APPENDIX - I

1. Natural Conditions of Planned Sites and Their Environs

1-1 Weather Conditions

1-1-1 Meteorological Outline of Papua New Guinea

Since Papua New Guinea is located in the tropical zone, it is generally very hot and humid excluding the plateau areas. As there is practically no change in the mean temperature throughout the year, there is no seasonal change as is observed in the high latitude zone.

The weather of Papua New Guinea is characterized by trade winds and monsoons. SE trade wind blows during the period from April to November, which is known as the dry season. On the other hand, during the period from November to April, which is known as the rainy season, the NW monsoon blows and because of the winds that fully contain moisture, humidity is high, with 3/4 of the year visited by cloudy days.

Meanwhile, there is much rainfall, with a mean annual precipitation of 2,500 mm observed in more than half of the national land. However, partly because of the influence of geographical features such as mountains, there is much regional difference in the precipitation, with some areas registering a precipitation of not more than 1,000 mm annually, while others registers ones as high as 6,000 mm.

As for winds, SE winds prevail in the dry season and NW

winds in the rainy season, but the wind force is weak.

Tropical cyclones often generate in, or pass over the northern part of the country, but most of the cyclones disappear before they gather full force: occasionally, a comparatively developed cyclone leaves damage to some extent.

1-1-2 Kavieng

(1) Temperature

As may be seen from Table 1-1-2-(1), the monthly mean and extreme minimum temperatures are all very high, and seasonal changes are practically nil.

(2) Precipitation

Precipitation is relatively heavy, reaching as high as 3,200 mm annually on the average. Viewed over the whole year, the monthly mean precipitation, as shown in Table 1-1-2-(2), exceeds 300 mm, because of the prevailing trade winds which fully contain moisture in the rainy season, notably in December and January. However, even during the dry season, the monthly mean seldom drops below 200 mm, and there is no notable difference in precipitation between the rainy and dry seasons.

(3) Winds

As shown in Table 1-1-2-(3), W to NW trade monsoons previal in January, but in April, NE to E winds are observed more frequently, and from July to November when the dry season ends, E to SE trade winds start to prevail.

The wind velocity tends to become larger in the afternoons than in the mornings. Maximum wind velocity seldom exceeds 7.5 m/sec, and gales are seldom, or regionally, observed.

1-1-3 Rabaul

(1) Temperature

Similar to Kavieng, no marked monthly change of temperatures is observed.

(2) Precipitation

The annual mean precipitation is relatively small, being 2,000 mm, with monthly changes largely the same as those in the Kavieng area.

(3) Winds

As illustrated in Attached Chart 1-1-3-(3), the dry season is characterized by high E to SE winds, while from November to April, W to NW winds are recorded more frequently than winds of other directions, although they are not so strong as the E to SE winds that prevail from April to November. However, this is thought to be partly due to the location of the observation point, with the northern side shielded off with mountains, while it faces the Simpson Bay on the southern side.

TAB 1-1-2-(1) MEAN MONTHLY ANNUAL AND EXTREME TEMPERATURE CHARACTERISTICS

UNIT : DEG. C

STATION	TEMPERATURE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
KAVIENG	EXTREME MAX	34.4	34.6	35.6	37.6	35.8	36.1	35.6	37.8	37.8	37.2	37.2	35.6	37.8
	MEAN MAX	30.4	30.4	30.3	30.1	30.4	30.1	29.7	29.9	30.2	30.4	30.3	30.1	30.2
	MEAN	26.6	26.7	26.6	26.5	26.5	26.1	25.8	25.9	26.1	26.3	26.5	26.4	26.3
	MEAN MIN	22.8	22.9	22.9	22.8	22.6	22.1	22.0	21.9	22.0	22.2	22.6	22.6	22.5
	EXTREME MIN	18.1	18.9	20.6	18.3	15.6	18.0	18.3	17.8	18.9	15.6	15.6	16.7	15.6
RABAUL	EXTREME MAX	35.4	34.1	36.1	34.4	34.9	35.5	35.0	35.2	36.1	35.9	35.0	34.7	36.1
	MEAN MAX	30.9	30.9	30.7	30.8	31.2	30.9	30.4	30.7	31.4	31.6	31.3	30.9	31.0
	MEAN	27.1	27.1	27.0	27.1	27.4	27.1	26.8	27.0	27.4	27.5	27.3	27.1	27.1
	MEAN MIN	23.2	23.2	23.3	23.3	23.6	23.3	23.2	23.2	23.4	23.3	23.3	23.2	23.3
	EXTREME MIN	20.2	20.0	20.3	20.0	20.6	17.8	19.4	19.4	19.3	19.3	20.4	16.1	16.1
MADANG	EXTREME MAX	33.2	33.3	33.3	33.7	32.2	32.2	31.5	31.7	33.4	31.7	32.5	33.6	33.7
	MEAN MAX	30.2	30.1	30.1	29.9	30.2	29.8	29.6	29.7	29.9	30.1	30.2	30.1	30.0
	MEAN	26.7	26.6	26.7	26.6	26.8	26.4	26.2	26.3	26.4	26.5	26.6	26.7	26.5
	MEAN MIN	23.2	23.1	23.2	23.2	23.3	22.9	22.8	22.9	22.9	22.9	23.0	23.2	23.1
	EXTREME MIN	21.0	20.7	20.8	21.1	20.1	19.9	20.0	18.9	20.8	20.3	20.0	19.4	18.9

TAB 1-1-2-(2) MEAN MONTHLY AND ANNUAL RAINFALL, RAINNYDAY (1956 ~ 1970)

UNIT OF RAINFALL : MM

STATION	ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
KAVIENG	RAINNY DAY	20.8	17.3	21.3	19.5	17.7	17.8	18.7	18.6	17.1	16.4	18.4	21.6	225
	RAINFALL	347	281	326	303	261	230	217	208	211	229	236	395	3282
RABAUL	RAINNY DAY	15.7	13.9	15.9	14.3	8.8	8.5	10.7	11.0	9.5	9.3	12.6	16.4	147
	RAINFALL	235	233	253	194	93	124	118	122	111	126	184	249	2014
MADANG	RAINNY DAY	17.1	16.8	18.2	19.5	17.7	13.8	13.1	9.5	10.0	13.9	16.8	19.4	186
	RAINFALL	382	287	343	436	332	204	172	151	144	324	378	404	3558

TAB 1-1-3-(3) MONTHLY VECTOR MEAN WINDS (1960 ~ 1969)

STATION	ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MADANG	DIRECTION	259	265	269	265	248	263	356	41	93	78	261	258	266
	SPEED	1.0	1.0	0.5	0.5	0.5	0.5	0	0.5	0.5	0	0	0.5	0.5
RABAUL	DIRECTION	306	302	305	125	124	126	129	128	131	131	132	261	130
	SPEED	1.0	1.0	0.5	0.5	2.1	2.6	3.6	3.1	3.1	2.6	1.5	0	1.5

TAB 1-1-3-(4) HIGH WIND ON THE RABAUL (1976)

DATE	TIME	DIRECTION	AV.SPEED	GUST
		°	M/SEC	M/SEC
24 JUN	0400	340	2	
	0430	"	10.5	20
	0500	320	12	23
	0530	330	10	20
	0600	"	9	
	0700	"	5	
16 FEB	0600	310	5	10
	0700	"	10	18
	0800	320	3.5	
31 JUL	2100	150	8	
	2130	"	9	13
	2200	"	"	"
	2230	"	12	18
	2300	"	13	17
	2330	"	"	18
01 AUG	0000	"	11	16
	0030	"	14	18
	0100	140	13	16
04 SEP	0001	140	7	11
	0100	"	9	13
	0200	"	"	12
	0300	"	9.5	"
	0330	"	9	17.5
	0400	"	10	15.5
	0500	"	7	12
	0600	130	"	11
	0700	110	7.5	14
	0800	90	8	11

DATE	TIME	DIRECTION	AV.SPEED	GUST
04 SEP	FROM 0800 FOR NEXT 10 HOURS AVERAGED 7M/SEC FROM 110°			
11 SEP	0001	120	8	11.5
	0100	"	8.5	"
	0200	140	7	12
	0300	"	9	
	0400	120	10.5	14
	0500	"	8	13
	0600	"	9.5	13.5
	0700	"	10	13
	FROM 0700 TO 2100 AVERAGED 100° TO 120° AT 8.5 M/SEC			
	2130	120	10	15
	2200	"	11	14
	2230	140	12.5	17.5
	2300	150	"	"
12 SEP	0001	140	"	16
	0030	"	14	17.5
	0100	"	13	17
	0130	"	13	"
	0200	"	12.5	16
	0230	130	12.5	15

SAURCE MATERIAL

PAPUA NEW GUINEA NATIONAL METEOROLOGICAL SERVICE

Fig. 1 - 1 - 2(3)

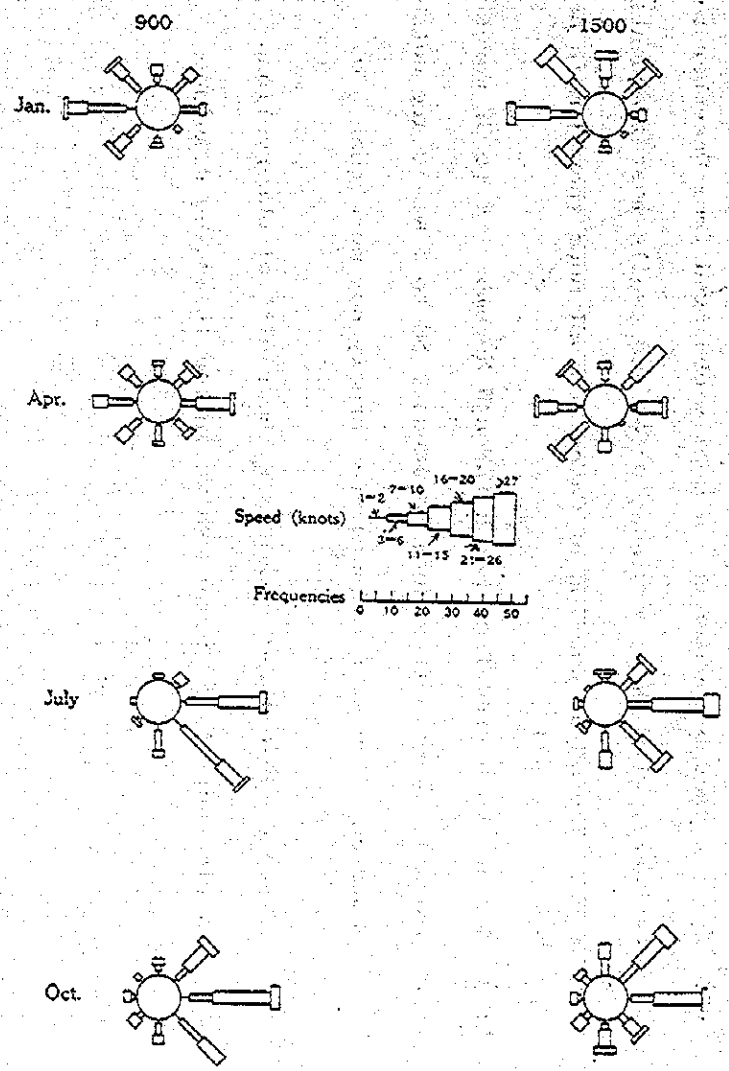
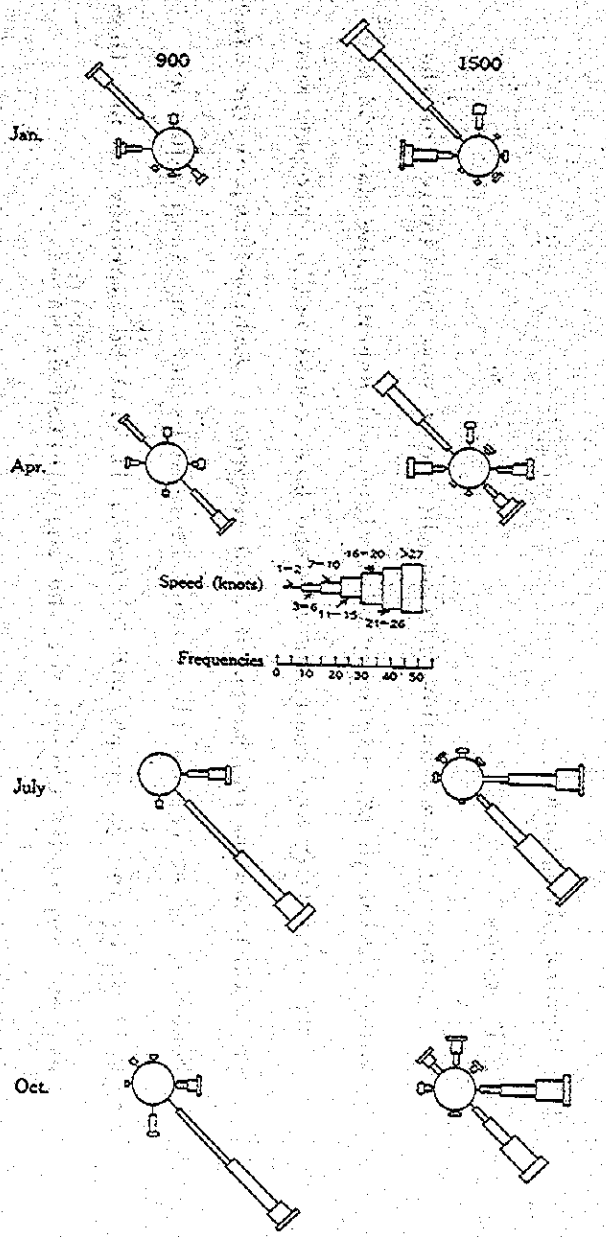


Fig. 1 - 1 - 3(3)



1-2 Marine phenomena

1-2-1 Waves

Since no observation data on the waves were available for the water basins in the vicinity of Kavieng and Rabaul, the data of wave dimensions that are required for the base construction program must be calculated on the basis of wind records. Nonetheless, as the wind records, as stated earlier, are affected by sea and land winds as well as by the geographical features, it will be improper to use them without any modification for the calculation of waves.

Results of observations carried out from 1932 to 1940 on oceanic winds, waves and swells tell us that the waves in the water basins in the vicinity of the East coast of New Guinea, New Britain Island and New Ireland Island largely have the following characteristics.

(i) Waves caused by monsoons are mostly observed from December to February, with NW to W winds, waves and swells most frequently seen. The major portion of waves are not more than 3 m in height.

(ii) During the period from March through November, E to SE waves prevail, whereas from June to August, SE to S waves are notably observed. The wave heights are largely not more than 3 m.

Attached Table 1-2-1 summarizes the rsults of observations carried out at the points shown in the following drawing.

