–130 pp. (in Japanese)

_____, H. Hashi, S. Tabata and T. Kamimizutaru. 1979. On the fish gathering effect of the artificial reefs ascertained by the diving observation – III. Mem. Fac., Kagoshima Univ. (27): 91–105 pp. (in Japanese)

_____ and S. Tabata. 1979. On the fish gathering effect of the artificial reefs ascertained by the diving observation – IV. Mem. Fac., Kagoshima Univ. (28): 107–117 pp. (in Japanese)

_____, H. Hashi, M. Goto, S. Tabata and M. Kakimoto. 1980. On the fish gathering effect of the artificial reefs ascertained by the diving observation – V. Mem. Fac., Kagoshima Univ. (29): 23–35 pp. (in Japanese)

_____, _____, and T. Kamimizutaru. 1980. On the fish gathering effect of the artificial reefs ascertained by the diving observation – VI. Mem. Fac., Kagoshima Univ. (29): 37–50 pp. (in Japanese)

_____, _____, I. Takahama and S. Tabata et al. 1980. On the fish gathering effect of the artificial reefs ascertained by the diving observation – VII. Mem. Fac., Kagoshima Univ. (29): 51–63 pp. (In Japanese)

Hyogo Fisheries Experimental Station. 1971. Study on the artificial reef for propagation with the use of lamps. Reports on the studies of the synthetic aid project in 1970. 12 p. (in Japanese)

Murdy, E.O. 1979. Fishery ecology of the Bolinao artificial reef. Kalikasan, Philipp. J. Biol. 8 (2): 121–154 pp.

Ogawa, Y. 1969. Some problems of marking fishing ground with imitative sea-weeds. Study of artificial fishreefs (11): 24 p. (in Japanese)

_____. 1975. Artificial reefs of scrap tires in Japan. Bridgestone Tire Inc. technical reports on artificial reef – 1 12 p. (in Japanese)

_____. 1977. Technology on the installation of artificial fishreefs. Fish culture technology symposium 2-21 – 2-45 pp. (in Japanese)

_____. 1979. Present situation and prospect of artificial reef. Ocean Age. 11 (8): 13–21 pp. (in Japanese)

_____. 1981. History and trend of research on midwater type of artificial reef. Ocean Age. 13 (7): 11–16 pp. (in Japanese)

Oshima, Y. Housing scheme for fishes. Association of Japan Fishery Resources Conservation. Tokyo. 53 p. (in Japanese)

_____, et al. 1976. A review of artificial fishreef research – I, Primary subjects of artificial fishreef study. Association of Japan Fishery Resources Conservation. Tokyo. 119 p. (in Japanese)

Schroeder, R.E. 1980. Philippine shore fishes of the western Sulu Sea. Bureau of Fisheries and Aquatic Resources. Manila, Philippines. 266 p.

Tokyo Fisheries Experimental Station. 1968. Feasibility study on Large-type concrete block artificial reef project. Tokyo Fisheries experimental station technical report series 63. 50 p. (In Japanese)

_____. 1969. Studies on the setting condition and fish gathering effect of the large-type concrete block artificial reef. Tokyo Fisheries Experimental Station technical report series 74. 35 p. (in Japanese)

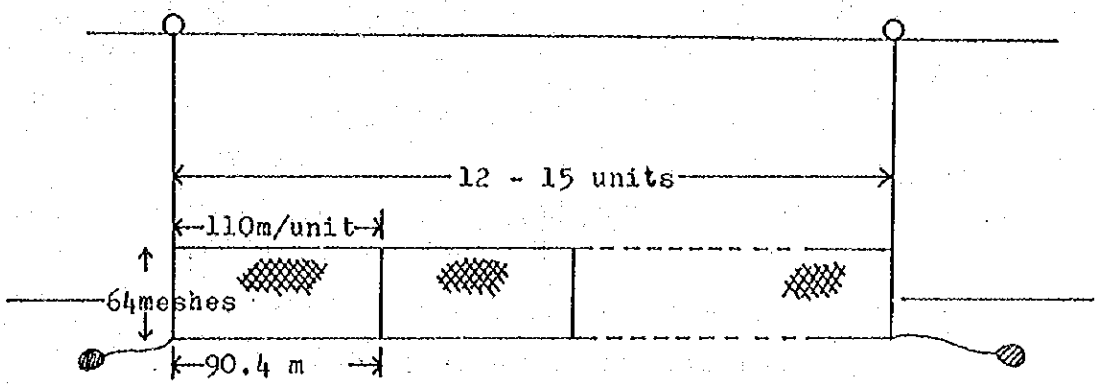
Yoshiwara, M. et al. 1971. Study on the effect of artificial reef. Niigata Fisheries Experimental Station technical report series 71-1. 65 p. (in Japanese)

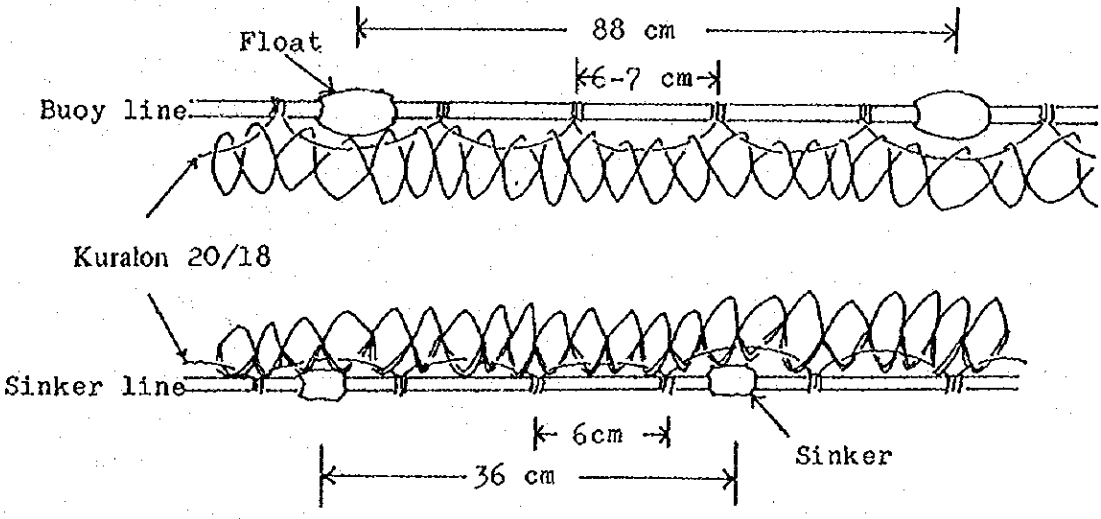
APPENDIX A

Fishing Gear Observed in Lingayen Gulf

Gear No. 1 Bottom Set Gill Net

Local Name: Panti (Tagalog)
Sigay (Ilocano)
Tankok (Pangasinan)

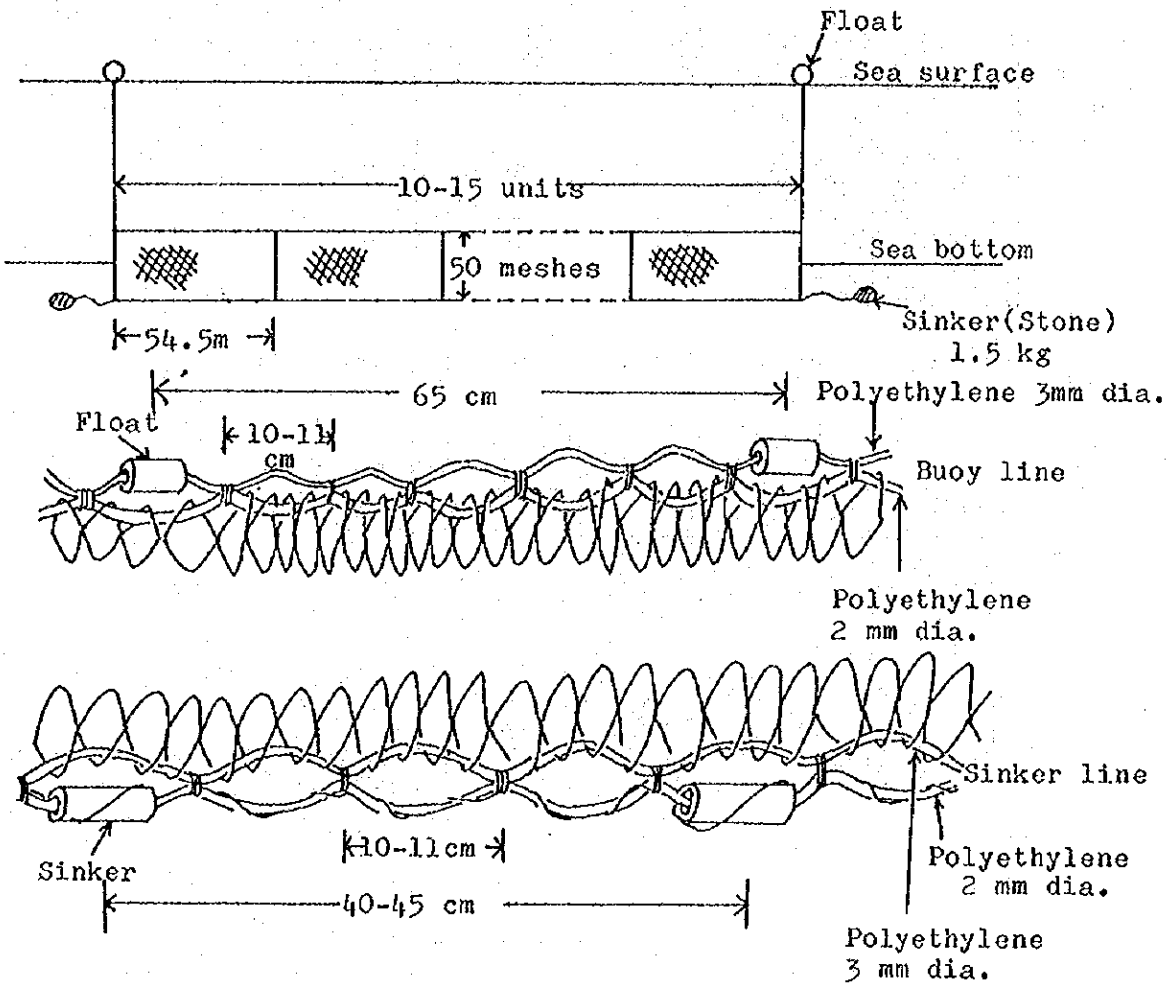




Name	Material	Standard/unit	Remarks
Net	Nylon	110d/2, 12 knots, 64 meshes, 100 m, 1 pc.	
Buoy line	Polyethylene	3 mm dia., 110 m, 1 pc.	
Sinker line	Polyethylene	3 mm dia., 90.4 m, 1 pc.	
Float	Rubber	2.0 cm x 5.8 cm, 8 pcs.	
	Wood	6.0 cm x 2.5 cm, 17 pcs. 4.5 cm x 2.1 cm, 100 pcs.	Total buoyancy 0.9 kg
Sinker	Lead	1.5 cm x 1.0 cm, 262 pcs.	Total sinking power 2.4 kg

