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(O.R.S.T.O.M.)

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SUMMARY

- ABSTRACT -

Traditionally, industrial tuna fishing in the Pacific Ocean has been done by four major countries : Japan, USA, Taiwan and South Korea ; all of them catching tuna mainly outside their exclusive economic zone (EEZ).

For some years, industrial fishing has been extensively developed by new countries which have the resources in their own EEZ but did not have the required technology nor the access to the markets, which are essentialy limited to Japan and the United States. Those new countries are Mexico in the Eastern Pacific and the Philippines in the Western Pacific.

In Indonesia, as in the Philippines, consumption of tuna is high, depending on the area, and tuna fishing is traditional in many islands as it is shown by the great number of artisanal technics used to catch those fishes.

Until now, areas exploited were usually very close to the shore and quite limited and offshore resources were almost not exploited at least by the Indonesian themselves.

There is no doubt about the fact that Indonesia will become, in the future, a major tuna producer in the Western Pacific and the Indian Ocean and will increase its possible future development.

In this report, we will describe the present tuna fishing and its possible future development.

It is almost impossible to completely review tuna fishing in a country like Indonesia because the area to study is too wide and the fishing methods used as well as the species caught are so diversified ; instead we have limited our study to the main commercial species which are yellowfin, bigeye tuna and skipjack, the most abundant ones.

Fishing of tuna-like fishes, generally done by small scale fisheries, as it occurs in the Java Sea, is not included in this report.

After a short presentation of the statistics of tuna and tuna-like fishes in the country (chapter 1), we will study the catches of big tunas using longliners (chapter 2 to 5) and its possible development, then skipjack catches by industrial purse seiners (chapter 6 to 8) and industrial pole and line boats (chapter 9).

Artisanal fishing of skipjack by pole and line is well developed in many areas of Western Indonesia. It will be presented in chapter 10 to 12.

Many other artisanal technics such as trolling, angling on fish shelter, purse seining and gillneting are used to catch skipjack and other tuna and tuna-like fish. Depending on the areas, one or several of these methods may be predominent ; some of those technics and areas are covered in chapter 13 to 17.

In chapters 18 to 20, we will expose a few of our ideas about the effect of the industrial purse seine developmant on the artisanal activities and about the possible development of artisanal and industrial technics to catch tuna in Indonesia, also considering national and international implications.

RESUME

"LA PECHE AU THON EN INDONESIE"

Traditionnellement la pêche thonière industrielle dans l'océan Pacifique était le fait de quatre pays principaux : le Japon, les Etats Unis, Taiwan et la Corée du Sud. Presque tous ces pays pêchent le thon en dehors de leur zone économique exclusive.

Depuis plusieurs années, la pêche industrielle s'est considérablement développée dans des pays nouveaux qui possèdent la ressource, mais qui jusqu'alors n'avaient ni la technologie requise ni l'accès aux marchés ; les principaux sont le Mexique, dans le Pacifique Est, et les Philippines, dans le Pacifique Ouest.

En Indonésie, comme c'est le cas aux Philippines, la consommation des thons est importante, au moins dans certaines régions, et leur pêche y est une activité très ancienne comme le suggère la grande diversité des techniques artisanales qui existent. Les zones exploitées se situent en général à proximité des côtes et, de ce fait, les ressources du grand large ne sont jusqu'à présent que très peu touchées.

Il ne fait pas de doute que l'Indonésie deviendra, dans un futur proche, un producteur important de thons destinés aussi bien à l'exportation qu'au marché intérieur. Dans cette perspective, il paraissait utile de faire un état de la pêcherie actuelle et de ses possibilités de développement.

Entreprendre une revue complète de la pêche au thon en Indonésie est une tâche presque impossible du fait de la taille même de cet immense archipel et de l'extrême diversité des techniques de pêche qui y sont employées. Pour cette raison, nous nous sommes limités à l'étude des trois principales espèces qui sont commercialisées sur le marché international, à savoir l'albacore, le patudo et le listao. Les pêcheries des autres petits thonidés, qui peuvent être localement très importantes, en mer de Java par exemple, ne sont pas étudiées en détail.

Après une courte présentation de l'ensemble des statistiques thonières (chapitre 1), nous examinons plus en détail les prises obtenues par les palangriers (chapitre 2) et les possibilités de développement offertes par l'introduction de palangres profondes (chapitres 3 à 5). Les pêches de listao par les senneurs et les canneurs industriels récemment introduits, sont présentées dans les chapitres 6 à 9.

La pêche artisanale au moyen de canneurs à appât vivant est importante et déjà ancienne dans tout l'ouest indonésien ; les chapitres 10 à 12 y sont consacrés.

De nombreuses autres techniques artisanales sont employées pour pêcher le thon : pêche à la traîne, à la ligne à main, à la senne ou au filet maillant. Suivant les régions, certaines de ces techniques prédominent ; elles sont étudiées dans les chapitres 13 à 17.

En fin de rapport nous examinons l'effet du développement récent de la pêche à la senne sur la pêche artisanale à la canne dans les secteurs limitrophes(chapitre 18) et envisageons les possibilités d'accroître les pêcheries tant industrielles qu'artisanales (chapitre 19), en considérant les implications nationales et internationales de ce type de développement (chapitre 20).

PENDAHULUAN

"PENANGKAPAN IKAN TUNA DI INDONESIA"

Secara tradisi penangkapan ikan tuna untuk industri lautan Pasifik adalah masalah empat negara : Jepang, Amerika Serikat, Taiwan dan Korea Selatan.Hampir semua negara itu menangkap ikan tuna di luar zona ikonomi eksklusif.

Sejak beberapa tahun yang lalu, penangkapan tuna untuk industri berkembangpesat di negara-negara yang memiliki sumber tetapi yang sejauh itu belum mempunyai teknologi yang diperlukan ataupun daerah pemasaran ; yang paling utama adalah Meksiko di Pasifik Timur dan Pilipina di Pasifik Barat.

Di Indonesia, seperti halnya di Pilipina, konsumsi ikan tuna sangatlah besar, sekurang-kurangnya di daerah-daerah tertentu, dan penangkapannya di sana merupakan kegiatan yang sudah sangat kuno seperti yang diperlihatkan oleh beraneka ragam teknik dalam perikanan rakyat. Daerah-daerah penangkapan biasanya terdapat di dekat pantai dan karena itu sumber-sumber di laut lepas sampai sekarang kurang disentuh.

Tak pelak lagi bahwa Indonesia, dalam waktu dekat, akan menjadi produsen penting ikan tuna yang ditujukan baik untuk ekspor maupun untuk pasaran dalam negeri. Dalam prospek ini, tampaknya penting untuk mengemukakan keadaan perikanan sekarang dan kemungkinan-kemungkiana pengembangannya.

Membuat suatu gambaran yang lengkap tentang penangkapan tuna di Indonesia adalah suatu pekerjaan yang sangat sukar karena luasnya kepulauan ini dan karena sangat beraneka ragamnya teknik penangkapan yang digunakan ki sana. Karena alasan ini kami membatasi kiri pada penelitian tiga jenis utama yang diperdagangkan di pasaran internasional, yaitu : madidihang, tuna mata besar san cakalang. Penangkapan jenis-jenis tuna kecil yang lain, yang secara local bisa sangat penting, misalnya di laut Jawa, yang belum depelajari secara terperinci.

Setelah dekemukakan secara ringkas keseluruhan statistik ikan tuna (bab 1), kami pelajari lebih terperinci penangkapan dengan rawai tuna (bab 2) dan kemungkinan-kemungkinan pengembangannya perikanan industri untuk cakalang dengan pukat cincin dan huhate yang baru-baru ini diperkenalkan, dikemukakan dalam bab-bab 6 sampai 9.

Penangkapan ikan tuna dengan menggunakan kail berumpan hidup yang telah berkembang di Indonesia bagian Barat ; disajikan dalam bab 10 sampai dengan bab 12.

Berbagai teknik penangkapan yang digunakan untuk menangkap ikan tuna seperti tonda, pancing, jaring insang, pukat cincin dan rumpon sebagai mana diterapkan didaerah-daerah tertentu ; diliput dalam bab 13 sampai dengan 17.

Pada akhir laporan dipelajari akibat perkembangan baru penangkapan ikan dengan pukat cincin terhadap perikanan rahyat (bab 18) dan merencanakan kemungkinan untuk pengembangan perikanan industri dan perikanan rahyat (bab 19), dengan mempertimbangkan keterlibatan nasional dan internasional dari jenis pembangunan ini (bab 20).

1 CATCH STATISTICS OF TUNA AND TUNA-LIKE FISHES IN INDONESIA.

Statistics on tuna and tuna-like fish catches are collected each year by the Directorate General of Fishery and are estimated for all provinces by species and by year.
There are three main categories of species : "Tuna", "Cakalang" and Tongkol".

The first category, "Tuna", includes all big tunas such as albacore, yellowfin and bigeye ; the two dominant species caught in Indonesia, mainly with longline gears and troll lines are yellowfin (Thunnus albacares) and bigeye tuna (Thunnus obesus).

The second category, "Cakalang", is more homogenous since it only includes skipjack tuna (Katsuwonus pelamis) caught by pole and line boats and trollers ; sometimes locally frigate mackerel (Auxis thazard) and eastern little tuna (Euthynnus affinis) may be included in this category.

The third one, "Tongkol", includes all kinds of tuna-like fish such as longtail tuna (Thunnus tonggol), frigate mackerel and bullet mackerel (Auxis thazard and Auxis rochei), eastern little tuna (Euthynnus affinis) or oriental bonito (Sarda orientalis).

Total production of Indonesia is given in Table 1 by species category and year.

Years	Tuna	Skipjack	Tuna-like fishes	Total
1973	11 334	26 405	36 782	74 251
1974	11 236	28 060	47 116	86 412
1975	11 931	27 241	47 335	86 507
1976	9 354	30 851	52 235	92 439
1977	13 204	30 410	62 382	105 996
1978	13 412	33 515	55 244	102 169
1979	17 899	42 834	66 582	127 315

Table 1 - Total production of Tuna (yellowfin + bigeye) skipjack and tuna-like fishes in Indonesia - years 1973 -1979, in tons.

Catches of tuna and tuna-like fishes were estimated to be 80 000 tons in years 1973 - 1974 and increased slightly in 1979 - 1980 up to 130 000 tons. Out of this, skipjack represents 30 % to 35 % of the total catches and the category "Tuna" 10 % to 15 %.
Many kinds of gear are used to catch tuna, skipjack and tuna-like fishes ; the total production by year is given in Table 2 for the year 1979.

Tongkols are taken mainly with troll lines, drift gill nets, purse seines, payang seines and by angling, methods which can be considered as artisanal.

Skipjacks are taken mainly by pole and line (46 % of total catches in 1979), by trolling (25 %) and angling (15 %). A smaller proportion is taken with payang, drift gill nets (4,3 and 4,5 %) and with traps. Since the introduction of industrial purse seine in 1980, a significant proportion of the catches is caught using this method.

Tuna are mainly caught by artisanal methods such as angling and trolling, but also using pole and line, drift long line and gill nets. The catches by industrial long line vessels were estimated to 8 % of total tuna catch in 1979.

Gears	Tuna	Skipjack	Tuna-like fishes
Payang	67	1 792	6 003
Purse seine	32	338	6 388
Gill net	432	1 875	17 316
Tuna longline	1 487	-	41
Other longlines	2 907	842	2 871
Pole and line	2 004	19 037	724
Angling	5 811	6 629	9 505
Troll	4 760	10 061	16 040
Traps	34	191	360
Other gears	92	667	3 742

Table 2 - Production of tuna, skipjack and tuna-like fishes by gear in 1979 (in tons).

Most of the tuna-like fishes, or "Tongkol", are caught on the Northern coast of Java (15 000 tons in 1979), in the South of Sulawesi (9 000 tons), in the North of Sulawesi (6 000 tons), and in Bali.

Catches of tuna and skipjack are mainly done in Eastern Indonesia, in the Pacific Ocean and adjacent Indonesian seas. We give (Tables 3 and 4) for each major area, the evolution of the tuna and skipjack catches from 1973 to 1979, and in Figure 1, the major landing places of skipjack and tuna.

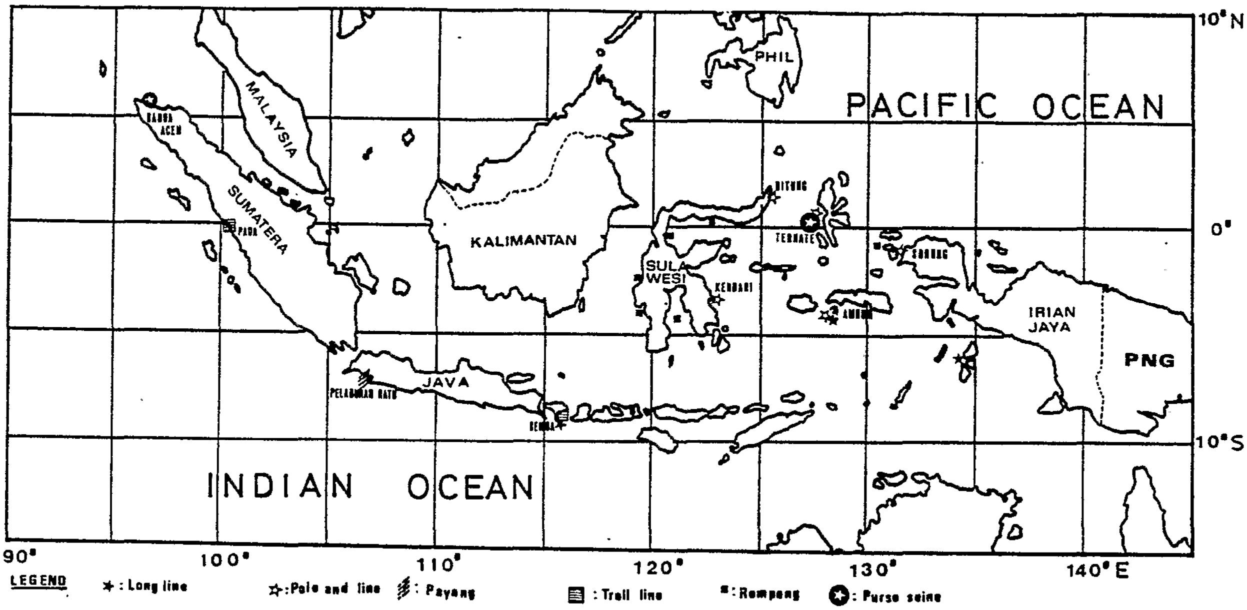


Figure 1 - Map showing the main tuna and skipkack fishing bases in Indonesia.