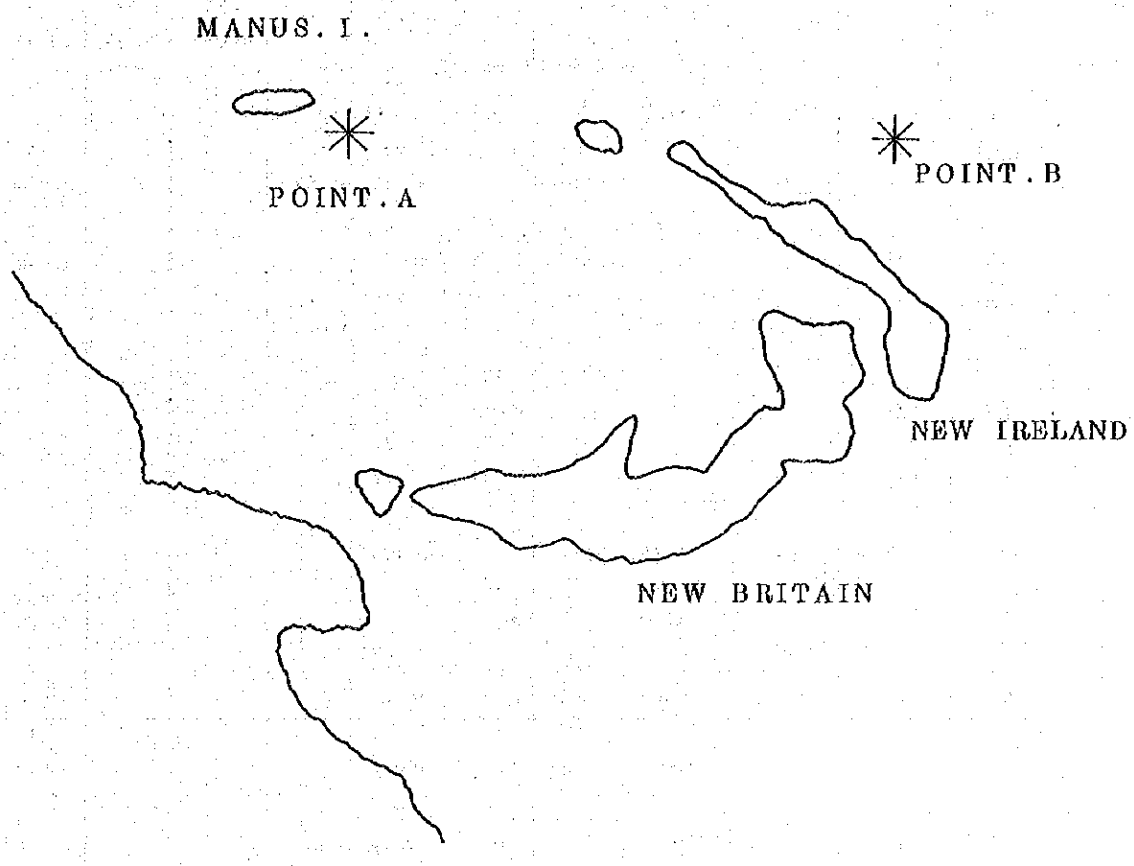

MANUS. I.
POINT. A
POINT. B
NEW IRELAND
NEW BRITAIN

Table 1-2-1 Wave Observation Results (1932 ~ 1940)

Point	Month	Observation frequency	No. of calm times	Frequency of wave height generation by direction (%)							
				N	NE	E	SE	S	SW	W	NW
A	DEC ~ FEB	16	0		12 100-0				12 100-0	19 100-0	19 33-67
		18	1	22 75-25					11 100-0	22 25-75	28 20-80
	MAR ~ MAY	28	14	7 100-0			25 86-14				
		31	7		10 100-0		29 67-33	16 40-60			10 100-0
	JUN ~ AUG	28	12	8 100-0	10 100-0	24 57-43	25 100-0				7 100-0
		29	2				41 58-42	7 100-0			
	SEP ~ NOV	51	6			19 100-0	23 83-17				
		52	19			23 67-33	37 37-47				
B	DEC ~ FEB	19	1	57 82-18	16 67-33		11 0-100				
		19	1	26 100-0		16 100-0					52 12-88
	MAR ~ MAY	19	3	7 0-100	14 100-0	21 67-33	21 100-0				7 100-0
		14	4	10 100-0	11 0-100	11 100-0	21 100-0				11 100-0
	JUN ~ AUG	34	12	7 100-0		7 100-0	23 57-43	19 0-100			
		27	6			11 100-0	30 62-36	15 25-75		11 100-0	
	SEP ~ NOV	30	6			36 100-0	16 100-0	5 100-0			
		25	7			40 92- 8	17 100-0				

Note: How to use Table

(Example of Point A)

Of the 18 times of observations carried out from December to February, the waves were calm only once.

Of the 18 times of wave observations, N-waves account for 22%, of which, small waves (not more than 1 m in height) account for 75% and medium waves (1 - 3 m high) account for 25%.

1-2-2 Tides

Tidal level differences are small (not more than 1 m) in the water basins in the vicinity of the East Coast of New Guinea and of the New Britain and New Ireland Islands. Normally, there is one tide per day.

Tables 1-2-2-(1) and 1-2-2-(2) show the tidal level differences and harmonic constants extracted from the Australian National Tide Tables (1976) for the vicinity of the planned sites.

Table 1-2-2-(1) Time & Height Differences

Place	Position		Time Differences		Height Differences (In Metres)			
	S	E	H.H.W.	L.L.W	MHHW	MLHW	MHLW	MLLW
(Standard)	° ′	° ′						
Dreger Harbour	6-39	147-53			1.5			0.9
Massava Bay	4-13	151-50	X	X	-0.7	X	X	X
Rabaul	4-12	152-11	+0012	+0012	-0.6			-0.5
Kavieng	2-35	150-48	-0007	+0037	-0.7			-0.5

Remarks:

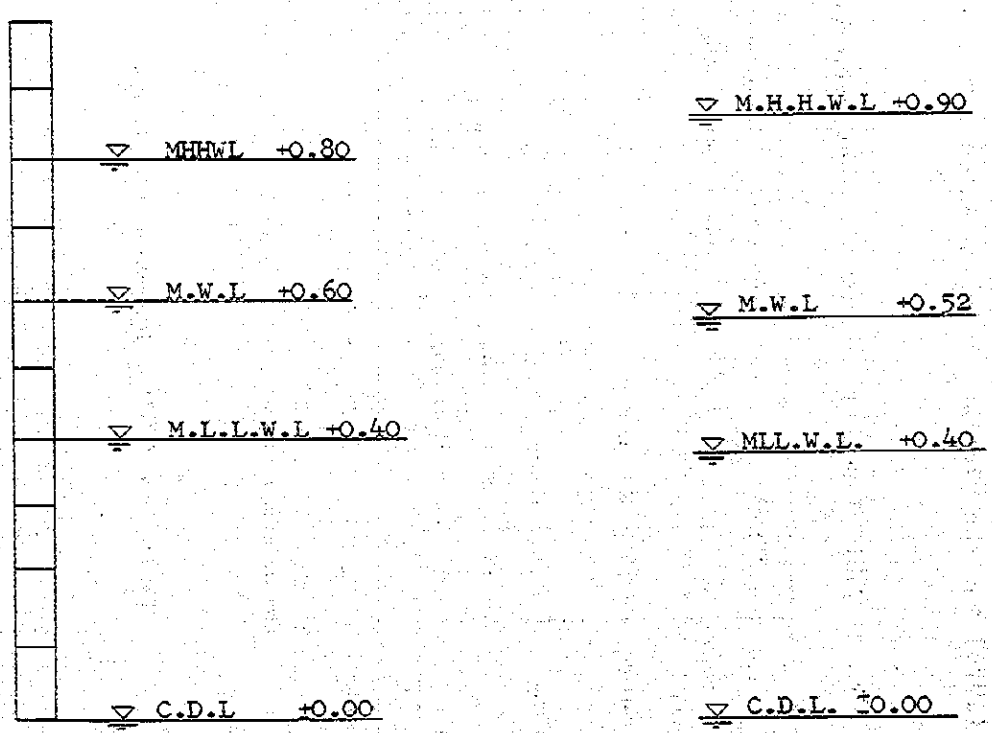
No Data

Tide is usually diurnal

Table 1-2-2-(2) Harmonic Constants

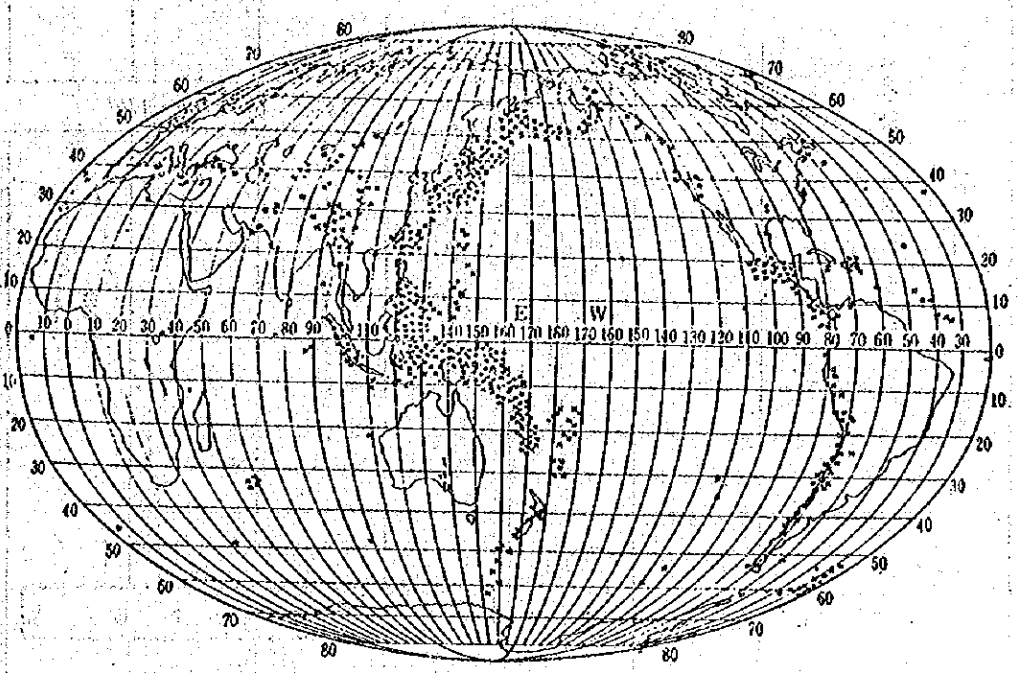
Place	Z_o	Harmonic Constants							
		M_2		S_2		K_1		O_1	
		g	H	g	H	g	H	g	H
	m	°	m	°	m	°	m	°	m
Rabaul	0.52	161	0.04	117	0.07	204	0.03	175	0.12
Kavieng	0.60	0.84	0.07	114	0.11	220	0.20	1.10	0.13

Fig. 1-2-2 Tidal Level



1-3 Earthquakes

Being located in the Circular Pacific Volcanic Zone, earthquakes occur quite frequently in Papua New Guinea. In fact, 5 to 10% of earthquakes that generate over the world having magnitudes of 6, or more, have generated in the vicinity of Papua New Guinea.



By Gutenberg, Richter, Seismicity of the Earth

1-4 Soil

Table 1-4-1 ~ 1-4-4 show results of soil surveys carried out in Kavieng and Rabaul (Kilinwata and New Massava).

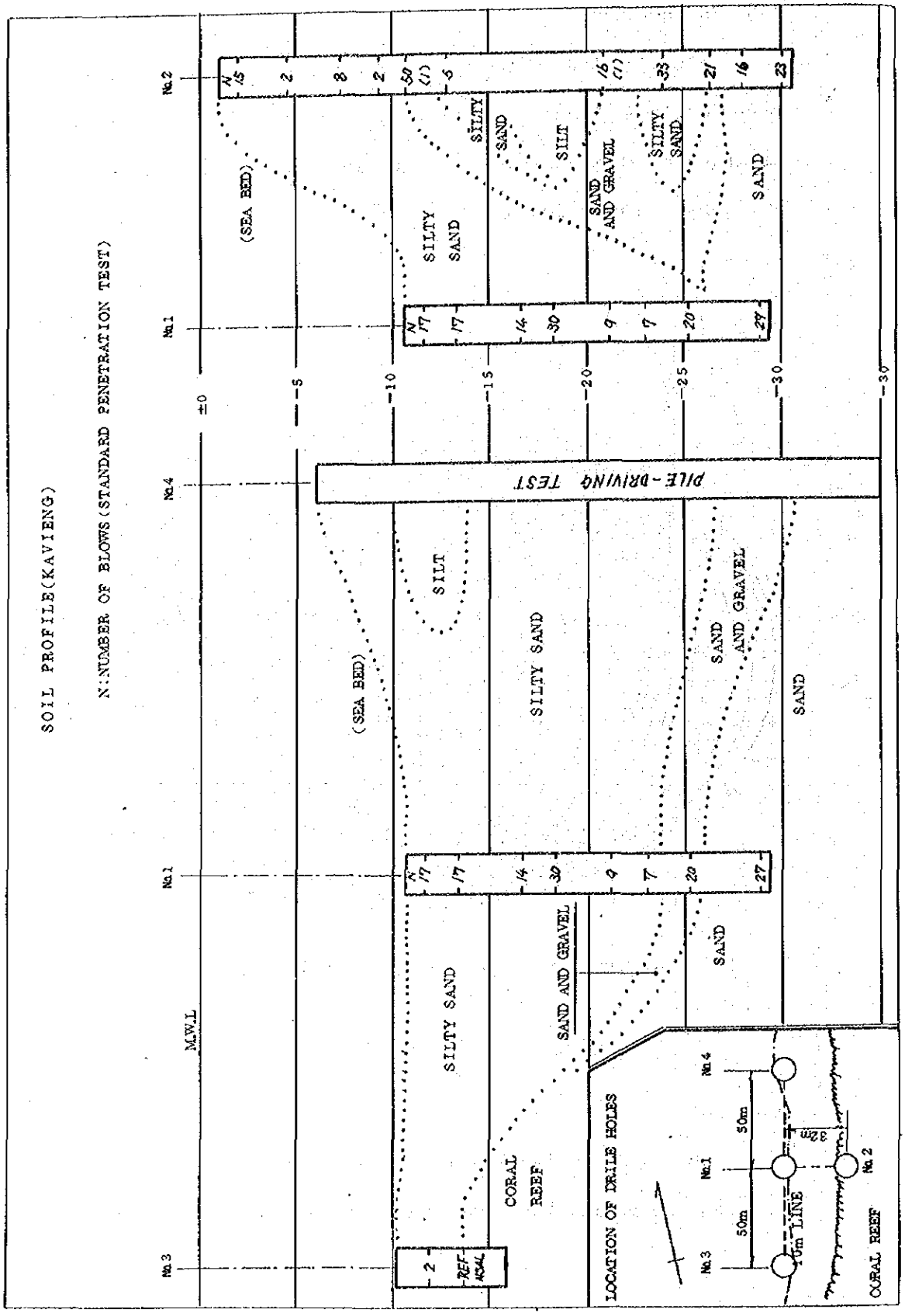

SOIL PROFILE(KAVIENG)
N:NUMBER OF BLOWS(STANDARD PENETRATION TEST)
No.2
No.1
No.4
No.3
±0
M.W.L
(SEA BED)
SILTY SAND
SILT
SAND AND GRAVEL
SAND
PILE-DRIVING TEST
CORAL REEF
LOCATION OF DRILE HOLES
50m
0m LINE