Gear No.2 Bottom Set Gill Net

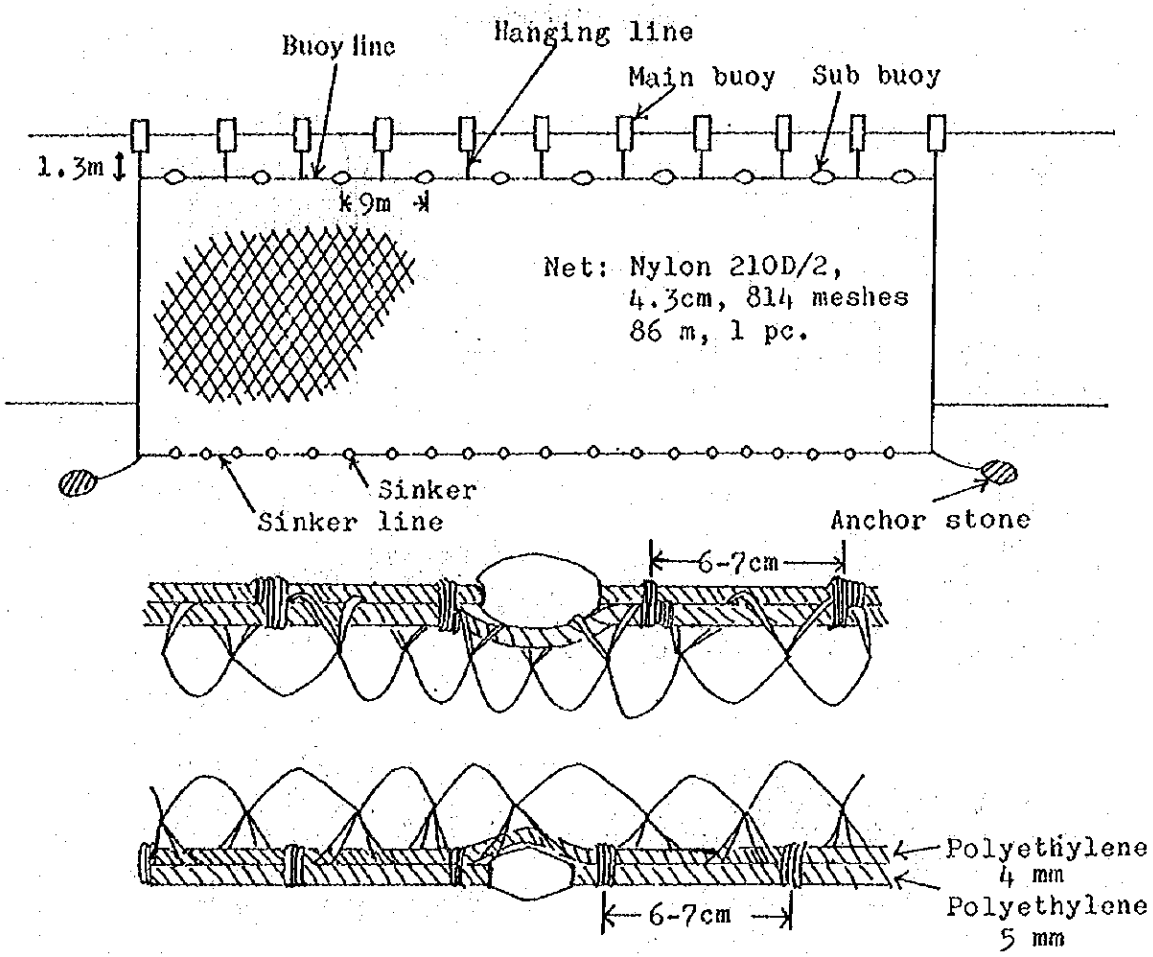
Local Name: Panti (Tagalog)
Sigay (Ilocano)
Tankok (Pangasinan)



Name	Material	Standard/unit	Remarks
Net	Nylon mono	0.2 mm dia., 6.5, 7.0, 7.5, 9.0, 12.0 knots 50 meshes, 54.5 m, 1 pc.	Shrinkage 37 – 46%
Buoy line	Polyethylene	3 mm, 54.5 m, 1 pc. 2 mm, 54.5 m, 1 pc.	
Sinker line	Polyethylene	3 mm, 54.5 m, 1 pc. 2 mm, 54.5 m, 1 pc.	
Float	Wood or Rubber	5.0 cm x 2.3 cm, 84 pcs.	Buoyance 1.1 kg
Sinker	Lead	4.5 cm x 0.7 cm, 128 pcs.	Sinking power 1.9 kg

Gear No.3 Bottom Set Gill Net

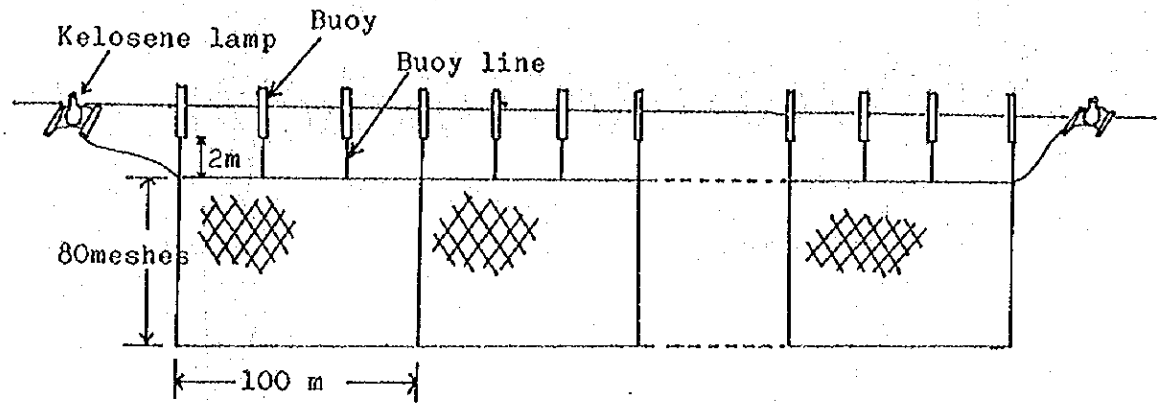
Local Name: Largarite



Name	Material	Standard/unit	Remarks
Net	Nylon	210D/2, 8 knots 814 meshes, 86.4 m	Hang-in ratio 28.5%
Buoy line	Polyethylene	4 mm dia., 86.4 m, 1 pc. 5 mm dia., 86.4 m, 1 pc.	
Hanging line	Polyethylene	4 mm dia., 1.3 m, 11 pcs.	The length is adjusted by sea depth.
Sinker line	Polyethylene	5 mm dia., 86.4 m, 1 pc.	
Sub buoy	Steroid foam	7.5 cm x 5.0 cm, 10 pcs.	Buoyance 0.7 kg
Main buoy		22 cm x 12 cm, 10 pcs.	
Sinker	Lead	2.2 cm x 1.7 cm, 133 pcs.	Sinking power 3.8 kg
Anchor	Stone	3 kg, 1 pc. 5 kg, 1 pc.	

Gear No.4 Tuna Drift Gill Net

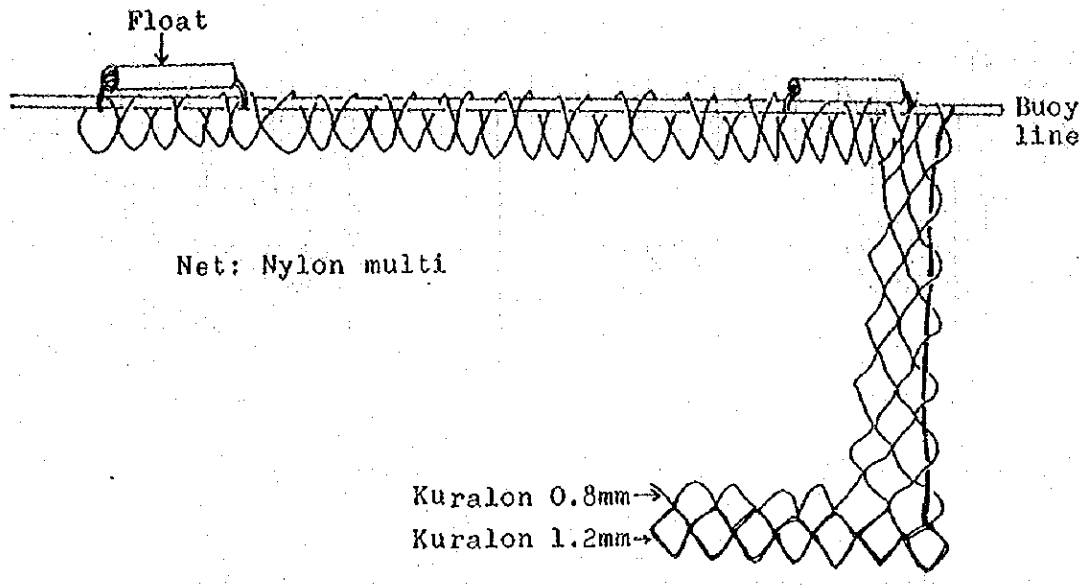
Local Name: Liting



Name	Material	Standard/unit	Remarks
Net	Nylon	210D/21, 15 cm, 80 meshes, 100 m, 1 pc.	
Buoy	Wood	45 cm x 3 cm, 45 pcs.	
Buoy line	Polyethylene	2.5 mm dia., 2.1 m, 45 pcs.	