- Emplacement des principales bases de pêche thonière en Indonésie.

	1973	1974	1975	1976	1977	1978	1979
East Sumatra	1 430	1 751	869	1 251	2 177	2 764	3 151
South Java	-	-	-	66	168	47	85
Malacca Strait	-	-	-	-	554	453	456
West Sumatra	-	-	254	330	338	145	-
North Java	-	-	10	-	15	14	16
Bali-Nusatengara	222	56	1 210	1 585	2 373	2 640	2 255
East and South Kalimantan	-	-	-	-	-	-	-
West Kalimantan	-	-	-	145	153	70	122
South Sulawesi	7 607	5 968	6 041	919	1 844	2 333	6 164
North Sulawesi	1 877	2 657	1 762	3 535	3 544	2 637	2 934
Maluku Islands	65	668	1 686	1 245	1 712	2 126	2 081
Irian Jaya	78	136	99	279	276	183	635
Total	11 334	11 236	11 931	9 354	13 204	13 412	17 899

Table 3 - Statistics of "Tuna" catches (mainly yellowfin) by major areas of Indonesia from 1973 to 1979 (in tons) (source : Directorate General of Fishery).

Years	1973	1974	1975	1976	1977	1978	1979
East Sumatra	3 407	3 748	3 438	4 617	2 243	3 242	5 333
South Java	333	370	487	896	1 791	851	1 191
Malacca Strait	960	1 000	1 256	1 594	947	1 183	2 063
West Sumatra	22	-	-	67	-	-	-
North Java	130	168	193	102	84	116	458
Bali-Nusatengara	2 239	2 990	1 702	2 083	1 904	1 331	1 347
East and South Kalimantan	-	-	-	-	-	-	-
West Kalimantan	-	-	48	96	120	9	172
South Sulawesi	5 025	5 891	5 961	4 895	6 898	6 977	9 691
North Sulawesi	6 726	7 197	4 674	7 293	5 500	5 623	8 532
Maluku Islands	6 635	5 533	9 158	7 589	8 650	8 665	9 995
Irian Jaya	928	1 163	324	1 619	2 273	5 521	4 052
Total	26 405	28 060	27 241	30 851	30 410	33 515	42 834

Table 4 - Statistics of skipjack catches by major areas of Indonesia from 1973 to 1979 (in tons) (source : Directorate General of Fishery).

In East Sumatra and Sulawesi, the tuna catches are mainly done by trolling and angling or with artisanal long lines and, in the Maluku Islands by pole and line. In Bali, almost all catches are made by industrial longliners fishing in the Indian Ocean and in the Banda Sea.

The skipjack catches are very high in North and South Sulawesi: 8 500 and 9 700 tons respectively in 1979 ; they are obtained by trolling and pole and line and sometimes in South Sulawesi by purse seining with "payang". In Maluku and Irian Jaya (10 000 tons and 4 000 tons) almost all skipjack are caught by pole and line with live bait, in East Sumatra by trollers and in Malacca Strait by purse seine, "payang" and troll.

Small tunas are almost all consumed locally, fresh, smoked or boiled and salted as well as a part of skipjack and yellowfin. Exportation of frozen fish is yet very limited, but has increased for the past five years : from 2 000 tons in 1977, it reached 11 000 tons in 1980 with a FOB value of 12.9 million $ US, representing 4 % of the total exportation value from marine products in Indonesia (Table 5).

	Tuna and Skipjack* in tons	Value FOB US $ x 1 000
1975	424	258
1976	621	409
1977	1 898	1 320
1978	9 426	6 193
1979	8 951	7 538
1980	11 093	12 887

Table 5 - Exports of tuna and skipjack in Indonesia from 1975 to 1980.

2. INDUSTRIAL LONGLINE FISHING IN INDONESIA.

2.1. Introduction.

Longline fishing is a very old technique which has been well developed by Japan. Fishing first occurred in the Western Pacific Ocean and the fishing grounds extended to the Indian Ocean and in the Banda Sea during the years 1952-1954. Over the years 1968-1972, the japanese longline fleet began to decrease and was progressively replaced by Taiwan and korean ones. Korean vessels have increased their activity in both the Pacific and the Indian Oceans and, at the present time, the main fishing efforts on yellowfin and bigeye stocks in the Indian Ocean are done by this fleet.

Japanese long range vessels have oriented their activities towards the southern bluefin tuna, a very high priced species, as well as bigeye tuna.

The first species is very scarce in indonesian waters, but the second one can be very abundant, especially in the Banda Sea area when it is caught with deep longlines. This is the reason why japanese longline vessels have concentrated their activity in this area under a joint agreement with the indonesian government.

Indonesia began tuna longline fishing in 1972. A state enterprise was set up with cold storages in Sabang (North Sumatra) and in Benoa (Bali). All the vessels of this company, P.T. - Perikanan Samodera Besar, operate now from Bali.

There were 39 longliners in Indonesia in 1982 (Table 6), 20 of them, operated by the state company, are based en Bali and have been in operation for almost ten years. The others have been newly introduced and operate from Ambon and Aertembaga mainly in the Banda Sea.

In the present chapter, only the data from the state company will be presented.

Name of company	Number of vessels
P.T. Perikanan Samodera Besar	20
P.T. Sumber Mina	6
Daya Guna Samodera	6
Kartika Mina Samodera	2
Cipta Samodera	1
Bina Mina Nusantara	1
Sarunta Waya	1
P.N. Perikani Sulawesi Utara	(1)
Perum Perikani Maluku	1
Total	39

Table 6 - Number of longliners operating in Indonesia in 1982.

2.2 The fleet

All the vessels of the company are of the same type. Specifications are given in Table 7. Boats are 110 to 115 GT, 370 to 400 HP, with 40 tons fish hold capacity and 2 tons/day freezing capacity.

Longlines used are typical subsurface longline with six branch lines per basket.

GT	111 - 114 t
Net tonnage	40 - 44 t
Length	27,8 m
Large	5,9 m
Freezing capacity	2 ton/day
Fish hold capacity	80 m3
Fuel tank capacity	50 m3
Engine power	370 HP(S 01 S 09) 400 HP(S 10 S 19)
Auxiliary engine	100 KVA
Compressor	30 kg/m2, 2,2 kw
Refrigerant	amoniak
Speed	10 knots
Crew	23 men

Table 7 - Specifications of the longliners Samodera 1 - Samodera 19 of the state enterprise, P.T. Perikanan Samodera Besar.

2.3. Production and catch composition.

The two major species caught are yellowfin and bigeye (62 % and 18 % respectively of the total catch), then comes albacore (6 %), white marlin (4 %), black marlin (2,4 %), sword fish, sail fish and striped marlin. Catches of bluefin are only done in South of Bali and are rather scarce. Correspondence between latin, english and indonesian names are given in Table 8 and the annual production of the State Company in Table 9.

Nº	Indonesian name	English name	Latin name	Samodera Besar Name	Samodera Besar Code
1	Madidihang	Yellowfin tuna	*Thunnus albacares*	Yellowfin	YF
2	Mata besar	Bigeye tuna	*Thunnus obesus*	Bigeye	BE
3	Albacore	Albacore	*Thunnus alalunga*	Albacore	AL
4	Bluefin	Southern Bluefin tuna	*Thunnus maccoyii*	Bluefin	BF
5	Setuhuk hitam	Black Marlin	*Makaira indica*	Black Marlin	BM
6	Setuhuk putih	White Marlin	*Tetrapturus albidus*	White Marlin	WM
7	Setuhuk loreng	Striped Marlin	*Tetrapturus audax*	Striped Marlin	SM
8	Ikan layar	Sail fish	*Istiophorus platypterus*	Basho	BO
9	Ikan pedang	Sword fish	*Xiphias gladius*	Meka	SF
10	Tenggiri	Spanish mackerel	*Scomberomorus spp.*	Sawara	SA
11	-	Moro shark	-	Moro	MR

Table 8 - Major species caught by longline vessels.

Species	1973	1974	1975	1976	1977	1978	1979	1980	1981	Average 1976-1981 in %
Yellowfin	105	275	629	887	1 194	1 243	1 244	1 367	1 805	62,15
Bigeye	27	219	393	284	293	390	396	418	527	18,53
Albacore	-	41	52	135	114	119	152	114	67	5,63
Bluefin	-	-	-	7	5	7	13	8	6	0,37
Black Marlin	11	46		30	37	53	72	66	67	2,61
White Marlin	11	35	144	50	44	90	84	127	186	4,67
Striped Marlin	1	7		30	10	16	22	21	6	0,84
Swordfish	-	13		15	15	21	40	38	53	1,46
Sailfish			93	25	30	28	15	19	38	1,24
Moro shark	19	43		30	38	36	63	60	76	2,43
Mackerel				2	2	1	1	1	1	0,06
All species	174	679	1 311	1 494	1 781	2 004	2 104	2 239	2 832	

Table 9 - Annual production by species of the State Enterprise P.T. Perikanan Samodera Besar from 1973 to 1981 (in metric tons).

Since 1973, the total annual catches have been ever increasing ; they reached 2 000 tons in 1978 and 2 800 tons in 1981. Composition by species (Tables 9 and 10) shows, each year, a high predominance of yellowfin in terms of weight as well as in number of fishes caught.

Fish Code \ Year	1975	1976	1977	1978	1979	1980	1981
YF	51,4	55,7	67,0	60,7	59,2	64,4	73,5
BE	20,2	18,2	15,1	18,2	17,3	17,3	12,3
AL	14,1	14,4	8,7	9,5	11,9	8,2	5,7
SM	1,6	1,3	0,3	0,5	0,8	0,6	0,1
BM	1,5	0,7	0,7	1,1	1,3	0,9	0,6
WM	1,7	2,2	1,4	3,1	2,3	4,0	3,5
SF	2,7	1,7	1,5	2,1	1,6	1,5	1,4
BF	0,9	0,2	0,1	0,1	0,2	0,1	0,1
BO	2,2	2,2	2,0	1,8	1,0	1,0	1,3
MR	3,1	2,8	2,9	2,8	3,8	2,0	1,5
SA	0,5	0,2	0,3	0,1	0,1	0,0	0,0

Table 10 - Composition of the catches by species - relative proportion in number of fishes -.

The proportion of yellowfin, in number of fishes, was higher in 1981, versus an average 60 % for years 1975 to 1980 ; the proportion of bigeye tuna was similar in terms of weight, but much lower in number of fish during the year 1981 ; catch of albacore was very low, both in weight and in number of fishes during this same year.

Those differences may come from the greater fishing efforts developed in the Banda Sea in 1981 for, in this area, small yellowfin are probably more abundant, large bigeye of bigger size and albacore beeing more scarce. In both years 1980 and 1981, good hookrates and catches of white marlin have been obtained.

2.4. Fishing grounds.

Fishing grounds are located South and West of Sumatra, South of Java, Bali and the Nusa Tangara Islands and in the Banda Sea. Until 1979, 75 to 80 % of the total fishing efforts were developed in South East and West of Bali, thus very close to the base, less than 10 % in the Banda Sea and about 7 to 12 % South and West of Sumatra, (Fig. 2 and 3).

A change in the fishing grounds began in 1980 ; during this year only 30 % of the fishing effort occurred West of Bali ; 42 % was developed in the East and South East and 18 % in the Banda Sea. In 1981, fishing effort in West of Bali, remained at the same level (29 %) but 50 % of it occurred in the Banda Sea as the Maluccu Islands and western Irian Jaya.

2.5. Catch per unit effort.

The evolution of the fishing effort in number of fishing days (days when longline is set) is given in Fig. 4 from 1973 to 1981. With 20 boats in operation the number of fishing days is stabilised to 3 000 days since 1978.

Distribution of fishing effort by the longliners of the State enterprise P.T. PSB based in Benoa (Bali).

Numbers indicate the percentage of the total number of sets in a 5° square area.

Distribution de l'effort de pêche des palangriers de l'entreprise P.T. PSB basés à Benoa (Bali).

Les nombres indiquent le pourcentage de l'effort de pêche effectif dans chaque secteur de 5° de côté.