Fig. 1 — 4 — 1

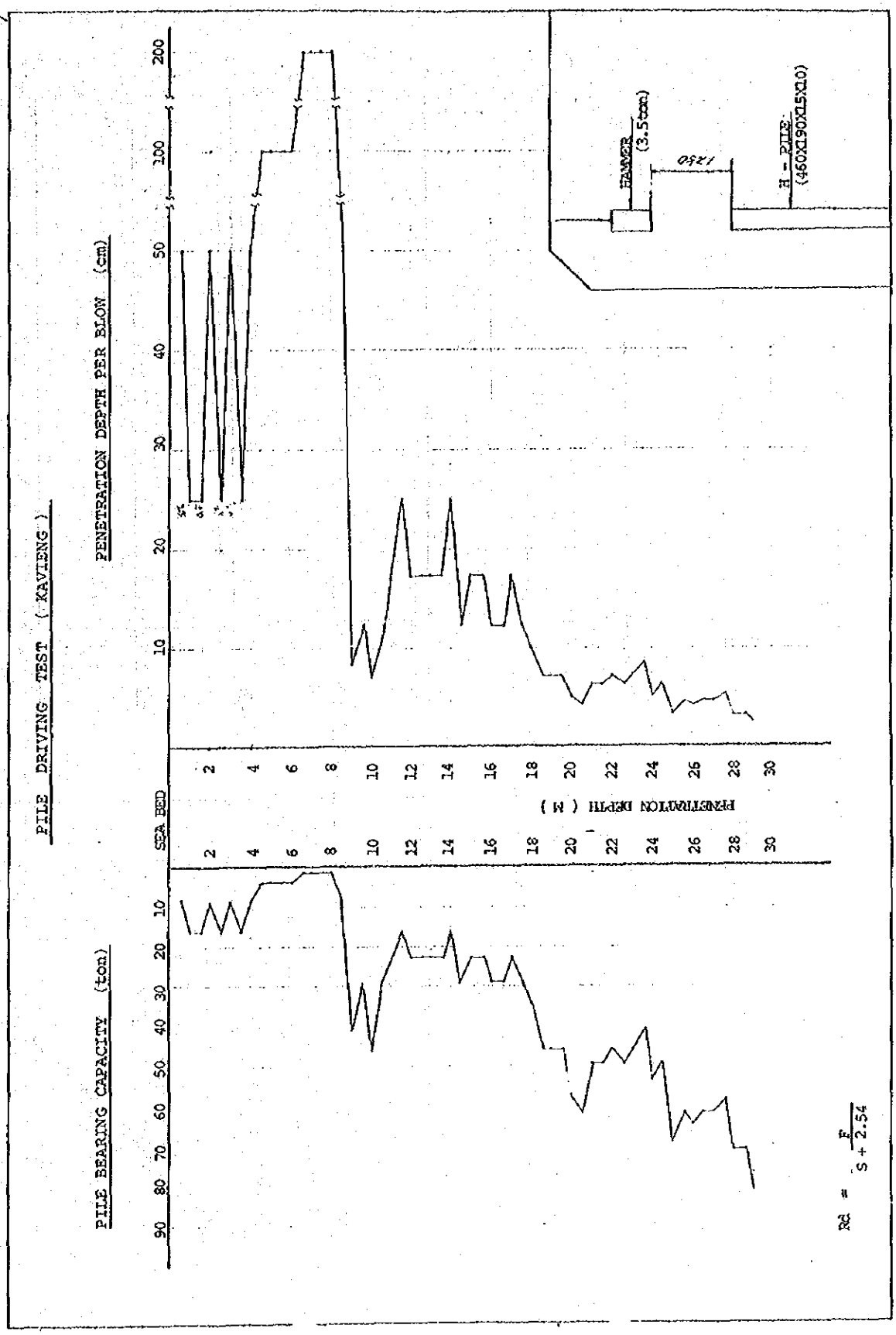

PILE DRIVING TEST (KAVIENG)
PENETRATION DEPTH PER BLOW (cm)
PILE BEARING CAPACITY (ton)
SEA BED
PENETRATION DEPTH (M)
HAMMER (3.5ton)
H - PILE (460X190X15X10)
Ra = E / S + 2.54

Fig. I - 4 - 2

Fig.1 — 4 — 3

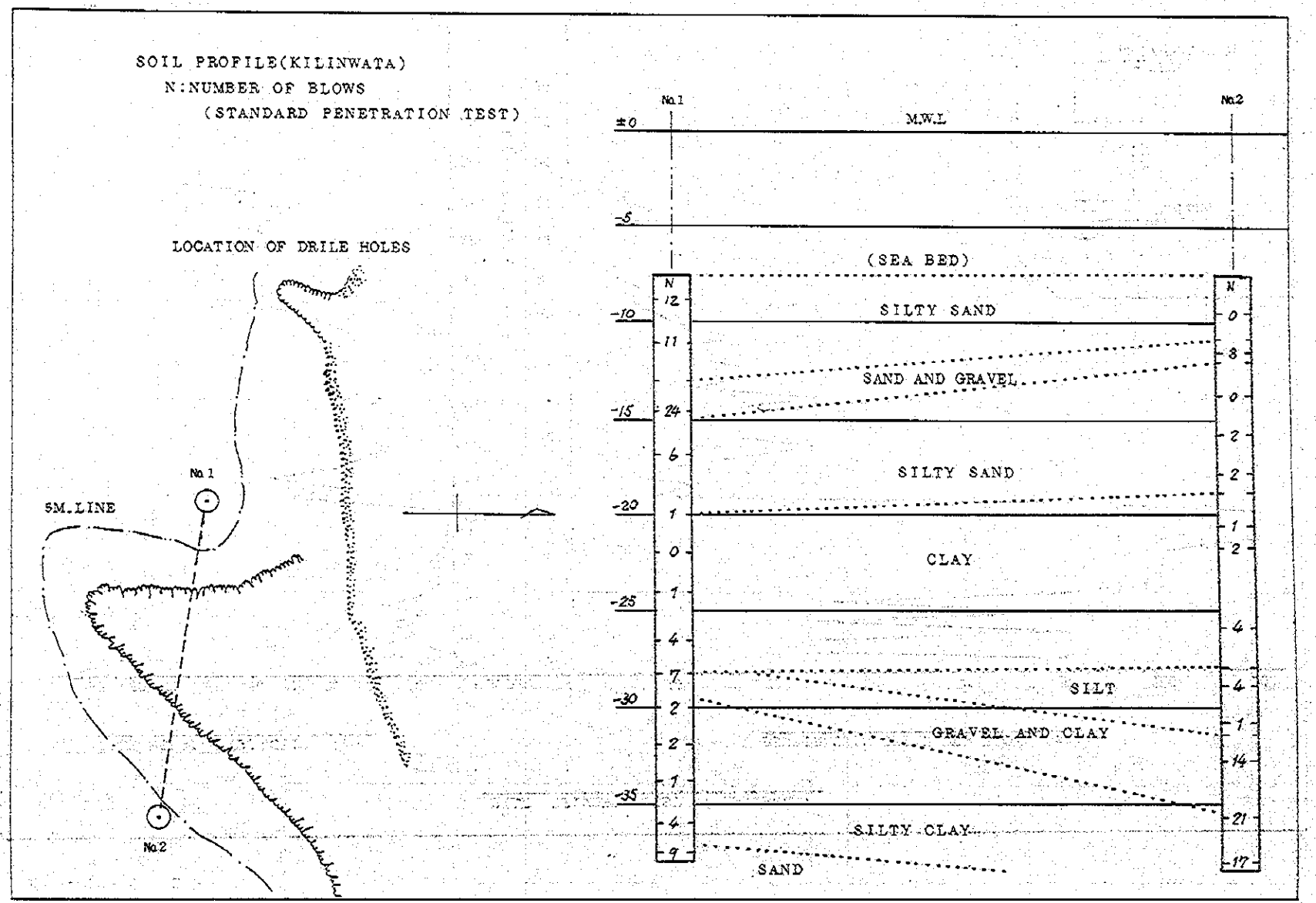
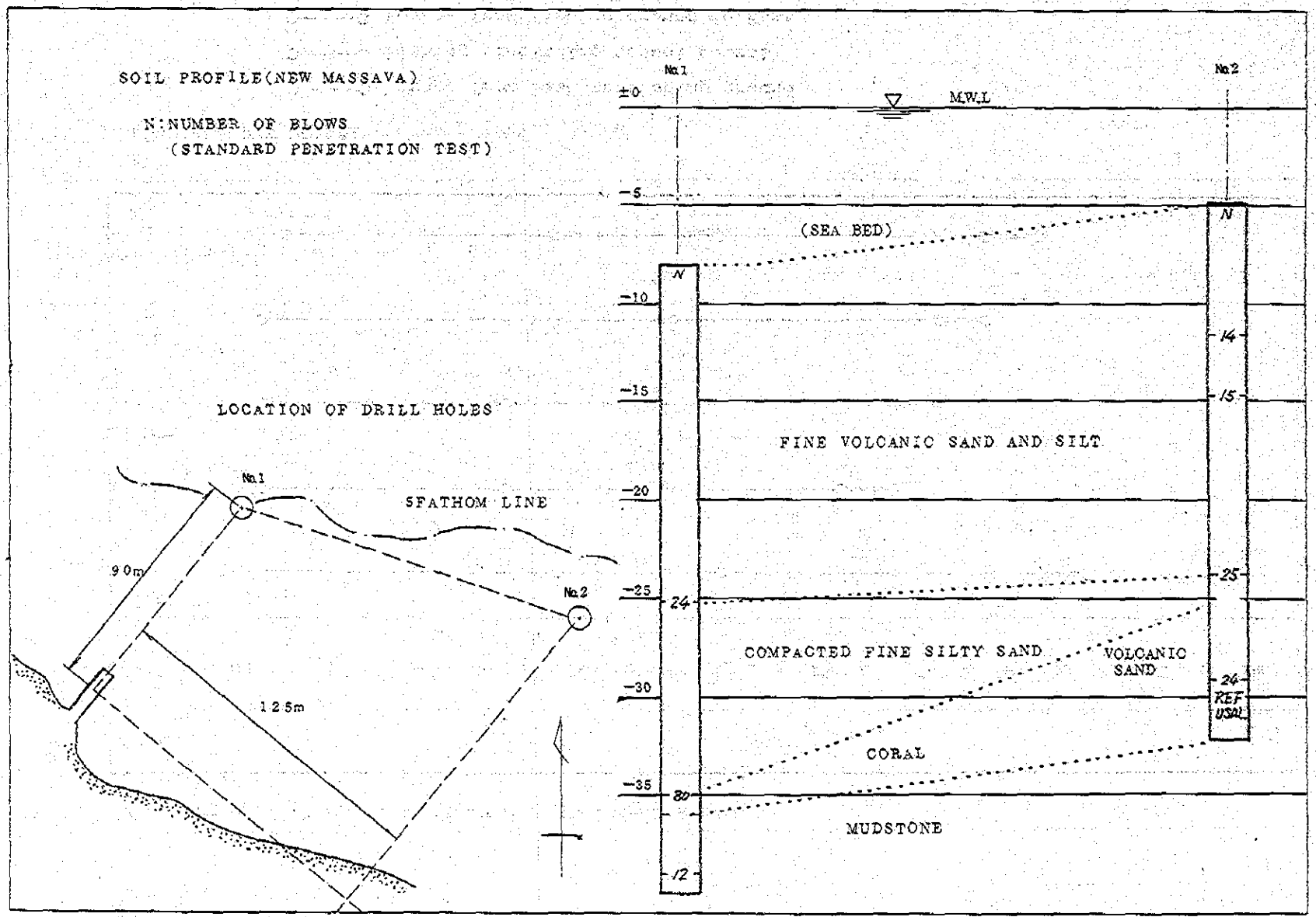
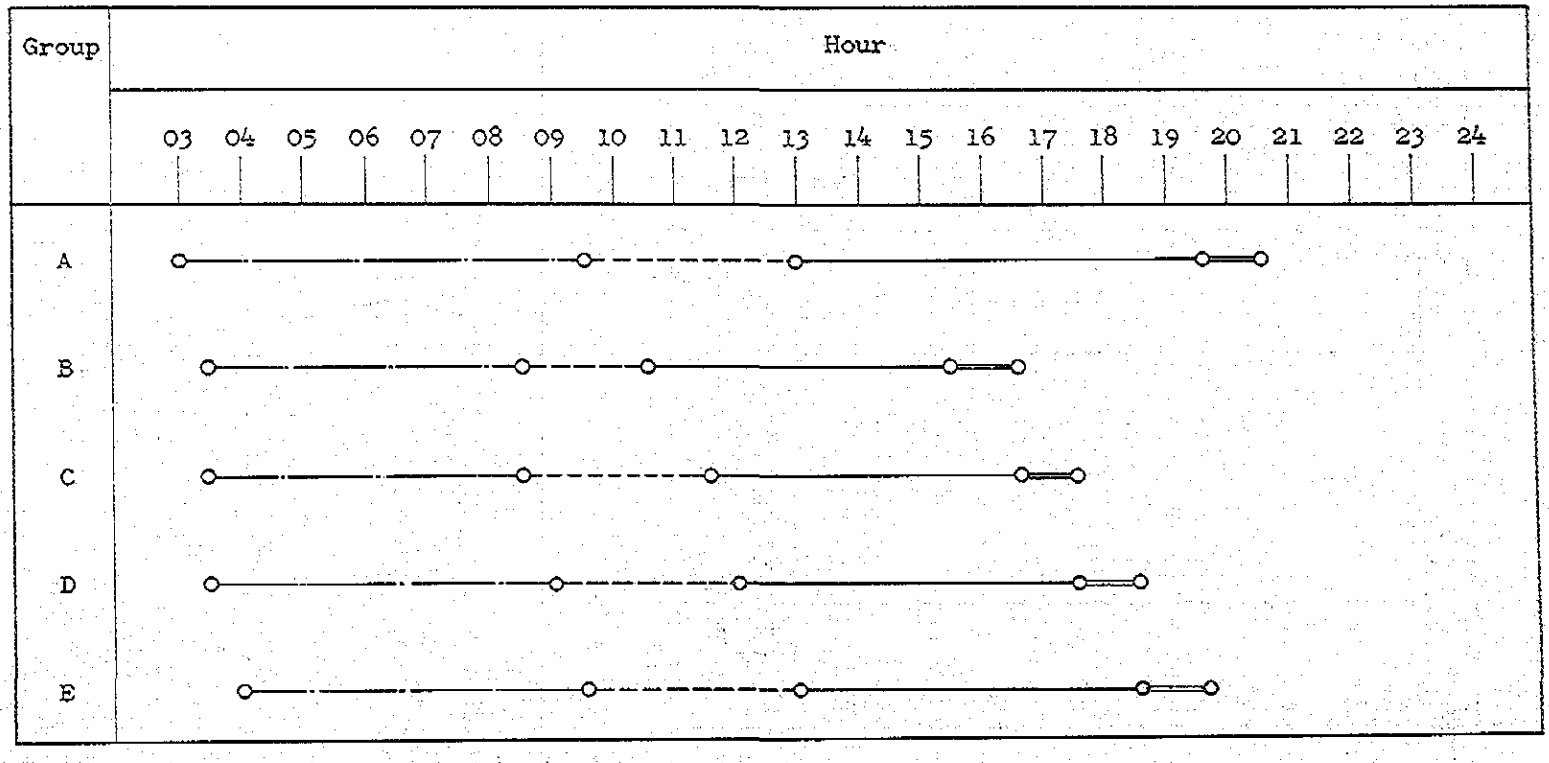