Gear No.5 Surface Gill Net

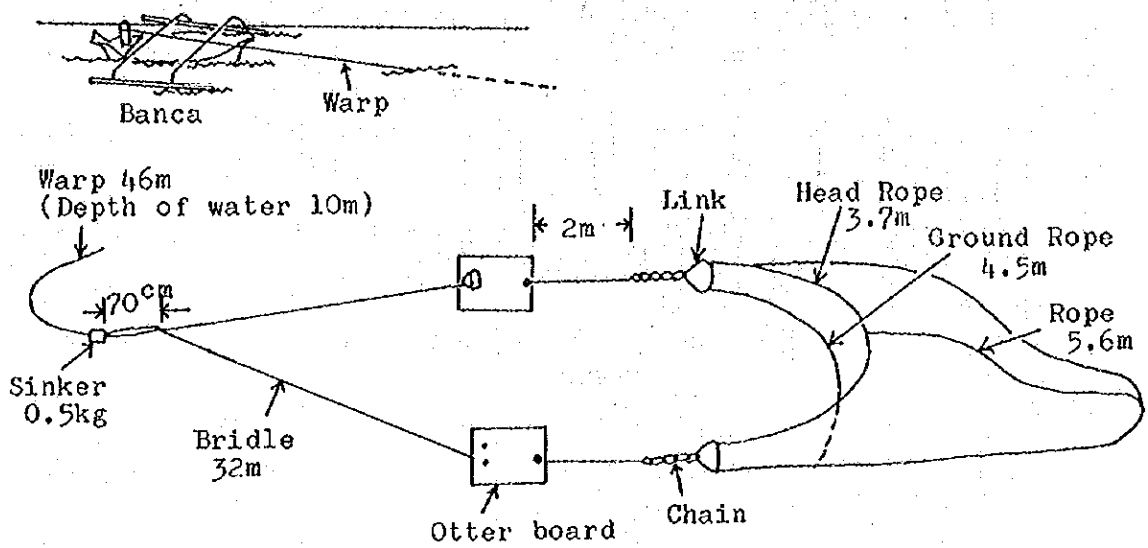
Local Name: Paltaw (Ilocano)



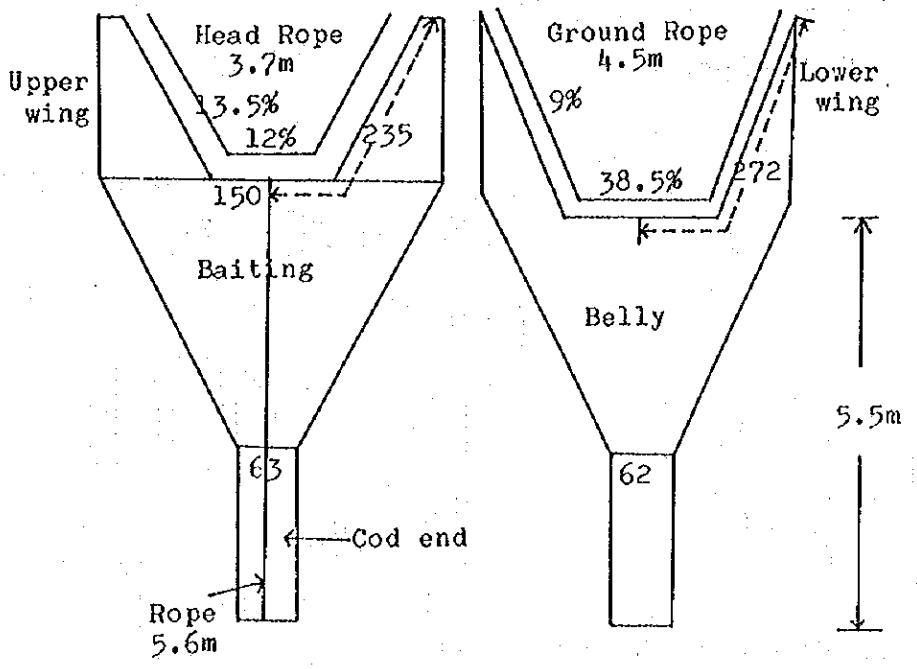
Name	Material	Standard/unit	Remarks
Net	Nylon Multifilament	210D/2, 7 knots, 18 meshes, 115 m, 1 pc.	Hang-in ratio 42%
Buoy line	Polyethylene	1.2 mm dia., 115 m, 1 pc.	
Float	Wood	10 cm x 1 cm, 198 pcs.	Total buoyancy 0.9 kg