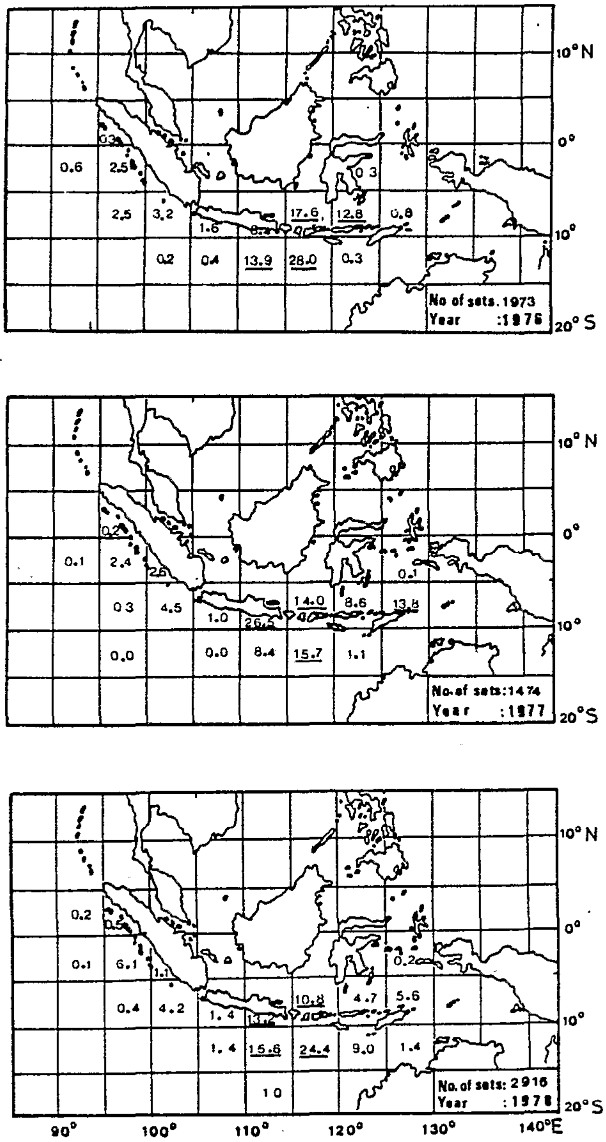


Figure 2 - Years/Années 1976, 1977 et 1978.

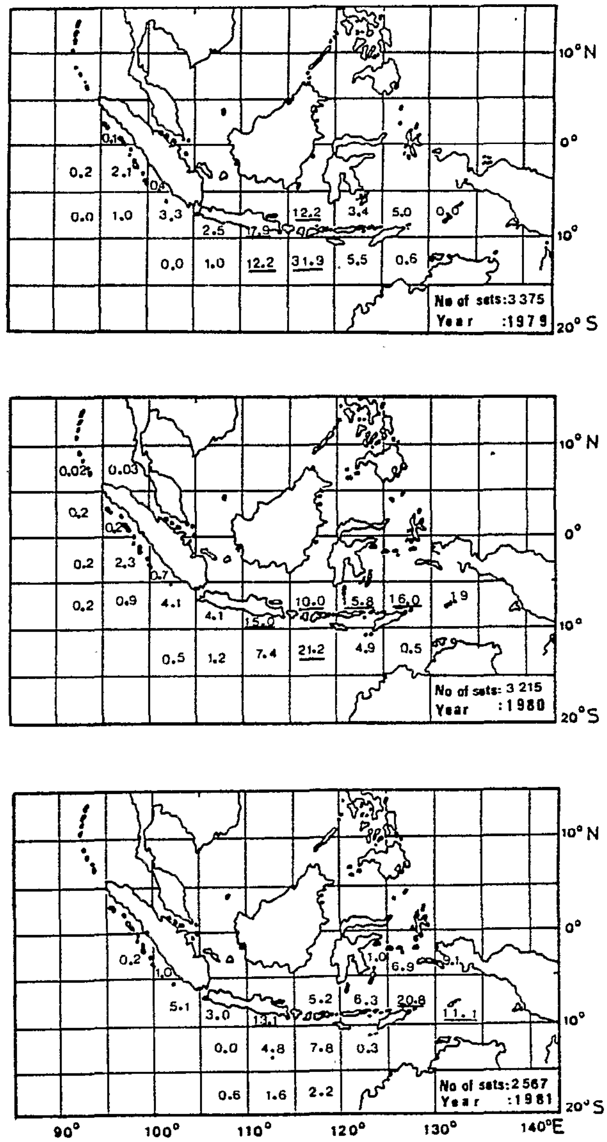


Figure 3 - Years/Années 1979, 1980 et 1981.

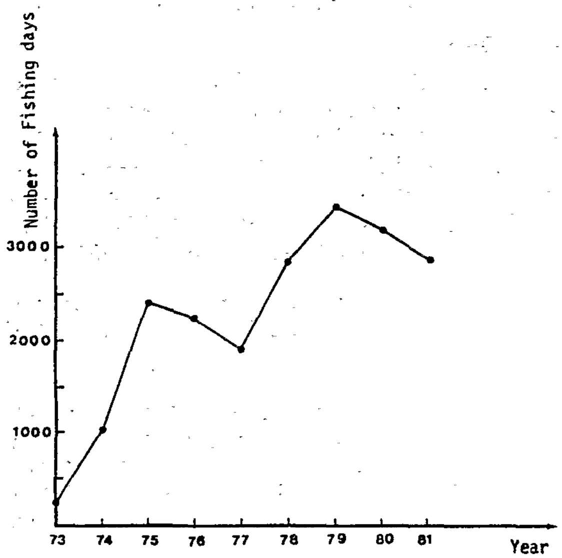


Figure 4 - Number of annual fishing days by P.T. PSB from 1973 to 1981.

- Nombre de jours de pêche effectués par les navires de P.T. PSB de 1973 à 1981.

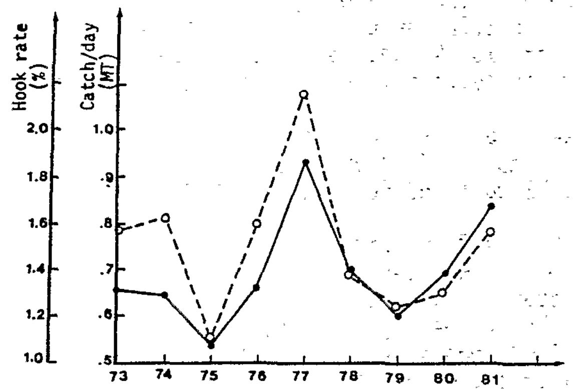


Figure 5 - Evolution of catch by day in metric tons (strait line) and of hook rates (dotted line) from 1973 to 1981.

- Evolution de la prise par jour de pêche en tonnes (ligne continue) et du rendement par 100 hameçons en nombre de poissons (ligne pointillée) de 1973 à 1981.

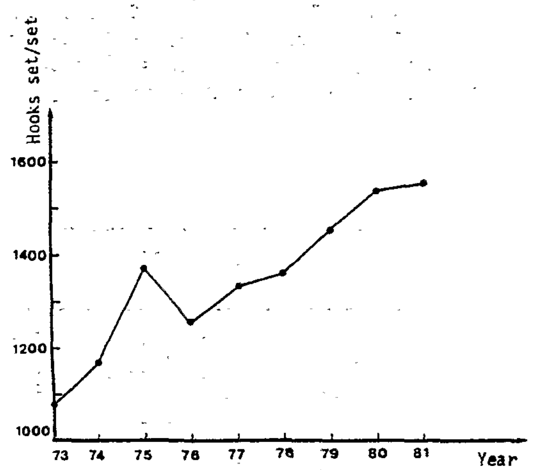


Figure 6 - Evolution of the number of hooks set by boat and by operating day from 1973 to 1981.

- Evolution du nombre d'hameçons posés par bateau et par jour d'opération de 1973 à 1981.

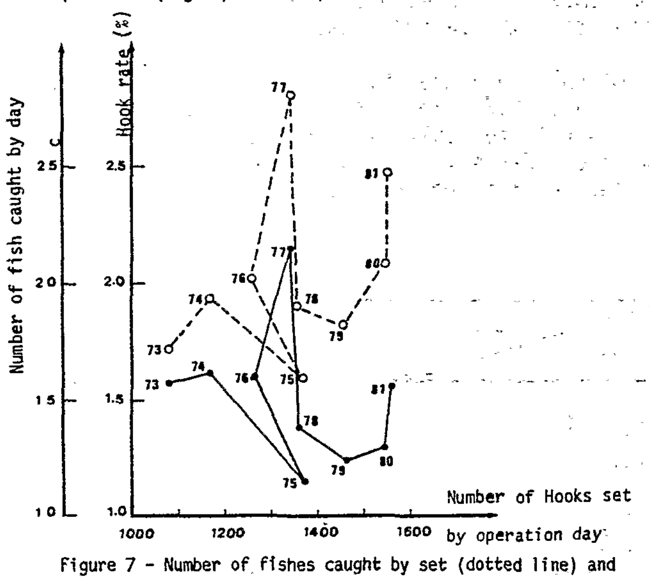


Figure 7 - Number of fishes caught by set (dotted line) and hook rates (strait line) according to the number of hooks set.

- Relation entre le nombre de poissons capturés par opération de pêche et le nombre total d'hameçons posés (ligne pointillée) ; relation entre le rendement par 100 hameçons et le nombre d'hameçons posés par jour (ligne continue).

Usually, estimations of catch per unit effort from longline vessels are given in hook rate (HR) which is the number of fishes caught for 100 hooks or in catch by day which is the total catch in weight by fishing day.

Evolution of average annual catch by day and and hook rates are given Fig. 5. If we except the years 1975 and 1977 where the hook rates were respectively much lower and much higher than the average, we can see that the hook rates during the first years of operations, 1973, 1974, 1976, were higher than during the years 1978 to 1981. Average HR for years 1973 to 1977 was 1.62 versus 1.37 for the average HR value of the years 1978 - 1981, so there is a decline of 15 % between the two periods. On the contrary, we can observe that the average catch by day between those two periods has slightly increased (from 690 kg/day to 710 kg/day).

Those two observations are not in contradiction as we can see on Figure 6 that the average number of hooks set by operating day has been increasing steadily from 1 100 hooks set in 1973 to 1 550 for 1980 and 1981 (40 % more).

On Figure 7, we can see what could be the relation between the hook rate and the average number of hooks set by operating day. If such a relationship exists, (decreasing hook rate when number of hooks set by operating day increases), then we cannot expect much higher catch by day by increasing the number of hooks set. Maximum catch could probably be obtained for 1 800 to 2 000 hooks set by operating day, which corresponds to the average number of hooks set by the japanese longline vessels.

According to this analysis, we can consider that the annual average value of the hook rate may not reflect the abundance of tuna which has been rather constant, if we except the exceptional catches of the year 1977.

We have seen in the previous paragraph, that the fishing grounds in 1981 were different from those of previous years, as 50 % of the fishing effort has been done in the Banda Sea area ; this may be the reason of the higher hook rates and catches by day obtained in 1981.

Monthly average hook rates, production and catches by day are given in Tables 11 to 13 from July 1973 to April 1982. Those tables show that the best catches are usually obtained from April to July, in November and December. Catches and hook rates are almost always very low from January to March and between August and October, those months can therefore be choosed for repairs and docking.

Month \ Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
January		1,0	1,3	0,96	2,30	1,53	0,92	1,23	1,05	1,13
February		1,6	0,9	1,02	0,86	1,19	0,90	1,29	1,09	1,13
March		1,3	1,0	1,03	1,30	1,25	0,81	0,82	0,97	1,33
April		1,6	1,1	1,31	1,52	1,46	1,58	1,75	1,62	1,65
May		2,0	1,2	1,20	2,00	1,79	1,45	1,46	2,23	
June		2,3	1,0	1,80	3,81	1,96	1,37	1,28	1,98	
July	3,0	1,9	1,0	1,99	3,74	1,77	0,87	1,26	2,20	
August	1,5	1,1	1,4	2,45	2,49	1,19	1,08	1,11	0,96	
September	2,0	1,5	1,1	1,67	2,33	1,07	1,29	1,26	2,00	
October	1,3	1,4	1,3	1,94	2,20	0,92	1,50	1,09	1,37	
November	1,2	1,4	1,16	1,97	1,91	0,96	1,52	1,14	1,83	
December	1,3	1,7	1,57	2,00	1,85	1,06	1,36	2,37	1,70	
Total	1,58	1,62	1,15	1,60	2,16	1,39	1,23	1,30	1,56	

Table 11 - Average monthly hook rates in number of fishes by 100 hooks of longliners of the State Enterprise P.T. Perikanan Samodera Besar from July 1973 to April 1982.

Month \ Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
January		11	98	57	106	197	114	150	175	195
February		32	67	110	56	98	116	167	131	163
March		34	115	77	67	151	124	108	183	217
April		15	94	135	61	182	191	188	186	237
May		31	130	79	82	226	231	204	274	
June		101	87	164	126	260	185	148	196	
July	22	143	110	139	289	313	122	168	228	
August	16	171	143	178	182	139	139	141	100	
September	42	53	171	70	162	83	234	170	193	
October	30	45	105	177	224	108	193	173	170	
November	25	56	113	139	220	99	221	215	262	
December	39	115	78	168	206	147	234	407	316	
Total	174	679	1 311	1 494	1 780	2 004	2 104	2 239	2 414	

Table 12 - Monthly production of the state enterprise P.T. Perikanan Samodera Besar (in metric tons).

Month \ Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
January		505	628	420	1 019	777	510	647	599	723
February		815	530	410	391	536	530	772	647	688
March		589	483	436	563	860	460	409	510	769
April		556	543	527	630	741	719	832	856	856
May		614	623	478	870	839	840	653	1 170	
June		741	499	714	1 272	930	617	612	886	
July	523	642	456	808	1 630	893	380	621	943	
August	446	591	566	1 013	1 040	520	439	569	452	
September	857	633	523	678	990	497	590	600	967	
October	645	531	559	832	937	491	676	575	779	
November	538	585	537	845	811	464	811	721	1 276	
December	863	646	778	860	834	653	761	1 267	1 189	
Value	656	646	548	662	942	703	610	696	839	

Table 13 - Average catch by day of operation from July 1973 to April 1982 (in kgs).