SOIL PROFILE(KILINWATA)
N:NUMBER OF BLOWS
(STANDARD PENETRATION TEST)
LOCATION OF DRILE HOLES
No.1
No.2
5M.LINE
No.1
No.2
±0
M.W.L
-5
(SEA BED)
-10
-15
-20
-25
-30
-35
N
12
11
24
6
1
0
1
4
7
2
2
1
4
9
N
0
8
0
2
2
1
2
4
4
1
14
21
17
SILTY SAND
SAND AND GRAVEL
SILTY SAND
CLAY
SILT
GRAVEL AND CLAY
SILTY CLAY
SAND

Fig. 1 — 4 — 4


SOIL PROFILE(NEW MASSAVA)
N:NUMBER OF BLOWS
(STANDARD PENETRATION TEST)
LOCATION OF DRILL HOLES
No.1
No.2
5FATHOM LINE
90m
125m
No.1
No.2
±0
M.W.L
-5
(SEA BED)
-10
-15
-20
-25
-30
-35
N
14
15
25
24
REF USAL
80
12
FINE VOLCANIC SAND AND SILT
COMPACTED FINE SILTY SAND
VOLCANIC SAND
CORAL
MUDSTONE

2. Behavior of Fishing Boats Operating on Day-Trip Basis



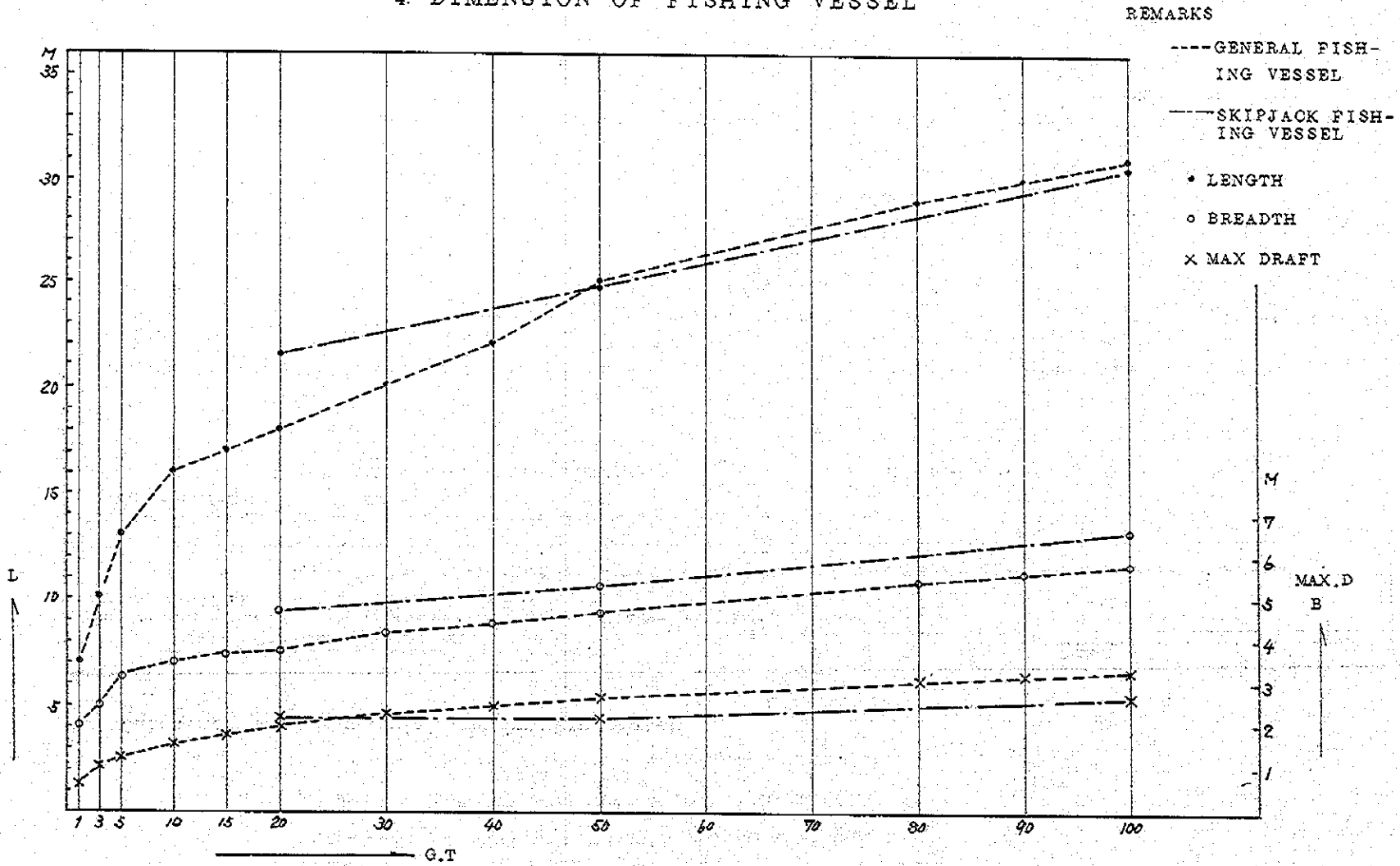
Explanatory notes:

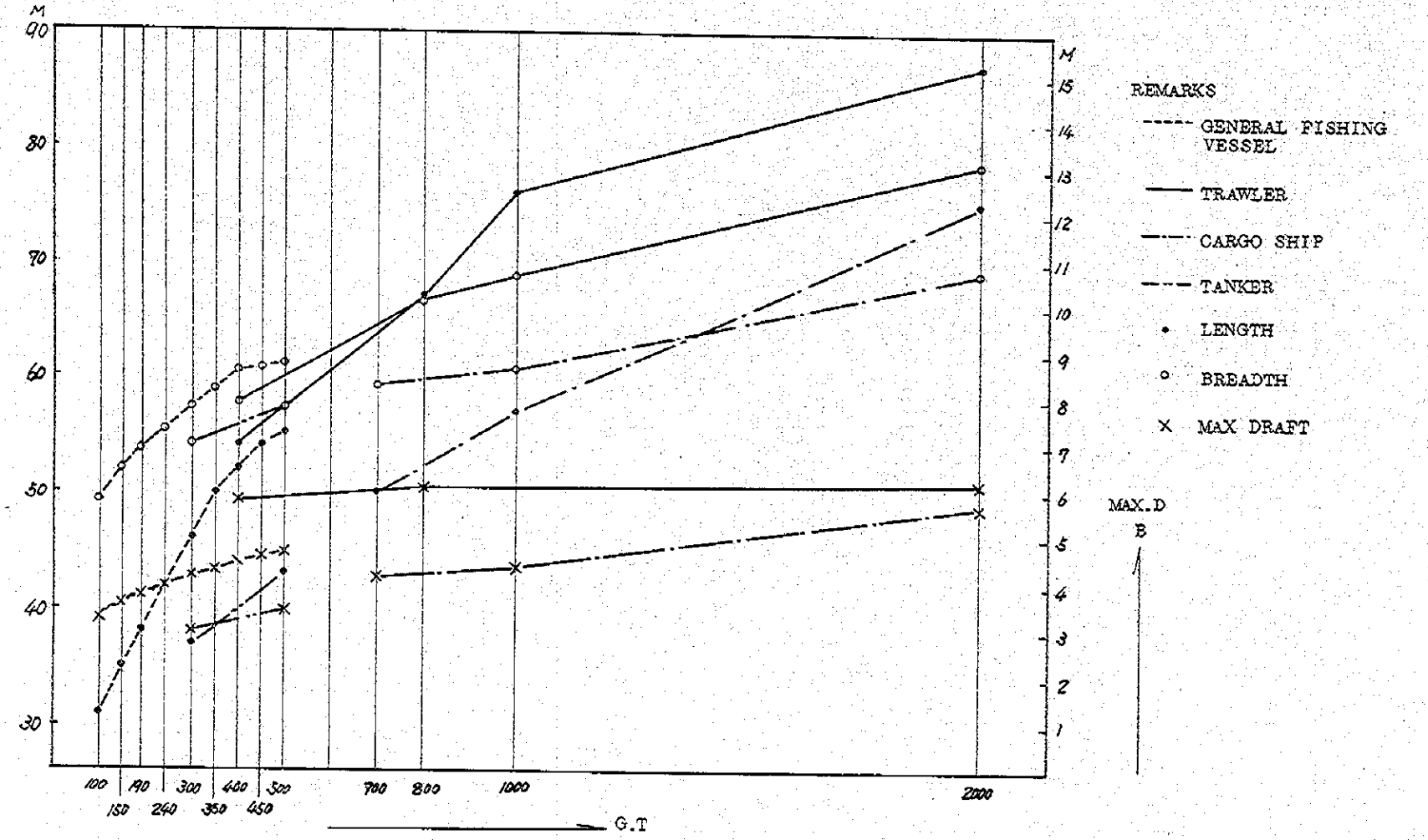
- Voyage from Base to fishing ground
- Fishing (including school patrol)
- Voyage from fishing ground to Base
- Landing

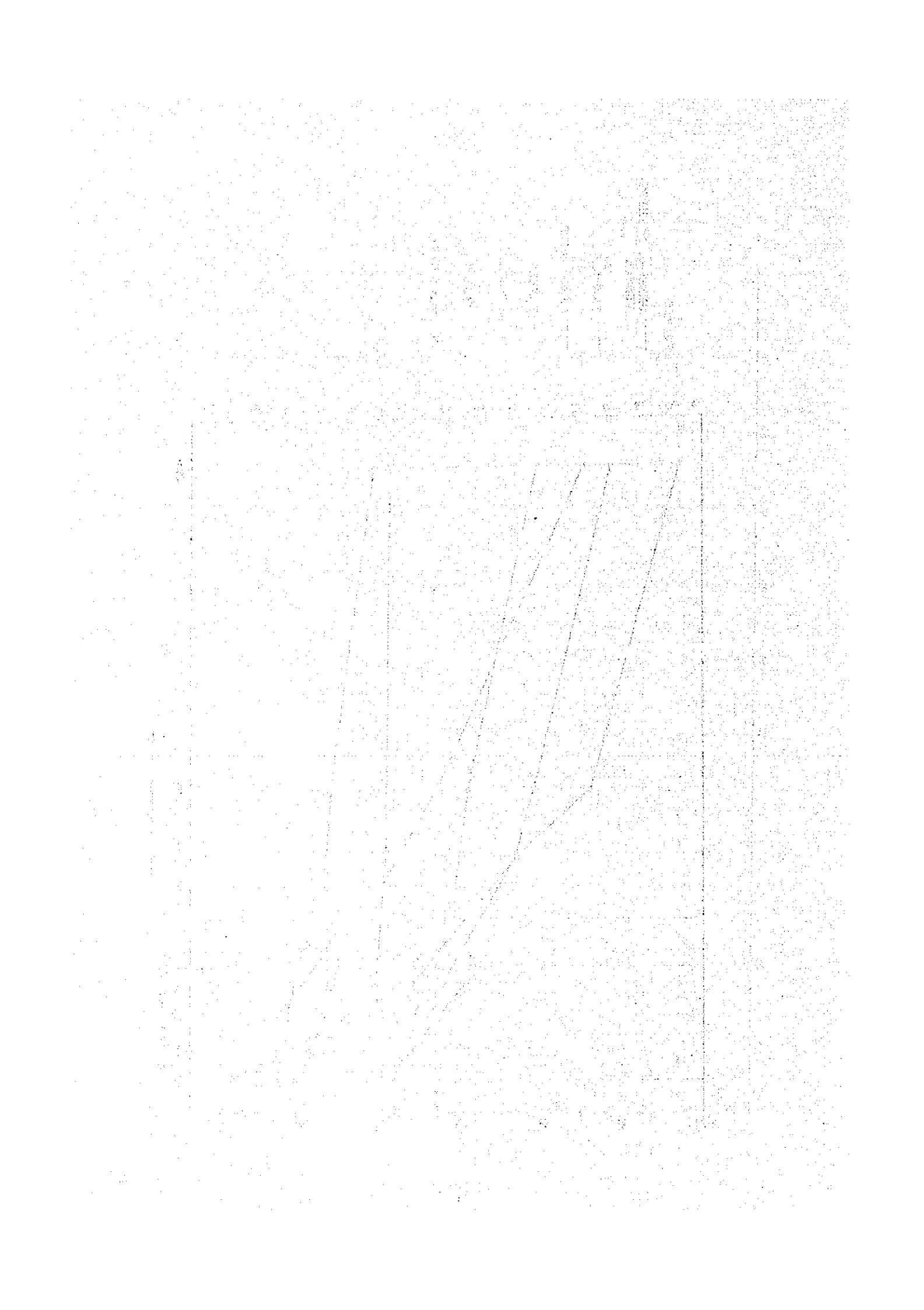
3. Calculation of Industrial and Drinking Water