Gear No.6 Baby Trawl Net

Local Name: Karkar

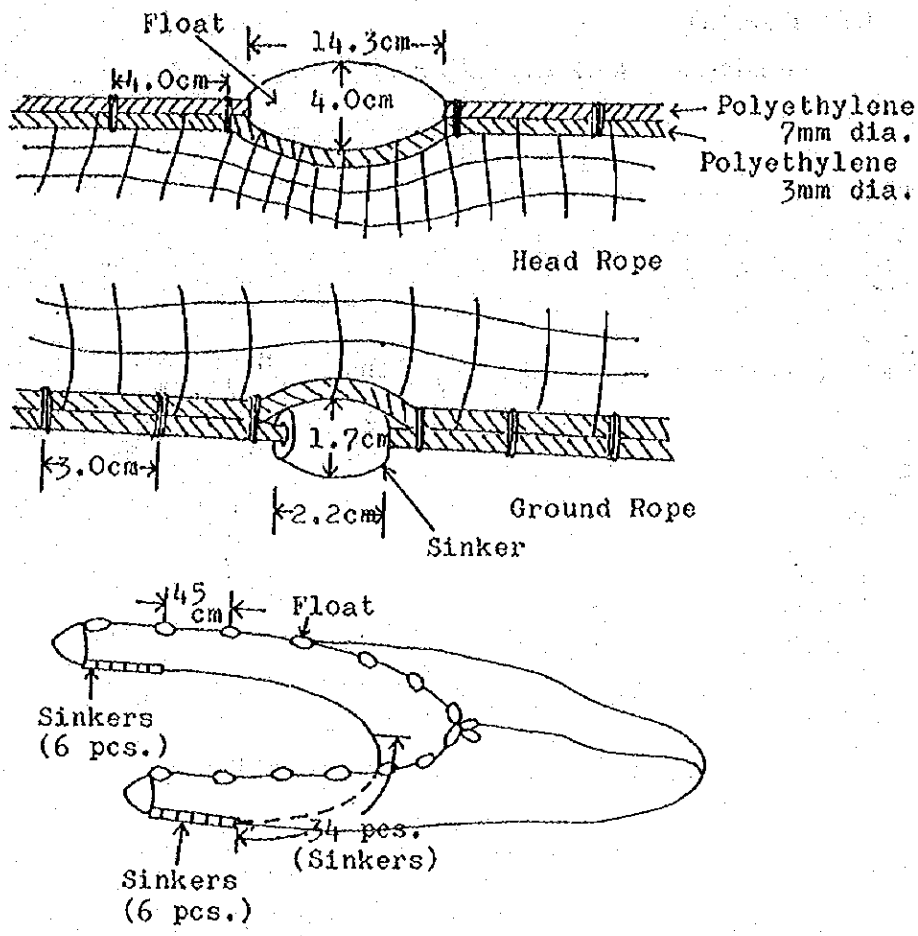


Design of the fishing operation

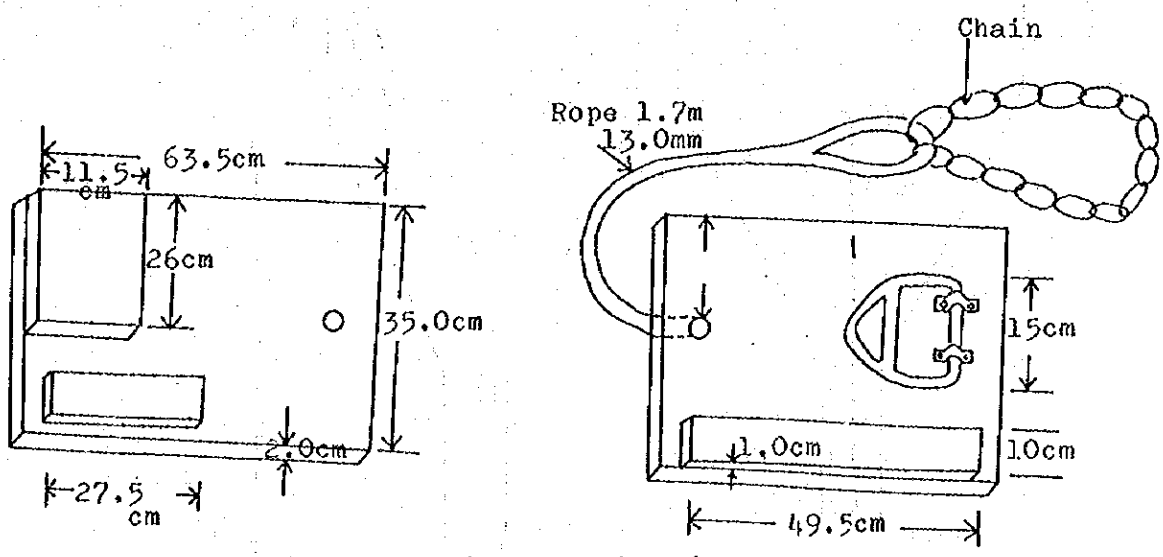


Design of the net

– continued –



Placement of floats and sinkers



Design of the otter board

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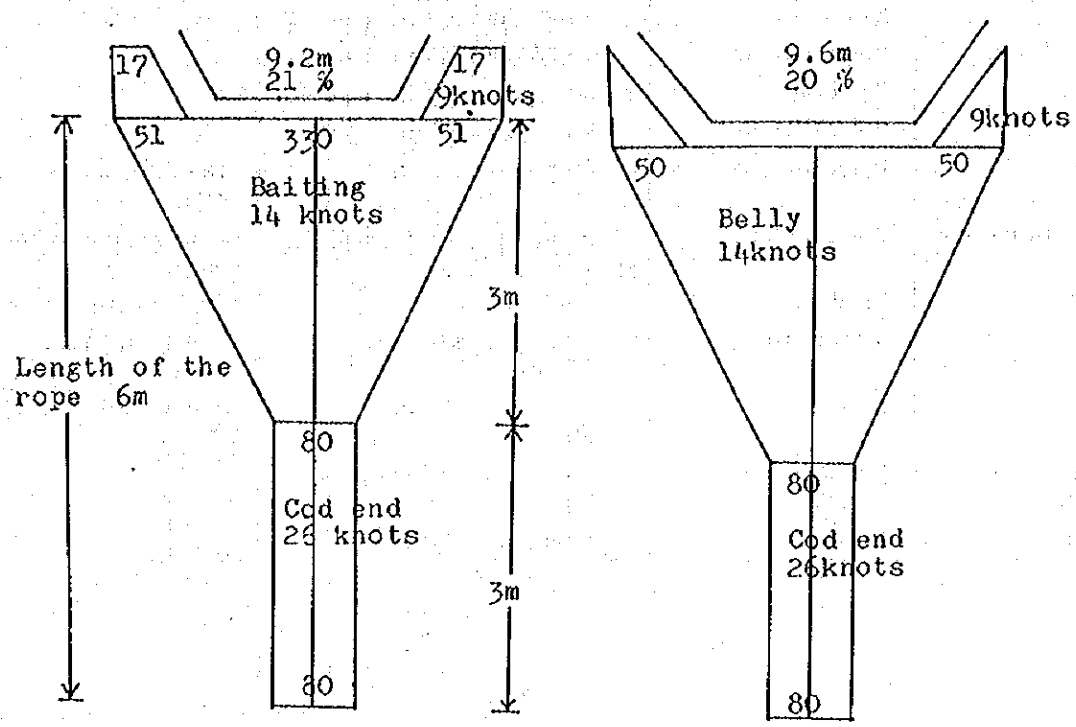
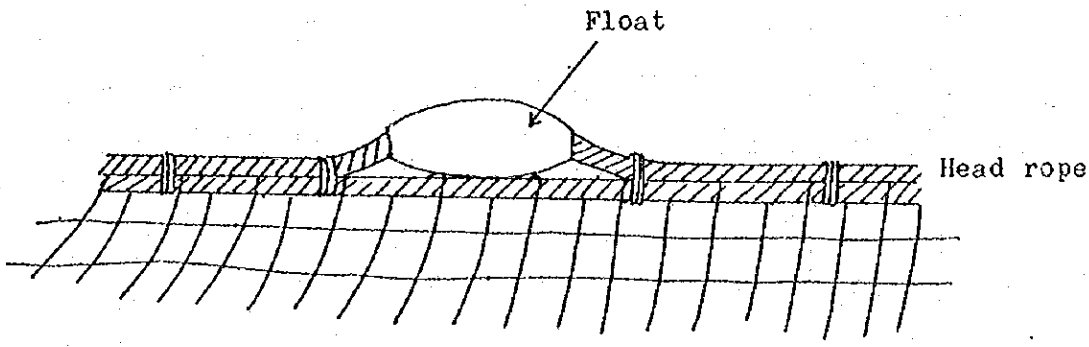
Name	Materials	Standard/unit	Remarks
Net	Nylon	210D/6, 9 knots English knot	Coal tar dyeing
Head rope	Polyethylene	7 mm dia., 3.7 m, 1 pc.	
	Kuralon	3 mm dia., 3.7 m, 1 pc.	
Ground rope	Polyethylene	7 mm dia., 4.5 m, 1 pc.	
	Kuralon	3 mm dia., 4.5 m, 1 pc.	
Bridle	Polyethylene	8 mm dia., 32 m, 2 pcs.	
Warp	Polyethylene	10 mm dia., 46 m	Depth of water 10 m
Rope for baiting	Polyethylene	3 mm dia., 5.6 m, 1 pc.	from bosom to cod end
Link	Steel	8 mm dia.	Triangular shape
Float	Steroid foam	14.3 cm x 4.0 cm, 16 pcs.	Total buoyancy 1.2 kg
Sinker	Lead	2.2 cm x 1.7 cm, 80 pcs.	Total sinking power 2.3 kg
Otter board	Wood & Iron	63.5 cm x 35.0 cm, 2 pcs.	
Chain	Iron	8 mm dia., 2 pcs.	

Gear No.7 Baby Trawl Net

Local Name: Karkar



Design of the net



Float and Head rope

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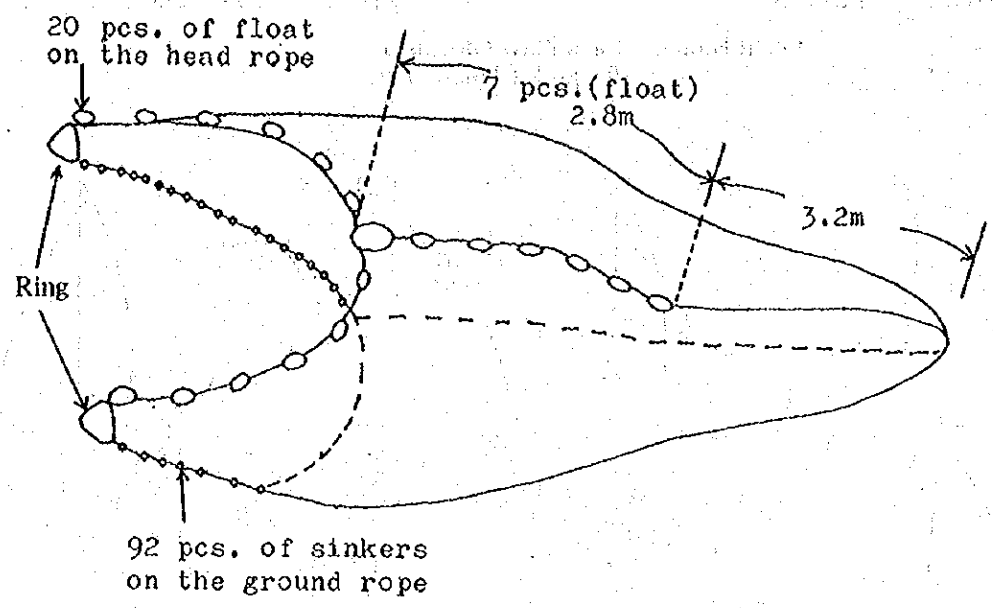
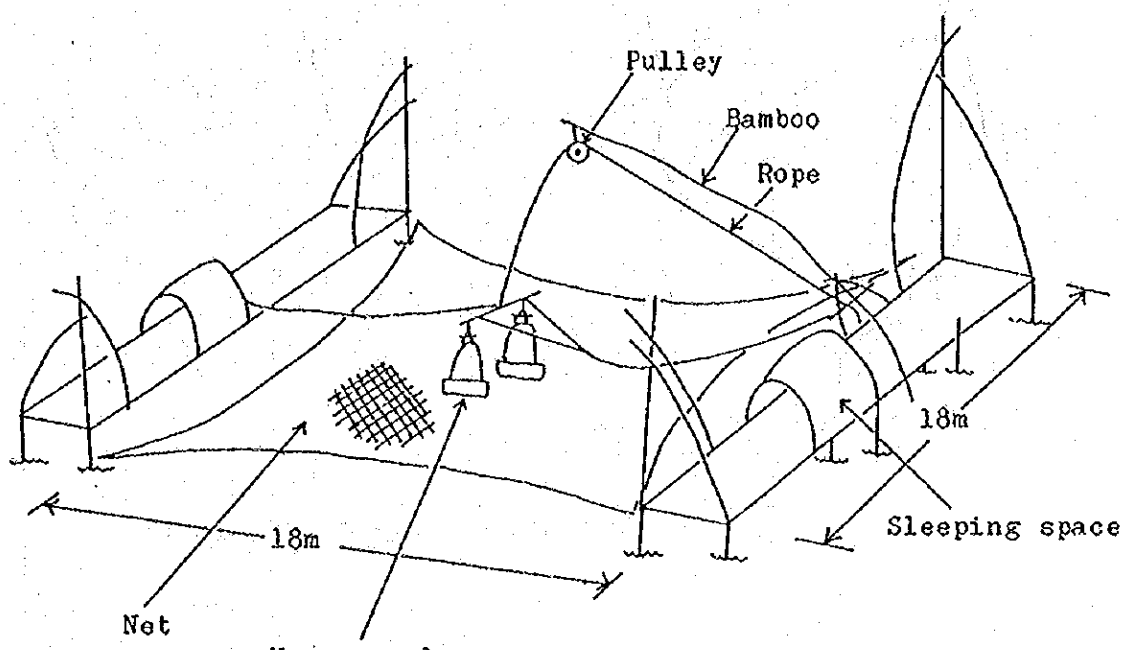