Before 1978, hook rates by species were not available but we give in Table 14, the monthly HR values of yellowfin and bigeye for the last four years 1978 -1981. The hook rate of yellowfin presents some monthly variations with usually lower HR from February to April as well as in August and higher HR from May to July and November to December. The hook rates of bigeye stay more constant all over the year with, however, lower values between November and February.

	1978		1979		1980		1981	
	YF	BE	YF	BE	YF	BE	YF	BE
J	1,26	0,08	0,63	0,18	0,98	0,13	0,82	0,11
F	0,82	0,23	0,47	0,21	0,88	0,25	0,86	0,09
M	0,80	0,33	0,49	0,15	0,44	0,24	0,62	0,15
A	0,88	0,33	0,48	0,25	0,70	0,20	1,00	0,22
M	0,57	0,33	0,75	0,18	0,95	0,19	1,81	0,19
J	1,25	0,39	0,62	0,35	0,64	0,30	1,24	0,18
J	1,04	0,35	0,46	0,25	0,79	0,26	1,64	0,19
A	0,61	0,29	0,62	0,22	0,64	0,23	0,52	0,20
S	0,63	0,31	0,93	0,26	0,82	0,30	1,35	0,48
O	0,58	0,23	1,20	0,15	0,64	0,29	1,06	0,18
N	0,60	0,21	1,14	0,21	0,82	0,15	1,51	0,21
D	0,81	0,15	1,05	0,18	2,10	0,14	1,36	0,25
$\bar{A}$	0,82	0,27	0,74	0,22	0,86	0,22	1,15	0,20

Table 14 - Average monthly hook rate for YF and BE from 1978 to 1981.

The average weight of individual fish presents some variations from year to year, but the main variations are seasonal.

The average weight of bigeye is higher than the average weight of yellowfin, 37.6 kg/fish versus 32.9 kg/fish for the period May 1978 to April 1982. During the period November to June, the yellowfin caught are bigger (33 to 36 kg/fish) than during the East Monsoon period between July and October (Fig. 8). A similar variation is observed for bigeye tuna with bigger individual weight (40 to 42 kg/fish) between December and February, then decreasing from April to October (35 to 37 kg/fish).

2.6. Conclusion

Tuna longline fishing is done in Indonesia with subsurface longlines (5 to 6 hooks per basket), a technique which has been developed to catch mainly yellowfin tuna in the upper part of the thermocline, between 90 and 150 meters. This species represents more than 60 % of the total catches.

All year long, bigeye tunas are also caught in all the present fishing grounds which extent from Sumatra to the Banda Sea. As this species has a very deep habitat, only the upper part of the stock is available with the gears used presently.

Hook rates of yellowfin are relatively low in the areas where longliners of the State Enterprise operate, compared with those which could be obtained for this species in other areas such as the North of Irian Jaya in the Pacific Ocean, still using the same kind of gear. However as incidental catches of bigeye are relatively high, the present fishing grounds can probably be considered as productive in terms of total CPUE as those located in the Western Pacific.

Because hook rates seem to decrease when the number of hooks set increases, higher CPUE may not be obtained while increasing the present number of hooks set daily. However it will more particularly be studied in the next chapter that hook rate of bigeye tuna could probably be higher when setting deep tuna longline which can fish between 90 and 280 meters.

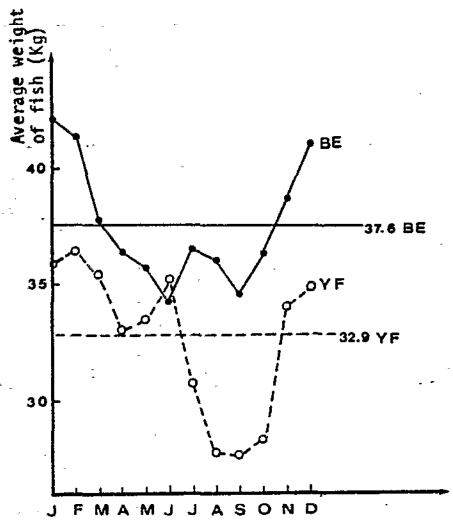


Figure 8 - Average individual weight by month of yellowfin and bigeye (average value : may 1978 - april 1982).

- Poids individuel moyen, par mois, des albacores et patudos (valeur moyenne de la période mai 1978 - avril 1982).

3 EXPECTED BENEFIT, INTRODUCING DEEP TUNA LONGLINE GEARS IN INDONESIA.

3.1. Introduction.

The longline fishing gears have generally been quite uniform throughout the history of tuna fishing and until 1974 almost all longliners have operated with the same type of gear.

However, since 1975, more and more small and medium size japanese longliners have set deeper longline, resulting in a more efficient bigeye tuna catch. In Indonesia, the major longline fishing company, P.T. Perikanan Samodera Besar, based in Denpasar, Bali, operates with 20 vessels 110 GT each, setting usual subsurface longlines.

In the present chapter, we study what benefits could be expected by introducing deep longline gears to catch tunas in the areas where this company operates, which extend mainly to the South and South West of Java and the Banda Sea(Figure 9).

This work is based on a systematic comparison of the hook rate of the two types of gear in the same 5° square areas during the same quarters of year, between 1976 and 1979*.

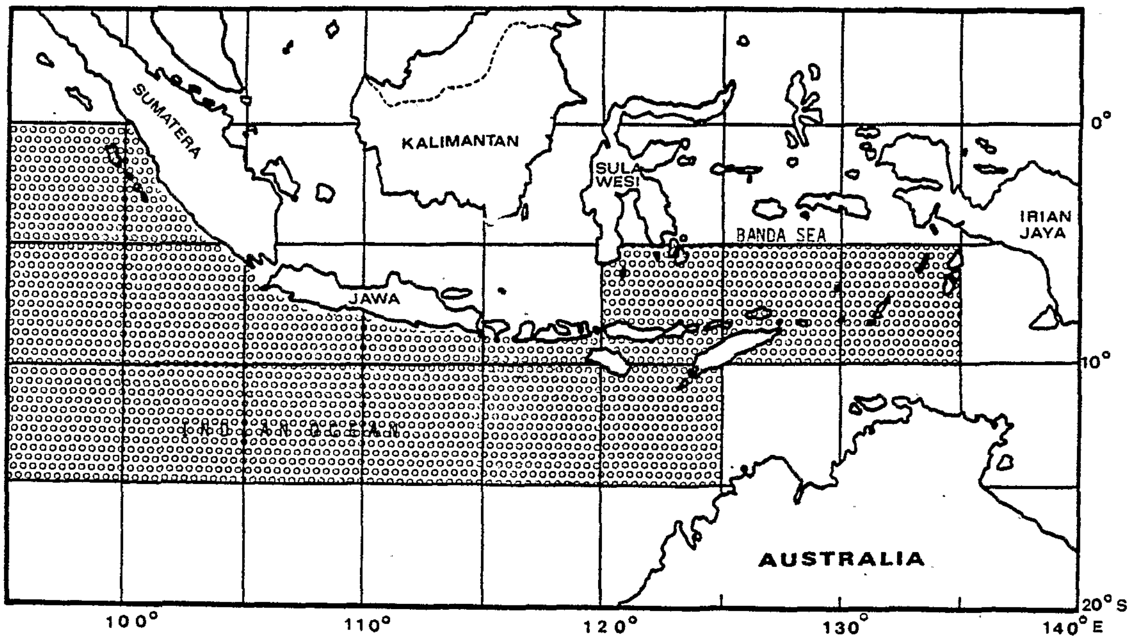


Figure 9 - Area covered by the P.T. PSB longliners from 1976 to 1979.

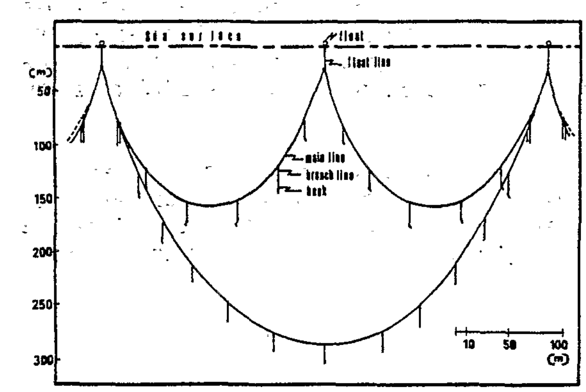
- Aire de pêche exploitée par les palangriers de P.T. PSB de 1976 à 1979.

3.2. Difference between subsurface and deep longline gears.

The longline gear is made up of the main line, branch lines, float lines and floats. The section between two floats is called the basket of the gear and this unit normally includes 4 to 6 branch lines for subsurface gears and 10 to 14 branch lines for deep longline gears. As typical examples of subsurface and deep gears, Figure 10 shows a six branch line gear to represent the former and a 13 branch line gear for the latter. Usually, all japanese vessels were reported to set approximately 2 000 hooks per operation, whatever the kind of gear they use ; so, the number of baskets used is about half when setting deep longline.

The gear components are more or less uniform for the two types : the float lines are almost 20 m long, branch lines 30 m, and the distance between branch lines per basket fish deeper .

* All the details of calculation will not be given here, in order to clarify the text, the purpose of the study being essentially practical.



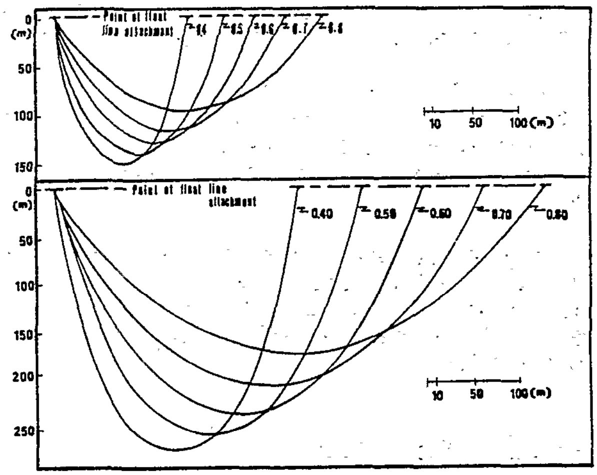
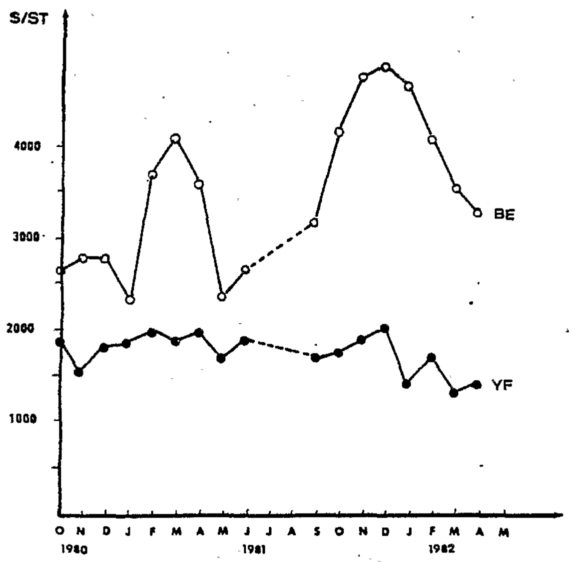


Figure 10 - Catenary curves of subsurface longline (above, represented by gear having 6 branch lines per basket), and deep longline (below) (from SUZUKI et al., 1977).

- Schéma comparant la répartition selon la profondeur des hameçons des palangres de surface (représenté ci-dessus par une palangre ayant 6 lignes secondaires par panier), et des palangres profondes (ci-dessous, 12-13 lignes secondaires) (SUZUKI et al., 1977).

Figure 11 - Changes in the shape and depth of the main line in unit basket with various sagging rates, ranging from 0.4 to 0.8 for typical subsurface and deep gears (from SUZUKI et al., 1977).

- Profondeurs atteintes par la ligne principale d'une palangre de surface et d'une palangre profonde pour des taux de pénétration variant de 0,4 à 0,8 (SUZUKI et al., 1977).



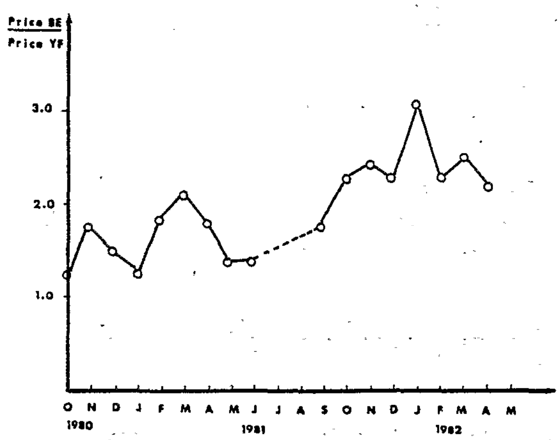


Figure 12 - Evolution of yellowfin and bigeye tuna prices in Yaizu market from october 1980 to april 1982 (prices in US $ per short ton).

- Evolution du prix de l'albacore et du patudo sur le marché de Yaizu d'octobre 1980 à avril 1982 (prix en US $ par short ton).

Figure 13 - Evolution of the ratio of the prices of bigeye over the prices of yellowfin in Yaizu market from October 1980 to April 1982.

- Evolution du prix du patudo par rapport à celui de l'albacore au marché de Yaizu d'octobre 1980 à avril 1982.