	Kavieng	Rabaul
For freezing & cold storing facilities	Water required for one ton of nominal cold storing facility is 1.3 ton/yr. $720^t \times 2 \times 1.3^t \div 365$ day $\div 24$ hr = 0.21 t/hr	$800^t \times 2 \times 1.3^t \div 365$ day $\div 24$ hr = 0.24 t/hr
For ice making and storing facilities	Water required for manufacturing one ton of ice is 1.5 ton/day. $35^t \times 1.5^t \div 24$ hr = 2.19 t/hr	$40^t \times 1.5^t \div 24$ hr = 2.5 t/hr
For vessels		
Not more than 5 tons	3 persons x 1 /day x 50 boats = 150	3 persons x 1 /day x 33 boats = 99
59 G.T.	20 x 7 x 25 = 3,500	20 x 7 x 25 + 20 x 14 x 5 = 4,900
	7010 ÷ 24 hr = 0.29 t/hr	8359 ÷ 24 hr = 0.35 t/hr
100 "	15 x 7 x 2 = 210	
150 "		15 x 7 x 2 = 210
600 "	20 x 70 x 1 = 1,400	20 x 7 x 1 = 1,400
2000 "	25 x 70 x 1 = 1,750	25 x 70 x 1 = 1,750
	75 persons x 10 /day ÷ 24 hr = 0.03 t/hr	94 persons x 10 /day ÷ 24 hr = 0.04 t/hr
Total	2.72 t/hr	3.13 t/hr
Planned	2.72 t/hr x 1.5 = 4 t/hr	3.13 t/hr x 1.5 = 4.7 t/hr

4. DIMENSION OF FISHING VESSEL




M
90
80
70
60
50
40
30
M
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
100
150
190
240
300
350
400
450
500
700
800
1000
2000
G.T
REMARKS
GENERAL FISHING VESSEL
TRAWLER
CARGO SHIP
TANKER
LENGTH
BREADTH
MAX DRAFT
MAX.D
B



APPENDIX - II

Survey on Fisheries Resources and Research Facilities

1. Survey on Fisheries Resources and Research Facilities

General

The Papua New Guinea - Japanese Fishery Conference was held in February, 1976. Papua New Guinea sought assistances and co-operation for the establishment and improvement of fisheries research facilities as a part of request. Accordingly, the survey team made a related field survey. A request for establishment of fisheries research facilities is made at 8 places (Daru, Sepik, Manus, Kavieng, Rabaul, Samarai, Goodenough Island and Kikori). There also is a request to improve Kanudi Central Research Laboratory in Port Moresby. The survey team made a field survey from June 11 to 23, 1976, to study the necessity for these requests and to obtain background information on fisheries and their resources.

1) Locations

The survey covered Port Moresby, Sepik, Rabaul, Kavieng and Daru Districts. Manus, Samarai, Goodenough Island and Kikori were not covered because of the time limitations.

2) Results

The survey was made superficially because of the time limitation at each location. Detailed analyses were also not made because of the scarcity of data in some cases. The results of the survey are discussed here in the following order, namely, (a) inland water fishery, (b) skipjack and tuna fishery, (c) coastal fishery.

a. Inland Water Fishery

(1) General

A thorough field survey was difficult because of limitations of time and difficulties of communication in Papua New Guinea. (Few land traffic services are available to the districts surveyed.) For this reason, the survey was based mainly on the oral information from the people concerned, and the existing literature. The general environment of the basin of the River Sepik and the coast of the Gulf of Papua was surveyed from a chartered plane alone. The fisheries along the coast of the Gulf of Papua and inland water will be discussed later with coastal fishery.

(2) River Conditions

A central mountain range, called the roof of Papua New Guinea, runs from the east to the west. It forms the watershed of the country. Rivers from this mountain range pass through jungles and join lakes or swamps or other rivers in the flat areas to become large rivers, finally draining into the Bismarck, Solomon & Coral Sea. The largest of these are the Sepik and the Fly. Both rise in the area close to the boundary with West Irian. The other major rivers are Ramu, Markham, Aramia, Wawoi, Guavi, Turama, Kikori, Purari and Era. The major rivers for inland waters fishery are the Sepik and Ramu in the north and Fly, Turama and Purari in the south (Fig. 1).

(3) Fish Fauna and Introduced Fishes

The major available fishes include giant perch, river perch, catfish and freshwater snapper. Most native fishes originate from seas.

The first fish introduced into the country was mosquito fish (Gambusia affinis) in 1930. Subsequently, twenty-one fishes had been introduced, with brook trout (Salvelinus fontinalis) the most recent, in 1974. Among the fishes introduced, Tilapia mossambica (introduced in 1954) has become commercially valuable. Rainbow trout (Salmo gairdneri) has also acclimatized well and is breeding naturally in upland rivers. Carp (Cyprinus carpio) support important subsistence fisheries in some parts of the highlands. Table 1 lists the fishes that have been introduced.

(4) Distribution of Tilapia

Large-scale breeding of Tilapia mossambica is found in the basins of the Sepik and Ramu as well as the Central Province from Beraina to the Kemp Welch River. Fig. 2 shows the major distribution areas and ranges of tilapia.

Tilapias living in the basin of River Sepik are the offspring of the tilapias which were introduced to ponds in the Maprik area, and subsequently entered the Sepik via the Screw River, around 1959. They were introduced to the Ramu River in 1969. Tilapias in the Central Province are the result of transplantation in around 1960. They have also been transplanted to some Highlands areas. Its distribution may

extend to Kerema. Tilapia have purposely not been introduced to the Western nor in the Gulf areas since fry and adults of barramundi (the only inland water fish exported) grow in these areas.

The total annual production of tilapia in Papua New Guinea is estimated to be of the order of 30,000 - 50,000 tons. It is expected to become an important source of protein in Papua New Guinea.

(5) River Sepik Telapia Fishery

(i) General Description

The River Sepik is one of the two largest rivers in Papua New Guinea. It has a large basin area and numerous tributaries. It is connected with the River Ramu by ditches on the coastal plains. It has a large volume of water. The rate of discharge varies from 85,000 to 200,000. The velocity of flow varies from 6 to 10 km/h. The water depth averages 5 - 6 m during a flooding period and 4 m during a dry period.

The distance between the river mouth and May River is 560 km (Fig. 3). The river forms meanders in many places. The watercourse is easily changed naturally during a flood period and crescent-shaped oxbow lakes are formed everywhere. They become haunts for fishes and thus valuable fishing grounds. Nemerous lakes and swamps grow tremendously in volume during floods, and they are the most important fishing grounds in the basin of the Sepik.

The largest lake, Lake Chambri, becomes large and deep during a flood season, while it is about 1 m deep during a dry season. This lake is the largest fishing ground in the basin of River Sepik. The distribution of tilapia terminates at the May River in the upsteam area.

A chartered plane was used for surveying the general environment of the basin of River Sepik. The route of survey flight is shown in Fig. 3. The team took off at Wewak, flew to the east along the coast, then flew over the Sepik from the river mouth to the upstream area, where the lakes, swamps and crescent-shaped oxbow lakes in Angoram area were observed. The team landed at Angoram and obtained information on the fishery in the basin of the River Sepik from Angoram Laboratory of Kanudi Central Research Laboratory. Then, the team flew back along River Sepik, after observing the Lake Chambri and returned to Wewak via Ambunti.

(ii) Fishing Gears and Fishing Methods

Gillnets are the main fishing gear used in the basins of River Sepik and River Ramu and in Yule area. Traps are also used, but hooks and lines are hardly used. The quantity of gillnets used by approximately five hundred fishermen working at Lake Chambri is given below.

Mesh size		Quantity in use
6 inches	-	30 yards
4.5 inches	-	19 yards

Mesh size		Quantity in use
4 inches	-	555 yards
3.5 inches	-	159 yards
3 inches	-	491 yards
2.5 inches	-	22 yards
2 inches	-	27 yards

The mesh sizes between 3 and 4 inches are widely used. Each fisherman household owns about 50 yards of gillnets on average. Two men work together to cast gillnets from a canoe. Motor boats are not used. Fisherman households work either independently or co-operatively.

Nets are cast in the evening and hauled early in the mornings.

At the time of net hauling, 20% of fishes are alive, 70% are about to die and 10% are dead. Dead fishes are discarded. Gillnets are also used for catching catfishes. The nets are set mostly in standing waters and rarely in the main stream. (Since catfishes live mainly in the river, gillnets are cast from the bank toward the center of the downstream. Carfishes are hardly caught since the casted nets in the river are often torn by logs and others flowing down.)

(iii) Fishery and Stock

Although tilapia is the main product, catfishes, fresh water shrimps and eels etc. are also caught. The

main fishing grounds of tilapia are oxbow lakes and swamps. Catfishes are caught in the same fishing grounds grounds as tilapia. (main basin). The fishing product in these waters had been poor until tilapia was liberated. The recent enmeshment is approximately 25 kg per operation. Tilapias caught in these waters range between 1 inch and 12 inches in body length. Most of them caught in the commonly used gillnets are 10 inches long. This coincides with the mesh size commonly used. The estimated annual catch of tilapia is 10,000 tons and 5,000 tons in the basin of River Sepik and River Ramu, respectively.

The annual production of tilapia is estimated to be 30,000 ton according to the stock survey made in 1972 by a fresh water fish specialist of Asia Development Bank. The basin of the River Sepik with tilapia distribution comprises fifteen districts (with 225 villages and 47,140) has 80,000 residents. The total area is 19,493 km^2. (The population density is 2.42 persons/km^2. It is said that the daily consumption of tilapia per capita is 0.6 kg. This means that about 28 tons of tilapias are consumed daily in the whole area.) The annual catch of tilapias in this area is said to be about 8,000 tons. This means that most of the catch is consumed locally.

Tendencies in decreasing catch or reducing body size are not observed.

The consumption of fishery products per capita is 68.0 kg/year (42.4 kg of fresh fishes and 25.9 kg of

processed fishes) (in 1974). The daily consumption per capita is 116 g of fresh fish and 71 g of processed fish. If the yield rate of fish processing is assumed to be 0.6, 71 g of processed fish will be equivalent to 118 g of fresh fish. This means that one person consumes about 0.23 kg of fresh fish daily. The fish consumption per capita in Sepik area should be regarded as extremely high.

(iv) Cooking and Processing

Tilapias are consumed either as fresh fish or processed fish. Large tilapias and small tilapias are handled together.

Fresh tilapias are cooked into soup by fishermen and local people. (They are mixed with palm starch).

Tilapias are processed either by smoking (mild cure) or salting (curing). (A large amount of salt is used.) One kg salt cures 3 kg split fish or 5 kg of fillets. It takes 2 days for curing and 2 to 3 days of sundrying. Processed tilapias are mostly consumed by fishermen's households except some cured tilapia.

In the highland area, cured tilapia is steamed with taros to have the latter absorb the salt. The quantity of salt consumed in the inland area has decreased since the shipment of cured tilapia began.

(v) Distribution

Road conditions are poor in Papua New Guinea except in major cities. Therefore, the distribution of fishery

products, especially in fresh state, is not promising at present.

Therefore, fishery products must be processed for distribution. Products are processed, not by specialized processors, but by fishermen.

Processed products in the basin of the River Sepik are collected at Pagwi and Angorum, and then shipped to the inland (Maprik area). In the fiscal year of 1975, cured tilapia production amounting 14.4 tons; this was experimentally shipped to the highland area. (The processed products is said to have amounted 50,000 - 60,000 KN.)

There is a plan to carry the catch in the basins of the Sepik and Ramu to the highland area by way of Madang or Lae. The population of the highland area is 1.5 millions. This area is said to have the potential of consumption amounting to 20,000 tons.

(vi) Culturing

Hardly any attempt has been made to culture native fishes in Papua New Guinea. More than five types of fishes have been introduced for culturing, but the possibilities of culturing have been studied only for carps, catfishes (native), rainbow trouts and tilapia (Table 1).

Cap was introduced from Asia in 1959 and hatcheries constructed in Aiyura and Dobel. Fingerling are still distributed to institutions but small holders are

discouraged from pond construction. The failure seems to attribute to the lack of will is the part of farmers, poor culturing techniques and the lack of feed (protein) etc. (Carp culture seems to have been attempted in the highland area, but it has been discontinued because of the failure to find adequate sites. Therefore, carp culture is not in progress at present. Fig. 4 shows the distribution of carp.)

Rainbow trouts are being cultured in some areas. Cultured rainbow trouts are sold at considerably high price mainly to foreigners (Caucasians). The team was n not able to obtain information of feed to rainbow trout because of the lack of related materials. Eggs are im imported from Australia but reproduction from New Guinea stocks will soon be attempted in Mendi.

Mendi has a hatchery, where egg handling and hatching techniques have been established. (However, they are applied to imported eggs alone.)

Rainbow trouts seem to have increased naturally in rivers in the highland area. However, their stock seems to be still small. (Since it is difficult to catch naturally grown adult trouts which can be used for egg collection, artificial reproduction seems quite difficult at present. Fig. 5 shows the distribution of rainbow trouts propagating naturally.)

(vii) Problems

Including the tilapia fishery in the basin of the the River Sepik and the River Ramu, the inland waters fishery and fish culture in Papua New Guinea still leave many fields to be developed. Efforts should be made to develop these fields in the future. It will be of urgent necessity to promote inland waters fishery in Western Province and Gulf Province and to promote distribution of fisheries products through improvements of transport facilities. The problems that can be pointed out from the survey are listed below.

(a) Possibilities of setting and culturing newly introduced fishes must be examined. Methods to propagate them, especially in natural waters, should also be studied. Adequate species should be selected for liberation among new and native species.

(b) No conclusion could be made on the fatness of tilapias in the basin of the River Sepik because of the lack of materials. However, in the Central Province, the appearance of fresh tilapias and the conditions of processed tilapias led to suspect poor fatness. Both the River Sepik and the River Ramu originate from high mountains and flow through jungles. For this reason, their water does not seem to contain enough nutrient salts and, therefore, available organisms seem insufficient for tilapias' feed. This suspicion is confirmed by the fact that their food consisted only of duckweeds and emerged

Plants. This can be interpreted as that the number of tilapias is too many for available food organisms.

(c) Eluers in the River Sepik and fresh water shrimps have hardly been exploited. A large school of eluers has been observed to go up the river for several days during the wet season. This cannot be reviewed at present because of the lack of materials. The stock of eels should also be investigated. Among numerous varieties of eels, Anguilla bicolor pacifica, A. obscura, A. marmorata, A. megastoma and A. interioris etc. are known to go up rivers. It will be important to investigate the quantity of each species available.

(d) At present, single drift gillnets are used. Triple drift gillnets are recommended for more effective fishing. Tilapias are slow swimmers both behaviorally and physically. Since tilapias have an overhanging occiput, they touch meshes first, and then, become enmeshed by fin ray. Tilapias swim straightly to some point by habit, but they can make a sudden stop in case of a danger. In this case, they retract quietly by using pectoral fins. With a triple sillnet, tilapias will pass without touching the external net and become enmeshed in front of the middle net.