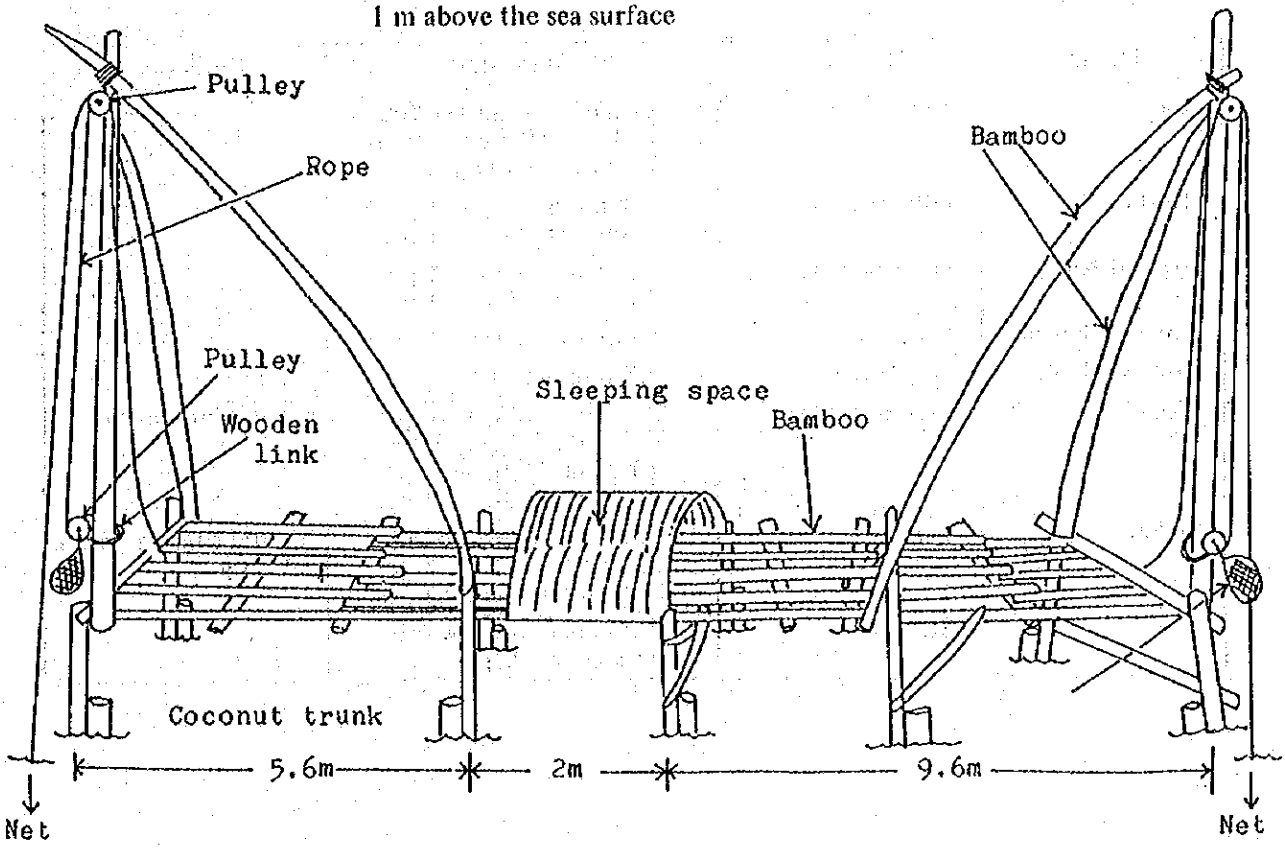
Arrangement of floats and sinkers

Name	Materials	Standard/unit	Remarks
Net	Nylon	210D/12, 9 knots (Wings) 14 knots (Belly, Baiting) 26 knots (Cod end)	
Head rope	Polyethylene	5 mm dia., 9.2 m, 1 pc. 3 mm dia., 9.2 m, 1 pc.	
Ground rope	Polyethylene	5 mm dia., 9.6 m, 1 pc. 3 mm dia., 9.6 m, 1 pc.	
Rope on baiting	Kuralon	3 mm dia., 6.0 m, 1 pc.	
Rope on belley	Polyethylene	2.5 mm dia., 1 pc.	
Float	Steroid foam	9.8 cm x 5.2 cm, 16 pcs. 6.3 cm x 3.8 cm, 9 pcs. 13.5 cm x 8.0 cm, 1 pc. 13.2 cm x 3.8 cm, 1 pc.	Total buoyancy 2.0 kg
Sinker	Lead	3.8 cm x 2.2 cm, 6 pcs. 2.1 cm x 1.5 cm, 18 pcs. 2.7 cm x 0.9 cm, 68 pcs.	Total sinking power 1.6 kg
Ling	Steel	8 mm dia., 8 cm width Triangular shape	

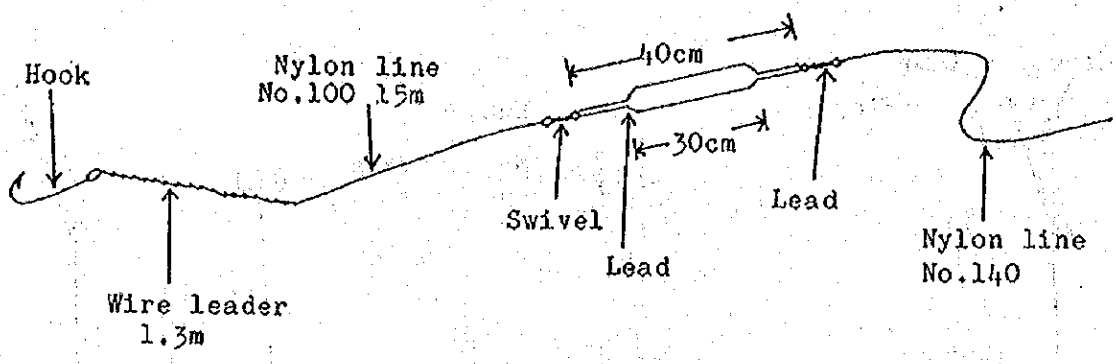
Gear No.8 Lift Net

Local Name: Salambaw (Ilocano)
Paligdik (Pangasinan)



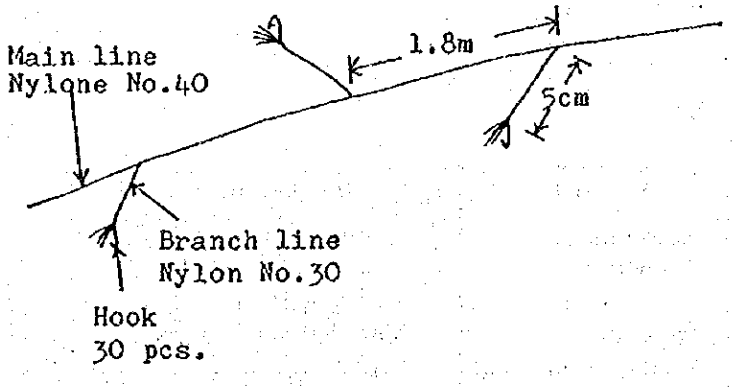


Gear No.9 Hand Line (for tuna fish)



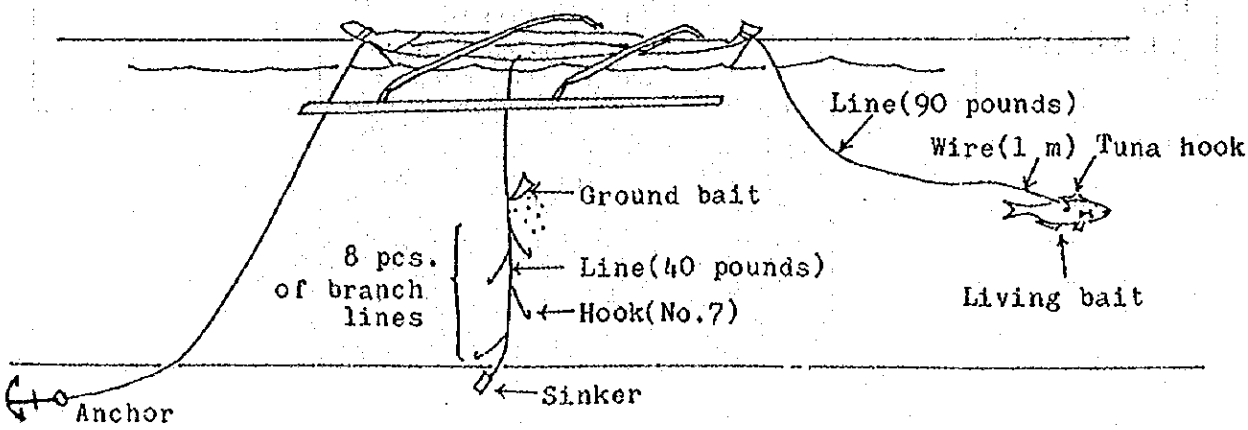
Bait: Small fish (jacks, mackerels, etc.)
Fish caught: Dorado, Bonito, Frigate mackerels, etc.

Gear No.10 Hand Line (for small fish)



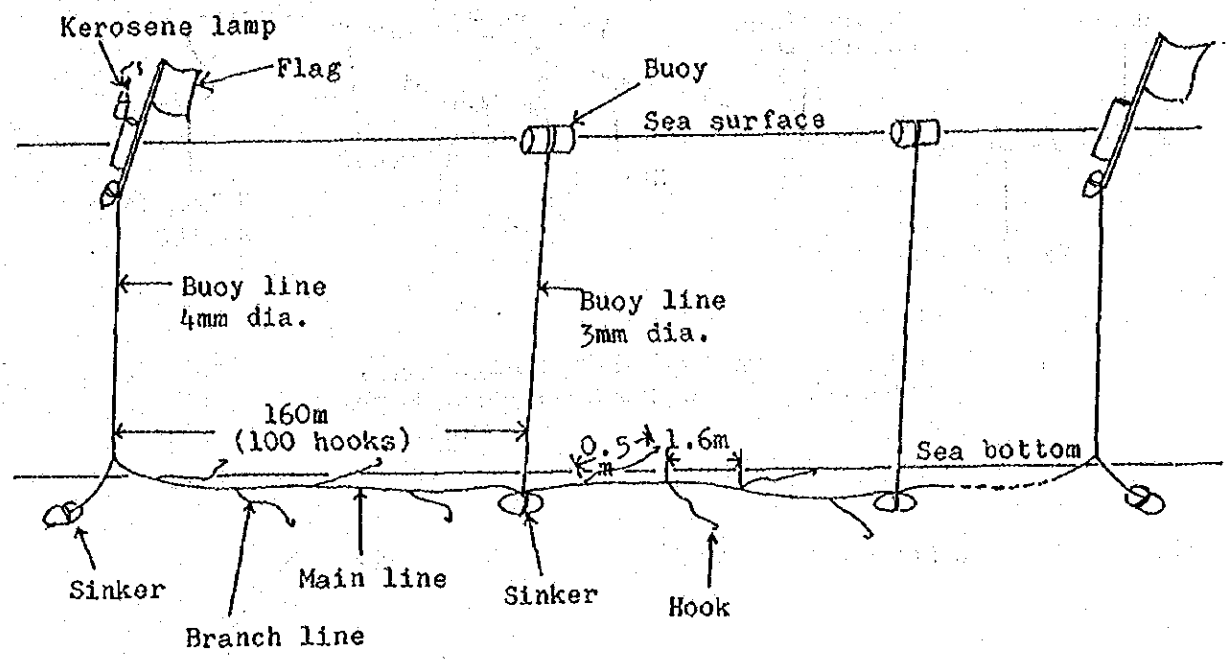
Fish caught: Round scad (Boriri), etc.