Before 1974, japanese longliners using subsurface gears predominated, while the contrary happened after 1975, this in order to catch more bigeye tuna which live deeper.

P.T. Perikanan Samodera Besar longliners have been using typical subsurface longlines ever since the begining of their operations in 1973 : float lines are about 20 to 25 m, and the distance between branch lines in 50 to 60 m ; there are 6 branch lines per basket. The number of hooks set by operation has been substancially increased from 1 300 in 1976 to 1 550 in 1981.

Figure 11 shows the changes in the shape and depth of the main line in unit basket with various sagging rates, ranging from 0.4 to 0.8 typical subsurface (6 branch lines) and deep (12 branch lines) gears. Taking into account the length of branch lines and float lines, we can estimate that subsurface longlines fish between 90 m and 180 m and deep longlines between 90 m and 290 m.

3.3 Difference of hook rates by gear type.

From 1976 to 1979 and for each quarter of year and 5° square areas which have been exploited simultaneously by indonesian and japanese longliners, we have done a systematic comparison between the obtained hook rates. The data available for indonesian vessels were the total hook rates of the two main species caught, which are bigeye and yellowfin tunas.

For 119 couples of data, the average hook rate by deep longlines is 1.52 time the value of the subsurface hook rate. The ratio hook rate using deep longline over hook rate subsurface longline is greater than one for any quarter of the year considered. We give in Table 15 the value of this ratio for the years 1976 through 1979 (A).

As this ratio is underestimated because the hook rates obtained by the japanese vessels do not include other species than bigeye and yellowfin, we have also estimated the average hook rate of indonesian vessels for those two species (B). We must take into consideration that the average quartely hook rate by 5° square area does not necessarily reflect the average hook rate of the fleet for the whole year which is always higher because the boats rate operate more intensively in areas of higher hook rate ; so we also present in Table 15 (C) the average annual hook rate for yellowfin and bigeye obtained by Indonesian vessels and the ratio over japanese hook rate calculated using average value by 5° square area.

All the results of the calculations show that japanese longline vessels, using deep longline gears, have higher hook rates that indonesian ones, using subsurface gears. This ratio averages 1.1 to 1.4 for the years 1976 and 1977, and 1.6 to 2.0 for the years 1978 and 1979. The increasing ratio during the two latter years may reflect the increasing proportion of the deep long line gears used by the japanese fleet, which is shown by an increased proportion of bigeye tuna in their catch, from 56 % to 68 % between the two periods.

3.4. Ratio of deep longline hook rate over subsurface longline hook rate for yellowfin and bigeye.

We have considered that the average hook rate of indonesian longliners is 0.89 for yellowfin and 0.23 for bigeye (average of the years 1978 to 1981). Taking this into account and using different ratios of hook rate between deep longline and subsurface longline and an average estimation of 62 % of bigeye for deep longline catch in number of fishes (average value from 1976 to 1979), we give, in Table 16, different estimations of the ratio deep over subsurface hook rates for yellowfin and bigeye. We also give estimation of this ratio for the years 1978 and 1979.

	Years		1976	1977	1978	1979
	Number of 5° square areas and quarter of years with simultaneous operations.		24	15	35	45
A	PT SAMODERA BESAR total hook rate	(1)	1,27	1,56	1,19	1,08
	Japanese hook rate (YF + BE)	(2)	1,40	1,82	2,18	1,54
	Ratio (1) / (2)		1,10	1,17	1,83	1,42
B	PT SAMODERA BESAR hook rate (YF + BE)	(3)	0,93	1,28	0,94	0,84
	Ratio (2) / (3)		1,50	1,42	2,32	1,83
C	PT SAMODERA BESAR hook rate (YF + BE) average year	(4)	1,16	1,77	1,10	0,96
	Ratio (2) / (4)		1,20	1,03	1,98	1,60

Table 15 - Average hook rate for the same 5° square areas and quarter of year, for Japanese longliners and Indonesian ones (A, B and C, cf. text) .

	Simulations			1979	1978
Hook rate ratio Deep over subsurface gear (YF + BE)	1,1	1,2	1,3	1,60	1,98
Percentage of bigeye for deep longline	57**	62***	62***	67	69
Percentage of bigeye for subsurface longline	21*	21*	21*	23	25
Ratio deep over subsurface for yellowfin	0,60	0,58	0,63	0,69	0,81
Ratio deep over subsurface for bigeye	2,9	3,5	3,8	4,7	5,5

* Average value 1978-1981 (PT Perikanan Samodera Besar)
** Japanese fleet average value in 1976.
*** Japanese fleet average value in 1976-1979.

Table 16 - Estimation of the ratio of deep longline hook rate over subsurface longline hook rate for yellowfin and bigeye.

We can see that deep longlines allow catches 3 to 5 times more important for bigeye tuna with the same number of hooks set and 20 to 40 % less for yellowfin, comparatively with subsurface gears.

In similar study done by SUZUKI, WARASHINA and KISHADA in 1977, in Western Pacific between 10°S-20°N and 160°W, the estimation of the ratio of deep gear over subsurface gear had been estimated as 1.79 for bigeye and 0.73 for yellowfin. The ratio we have estimated for the indonesian area is similar for yellowfin, but much higher for bigeye tuna, and shows us that areas including the Southern part of Indonesia, the South of Sumatra and Banda Sea are mainly bigeye fishing grounds.

3.5. Ratio deep longline hook rate over subsurface longline hook rate for fishes other than yellowfin and bigeye.

A lot of other fishes are caught by subsurface longline. The total averages 19.3 % of the total catch in weight of PT Perikanan Samodera Besar for the period 1976 to 1981. The main species are by importance : albacore (5.6 %), white marlin (4.7 %), black marlin (2.6 %), moro shark (2.4 %), swordfish (1.5 %), sailfish (1.2 %), striped marlin (0.8 %) and bluefin (0.4 %). Average catch in weight for yellowfin and bigeye was respectively 62.2 % and 18.5 % for the same period.

We have seen in the precedent chapter that the hook rate of bigeye was higher when using deep longline. On the contrary, hook rate for yellowfin tuna is lower when using this gear, this is also true for all billfishes and albacore.

From the work of SUZUKI (1977), we can estimate that :

- For swordfish the difference in fishing efficiency by gear type is relatively small with a tendency of slightly higher hook rates for subsurface gear except perhaps in Banda Sea.

- For striped marlin, hook rate by subsurface gear show generally higher value ; the same is true for white marlin.

- For sailfish and shortbill spear fish, the hook rates by subsurface gears are much higher than those obtained by deep gears.

- For albacore, the difference between the two types of gear is low.

The average ratio of specific hook rate of deep gear over subsurface gear as estimated by SUZUKI are the following :

albacore	: 0.82	swordfish	: 0.79
white marlin	: 0.55	sailfish	: 0.06
black marlin	: 0.34	striped marlin	: 0.28

No estimation has been made for moro sharks and bluefin ; but if we arbitrarily give a ratio of 0.5 for both, we obtain an average ratio of 0.5 for all species other than yellowfin and bigeye.
All this estimation is done using individual ratio values by species calculated for others areas than those exploited by indonesian longliners ; it must be taken cautiously : this is why we have done the following calculations with a "pessimistic" value of 0.3 which means that we have considered that deep longlines fish about three times less (except for yellowfin and bigeye) than subsurface longlines.

3.6. Estimation of the expected benefit by using deep longline.

3.6.1 Benefit in weight.

For the average years 1976 to 1981, catches of yellowfin and bigeye represent respectively 62.2 % and 18.5 % of the total catches of PT Perikanan Samodera Besar and other tuna and billfishes 19.3 %. Using, for yellowfin and bigeye, the different ratio calculated in table 16 and for others, such as tunas and billfishes, the value 0.3, we can estimate the benefit expected, in weight, when using deep longline gear (Table 17).

	Subsurface gear average 1976 - 1981	Deep longline gear				
		Simulations			1979	1978
Hook rate ratio deep over subsurface		1,1	1,2	1,3	1,6	1,98
Yellowfin	60,2	36,1	34,9	37,9	41,5	48,7
Bigeye	19,8	57,4	69,3	75,2	93,1	108,9
Other fishes	20,0	6,0	6,0	6,0	6,0	6,0
Total	100,0	99,5	110,2	119,1	140,6	163,6
Benefit in %		- 0,5	+ 10,2	+ 19,1	+ 40,6	+ 63,6

Table 17 - Estimated catches expected by using deep longline gear, considering catches by subsurface to be 100.

With hook rates ratio of 1.1 and 1.2 which can be considered very pessimistic estimations, the global benefit in weight is not obvious because the benefit expected from better hook rates on bigeye is much lowered by the poor rates on yellowfin and other tunas and billfishes.

However, if we consider the ratio calculated in 1978 and 1979, we can estimate that the total catch when using deep longline gear is 35 % to 57 % higher for the same number of hooks set. We consider, as a reasonable estimation, catches 15 % to 35 % higher with deep longlines.

3.6.2. Benefit in value.

It is wrong to only consider the benefit in weight because the value according to species is very different. So we have made an estimate of the benefit in value which can be expected when using deep longlines.

The benefit of introducing deep longline gear mainly depends on the relative price of yellowfin and bigeye. As shown in Table 18, the price of bigeye and yellowfin mainly depends on the size category ; bigger fishes get higher prices for both species, ranging up to two to three times the prices of the lower category. The ratio of the price of bigeye over the price of yellowfin ranges between 1.1 to 1.4 according to the size category : this was calculated from the Japanese Skipjack and Tuna Bulletin for fishes caught by longliners in 1980 and landing in Sukichi market in Tokyo. We cannot use in our calculations the real price of the fishes purchased from PT Perikanan Samodera Besar in Bali because in this company, fishes are not sold by species but as a whole. Anyway, as the price of yellowfin is always lower than the price of bigeye, we can expect that the advantage of deep longline, which catches mainly bigeye, will be higher in value than in weight.

Using relative price of 1.1 and 1.3 (price of bigeye over price of yellowfin) we give ,in Tables 19 and 20, an estimation of the expected benefit. We can see that, even in the most "pessimistic" estimations of hook rate ratio of deep longline over subsurface longline, the benefit in value, when using deep longline gear reaches 10 to 15 %. We consider that a reasonable estimation should be an increasing value of the catches ranging from 20 % to 50 %. The present average weight by individual fish in catches of PT Perikanan Samodera Besar is

32.9 kg for yellowfin and 37.6 kg for bigeye (average of the years 1978-1981). We can expect that deep longline will catch bigger average size fish for both bigeye and yellowfin, because bigger fishes are generally found deeper and, as price is higher for them, the previous estimation may be yet underestimated. However, the lack of data does not allow us to evaluate the profit expected from this and we did not take it in to account.

Size category in kg	inf. 10	10 - 15	15 - 25	25 - 40	sup. 40
Bigeye	338	434	675	760	953
Yellowfin	324	406	509	696	696
Ratio BE/YF	1,04	1,07	1,33	1,08	1,37

Table 18 - Average price (in US $ per ton) of bigeye and yellowfin by size category in 1980 (from Japanese Skipjack and Tuna Bulletin).

	Subsurface gear average 1976 - 1981	Deep longline gear				
		Simulations			1979	1978
Hook rate ratio deep over subsurface		1,1	1,2	1,3	1,6	1,98
Yellowfin	62,2	37,3	36,1	39,2	42,9	50,3
Bigeye	18,5	53,7	64,7	70,3	86,9	101,7
Other fishes	19,3	5,8	5,8	5,8	5,8	5,8
Estimated catches	100,0	96,8	106,6	115,3	135,6	157,8
Benefit in %		- 3,2	+ 6,6	+ 15,3	+ 35,6	+ 57,8

Table 19 - Estimation of the expected value of the catches using deep tuna longline gear, considering value of the catches by subsurface gear to be 100, and using a ratio of the price of bigeye over the price of yellowfin of 1.1.

	Subsurface gear average 1976 - 1981	Deep longline gear				
		Simulations			1979	1978
Hook rate ratio deep over subsurface		1,1	1,2	1,3	1,6	1,98
Yellowfin	57,6	34,5	33,4	36,3	39,7	46,7
Bigeye	22,4	64,9	78,4	85,1	105,3	123,2
Other fishes	20,0	6,0	6,0	6,0	6,0	6,0
Total	100,0	105,4	117,8	127,4	151,0	175,9
Benefit in %		+ 5,4	+ 17,8	+ 27,4	+ 51,0	+ 75,9

Table 20 - Estimation of the expected value of the catches using deep longline gear, considering value of the catches by subsurface gear to be 100, and using a ratio of the price of bigeye over the price of yellowfin of 1.3.

3.7. Tendency of bigeye price.

We have seen that the benefit of introducing deep longline gear mainly depends on the relative price of yellowfin and bigeye. This is why we present on Figure 12, the evolution of the price of those two species from October 1980 to April 1982 in Yaizu market. These values must be taken cautiously as they are average prices which do not reflect the quality of the fish nor the size category. However, we can see that the average ratio of the price of bigeye over the price of yellowfin (Figure 13) is increasing. A conclusion could be that the interest of catching more bigeye by using deep longline becomes higher.

3.8. Investments to be made to convert the vessels.

Investments must be made in order to convert subsurface gear longliners into deep gear longliners. Particularly, vessels must get bigger haulers and also more powerful generators. Those used at present by indonesian longliners of the society PT Perikanan Samodera Besar are 150 HP ; generators 200 HP could probably be used to replace the former. A study of the necessary investments has yet to be done. It would take us beyond the scope of this paper.