Tilapias swim at the angle of about 45° for going up or down. Therefore, the catch will be increased by adopting midwater gillnets.

(e) Smoking and curing seem to be adequate to tilapia

processing methods for the domestic consumption, canning should be studied in future, but it is not promising at present.

It will be difficult to export tilapias, whether fresh, or processed. Tilapia mossambica is distributed widely in South East Asia, but is not sought offer.

(f) The lack of culturing techniques and the lack of feed account for the current poor state of culturing fishery. It is also attributable to some other factors. For example, personal expenses are high in Papua New Guinea because of the Minimum Wage Law. For this reason, the cost of production is too high. In addition, neither the distribution, nor the domestic consumption of products is promising, since there is only a ting market for premise priced fish.

(g) The Papua New Guinea government is expected to take a policy to promote culturing in the future, but not in immediate future. At this stage, adequate culturing sites should be searched and their distribution map must be prepared.

Papua New Guinea is located in tropical zone (at 2° - 10° S.Lat.). However, the altitude difference between the central mountain range and the coastal region is large. The altitude at the so-called highland area is 3,000 - 13,000 ft. The rivers and springs originating from this area are quite cold. The water temperature rises as the altitudes becomes low, and becomes quite

warm near the coasts. Both cold water fishes and warm water fishes can be cultured if temperature difference according to the altitude is considered. The survey team was not able to obtain enough materials to study whether the highland area has sufficiently large sites for making ponds.

(6) Measures for Promotion

Inland fisheries and fish culture are closely related to agriculture. They developed with agriculture in China, Japan and South East Asia with a long history in these fields. In other words, fishes living in natural waters were caught mostly for home consumption as the source of protein in agricultural and mountain villages. Therefore, full-time fihsermen were rare.

The development of agriculture (agriculture, forestry and livestock raising) promotes the development of inland waters fishery for the following reason. As the agriculture in the basin develops, farms become increasingly infertile, and more and more nutrients salts flow into rivers. In other words, netrients fishery productivity is increased by agricultural development through the accumulation of in river water.

For this reason, the promotion of inland water fishery should be coordinated with agricultural promotion. Culturing is hardly practised at present. It is desirable to promote culturing in parallel with agricultural development since the two have specially close relation. In other words, farm

store the live bait in its hold and catches skipjack at a fishing ground located within an approximately 60 mile range from a baiting ground. They return to a mother ship in the evening to unload the catch.

The catches are immediately frozen on a mother ship and they are exported mainly to Japan and U.S.A. Some are processed in a half dried smoked skipjack factory in Kavieng and exported to Japan.

Skipjack fishery is generally characterized by considerable fluctuations annually as well as seasonally. The same tendency is observed also in Papua New Guinea. According to the internal reports, the annual catch in Papua New Guinea ranged between 13,100 tons and 41;800 tons in 1971-1975. The average daily catch of catchers, by year, ranged between 2.7 tons and 4.8 tons. The catch was extremely poor in 1972 and 1975, while it was good in 1976. The catch during January through June in 1976 reached 11,700 tons. If such a good catch continues during the latter half of the year, the catch in 1976 will be close to that of the 1974 when the best catch was recorded (Table 2).

Only six years have passed since skipjack fishery was commenced in Papua New Guinea. Although the history is too short to analyze the fluctuation of the catch, the available data seem to suggest a three-year cycle. If the same cycle repeats in the future, its causes must be studied and adequate countermeasures must be taken.

(2) Surveys

In compliance with the Japan-Australia Fishery Agreement, Japan dispatched a survey vessel ten times for the survey of skipjack and tuna stock in the Papua New Guinea waters during 1968-1975. The surveys were made in collaboration with Papua New Guinean scientists (Table 3). Papua New Guinea also make independent investigations. They conducted visual observation of schools of skipjack and tunas in the entire adjacent waters in November 1972 by using aircraft. The joint ventures have also cooperated with local scientists. For example, they obtained samples from the catcher boats to identify skipjack stocks, and took body measurements on board. In 1974, they chartered Daido-maru (192 tons) from Gollin Kyokuyo for live bait survey.

According to the report on the tagging experiments made by Papua New Guinea, skipjack schools in the adjacent waters behave in one of the two following patterns.

(i) Schools migrating toward south from the Carolines--Marianas enter and stay in Bismarck Sea for a short period and return to the north again.

(ii) Schools entering the Bismarck Sea migrate to the South Solomon Sea Clockwise. Some of them return to the Bismarck Sea and remain in adjacent waters for several months or even more than two years.

Skipjack movements change every year. In any event, a a good skipjack fishing grounds usually develop in the northern and the northeastern parts of the Bismarck Sea (Fig. 7).

preparation and culture pond construction should be planned together.

Irrigation for fish culture should be planned as a part of agricultural irrigation. The distribution of swamps in Papua New Guinea is shown in Fig. 6.

b. Skipjack and Tuna Fishery

(1) Current State

Skipjack and tuna fishery is extremely important for the fisheries in Papua New Guinea as it accounts for most of her fisheries production. For this reason, the Papua New Guinea Government is highly interested in skipjack and tuna fishery. Papua New Guinea's so-called exclusive waters will become as wide as 700 thousand square miles when the 200 miles fisheries economic zone is established. Therefore, the Government has special interest in the skipjack and tuna stock in the waters.

In Papua New Guinea, skipjack and tuna fishery was begun by four joint ventures in 1970. They were New Guinea Marine Products in Madang, Starkist in Kimbey Bay, Gollin Kyokuyo in Kavieng and Carpenter Kaigai (PNG) Pty. in Rabaul. The four companies have used Okinawan coastal skipjack vessels. Although New Guinea Marine Products ceased operation in 1976, the remaining three companies are still operating the skipjack fishery using Kavieng and Rabaul as the base.

So-called mother ship method is adopted for the skipjack fishery. A bait ship attached to a fleeter catches live bait by using stick-held dip nets within a reef. Catcher boats

Easy access to sufficient live baits is essential for skipjack pole and line fishery. A lack of live bait isfatal to this fishery. The seven major varieties of live baits currently used are Stolephorus heterolobus ("tarekuchi" in Japanese), S. devisi ("debisu tarekuchi" in Japanese), S. bucaneeri ("taiyo tarekuchi" in Japanese) belonging to anchovy family; Spratelloides delicatulus ("minami kibinago" in Japanese), S. gracilis ("kibinago" in Japanese) belonging to round herring family; and Herklotsichthys punctatus ("tarai" in Japanese) belonging to herring family and Fusilier ("aka-muro" in Japanese) belonging to red fish family.

These live baits are widely distributed in harbours and bays along the Papua New Guinea coasts. It will be extremely difficult to make an overall study on the life history, migration, distribution and stock of these species. Limited such information seems to be available at present.

Surveys on live bait species have been made by Japanese survey vessels dispatched for a joint investigation with Papua New Guinea and independently by Papua New Guinea by chartering Daido-maru (skipjack clipper belonging to a joint venture) for half a month in November, 1974. The latter survey was made to study the survival rate of live baits to obtain essential information for high seas skipjack fishery. To study the effect of live bait handling at catching and transfering on the death rate, and their survival rate in live bait tanks, live bait transport tests were made from Kavieng to the south sea of the Caroline Islands and to the south coast of New

Caledonia Island. General information was obtained as a result.

The joint ventures are asked to submit monthly reports of live bait catch to the government. mThe report is consisted of daily catch of live bait by species and by boat.

For the protection of the stock, the enforcement of the regulations of live bait catch in specific waters (limitation of number of boats) shown in Table 4 was announced at the Tuna Resource Management Advisory Committee held at Port Moresby in January, 1976.

(3) Discussion

According to the Report on Fisheries Development Project in Papua and New Guinea (Overseas Technical Cooperation Agency, March, 1972), the maximum limit of annual skipjack catch in the Papua New Guinea waters is estimated to be 65,000 tons. The current skipjack fishery will continue without any problem as long as live bait supply lasts.

However, the Papua New Guinea Government is concerned about the overfishing of live baits by the joint ventures. The government insists that the currently used live bait catching and handling method raise death rate and, therefore, leads to wastage. The survey team, which observed live bait catching in Ysabel Channel in the west of Kavieng, had an impression that the Government is overworried. (At the Cape Lambert grounds, however, bait catches have fallen considerably over the last twelve months and the resident company has approached

the Government for assistance. Local scientists' worry at this stage is firstly with wastage of the present catch (up to 50% dies before reaching the fishing ground) and secondly with over-concentration of effort in a few areas because of the mother-ship style of operations, rather than actual over-fishing.

Under the instruction of the Papua New Guinea Government, the waters around Cape Lambert in Rabaul area are used as a baiting ground by Carpenter Kaigai and Starkist, while Ysabel Channel in Kavieng area is used by Gollin Kyokuyo and Starkist. The baiting grounds are fractionized more and more under the present governmental restrictions. The joint ventures have worries over stable availability of live baits. The exploitation of baiting grounds involves various problems with local people. For the development of skipjack fishery and stable continuation of fishery in Papua New Guinea, sufficient baiting grounds must be secured in a wider range and utilized the bait rationally.

This will stabilize skipjack fishery, promote participation of local people in fishery with increasing their opportunities to learn fishing techniques and lead to independent skipjack fishery.

c. Current Fishery Resources along Gulf of Papua and Progress of Research

The Gulf of Papua is characterized by the most developed continental shelves of all the coasts of Papua New Guinea. The inland has the Lake Murray (at the midstream of the River Fly) and numerous other inland waters. It also has very indented shorelines with well developed estuaries. These conditions account for the existence of a large variety of fishery resources in this area. Especially, prawns, lobsters and barramundi have become commercial fishery products. The development of many other resources is also being planned. The current state of fishery and the progress of research are summarized below. Our opinion on the research to be made is also summarized.

(1) Prawns

(i) Current Prawn Fishery

In 1960, a governmental agency and fishermen in Papua New Guinea began to investigate the stock of shrimp resources in the Papua New Guinea coasts. During the investigation, a shrimp fishing ground was discovered in the water between Orokolo Bay and Freshwater Bay in the south of Papua (off Kerema fishing ground). As a results, a shrimp fishery was commenced, and in 1971, twenty five shrimp trawlers were operated mainly by Canadian and Kuwait joint ventures, with the catch amount of 349 tons and the exports of 118,000 Australian dollars. However,

most of them stopped operations by 1974 because of the interruption of fishing during the southeast monsoon from October to March, in addition, of the low operating rate due to the aging and poor maintenance of trawlers. Under such circumstances, test operations by Japanese joint ventures were permitted from 1972. Three Japanese joint ventures began test operations in 1974, using fifteen trawlers during same period. The catch amounted to 947 tons (weight excluding heads). However, most of them proved to be a failure because fishing in the central fishing ground off Kerema was prohibited and the small trawlers had to stop operation during monsoon seasons. The Papua New Guinea Government changed policy to promote shrimp fishing. It gave a fishing permission to three Japanese joint ventures (four trawlers for each, making the total to 12 trawlers), to other foreign joint ventures (14 trawlers) and to a local enterprise (4 trawlers). The fishing regulations, which had been imposed on Japanese joint ventures alone, were mostly abolished. Taking advantage of the previous fishing operations, the Japanese joint ventures employed large shrimp trawlers of 150 tons class for all-season fishing, thus, the fishing conditions improved as a result. Nine trawlers are being operated by the Japanese joint ventures as of June, 1976. The remaining three trawlers of the quota are to begin operation in the near future. Two local trawlers have been in operation off Kerema and in Orangerie Bay.

Off Kerema has been considered as major fishing ground and the catch consist mostly of Banana prawns. Trawlers also operate off the mouth of the River Fly to catch endeavour prawns because the operation off Kerema is difficult during October to March when southeast monsoon prevails. Since it is known that lobsters migrate towards Yule Island from August or September, trawlers also operate there to catch them.

All the trawlers belonging to the Japanese joint ventures use Port Moresby as the base. Each navigation lasts for about one month. They operate about six times daily, working for 24 hours per day. Most of the catch is headed, selected and packed on trawlers, and they are exported to Japan. Some of small prawns are consumed domestically. The fishing conditions are good at present. The catch in the fiscal year of 1976 is estimated to exceed 1000 tons (without heads).

(ii) Current State of Research

The preliminary survey made in 1960 - 1968 revealed the rough distribution and species composition of shrimp resources. However, hardly any biological and resource study has been made since then. The following information has been obtained.

More than forty species of shrimp are distributed in the Papua New Guinea waters. Among them, seven species belonging to the genus *Penaeus* and seven species belonging to *Metapenaeus* are commercially caught. *P. mesguiensis*

(Banana prawn) accounts for 70 - 100% of the shrimpt catch off Kerema. Most of the remaining catch consists of *P. monodon* (Giant tiger prawn or "ushi ebi" in Japanese). Small species belonging to the genus *Metapenaeus* are also caught by trawlers during some seasons.

The waters from Orokolo Bay to Freshwater Bay (fishing ground off Kerema) have the largest stock of shrimps. Shrimps are also known to exist in Orangerie Bay, the Morobe Province, the mouth of the River Sepik and Sissano Lagoon, though in smaller quantities.

(iii) Direction of Future Research

The preliminary survey has not been followed by subsequent research. On the other hand, ten years have passed since the commencement of the commercial fishery, and the catch has reached the 1,000 ton level (without heads). Shrimp trawling is becoming the second major commercial fishery in Papua New Guinea. For this reason, considerable emphasis must be laid on the research in this field.

Neither any change in sizes nor any drop of CPUE has been observed so far. The present catch (1,000 tons) does not seem excessive in view of the rate of fresh water inflow to the extent of continental shelves. If efforts are maintained at the current level, there will be sufficient time to clarify the life history from biological study and to assess the stock size. It will also be important to obtain statistical data on catches and efforts

in the past and the present.

(2) Lobster

(i) Current Lobster Fishery

Lobsters inhabiting along the coast of the Gulf of Papua have been an important food for coastal residents for many years. Commercial fishery was initiated around Yule Island and Daru from the early part of 1960s. Considerable lobster was exported in the fishing season of 1963 - 1964. The export rose to 19 tons in the fishing season of 1971 - 1972. The recent catch (headless) is 60 tons near Daru, 7 - 25 tons near Yule Island and 100 - 150 tons by shrimp trawlers. A considerable amount of lobsters are also caught by coastal residents for their food.

Shrimp trawlers operate aiming at lobster in August to November. They tend to operate west of Kerema first, then move toward the east to the area south of Yule Island. Near Daru, coral reefs in the south are the main fishing ground. In this fishing ground, lobsters are available throughout a year, but large lobsters decrease after August.

The fishing season near Yule Island is between January and March.