Gear No.11 Hand Line



Gear No.12 Bottom Set Long Line

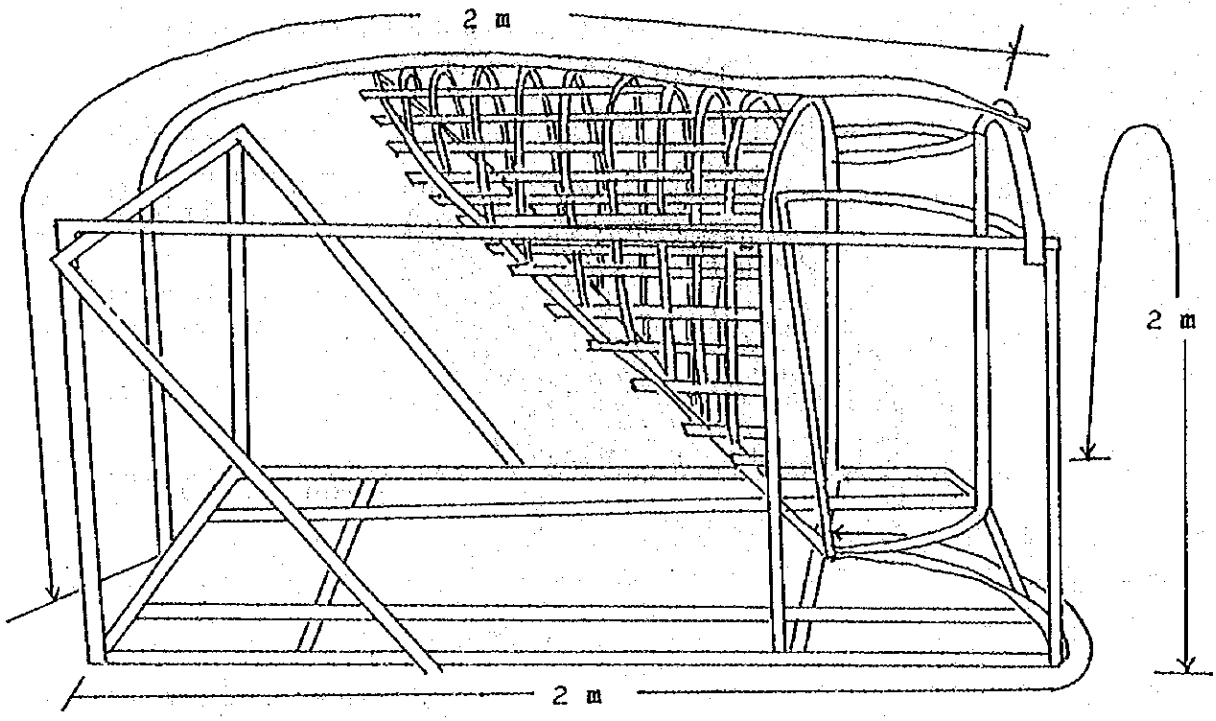
Local Name: Kittang

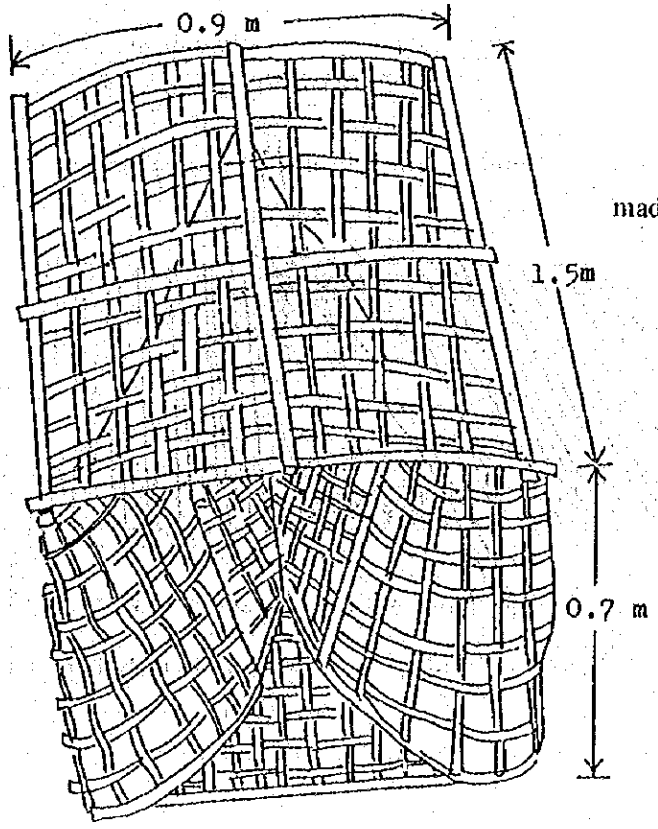


Name	Material	Standard/unit	Remarks
Main line	Nylon mono-filament	No.90 1,400 m/basket	
Branch line	Nylon mono-filament	No.45 or No.40 50 cm 800--1,000 pcs./basket	
Hook	Mustad-round bent sea hooks	No.566 or No.567 800--1,000 pcs./basket	
Buoy line	Polyethylene	No.8 125 m, 2 pcs. No.4 or No.6 125 m, 8 pcs.	
Sinker	Stone	0.25 kg, 10 pcs.	
Buoy	Bamboo	8 pcs.	
Flag		2 pcs. (both ends)	
Kelosene lamp		2 pcs. (one on the banca the other on the flag)	

Gear No:13 Fish Pot (large size)

Local Name: Nasa (Ilocano)

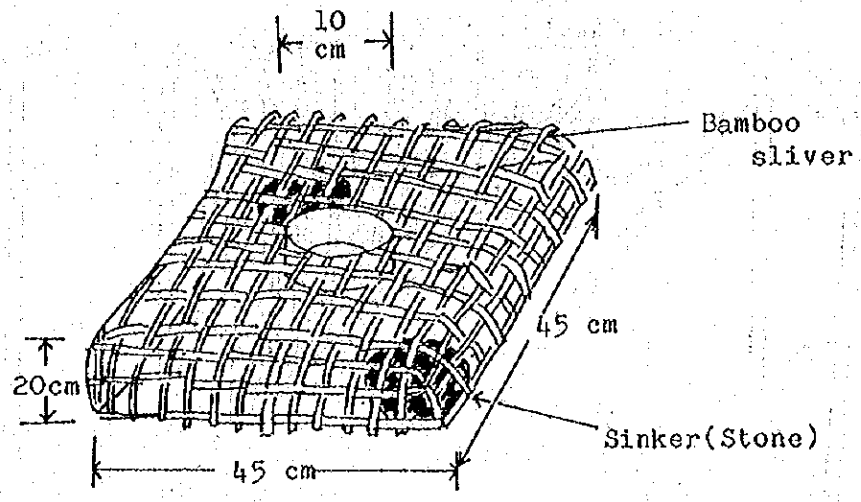


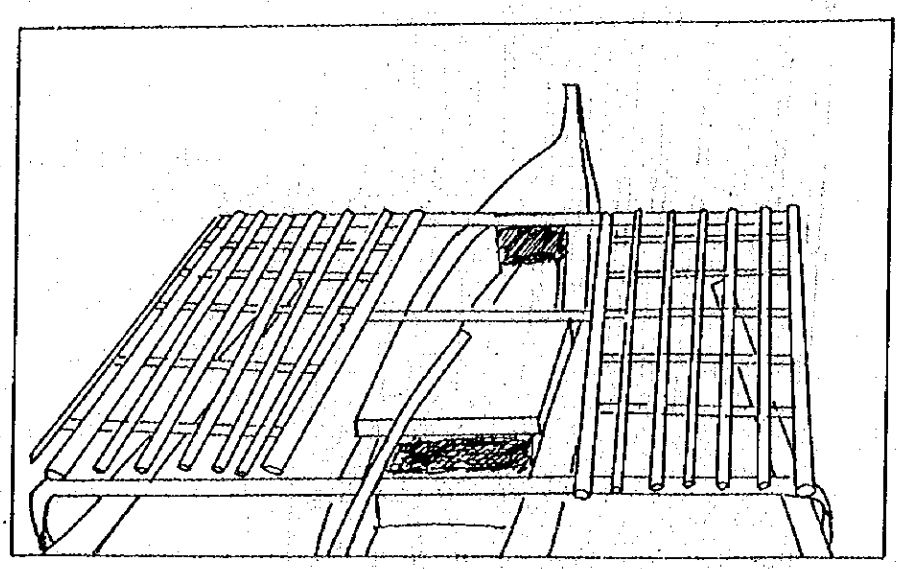


made of bamboo sliver

Gear No.14 Fish Pot (small size)

Local Name: Nasa (Ilocano)





Motorized bancas used for the small pot fishing.

APPENDIX B

Present Conditions of Various Fishing Gear in Fishing Villages along the Lingayen Gulf

A. Bottom Set Gill Net Fishing in Tobuan, Labrador, Pangasinan (Gear No. 1, Gear No. 2)

Bottom set gill nets were introduced to this barangay more than 20 years ago. Nylon multi-filament net is being replaced by nylon mono-filament net. Bottom set gill net fishing is economically important in this barangay.