3.9. Conclusions.

The areas where the indonesian longliners of the State Company PT Perikanan Samodera Besar operate, seem to be very good areas to catch bigeye tuna which is a fish with a deep habitat usually situated well under the thermocline. Introduction of deep longline gear could quite substantialy increase the total catches (about 15 % to 35 %) and the earnings of the company needing only relatively small investments compared to the benefits expected which have been estimated to range between 20 % to 50 % at least.

4 AREAS AND SEASONS TO CATCH BIGEYE TUNA WITH DEEP LONGLINE GEARS.

4.1. Introduction.

The major indonesian longline fishing company, P.T. Perikanan Samodera Besar, based in Denpasar, Bali, operates in the Indian Ocean and Banda Sea with 20 vessels 110 GT each setting typical subsurface longline.

It has been shown in a previous chapter, what is the expected benefit when introducing deep tuna longline gears to replace traditional subsurface longlines. It was estimated that total catches should be 15 % to 35 % higher and since deep longline catch mainly bigeye tuna which has a higher price than yellowfin, the benefit in value should range between 20 % to 50 %.

The question is now to settle where to fish if deep longline gears replace subsurface ones as the former are used to catch mainly bigeye and the latter, yellowfin.

4.2. Sources and limits of data available.

For many years, japanese longliners operate in Banda Sea and in areas South and West of Java to catch yellowfin and bigeye tunas. Until 1974, almost all vessels used the same type of subsurface longline ; however, since 1975, more and more small and medium size boats have set deeper longline in order to catch bigeye tuna more efficiently.

In our study, we used the 1976 to 1979 data from the annual reports of effort and catch statistics by area on japanese tuna longline fishery, published by the Research and Development Department, Fisheries Agency of Japan. Unfortunately hook rates are given by 5° areas which is a too wide and unaccurate representation to study fishing grounds. As an example, we give on Figure 14 the main bigeye fishing grounds in Indonesia waters, adapted from data by 1° square in SUDA et al., (1969). In Banda Sea, we can see that the fishing grounds are located between 4°S and 7°S and between 123°E and 132°E, so roughly, fishing occurs in 36 one degree square areas ; using 5° square data it should be represented in six different squares. The problem is the same for areas South and West of Java where main fishing grounds are usually located on a narrow longitudinal band. So representation by 5° square gives a wrong picture of fishing grounds which, in fact, have a much more limited latitudinal extension.

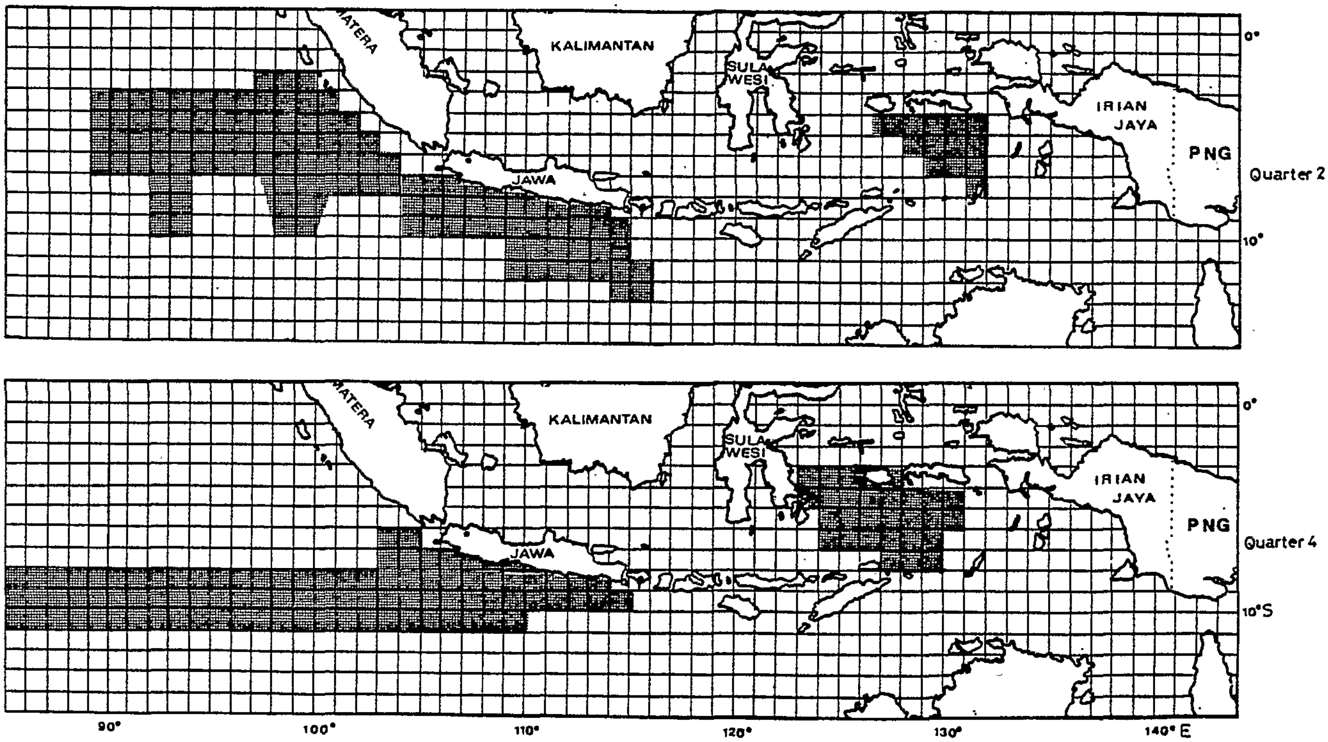


Figure 14 - Main bigeye fishing grounds in South West Indian Ocean and in Banda Sea during quarters of year 2 and 4 (adapted from SUDA et al., 1969).

- Secteurs de pêche du patudo dans le sud-ouest de l'Océan Indien et en mer de Banda au cours des trimestres 2 et 4 (adapté de SUDA et al., 1969).

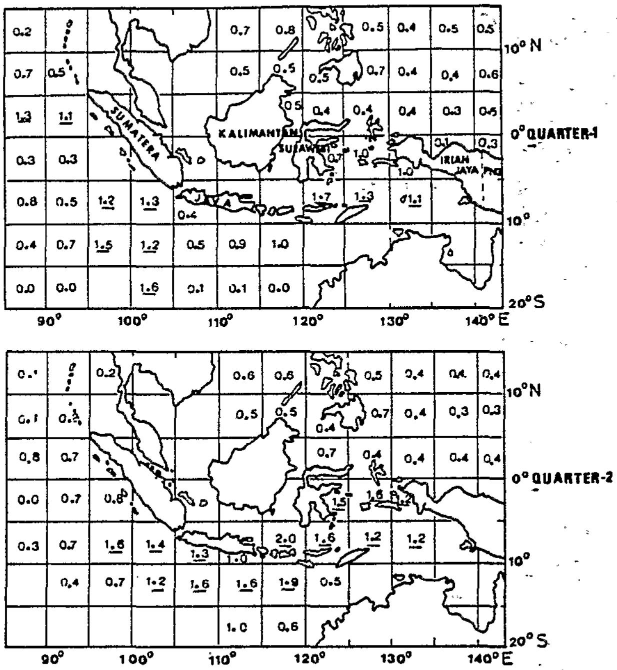
4.3. The Japanese bigeye tuna fishing grounds from 1976 to 1979.

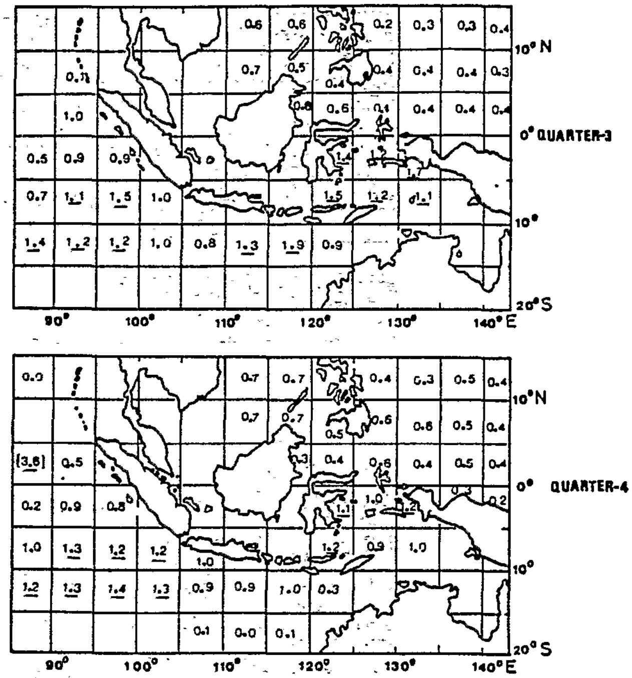
We present in Figure 15 average quarterly hook rates of bigeye tuna by 5° square area obtained by japanese longline fleet between 85°E - 140°E and 15°N - 20°S for average years 1976 to 1979.

From the maps presented we can see that there are thre major fishing grounds :

- the Banda Sea
- the Indian Ocean between 5°S - 15°S and 95°E - 105°E
- the South and South West of Bali.

During the first quarter (January to March) high hook rates occur South of Sumatra between 95°E and 105°E and usually are very regular from year to year South of 10°S. Regular and high rates occur also in Banda Sea South of 5°S.





Average quarterly hook rates of bigeye tuna, by 5° square area, obtained by the japanese longliners for years 1976-1979.

Rendement trimestriel moyen de patudo (en nombre de poissons par 100 hameçons) des palangriers japonais au cours des années 1976 à 1979, par secteur de 5° côté.

Figure 15a - Quarters 1 and 2/trimestres 1 et 2.

Figure 15b - Quarters 3 and 4/trimestres 3 et 4.

During the second quarter (April to June) the fishing grounds in the Indian Ocan shift to the East and are very regular South of Sumatra and West Java. The higher hook rates generally occur South and South East of Bali. In the Banda Sea, hook rates seem to be higher and more regular North of 5°S and West of 125°E.

During the third quarter (July to August) some good hook rates can still be obtained South East of Bali but the two major fishing grounds are located one in South West of Sumatra around 10°S between 90°E and 100°E and one in North of Banda Sea where hook rates are very regular from year to year.

During the fourth quarter (October to December) good catches may be obtained in Banda Sea but the higher hook rates occur West and South West of Java between 5°S and 15°S and more probably on a narrow line around 10°S.

The Banda Sea fishing grounds are mainly located between 4°S - 8°S and 124°E - 132°E as shown in Figure 16. During the years 1974 - 1975, good hook rates were obtained during quarters 1, 2 and 4 (there were no operations in quarter 3), but during 1976 to 1979, the higher hook rates were obtained during quarters 2 and 3.

In the Indian Ocean, the main fishing grounds are located between 5° S - 15° S and 90° E - 105° E during quarters 3 and 4 and shift towards East and North East during quarters 1 and 2. On the South and South East of Bali and Java, fishing is more seasonal and occurs during quarters 2 and 3 with very high hook rates during quarter 2.

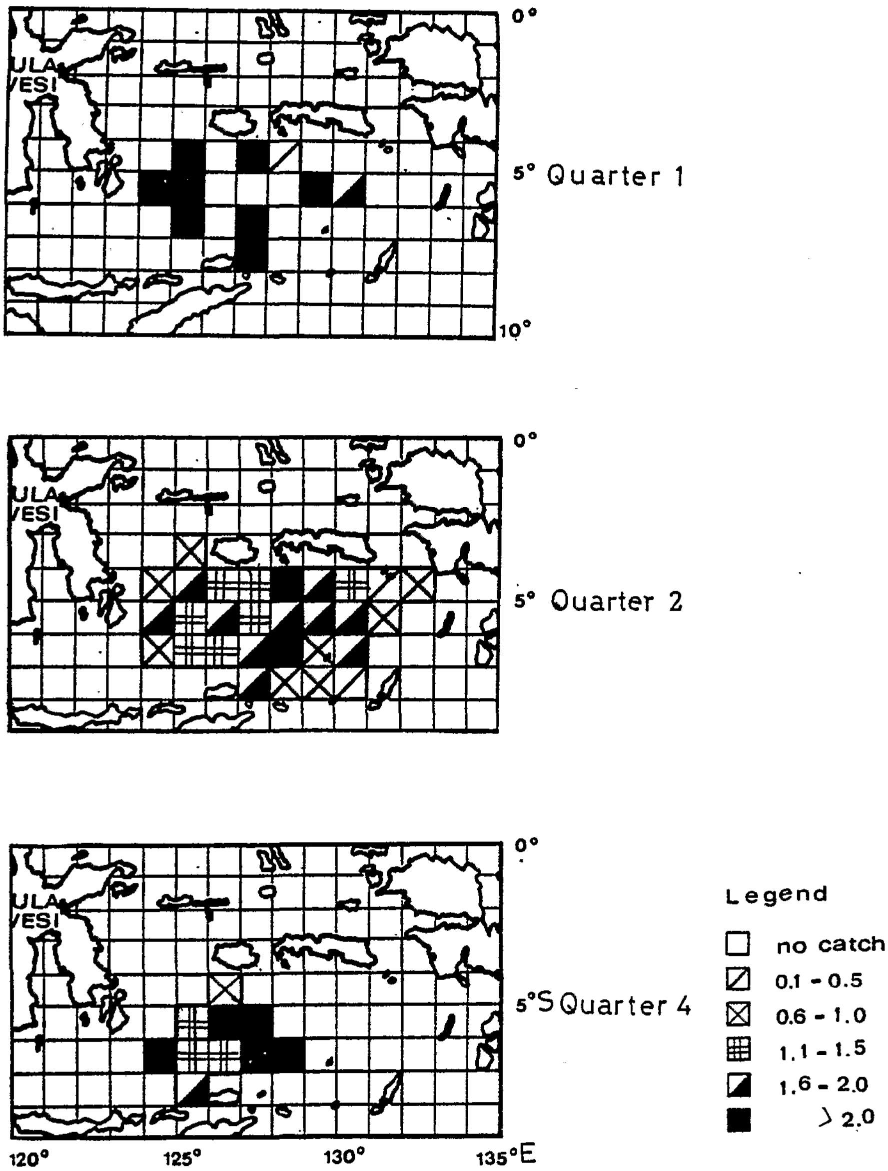


Figure 16 - Average quarterly hook rates by 1° square area for deep longline gears in Banda Sea over the years 1974-1975 (SUZUKI et al., 1977).