Local fishermen in Daru and Yule Island also catch lobsters with hand nets or gaff hooks and sell them to processors. Processors take off the head and freeze them

for export or boil them for the domestic consumption. A considerable portion of the catch around Yule Island is consumed in Port Moresby.

(ii) Current State of Research

The research on lobsters started in 1958. Schools of spawners were discovered near Yule Island in 1962. It led to the development of lobster fishery. A new research project was commenced in 1967 and ended in 1971, but it was limited to a local scale near Yule Island. A full scale research project started in 1975. Information on migratory routes and growth is being collected by tagging experiments of lobsters. Currently, three researchers are engaged in the study at Daru. The following information has been obtained.

Six species of lobsters live in the Papua New Guinean waters. Among them, *Panulirus ornatus* (Ornate crayfish, "nishiki ebi" in Japanese) is available in the largest quantity and being caught commercially. Eggs of this species hatch in 14 - 20 days after discharge and adhesion on the pleopods. The eggs are discharged again and adhere to the pleopods in 3 - 4 days after hatching of the previous cluster. This is repeated several times in one spawning period. Copulation takes place at least once during one spawning period. Copulation is not always necessary for the second and subsequent egg discharging. (Molting takes place only once before copulation.) Larvae (Phyllosoma) hatched out around Yule Island are settle on

the coral reefs between the northeastern coast of Cape York Peninsula (Australia) and the Torres Straits after transport by the southward current. Their growth is slow during the first one year. They grow 6 - 7 cm (from the tip of rostrum to the end of telson in one year, to 14 - 15 cm in two years and to about 25 cm in 3 -4 years. They grow in the numerous coral reefs in the Torres Straits between Daru and Cape York Peninsula. Males and females reach maturity in two years and three years, respectively. Mature lobsters migrate for spawning. Lobsters of all the sizes are found throughout a year at the fishing ground south of Daru. The large lobsters increase in May - August, and decrease suddenly in August. Large lobsters move toward the northeast and are caught off Kerema in September - October. Berried lobsters are caught in large quantity near Yule Island in December - February in most years. Spent lobsters are suspected to die; no return migration has been observed. Therefore, it seems likely that all the ornate crayfishes caught in the Papuan and Torres Strait waters belong to one stock. About three thousand ornate crayfishes have been tagged near Daru, and about 10% of them have been recaptured. Most of them were recaptured near the points of liberation. They were rarely recaptured off Kerema or around Yule Island. Therefore, lobsters seem to migrate to off Kerema and Yule Island not only from Daru, but also from numerous coral reefs in the Torres Strait.

Therefore, no undesirable effect will be given to the stock even by doubling the current catch in the Daru area. But increased catches by shrimp trawlers could seriously effect recruitment.

(iii) Direction of Future Research

The life history described previously is based on many assumptions. The current research project will be promoted to confirm these assumptions. It will be specially important to liberate spawners with a tag near Yule Island to check whether they go to coral reefs south of Daru and to estimate mortality rate due to the spawning. Lobsters have great importance in various respects. In other words, both their catch and value are large. It is one of few examples showing development from self-sufficient fishery by local residents to commercial fishery. For this reason, researchers must engage themselves not only in biological and resource studies, but also in stock and fishery management studies for the protection and encouragement of local fishermen.

(3) Barramundi

(i) Current State of Fishery

"Barramundi" is a bass type fish distributed both in fresh waters and marine. The Western Province and the Gulf Province have a large stock of barramundi. They have been one of the important foods for coastal and inland people. Commercial fishery started in 1950s by

the introduction of gillnets. A freezing plant with the capacity of about 100 tons was constructed in Daru in 1960s. Barramundi fishery made a rapid development as a result. Several European and Australian fishing vessels were engaged in barramundi fishing during some periods. Recently, barramundis are caught mostly by the local fishermen. The recent catch around Daru is estimated to be about 200 - 300 tons excluding the catch for home consumption. Barramundis go down rivers and move toward the south along the coast and spawn near Saibai Island. They move along sea shores, never going offshore. For this reason, the narrow straits between the Parama Island and the main land become the best fishing ground. Gillnets are usually used for barramundi fishery. Gillnets of 100 yards x 10 feet (7 inch mesh) are laid perpendicularly to a shore line. Most of the canoes are motorized. Gillnets below 6 1/2 inches (mesh size) are prohibited in some waters to protect barramundies smaller than 40 - 45 cm. All the catch around Daru are sent to the freezing plant at Daru to be packed as fillets. A cold storage station was recently constructed at Samari at the mouth of River Fly. Whenever the stock reaches near-capacity, it is carried to Daru. The fishing season is September - December. A considerable catch is obtained from Lake Murray (at the midstream of River Fly) during other months. The construction of a cold storage station is being planned at a lake-side town. Most of the products

are exported to Australia.

(ii) Current State of Research

A preliminary survey has been made since 1954 mainly through the efforts of Western Province. Efforts have been made to promote barramundi fishery since the introduction of gillnets. A new research project began in 1970. Information on spawning, migration, growth, other biological characteristics and the mortality rate of catch was obtained by tagging experiments. About six thousand barramundis were tagged during this project, which ended in 1974. The following information has been obtained through these researches. Barramundis are widely distributed in the tropical areas of the Indian Ocean and the Pacific Ocean. They belong to the same specie as "Akame" distributed in southern Japan. In Papua New Guinea, they are found in the sourthern coast alone. They are abundantly found in the area west of River Kemp Welch of Central Province, but less east of that river. Adults usually live in fresh water, but they begin to descend rivers in August - September when the water level begins to drop. They migrate toward Saibai Island, southwest Daru in September - January. Spawners gathered near Saibai Island come not only from the basin of River Fly, but also from numerious rivers around Kikori. Spawning adults typically hold 5 - 7 million eggs. Larger spawners tend to hold more eggs. A 1.2 m long female weighing 20 kg and holding 32 million eggs has been caught.

Spawning takes place near the coasts. Fry enters swamps near the shores 4 - 5 days after hatching. They spend the first half a year in fresh water area and go out to sea after they grow to 16 - 17 cm. The live near the coasts for about two years before ascending the rivers.

The commercial size ranges mostly between 8 kg and 10 kg (overall body length 90 cm). They are suspected to be at least eight years old. Barranundis are carnivorous. They feed on crustaceans and small fishes, especially shrimps. They feed mainly on fishes in fresh water areas. It suspected that the catch of barramundis achieved already at the MSY level. This is because they are easily caught when passing narrow straits at the time of spawning migration or pass a narrow range along a coast, and parly becuase old fishes alone are being caught for the commercial purpose. The use of gillnets below 6 1/2 inches (mesh size) is prohibited. Restrictions are being enforced at some fishing grounds. Therefore, increasing fishing efforts toward this fish due to the popularization of gillnets should be directed to other fishes.

(iii) Direction of Future Research

The research project begun in 1970 and ended in 1974. No research on barranundi is being made at present, although the commercial fishing is being monitored. However, barramundi fishery should be protected from declination because of insufficient research, since it is important not only from the view point of catch and value,

but also as one of few professional fisheries. The stock level of barramundi must be watched carefully and continuously since the catch has reached the MSY. Other resources should also be explored to direct excessive efforts, fishing boats and gears.

(4) Unexplored Resources

Numerous varieties of resources are said to be sleeping unexplored in the waters of the Gulf of Papua. However, they have hardly been investigated. Only some fragmentary information on stock level and potentials has been obtained.

(i) Freshwater Lobster

Freshwater crawfishes (*Cherax albertisii*), called "Yabbie," live in large quantities in the large inland waters located in the middle and the southern part of Western Province. Their overall body length including claw is about 25 cm. They look like American lobsters (*Homarus vulgaris*). They live mostly in stagnant water and rarely in flowing water. A fishing experiment was made in the southern part of Western Province. About thirty lobsters were caught per night per 1 m long wire net basket. The total annual catch in one small village was 3.5 tons. Therefore, it can be developed into promising fishery if a cold storage station and means of transportation are available.

(ii) Coastal and Offshore Fishes

Several varieties of sharks live abundantly from the Torres Straits to the northeastern coast of York Island. The main variety is ground shark (species belong to the genus Carcharhinus). The daily catch was 3 - 4 tons during experimental fishing. A considerably large shark fishing ground exists in Australia and Great Barrier Reef. It is considered as unexplored fishery of high potential. A large stock of Spanish mackerels is also available. Commercial development by trolling is being planned.

(iii) Other Coastal and Inland Resources

Numerous varieties of catfishes live in River Fly and Lake Murray. Some of them grow to weigh 25 kg. Fresh water gizzard shads and fishes similar to *Allothunnus* also live in Gulf waters. These resources can be developed for local consumption. Gulf Province and Western Province have large river mouths and estuaries. Two varieties of threadfin salmons exceeding 1 m and Mangrove crabs are said to live in them. The deltas at the mouth of River Fly have abundant shrimpts. However, their water depth (about 12 m) is too shallow for the operation of large commercial fishing boats. Local fishermen's small boats are more suitable for this purpose.

(5) Summary and Opinion

The survey team had a preconceived opinion that the Gulf of Papua, though located in a tropical zone, has

considerably high productivity because of large inflow of nutrient salt containing fresh water. At the end of the survey, the team was struck by unexpected poverty of resources. Prawn fishery is the second most important commercial fishery in Papua New Guinea. However, the catch of prawns is far smaller than Surinam fishing ground in South America, in spite of the similarity of various conditions (latitude, area of continental shelves, fresh water inflow etc.). As for barramundi fishery, the most important fishery in the Gulf of Papua, the MSY level has already been reached at the annual catch of 200 - 300 tons. Their stock is definitely small. The team has an impression that the stock of numerous unexplored resources may also be small.

The survey made in New Guinea (the northern coast of the main island and small islands) before the visit to Daru revealed that hardly any fishery is practised. Local people get some fishes and shellfishes for their home consumption. On the other hand, the team had an impression that real coastal fishery is growing in Daru. In Daru, many large canoes with a sail or an outboard engine were found. Daru has a few freezing factories which buy fishery products from local fishermen and freeze them which posses highly marketable value. In addition, coast of air transport of freezed products to Australia

is cheap because of closeness to Australia. Fishery of a similar level has been developed in Yule Island and Port Moresby. A cooperative association has been organized at some places. In sum, coastal fishery is gradually being developed along the coast of the Gulf of Papua.

The facilities and the staff for a research on fishery and resources in the Gulf of Papua are quite unsatisfactory. For example, a house smaller than 20 m^2, three young researchers and an old 35 feet long survey vessel are all that were available in Daru.

Some fisheries in the Gulf of Papua have great importance as relatively large-scale operations and as the basis for the development of coastal fishery. Some of of highly marketable resources are in a critical situation of overfishing. This is because their catch can be easily increased by the popularization of simple gears and facilities in spite of their limited stock.

Under these conditions, researches must cover various fields ranging from fundamental biology to advanced resource study. A project similar to the fishery improvement and popularization project in Japan will also become necessary. Fishery resources, though small, are extremely important for fishermen in Papua New Guinea. Researches should protect them from overfishing and coastal fishery from destruction.

3. Conclusions and Recommendations

The results of the survey pointed out some problems that must be considered in relation to the construction and improvement of research facilities.

First, fishery for export fishes is far more developed than local fishery for domestic consumption at any place. It is widely understood that the Papua New Guinea waters hold abundant fishery resources and the domestic demand is large as indicated by the consumption of canned mackerel. However, measures to connect resources with consumption have not been closely studied. Therefore, it is recommended to promote two lines of researches, namely, a research to explore fishes with established international market and a research to promote coastal and inland water fisheries. The former research will cover skipjack, tunas, shrimps, barramundi, lobsters, precious corals and pearl oysters. Most of the research techniques for these species have been established, thus the research will be easy to begin. On the other hand, fishes and fisheries for domestic consumption are diversified and varied greatly in stock size. Social and economic factors must also be considered. Therefore, the following factors must be sufficiently considered as the background for the research.

(a) People's demand for protein, especially fish protein, should be grasped.

(b) Current catch in each district should be investigated and a demand and supply plan of fishes should be prepared.

(c) Measures to complement fish shortage should be studied from the view point of catching methods and the number and the quality

of fishermen.

(d) Means to supply fishery products to consuming areas at adequate prices should be studied.

(e) The distribution and the stock of fishery resources should be investigated.

The time does not seem ripe, at present, to construct research facilities at various places. The activities to train fishermen and spread fishery techniques should be promoted in cooperation with the existing research facilities. The survey team had an impression that fishes are quite expensive in Papua New Guinea. Fishery promotion should be backed by social and economic studies.

The results of the survey led to the conclusion that the construction of research facilities should be kept to the minimum requirement for the time being. The team proposes to improve and increase such facilities along with the progress in researches. The team's concrete proposals are stated below.

(a) Construction of field laboratory for skipjack and tuna fishery in Kavieng

Skipjack and tuna fishery is the most important fishery in Papua New Guinea. It is expected to be developed further. Port Moresby has been the center for this research. Considerable results have already been accumulated and research efforts have been focused on some points. The team proposes to construct a field laboratory at a site of a new fishery base for thorough researches. Fortunately, a national fishery training college

and a base of training vessels are to be constructed in Kavieng. Some local fishery research facilities also exist in Kavieng. Kavieng will be a good site for a new research laboratory in view of the possibilities of cooperation among these facilities. No laboratory construction will be necessary in Rabaul since the same research subjects will be covered at Kavieng.

The major research subjects will include the population identification, migration and stock of skipjacks, the distribution, migration, estimated potential catch and catching methods of tunas, the distribution of bait fishes and effects of oceanic conditions, effects of catching pressure on bait fish stock and keeping test of bait fish.

For these purposes, a fields laboratory should be needed.

(b) Construction of field laboratory at Daru

The Gulf of Papua has a potential for the development of coastal fisheries. However, careful studies and resource control are required for their sound development. A research laboratory exists at Daru, which is one of promising fishery bases in the Gulf of Papua. However, the laboratory is small and its equipment is poor. It should be improved by supplying equipment and machines to establish a unified research system for the Gulf of Papua in cooperation with Kanudi Central Research Laboratory in Port Moresby.

(c) Research on Inland Water Fishery

A small research laboratory exists at Angoram in the basin of River Sepik. At present, there will be no need to construct

new facilities or improve existing ones. The team proposes to set up a project, as a need arises, for a few years of research concentration. Such a project should comprise tests of new fishing gears and a stock survey. A small type vessel with research equipment and fishing gear suitable for inland waters should be needed for this purpose.