Fishing season: All round year (Rainy season is better than dry season in catch).

Species caught:

Species	Size	Season
Indian Mackerels	about 20 cm	March – May
Cutlassfish	about 40 cm	October – February
Gizzard Shads	15 cm	June – August
Slipmouths	5 cm	All season

Fishing ground: Municipal waters from Sual to Binmarey
Depth . . . up to 35 fathoms
Bottom character . . . sand + mud
Time required to reach fishing ground . . . 5 min. – 30 min. by motorized boat.

Operation of the gear: The operation is held twice a day (twilight & dawn). Net hauling begins 30-60 min. after casting the net. It takes about 3 hours for one operation. 10-20 units of the net is used with a motorized banca. Two people are needed for the operation.

Disposition of catch:
Selling method: Buyers come from Dagupan City and Lingayen.
District of consumption: Dagupan City, Lingayen, Labrador
Price: Common size . . . ₱7/kg (dry season), ₱6/kg (rainy season)
Bigger size . . . . . ₱10/kg (dry season), ₱8/kg (rainy season)

Income and Expenses:
Cost of gasoline: ₱10-₱20/operation (2-4 liters/operation)
Other income: Some fishermen work in rice field from May to July.
(Philippine Peso 1.^{00} ≒ ¥ 30.^{00} as of October, 1982)

B. Bottom Set Gill Net Fishing in Cabaroan, Sto Tomas, La Union (Gear No. 2)

Bottom set gill net is the common fishing gear used in this barangay.

Fishing season: Better catch in rainy season (from June to November)

Species caught: Round Scads, Big-eyes, Jacks, Slipmouths

Fishing ground: 2 km from the shore line. Municipal waters from San Fabian to Sto Tomas.
Depth . . . 10 fathoms
Time required to reach fishing ground . . . 20-40 min.

Operation of the gear: 15-20 units of the nets are used by a motorized banca. The operation is held in the morning (AM 04:00 – AM 08:00) once a day. They begin hauling the net 30-60 min. after having casted.

Disposition of catch:

Selling method: Fishermen's wives go to the market in Agoo, La Union and sell it to buyers.

Price of fish: ₱12/kg

Income and Expenses:

Income from the fishing . . . ₱20-70;day/boat

Another source for income . . . Although a few fishermen have fish ponds, most of them depend on marine fishing income only.

Expenses for gasoline . . . . ₱16.5/operation (3 liters)

C. Bottom Set Gill Net Fishing in Casantaan, Sto Tomas, La Union (Gear No. 2)

Bottom set gill net is the common fishing gear and it is economically important in this barangay.

Fishing season: Better catch in rainy season

Species caught: Threadfin Breams, Indian Mackerels, Jacks, Slipmouths, Crabs, Shrimps. Size . . . about 20 cm

Fishing ground: Depth . . . 5-15 fathoms
Bottom character . . . Mud

Operation of the gear: The operation is held twice a day (AM 04:00-AM 08:00 & PM 05:00-PM 09:00).
Ten to twenty units of the nets are used by a motorized banca.

Disposition of catch:

Selling method: Mostly the wives of the fishermen sell their catch in Agoo, Rosario, Damortis and San Fernando. There are some buyers in the fishing villages also.

Price of fish: ₱12/kg

Income and Expenses:

Income from fishing: ₱15-20/operation (Gasoline expenses is subtracted.)

Expenses for gasoline: ₱5-15/operation

D. Bottom Set Gill Net Fishing in Bani, Rosario, La Union.. (Gear No. 1, Gear No. 2)

Nylon multi-filament net was used for many years, while nylon mono-filament net is now dominant type of net used in this barangay. About 30 bancas depend on the bottom set gill net fishing in this barangay.

Fishing season: All round year

Species caught: Threadfin Breams . . . 15-20 cm in length
Indian Mackerels . . . 20-25 cm in length, ₱12/kg
Slipmouths . . . 10-20 cm in length

Fishing ground: Depth . . . about 10 fathoms
Bottom character . . . mud
Time required to reach fishing ground . . . 1-2 hours by paddle banca

Operation of the gear: Time for operation . . . AM 04:00-AM 08:00
Amount of the gear used . . . 10-15 units
Daily catch . . . 5 kg

Disposition of catch:
Selling method: Fishermen's wives go to Damortis or Agoo for selling their catch.

E. Bottom Set Gill Net (Largarite) Fishing in Pagascasan, Sual, Pangasinan (Gear No. 3)

Fishing season: All round year

Species caught: Indian Mackerels, Cutlassfishes, Barracudas, Wolf Herring, Bonito, Jacks.

Fishing ground: Around Cabalitian Island
Depth . . . 15-25 fathoms

Operation of the gear: The gear is operated at night with two kerosene lamps on a banca for attracting fish. One unit of the gear is used. Casting and hauling the net is repeated four times at one night. Hand line is sometimes operated simultaneously.

Disposition of catch:
Selling method: Buyers come from Sual with bancas.
District of consumption: Dagupan City, Lingayen
Price of fish: ₱8/kg (large size), ₱5/kg (small size)

Expenses: Gasoline . . . ₱19-39/operation (4-8 liters/operation)
Kerosene . . ₱12 (4 liters)

F. Tuna Drift Gill Net (Liting) Fishing in Bani, Rosario, La Union, (Gear No. 4)

About ten bancas use tuna drift gill nets in this barangay.

Fishing season: December – June (dry season)

Species caught: Spanish Mackerels . . . ₱14-15/kg
Yellowfin Tuna . . . ₱10/kg

Fishing ground: Up to San Fernando area with motorized banca.

Operation of the gear: Fishing time . . . PM06:00-PM10:00 (no-moon night)
About 10 units of the nets are used.

Disposition of catch:
Selling method: Buyers come from San Fabian and Magardan, Pangasinan.

Cost of the gear construction: ₱2,000/set

G. Surface Gill Net (Paltaw) Fishing in Lucap, Alaminos, Pangasinan, (Gear No. 5)

This gear is not economically important in Lucap, Alaminos, Pangasinan at present. This net is being replaced by Nylon mono-filament net because of its poor fishing efficiency.

Fishing season: June – September (rainy season)

Species caught: Mullet, etc.

Fishing ground: in Lucap Bay
Depth . . . less than 1 fathom
Bottom character . . . mud
Time required to reach fishing ground . . . 10 min. (in Lucap Bay)
. . . 30 min. (near Hundred Is.) by non-motorized banca.

Operation of the gear: One unit of the net is used by a non-motorized banca or a raft. After they cast the net, they beat the sea surface with a stick to threaten fish and drive them into the net.

Disposition of catch:
Selling method: Buyer come from the Alaminos public market.
District of consumption: Alaminos

H. Baby Trawl Net (Karkar) Fishing in Capandanan, Lingayen, Pangasinan, (Gear No. 6)

This kind of fishing was started 30 years ago. Material of the net was changed from abaca to cotton to nylon. Size of the gear has become bigger. Engine horse power has been changed from 10 h.p. to 16 h.p. This is the major fishing gear in this barangay.

Fishing season: May . . . night time
June – December . . . day time & night time
(December – March . . . Alamang paste shrimp fishing with another type of net,)

Species caught: Tigar Shrimp, Pink Shrimp, White Shrimp, and other prawns.
Size . . . 21 cm (biggest), 11 cm (common), 7 cm (small)

Fishing ground: Municipal water of Lingayen, Pangasinan. Above all estuary of Limahong Channel.
Depth . . . about 7 fathoms
Bottom character . . . mud
Time required to reach the fishing ground . . . 15 min.

Operation of the gear: The net is often dragged in the estuary of Limahong Channel. U-turn dragging can be possible. The operation lasts for 8 hours. But when they catch little, they may go home after a few hours of the operation. One dragging time is from 30 min. to 120 min. They separate the shrimps and prawns from the fish on board and keep in an ice box after washing with sea water.

There is crowding because of the narrow fishing grounds with at least 50 plus bancas being operating within a visible site. Frequently the bancas are only 50 meters apart. There are 73 motorized bancas in this barangay and most of them use baby trawl fishing.

Disposition of catch:

Selling method: Buyers come from Lingayen and Dagupan City. Fish, shrimps and prawns are gathered at one place and sent to the markets.

District of consumption: Lingayen, Dagupan City

Price: Tigar Shrimp (12cm in length) . . . ₱30/kg
White Shrimp (10cm in length) . . ₱33/kg
(8cm in length) . . ₱18/kg
(5cm in length) . . ₱11/kg
Crabs (any size) . . . ₱ 7/kg

Income and Expenses:

Income from the fishing: ₱150-300/day (including all expenses)

Expenses for gasoline: ₱100 (20 liters)/8 hours dragging

Cost for constructing a net: ₱300/unit

Note: Fishermen in this barangay are much interested in diesel engines because of high price of gasoline.

I. Baby Trawl Net (Karkar) in Lucap, Alaminos, Pangasinan, (Gear No. 7)

This is not used commonly for fishing in Lucap, Alaminos. Hook & line and gill nets are more important economically. Five bancas operate this type of net in this barangay at present.

Fishing season: July – September (rainy season)

Species caught: Prawns . . . 7-13 cm in size
Crabs . . . small
Fish . . . 5-6 cm in size

Fishing ground: in Lucap Bay except rocky places
Depth . . . 2-5 fathoms
Bottom character . . . mud
Time required to reach the fishing ground . . . 3 min.

Operation of the gear: This is operated at night from July to September (rainy season). The net is hauled up after 2-3 hours dragging and it is repeated 4-5 times at night.

Disposition of catch:

Selling method: Fishermen's wives send the catch to buyers waiting in Alaminos public market.

District of consumption: Alaminos

Price: June–July . . . ₱40/basket
August–October . . . ₱25-30/basket (1 basket ≒ 11 – 15 kgs)

As some fishermen work in the rice field in June and July, the price of fish during those months is higher than that in the other seasons.