- Rendement trimestriel moyen par secteur de 1° côté des palangres profondes en Mer de Banda ; moyenne des années 1974-1975 (SUZUKI et al., 1977).

The main fishing grounds A, B and C are presented in Figure 17 and we give, in Tables 21 and 22, the average quarterly value of the bigeye and yellowfin hook rates for each of these areas, for the years 1976 to 1979. The higher average yearly hook rates for bigeye is obtained in area B, where high hook rates are regular during quarters 1 and 4 ; on the contrary, hook rates in area 1 are higher and more regular during quarters 2 and 3. In area C hook rates are usually very high in quarter 2 and low during the other quarters.

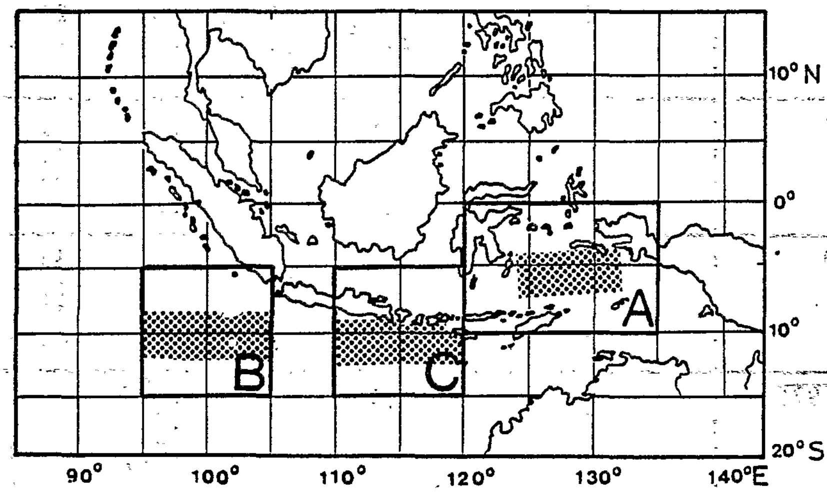


Figure 17 - Main bigeye fishing grounds in Indonesia.

- Principales zones de pêche du patudo en Indonésie.

Those results do not allow us to define a fishing operation strategy because data are not accurate enough ; we would need at least monthly and 1° square area data. Looking at Table 21, we can see also that some variations may occur from year to year. However we can expect that :

- during quarter 1 the best opportunity to get good catches of bigeye tuna is to prospect areas A and B which are approximately at the same distance from Bali.

- during quarter 2, the fishing grounds South of Java and Bali begin to have high hook rates and so may be prospected systematically.

- during quarter 3, prospect must be done South East of Bali and if unsuccessful, in Banda Sea.

- during quarter 4, major prospections must be done in area B.

Year	Quarter	A		B		C	
1976	1	1,1	(2)	0,7	(4)	0,6	(2)
	2	1,3*	(6)	1,4	(3)	1,1	(4)
	3	1,2*	(5)	0,3	(1)	0,3	(2)
	4	0,9	(3)	1,0*	(3)	0,4	(2)
1977	1	1,0	(4)	1,2*	(4)	0,3	(3)
	2	1,5*	(6)	1,0	(2)	-	-
	3	1,8*	(6)	1,4*	(4)	-	-
	4	1,1*	(5)	1,6*	(4)	0,3	(2)
1978	1	1,4	(6)	1,5*	(4)	1,0	(1)
	2	1,6*	(6)	1,7*	(3)	2,6*	(4)
	3	1,3*	(6)	1,4*	(4)	1,8*	(4)
	4	1,3	(6)	1,1*	(4)	1,5*	(3)
1979	1	1,1	(6)	1,7*	(4)	1,4	(3)
	2	0,9	(5)	1,1	(3)	1,3*	(4)
	3	1,0	(6)	1,0	(3)	1,0	(4)
	4	1,0*	(6)	1,4*	(4)	0,9	(4)
1976 - 1979	1	1,2		1,3**		0,8	
	2	1,3**		1,3		1,7**	
	3	1,3**		1,3		1,0	
	4	1,1		1,3**		0,8	
1976 - 1979	1 - 4	1,23		1,30		1,08	

Table 21 - Average bigeye hook rate in areas : A (Banda Sea), B (West Java), and C (South Java), of japanese longliners by quarter, for years 1976 - 1979.
- in brackets, number of 5° square areas with hook rate value.
- * all 5° square areas hook rates where higher than 1.0
- ** period of major occurrence of high hook rates.

4.4 Major fishing grounds to be exploited from Bali with deep longline gear.

In fact, in the precedent chapter we did not take into account the time needed to reach the fishing grounds from Bali. The benefits from going to the best fishing grounds are not evident and depend on the time lost to reach it. The more a fishing area is far from Bali, as the average trip is 40 days, the more the number of operation days or total hooks set per trip is low. In area C, near Bali, we estimate at 4 % the number of fishing operation days lost in travel ; in area A (Banda Sea), it is estimated to be 13 % to 23 % and in area B 17 % to 24 %. So the higher hook rates in area A and B are only of interest if they are respectively 13 % to 24 % and 18 % to 25 % higher than in area C.
We also need to take into account hook rates for other fishes and particularly for yellowfin which has been estimated to represent 30 % to 35 % of the total catches of yellowfin and bigeye, as well as the relative price of those two main species. Calculations were done for two price ratios of bigeye over yellowfin : 1.1 and 1.3 (see MARCILLE and SADHOMOTO in press) and with an estimated time lost in travels of 20 % for areas A and B and none for area C.

Year	Quarter	A		B		C	
1976	1	0,7	(2)	0,6	(4)	1,1	(2)
	2	0,9	(6)	0,4	(3)	1,0*	(4)
	3	0,8	(5)	0,1	(1)	0,3	(2)
	4	0,8*	(3)	0,9*	(3)	0,3	(2)
1977	1	0,6	(5)	0,6	(4)	0,7	(3)
	2	1,1*	(6)	0,6	(2)	-	-
	3	0,6	(6)	0,4	(4)	-	-
	4	1,3*	(5)	0,8	(4)	0,3	(2)
1978	1	0,6	(6)	0,8*	(4)	1,1	(1)
	2	0,6	(6)	1,4	(3)	1,0*	(4)
	3	0,6	(6)	0,5	(4)	0,2	(4)
	4	0,8*	(6)	0,3	(4)	0,2	(3)
1979	1	0,7	(6)	0,6	(4)	0,3	(3)
	2	0,3	(5)	0,3	(3)	0,8	(4)
	3	0,9*	(6)	0,4	(3)	0,3	(4)
	4	1,2	(6)	0,4	(4)	0,1	(4)
1976 - 1979	1	0,6		0,7**		0,7	
	2	0,7**		0,7		0,9**	
	3	0,7		0,4		0,3	
	4	1,0**		0,6		0,3	
1976 - 1979	1 - 4	0,75	(64)	0,60	(47)	0,55	(52)

Table 22 - Average yellowfin hook rates in areas A, B and C.
- in brackets, number of 5° square areas with hook rates value.
- * all 5° square areas hook rates where higher than 0.6
- ** period of major occurrence of high hook rates.

The calculated average index are given in Figure 18 for each year and quarter of years, and in Table 23 for average year and quarter.

- We can see that during quarter 1 the best opportunity to get a good value from total catches is to exploit areas A and B, where bigeyes are more abundant. As yellowfin can be abundant in area C and because of the high variability between different years, the choice of areas is difficult to make.

However, we have seen that the area B is the more regular fishing ground for bigeye as well as yellowfin. So after a quick prospect in area C, the interest of vessels is to go in area B West of Java.

- During quarter 2, the best fishing grounds are usually South of Bali in area C. However, as fishing in this area is very seasonal, the best way is to prospect also the Banda Sea (area A) if hook rates in area C are not high enough, as well as the area South of West Java.

- During quarter 3, the benefit expected in area C is very low based on average years 1976 - 1979 ; from average high value calculated for 1978 and 1979 (Figure 18), the benefit to shift to another area is not evident, but during this quarter, more regular high hook rates on bigeye and higher average hook rates on yellowfin are obtained in Banda Sea.

- During quarter 4, hook rates are usually very low in area C (except in 1978). The best earning, so, is to prospect and exploit areas A and B. During this quarter, higher bigeye hook rates are obtained in area B but as yellowfin hook rate is usually much lower than in area A, the benefit in value of going there is not evident.

Ratio of value BE/YF	Areas / Quarter	A	B	C
1,1	1	1,53	1,64	1,54
	2	1,74	1,68	2,76
	3	1,74	1,46	1,44
	4	1,76	1,60	1,08
	1 - 4	1,69	1,59	1,70
1,3	1	1,72	1,85	1,70
	2	1,94	1,89	3,10
	3	1,96	1,66	1,61
	4	1,94	1,80	1,23
	1 - 4	1,89	1,80	1,91

Table 23 - Average index of the value of the catch for 40 day trips done in area A, B, C, from Bali ; time lost in travel is estimated to be 20 % in areas A and B, and none in area C. Results are given for two ratios of price bigeye over yellowfin : 1.1 and 1.3.

In figure 19, we present a diagram which gives us a rough idea of what could be a fishing strategy to exploit the different fishing grounds. The large arrows represent the area where the major part of the fleet can be sent directly : area B during quarter 1, area C during quarter 2, A during quarter 3 and A and B during quarter 4. The thin arrows show areas where prospect must be done with some vessels only : area C during quarters 1,3,4 and areas A and B during quarter 2. The dotted thin arrows represent the transfer of vessels according to the catches obtained in the areas prospected.

4.5. <u>Other possible base to develop longline fishing.</u>

For a longline fleet based in Ambon, we present in Table 24 and Figure 20, the quarterly index of the value of the catches done with deep longline gears in areas A, B and C. We can see that the index is always higher in area A than in areas B and C, except in second quarter during which indices in areas A and C are very similar. For the calculation we estimated the time lost in travel to be 20 % for going in area C, 40 % for area B and none in area A. So, we can assume that all year long the best revenue for Ambon based longliners is obtained when exploiting Banda Sea with deep longline gear.

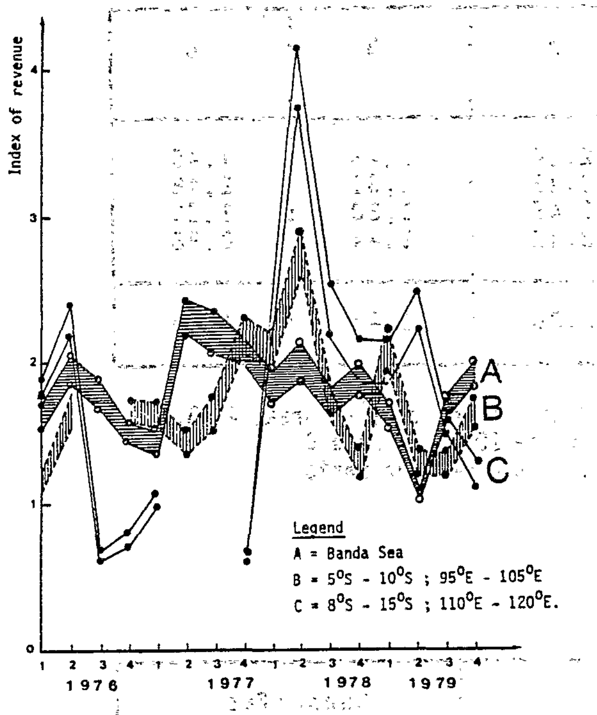


Figure 18 - Index of revenue by trip according to the fishing area exploited from Benoa (Bali) with duration of trip of 40 days and an estimate ratio of the price of bigeye over yellowfin of 1.1 and 1.3.
- Valeur relative des prises en fonction du secteur de pêche exploité à partir de Benoa - la durée des marées est estimée à 40 jours, et le rapport des prix du patudo et de l'albacore à 1,1 et 1,3 -.