(d) Improvement of Kanudi Central Research Laboratory (Port Moresby)

Kanudi Central Research Laboratory has been engaged in studying various problems arising at various places in the country. Since this tendency is expected to continue, this laboratory should be improved. Kanudi Central Research Laboratory should be the center of researches on the southern coast of Papua New Guinea, especially from Daru to Samarai. Two research vessels must be needed for this purpose. Problems arising at various places (Daru, for example) can be coped with more effectively by the use of these research vessels. Since Port Moresby is the base of shrimp fisheries in the Gulf of Papua, related researches should be carried out by the Kanudi Central Research Laboratory.

The team proposes to improve facilities for researches on processing. Some researches on the processing of fresh water fishes are in progress. Researches in this field are extremely important in view of the promotion of coastal fisheries in future and strict quality standards imposed on the export of fishery products. The houses and equipment currently in use

are already old.

(e) The team reserves opinion on Manus, Samarai, Goodenough Island and Kikori since they were not covered during the field trips.

4. Needs of Specialists

One researcher in skipjack and tuna stock will be needed for a laboratory at Kavieng, if constructed. For the improvement of Kanudi Central Research Laboratory, three researchers in fishery biology and one researcher in processing will be needed.

If an inland water fishery project is set up, specialists will be needed.

APPENDIX - III

Fishing Base Construction Program

for

Papua New Guinea Survey Program

Preface

The Government of Papua New Guinea newly incorporated measures for the promotion of processing marine products in its basic concept for the promotion of fisheries.

The canning industry was not included in the survey items when a field survey was carried out in November 1976. On the basis of the new measures adopted by the Government of Papua New Guinea, it was requested by the Government of Papua New Guinea to make a trial computation of the economic effects of the canning industry.

On the basis of the principal data supplied by the Government of Papua New Guinea, we calculated the economic effects of the canning industry by the way of trial and the results are contained in this report.

December 1977

Kiyohide Nemoto
Head
Survey Team for PNG Fishing
Base Construction Program

Fishing Base Construction Program for Papua New Guinea
Survey Program

1. Promotion of Marine Products Processing Industry

The Government of Papua New Guinea takes a great interest in an effective development and utilization of the abundant aquatic resources in its territorial waters. In particular, the pole-and-line fishing of skipjacks which is being carried out in the Bismarck Sea and the Solomon Sea turns out to be the biggest profitmaking undertaking, and their haul and output are great. Under the present circumstances, however, the skipjacks thus caught are immediately frozen in the fishing vessels, must of them being exported directly to foreign countries.

It might be described as a better orientation for the fishing industry to strive to reform this form of fishing operations, raise the added values of marine products, develop related industries, and provide more job opportunities in the region.

For this purpose, the primary requirement will be to construct a fishing base convenient to the landing of catches, berthing of catcher boats and supplying of necessaries. Secondly, it will be required to construct marine products processing facilities which will make it possible to handle and process landed catches with speed. Thirdly, there will be a need to redevelop the electric power supply and water service systems and make available skillful manpower in order to facilitate the operation of the marine products processing facilities.

If all these requirements are satisfied, it will be possible to realize a promotion of the marine products processing industry as it is associated with the overall

development of the fishing industry, thus providing an effective means for a raise in the national interests.

2. Target Areas for Promotion of Marine Products Processing Industry

At present, priority is given to Kavieng, Rabaul and Manus, as potential areas for the promotion of the marine products processing industry, as the pole-and-line fishing of skipjacks is being carried out in these waters.

One factor that is necessary for a realization of the marine products industry is that one and the same species of fish may be supplied in large quantities at all times. This factor will be really important for the maintenance of the marine products industry on a commercial and business basis. As the three areas may be described as satisfying these important conditions, it will be appropriate to construct fishing bases and facilities for the marine products processing industry in these areas. With respect to the promotion of the marine products processing industry, however, it would be risky to sustain the marine products processing industry on a business and commercial basis, unless the sales and consumption of processed marine products were well balanced, even though it was quantitatively possible to maintain fish as materials. Consequently, there would be a need to establish the marine products processing industry in one of the aforementioned three areas depending on the outcome, to establish it in the two other areas step by step.

3. Types and Scales of Processing of Marine Products

When skipjacks the pole-and-line fishing of which constitutes the main part of the fishing industry today, freezing, canning as well as the processing of smoke and loin will be the main lines of processing. Of these main lines, freezing is being carried out in the mothership for the fishing of skipjacks, but not in the land facilities, whereas the processing of smoke is being performed in Kavieng and on Nago Island.

In the event that the pole-and-line fishing of skipjacks is shifted from the mothership system to that of fishing bases, it will be necessary to immediately redevelop refrigerating and cold storage facilities. Moreover, it will become worthwhile to establish a canning plant for the high grade processing of skipjacks.

However, which should be emphasized, refrigerating, canning, smoke or loin, in establishing the processing facilities will have to be determined after a full study of the catch of fish landed in a given area, the demand in places to which the processed products are to be diverted, and their superiority on the international market for the formation of prices as processed merchandise.

With respect to the scale of marine products processing facilities, it will be essentially necessary to operate them at all times and any program for excessive facilities would eventually make it difficult to have access to raw materials, so that the processing facilities should be appropriate in scale so as to ensure a stabilized management of the enterprise.

The potential catch of skipjacks in Papua New Guniea is estimated at 75,000 tons. If marine products processing facilities are to be established on the basis of this

estimated output, it will be necessary for them to have a freezing capacity of 600 tons a day and for the refrigerating and cold storage facilities to have a cold storage capacity of 3,000-4,000 tons.

With respect to the establishment of a canning plant for the high grade processing of skipjacks, it will eventually have to have a processing capacity of about 15,000 tons a year in terms of fish resources. In the initial phase, however, the plant should be operated with a production capacity of 5,000-10,000 tons, and the production should be increased to 15,000 tons when the quality of the products is upgraded and it becomes possible to maintain the markets to which the products are diverted. In producing canned skipjacks, separate processing methods should be adopted for those which are to be diverted to the foreign markets and those which are set aside for domestic consumption, so that the production may effectively contribute to the supplying of food to the nation.

In the existing smoke processing system, in which about 2,000 tons of fish resources are processed, but the products are set aside for consumption by a limited number of countries, so that when the catch is increased in the future, the maximum output will presumably be about 3,000 tons.

As a simplified means of processing, it will be possible to process loin. Insofar as the loin products are concerned, however, it is necessary to develop consumption markets. Therefore, the scales of the processing facilities as well as the output should be determined after the demand is surveyed, but the maximum output will probably be about 3,000 tons.

4. Scale of Canning Plant

The canning plant should be established on the basis of a carefuly study and a comprehensive program. A considerable amount of investment is required for the establishment of a plant, and it will be required to pay considerable efforts and have managers skillful in high grade management to operate the plant as a profitable undertaking.

The scale of the proposed canning plant should be determined on the basis of the fund reserve, maintenance of fish resources, prospective demand of products and other factors. When consideration is given to the present catches in the pole-and-line fishing of skipjacks as well as the Papua New Guinea Government's policy of expanding the fishing industry, the plant will have to have an annual processing capacity of about 15,000 tons in terms of fish resources. In the initial phase of one or two years after the start of the plant, efforts should be concentrated on the training of production personnel and the upgrading of the quality of the products, and it will be a wise measure to start a full operation in the third year.

The basic figures associated with the scale of the canning plant are given in the following tables.

1. Scale of Production at Canning Plant

Operation phase	Canning facilities	Daily output of canned goods	Daily processing of fish resources	Number of work days	Annual output	Tonnage of fish resources used a year
Initial operation phase (1st and 2nd years)	1 line	830 C/S	16 tons	260 days	215,800 C/S	4,160 tons
Intermediate operation phase (3rd year)	2 lines	1,930	32	300	579,000	9,600
Full operation phase (5th year)	3 lines	2,900	48	300	870,000	14,400

The production scale of the canning plant should be expanded step by step. In the initial operation phase, there will be a need to make efforts for the training of production technology and the upgrading of the product quality. Therefore, the production coefficiency is underestimated for the period (1st and 2nd years) preceding the full operation phase.

* C/S in the table represents a case with four dozens in terms of tuna No.2 cans.

* The rate of canned goods to fish resources is estimated at 50% for the initial operation phase and 58% for the intermediate operation phase.

2. Number of Employees at Canning Plant

Operation phase	Administrative division	Plant workers	Total	Number of employees secured
	person	person	person	person
Initial operation (1st and 2nd years)	10	120∿140	130∿150	140
Intermediate operation phase (3rd year)	15	220∿235	235∿250	240
Full operation phase (5th year)	20	340∿380	360∿400	380

When the canning plant is established, it will be necessary to employ the aforementioned personnel. For the administrative division, the number of personnel concerned with canning is estimated, but in case the company which manages the canning plant directly exports canned goods, there will be a need for the employment of an additional five or six persons. As for the number of plant workers, the number of personnel corresponding to plant facilities is estimated. The number of employees secured includes an additional 10 persons or so who will be hired with due consideration given to absentism caused by diseases, injuries, etc.

3. Estimated Figures on Output

Product / Operation phase	Canned goods			Fish meal
	Canned skipjack in oil	Canned skipjack in flakes	Total	
Initial operation phase (1st and 2nd years)	(85) C/S 183,400	(15) C/S 32,400	(100)C/S 215,800	200 tons
Intermediate operation phase (3 year)	(92) 532,700	(8) 46,300	(100) 579,000	500
Full operation phase (5th year)	(92) 800,400	(8) 69,600	(100) 870,000	700

* (i) The rate of canned goods by product is given in brackets.

(ii) For the initial operation phase, the quantity of canned skipjacks in flakes is excessively estimated with due consideration given to the technology involved in the processing of fish resources.

(iii) Fish meal is produced to the tune of 5% of the fish resources used, but the quantity given in the table represents fish meal plus dried green scrap.

4. Economic Effects from Establishment of Canning Plant

The canning plant, if completed, will be the first full-scale venture in the processing of marine products in Papua New Guinea and will contribute greatly not only to the area where it is established but to the development of Papua New Guinea's industry and economy.

With respect to the economic effects which may be derived from the operation of the canning plant, some of the economic effects may be numerically computed, whereas there will appear a considerable number of indirect effects which may be difficult to compute.

Here, reference will be made to the economic effects which may be derived from the establishment of the canning plant and numerically computed.

1) Increase of Job Opportunities and Emergence of Employment Pays

Operation Phase	Number of persons employed	Average annualpay per capital	Annual pay
Initial operation phase (1st and 2nd years)	140 person	KiN[a] 1,620	KiN[a] 226,800
Intermediate operation phase (3rd year)	240 person	1,680	403,200
Full operation phase (5th year)	380 person	1,800	684,000

The number of persons who will be employed when the cannery is put into operation will increase in proportion to an expansion of the scale of the facilities. The numbers given in this table represent those engaged directly in canning and therefore do not include the number of auxiliaries whose employment will be required when a workers' billet or mess hall is prepared. Consequently, the actual increase in employment will be greater than the figures given in the table.

2) Acquistion of Hard Currency through Exportation of Canned Goods

In case 70% of the canned goods (skipjack in oil) are exported to foreign markets, the acquisition of hard currency may be estimated as indicated in the following table.

Operation phase	Hard currency acquired
Initial operation phase (1st and 2nd years)	(1,000 KiN[a]) 1,731
Intermediate operation phase (3rd year)	5,744
Full operation phase (5th year)	8,632

* Hard currency is computed in terms of KiN[a].
* The amounts are expressed in terms of CF.

For the computation of hard currency, possible fluctuations in foreign exchange are not incorporated. Naturally, the amounts shown in the table are subject to change. In case the domestic consumption of canned goods exceeds 30%, the exports will decrease accordingly, making it necessary to change the amounts shown in the table.

3) Saving of Hard Currency by Domestic Production of Canned Goods

If canned goods using skipjack meat as its resource are produced at home, the canned fish meat (mainly, boiled mackerel meat) the supply of which has had to be depended on imports will be replaced by domestic products, making it

possible to reduce the payment of hard currency for the imports.

Operation phase	Amount of hard currency saved
Initial operation phase (1st and 2nd years)	(1,000 KiN[a]) 940
Intermediate operation phase (3rd year)	2,213
Full operation phase (5th year)	3,325

* The amount of hard currency saved is computed in terms of KiN[a].

The saving of hard currency is computed on the assumption that 30% of the domestically canned skipjack meat in oil and 100% of the domestically canned skipjack meat in flakes are set aside for domestic consumption. The amount of payment which would have been made if they had been imported is locked upon as the amount of hard currency saved.

As elucidated in the foregoing, the establishment of a cannery will make it possible to increase new employment and to acquire and save hard currency with the domestic production of canned goods, thus contributing greatly to an improvement of the nation's foreign payments position. Then there will appear a considerably large number of secondary economic effects -- the effects which are not numerically computed here -- such as the increases in the bills of water and electric power the use of which will be necessiated by the establishment of the

cannery, and the increases in the consumption of daily commodities which will be brought about by rises in the income of the employed.

However, the computed figures of economic effects given in the foregoing are estimated figures. The computation is not the calculation of benefits, as is done for the management of a business undertaking, which is based on the computation of the amount of investments made for the construction of the cannery and the cost for the production of canned goods. In order to know about the economic effects in the strict sense of the word, therefore, there will be a need to compute the economic effects which fully reflect the various conditions and factors based on elaborate data.

Therefore, the data contained in this report do not represent the profitability in terms of business management when a cannery is established. In order to establish a cannery and operate it on a business basis, it will be necessary to perform a separate feasibility survey. Also with respect to the attempt to embark on the production of canned goods, there will be a need to start it on a small scale and a trial basis first and, to increase the scale of the cannery and the production capacity after a full examination.

Annexed Table

Computation method:		The volume of fish catachable -- 75,000 tons (a year)
(1)	Freezing capacity	1,000 tons (average catch) a year per catcher boat = 75 ships (50 ships) Number of days of operation a year per catcher boat -- 300 days on the average Maximum catch a day per catcher boat -- 8 tons. Maximum landing per day ÷ 8 tons x 75 ships = 600 tons (400 tons)
(2)	Refrigerating and cold storage capacity	Volume of fish catchable 75,000 tons ÷ number of days of operation 300 days = daily average. (a) Landing = 250 tons x storage for 15 days = 3,750 tons (b) Height of fishing season = 600 tons x 7 days = 4,200 tons Average (a) + (b) = 3,975 tons
(3)	For canning	Volume of fish catachable -- 7,500 tons For processing of types other than canning * For smoke processing 3,000 tons * For loin processing 3,000 * For unprocessed local consumption 1,000 Fish resources for canning 75,000 tons x 20% = 15,000 tons Fish as resources ÷ 15,000 tons

* The rate of fish diverted for canning (in terms of fish resources) is 10% of the total catch at a global (FAO Fishery Annual). In the case of Papua New Guinea, skipjack which is suitable for a material in the production of canned fish meat accounts for most of the total catch. The rate is estimated at 20%.