Income and Expenses:

Income from the fishing: ₱20-50/night (subtracted gasoline expenses)
Expenses for gasoline: ₱30/night (6 liters/night)
Cost for constructing a net: more than ₱500/unit

J. Lift Net (Salambaw) Fishing in Mangas Bakuen, Sual, and in Tobuan, Labrador, Pangasinan. (Gear No. 8)

Fishing season: all round year (especially June-November with the best catch on August).

Species caught: Anchovies . . . 4-5 cm . . . ₱9/limon (1 limon ≒ 2 kg)
Cutlassfish . . . 30-40 cm
Round scads . . . 10-20 cm
Squids

Fishing ground: Nine units of the gear in Cabalitian Bay and twenty nine units of the gear in/by Port Sual are seen. (One unit of the gear consists of one net and two platforms.)
Depth . . . 8-15 m

Bottom character . . . clay, sand, mud
Time required to reach the fishing grounds . . . 5-15 min.

Operation of the gear: Fishermen arrive at the fishing ground around PM 05:30 and prepare lamps, net and other outfits. The net is lifted up 3-4 times during one night, every 2-3 hours. The operation is finished by dawn.

Disposition of catch:

Selling method: Middle men come from Dagupan City or Lingayen. Sometimes the fishermen sell their catch in Sual by themselves.

District of consumption: Sual, Lingayen, Dagupan City

Price of the catch: ₱36/night (8 kg/night)

Income and Expenses:

Income from the fishing: ₱36/night

Expenses for oil { Kerosene . . . ₱10/night (for two lamps)
Gasoline . . . ₱10/night (for banca)

Cost for constructing a unit of the gear: ₱7,100/unit

{ Bamboo . . . ₱700 (100 pcs.)
Coconut trunk . . . ₱700 (20 pcs.)
Net, Rope, etc. . . . ₱5,700 }

K. Hook and Line Fishing in San Nicolas, Agoo, La Union, (Gear No. 9, Gear No. 10)

Fishing Ground: 20 km west from this barangay.

Price of fish: ₱5/kg (Bonito, Dorado), ₱12/kg (Round Scads)

Income and Expenses:

Income from the fishing: Sometimes gain, other time lose.

Expenses for gasoline: ₱88/trip (16 liters/trip)

L. Hand Line Fishing in Poblasion, Sual, Pangasinan, (Gear No. 11)

Fishing season: all round year (better catch in rainy season).

Species caught: Jacks, Slipmouths, Barracudas.

Fishing ground: near Hundred Islands, San Fabian Rock (north of Cabalitian Island).

Operation of the gear: The fishing operation is held in the morning (AM 05:00 -). Bait for small-size hooks is anchovies. Ground bait is used for the hooks. The other hooks are big in size to catch large-size fish such as tunas, spanish mackerels and jacks, etc. The bait used is the live fish caught by the smaller tackle.

Expenses: for gasoline . . . ₱20 (to Fan Fabian Rock)
for bait . . . ₱15 (anchovies)

M. Bottom Set Long Line (Kittang) Fishing in Victoria, Alaminos, Pangasinan, (Gear No. 12)

This kind of fishing gear was introduced to this barangay from Visayan region more than 15 years ago. At present, this is the major fishing gear in this barangay.

Fishing season: Better catch from May to December (rainy season).

Species caught: Tunas, Jacks, Indian Mackerels, Threadfin (0.2-4.0 kg/pc.)

Fishing ground: Along the municipal water from Bolinao to Labrador, Pangasinan.
Depth . . . up to 70 fathoms
Bottom character . . . mud, sand, rock and coral.
Time required to reach the fishing ground . . . 30 min. - 240 min.

Operation of the gear: Leaving the beach AM 03:00–04:00, they cast the line before dawn. As soon as they finish setting the line, they turn back to the first flag to haul the line immediately.

One fishing operation is conducted during one trip and it takes about one hour from casting to hauling the line. Anchovies, shrimps and other small fish are used as its bait.

Three units (baskets) of the fishing gear are usually used by a motorized banca. (1 basket has about 1,000 hooks.)

Disposition of catch:

Selling method: The fishermen go to the public market at Alominos to sell their catch by themselves.

District of consumption: Alaminos

Price of fish:

Species	May–December	Other months
Groupers	₱25/kg	₱25/kg
Threadfin Breams	₱13/kg	₱14/kg
Others	₱10/kg	₱12/kg

Gasoline expenses for banca:

6 liters (fishing ground near Bolinao, Pangasinan)
2 liters (fishing ground near Hundred Islands)

N. Fish Pot (Nasa) Fishing in Lucap, Alaminos, Pangasinan. (Gear No. 13)

This kind of pot was first used in this barangay more than 32 years ago. This is not a common fishing gear; only two fishermen know how to construct this fish pot in this barangay.

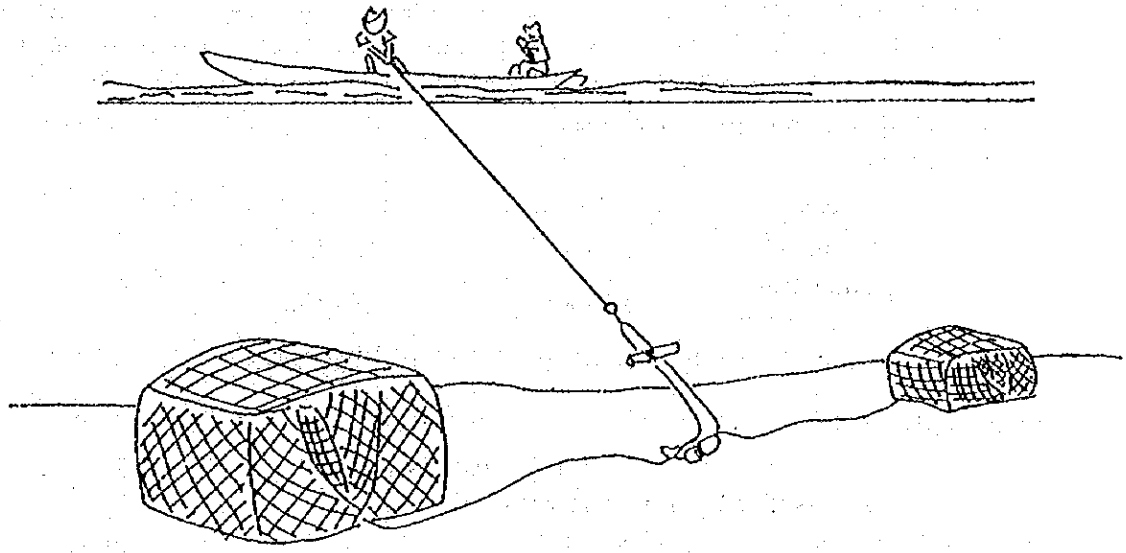
Fishing season: All round year

Species caught: Groupers (20-100 cm in length), Crabs.

Fishing ground: around Hundred Islands
Depth . . . 7-9 fathoms
Bottom character . . . mud, sand, coral.
Time required to reach the fishing ground . . . 20 min. by motorized banca

Operation of the gear: At present, 6 pots are placed at the area near Hundred Islands by the fisherman observed. Other 6 pots are being constructed. Two pots are connected by means of manila rope (about 40m) to each other.

The fisherman goes to the site twice a week at dawn to haul the pots. The pots are brought to shore once a month to dry. The pots are located in the ocean by dragging the anchor in order to catch the manila rope up (see figure). The pots are not baited.



Disposition of catch:
Selling method: Buyers come from the town proper of Alaminos.
District of consumption: Alaminos

Income and Expenses:
Income from the fishing: ₱0-200/week
Expenses for gasoline: ₱10-20/week (2-4 liters/week)
Cost for constructing a pot: ₱5/fish pot (cost of one pc. of bamboo)

Appendix C Budgetary Requirements

This is the budgetary requirements to construct and install the large size artificial reef (mentioned in the Chapter V) consisted of 1,000 pcs. of tires and ten payaos including a raft. This estimation was made in October, 1982 and at that moment, Philippine Peso ₱1.00 is equivalent to about Yen 30.00. Expenses for any kind of inspection activities are excluded in this estimation.

1. Construction & installation of the tire reef.

Old tire	large size	₱9.00/pc.	1,000 pcs.	...	₱ 9,000.00
Rope	polyethylene	18 mm dia.	500 m	...	2,500.00
Tire rope		₱0.40/m	6,000 m	...	2,400.00
Cement		₱35.00/bag	40 bags	...	1,400.00
Stone		₱150.00/load	8 loads	...	1,200.00
Mixed sand & gravel		₱150/load	2 loads	...	300.00
Transportation of tires		from Dagupan City to Tobuan, Labrador (via Pantranco Bus Cargo) ₱350/trip x 10 times		...	3,500.00
Laborer's fee		₱500/construction & installation of 200 tires		...	2,500.00
Gasoline		₱5.00/liter	700 liters	...	3,500.00
Oil		₱10.00/liter	14 liters	...	140.00
			Total		₱ 26,440.00

2. Construction & installation of the small-scale payao (10 units).

Bamboo		₱15/pc.	10 pcs.	...	₱ 150.00
Rope	polyethylene	12mm dia. 200m	₱470/coil	...	470.00
	polyethylene	10mm dia. 200m	₱320/coil	...	320.00
Coconut leaves		₱2/pc.	60 pcs.	...	120.00
Old tire	large size	₱9/pc.	10 pcs.	...	90.00
Cement		₱35/bag	20 bags	...	700.00
Mixed sand & gravel		₱150/load	1 load	...	150.00
Swivel		₱18/pc.	10 pcs.	...	180.00
Shackle		₱15/pc.	20 pcs.	...	300.00
Labor				...	500.00
Gasoline		₱5/liter	60 liters	...	300.00
Oil		₱10/liter	2 liters		20.00
			Total		₱ 3,300.00

3. Construction of a raft

Bamboo		₱15/pc.	88 pcs.	...	₱ 1,320.00
Rope	polyethylene 4mm dia.	6 coils	₱49/coil	...	294.00
Prop	wood	₱6/pc.	8 pcs.	...	48.00
Labor				...	300.00
			Total		₱ 1,962.00
			Grand Total		₱ 31,702.00