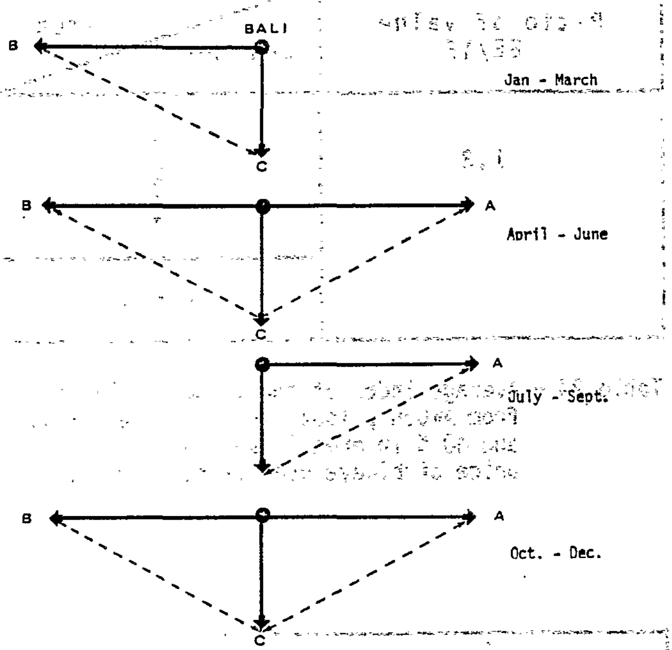


Figure 19 - Diagram of exploitation of areas A, B and C from Benoa (Bali) with a fleet of longliners setting deep longline gears.
+ large arrows : areas to be prospected by major proportion of the fleet.
+ thin arrows : areas to be prospected by some vessels only.
+ dotted arrows : shifting of the vessels according to the hook rates obtained in the different areas.
- Diagramme d'exploitation des secteurs A, B et C à partir de Benoa (Bali) avec une flottille de palangriers utilisant des palangres profondes.
+ traits larges : secteurs à prospecter par la plus grande partie de la flotille.
+ traits fins continus : secteurs à prospecter avec quelques navires seulement.
+ traits pointillés : changement de secteur des navires en fonction des résultats obtenus.

In the Pacific Ocean the main species available for longline gear is yellowfin ; SUZUKI et al. (1977) show that hook rates of bigeye by deep longline gear is very low South of 5° S and West of 150° E ; on the contrary, yellowfin hook rates are very high in those areas all year long and especially during quarters 1, 2 and 4. In Table 25, we give an estimation of the index of the value of the catch using subsurface longline gear in area D (South of 5° S, between 130° E and 145° E) ; time lost in travel being estimated to 10 % and the price ratio of bigeye over price of yellowfin to 1.3. Because we do not have accurate data to estimate the ratio of deep longline hook rate over subsurface longline hook rate in area D, we did not calculate any index for using deep longline gear. For operations done from Biak with subsurface gears, the annual average index is higher in area D than in area A when using deep longline gears from Ambon, or than in areas A, B or C, according with the season, for operations done from Bali. For longline operations done from Sorong, which is located at about the same distance between the yellowfin fishing grounds of the Pacific Ocean and the bigeye fishing grounds in the Banda Sea, the benefit in using deep longline or subsurface longline gears is not evident and may depend mainly on the relative price of the two species (Table 25).

Ratio of value BE/YF	Areas / Quarter	A	B	C
1,3	1	2,14	1,48	1,49
	2	2,42	1,51	2,48
	3	2,45	1,30	1,29
	4	2,42	1,44	0,98
	1 - 4	2,36	1,43	1,56

Table 24 - Average index of the value of the catch for 40 days trips done in areas A, B, C from Ambon ; lost time in travel is estimated to be 20 % in area C, and 40 % in area B, and none in area A. Results are given for ratio price of bigeye over price of yellowfin of 1.3.

Quarter	Deep longline gear				Subsurface longline gear	
	Bali		Ambon		Biak	
	Index	Area exploited	Index	Area exploited	Index	Area exploited
1	1,85	B	2,14	A	2,50	North
2	3,10	C	2,42	A	2,45	Irian
3	1,96	A	2,45	A	2,30	Jaya
4	1,94	A	2,42	A	2,60	
1 - 4	2,21	A - C	2,36	A	2,46	North Irian Jaya

Table 25 - Average index of the value of the catches for vessels based in Bali or Ambon using deep longline gears, and for vessels based in Biak using subsurface gears.

Another possible base to develop longline fishing, could be Pelabuhan Ratu in South West Java ; from this base the best fishing ground should all year long be area B, South West of Sumatra and Java, using the more convenient deep longline gear.

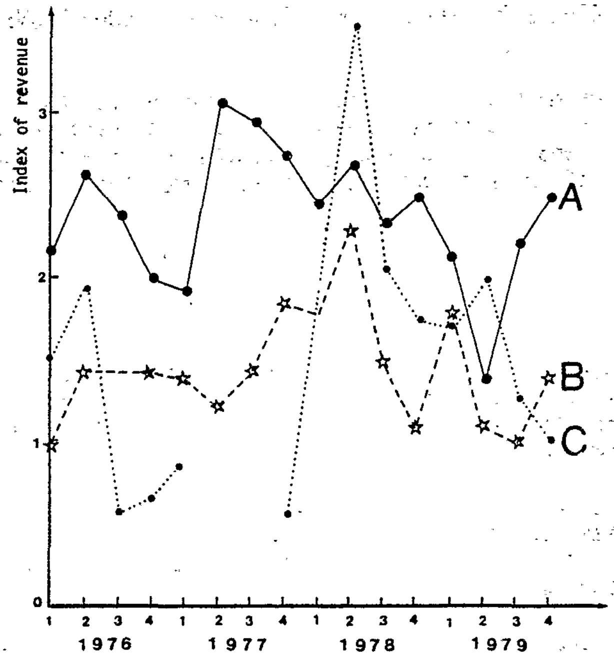


Figure 20 - Index of revenue by trip according to the fishing area exploited from Ambon on 40 days trip using an estimated price ratio of bigeye over yellowfin of 1.3.

- Valeur relative des prises en fonction du secteur de pêche exploité à partir d'Ambon. La durée des marées est estimée à 40 jours et le rapport des prix du patudo et de l'albacore à 1,3.

4.6. Conclusions.

There are three main fishing grounds to catch bigeye tuna in Indonesia. The most important one is the Banda Sea fishing ground, another one is located South and West of Java where high hook rates can be obtained all year long with deep longlines. The Bali area may be very productive during the first half of year, but this fishing ground is seasonal, so longliners based in the Bali area need also to exploit the former two. From this, it can be shown that, for this base, vessels able to do longer trips could get higher average catch rates. The exploitation of the Banda Sea fishing grounds from Ambon, could be made, on the contrary, with smaller vessels able to operate all year round in very close fishing grounds. Biak does not seem to be a good base for small tuna longliners using deep gears ; however, the area North of Irian Jaya has a very high yellowfin potential and could be better exploited by vessels using subsurface gears. A more difficult choice is presented for a base like Sorong, located between two different fishing grounds, both very productive, but which need very different fishing techniques.

5 BIGEYE OCCURRENCE AND OCEANOGRAPHIC CONDITIONS

From japanese studies mainly done in the Pacific Ocean, it has been shown a tendency for bigeye tuna to gather near boundary areas, between current systems (KUME, 1969) and in convergence areas (KUME, 1963) ; it is usually expected that their accumulation is associated with the discontinuity of oceanographic structures (KUME, 1963 ; NAKAMURA, 1962 ; IWOUE and IWASAKI, 1969).

5.1. Currents.

Generally the main ocean currents flow in East-West directions, therefore fishing grounds with similar characteristics are generally found in rather narrow East-West bands. Their boundaries correspond to the current boundaries (NAKAMURA, 1962). In some case it may occur on the margin of upwelling areas.

In this chapter, we will examine where such discontinuities occur in areas where indonesian longliners may operate. We present, from Wyrtki's Atlas, in Figures 21 and 22, areas of boundary between current systems and convergence zones in the South West of Indonesia, according to the season.

All year long, a strong convergence area is located South West of Sumatra between 7° S - 12° S, 85° E - 103° E.

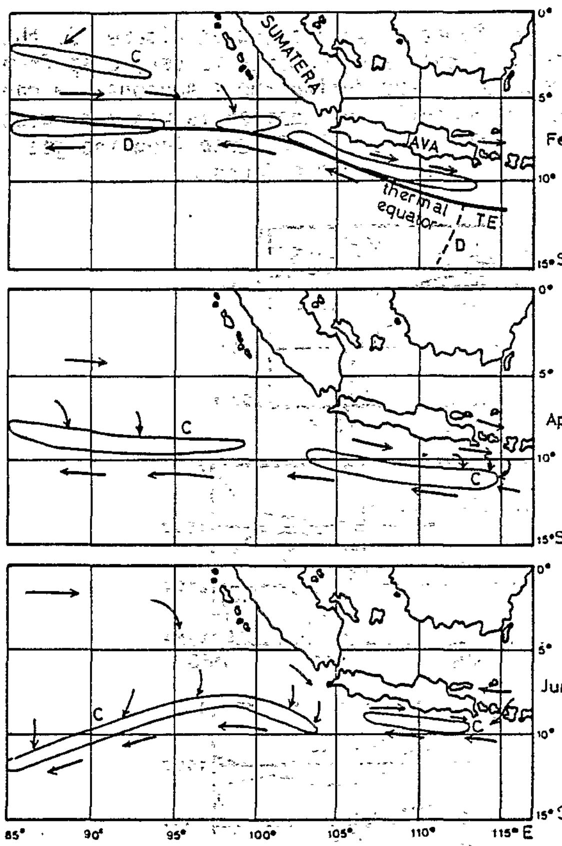
In February, the convergence is replaced by a divergence between equatorial counter-current which flows eastward North of 5° S and the South equatorial current which flows toward the West. Convergences are located nearer Sumatra by 7° - 100° E and South of Equator by 2° S - 90° E. It has been shown, by INOUE and IWASAKI, that concentrations of bigeye are expected to be found during this period in the lower temperature water masses located just South of the thermal equator. Usually, thermal equator lies around 8° S to 10° S during this period, so fishing may occur at those latitudes as well as in Northern boundary of South equatorial current.

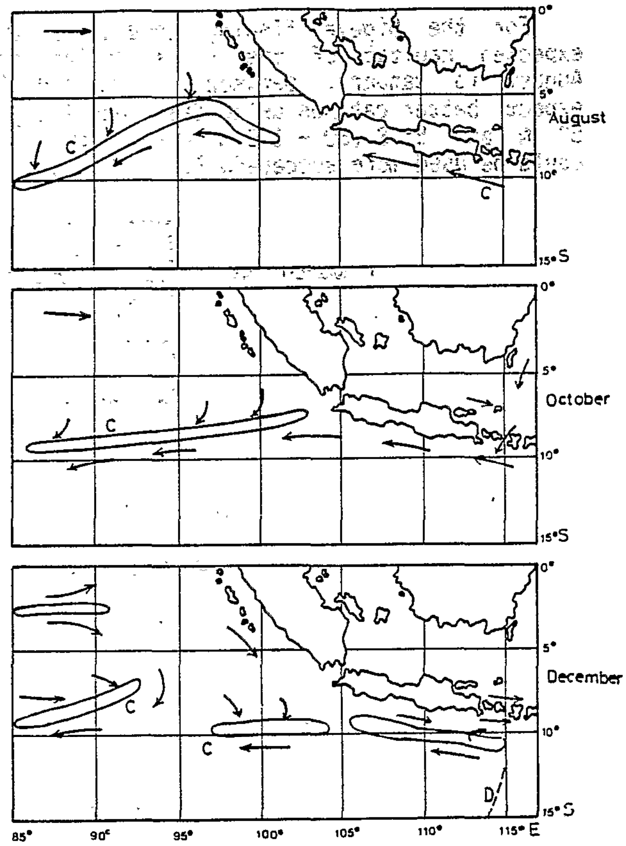
From May-June to August-September, the monsoon currents flow eastward North of 5° S and deflect toward South East off South Sumatra. Convergences shift to the North from May to August, from 9° S to 5° S, and may explain the good catch of bigeye obtained by japanese longliners between 5° S - 10° S and 95° E - 105° E. The axis of the convergence is oriented South-West, North-East, so fishing ground may be oriented more South toward East.

From September to December, the convergence shifts southward and is located near 10° S en December, so the northern boundary of the South equatorial current where fishing occur, also shifts southward to a latitude 9° S to 11 - 12° S.

South of Java and Bali, coastal currents flow eastward from December to June and toward West, because of the strong SE trade winds from July to October. An area of divergence is usually located between the two currents but convergence may occur from May to September, near Bali, between equatorial counter current or South equatorial current and a strong current coming from Banda Sea and Malacca Strait. The Northern boundary of the South equatorial current where bigeye tuna may be found is located between 9° S and 12° - 13° S.

In Banda Sea, because of the effect of Pacific Ocean and Indian Ocean circulations, as well as islands effect of Maluku, the system of currents is very complex. From November to February, the flow of the water comes mainly from the Indian Ocean, and in August from the Pacific Ocean. From March to June-July, and in September-October, currents from both oceans meet in Banda Sea and this is probably the reason of the development of very good fishing grounds for bigeye tuna during those two periods.





- Boundary areas between current systems and convergence zones. C = convergence, D = divergence.

- Zones de contact entre les systèmes de courant et zones de convergence. C = convergence, D = divergence.

Figure 21 - In February, April and June/en février, avril et juin.

Figure 22 - In August, October and December/en août, octobre et décembre.

5.2. Thermocline.

SUDA et al. (1969), regarding the distribution of bigeye tuna, set the hypothesis that the swimminglayer of bigeye was either within or just below the thermocline. From the work of SUZUKI in the Western Pacific, it can now be surmised that the distribution of bigeye tuna is much broader vertically than hitherto believed. However, in upwelling areas, where thermocline is too shallow, many of the deep longline hooks are located outside of relatively narrow thermocline and so get lower bigeye hook rates ; SUZUKI considers the temperature 15° C and 25° C as the enclosure of the thermocline and so as the potential bigeye tuna habitat.

For the bigeye fishing grounds South West of Sumatra, we present on Figure 23, the expected habitat of the fishes during three periods of the year. Habitat is very deep from August to January, between 100 m and 200 m, near 10° S and during these seasons, we can expect better catches using deep longline gears. In March-April, the habitat is wider between 5° N and 5° S (50 - 190 m) than in the Southern area (50 and 120 m). So deep longline gears could be used more successfully in the North and subsurface gears in the South.

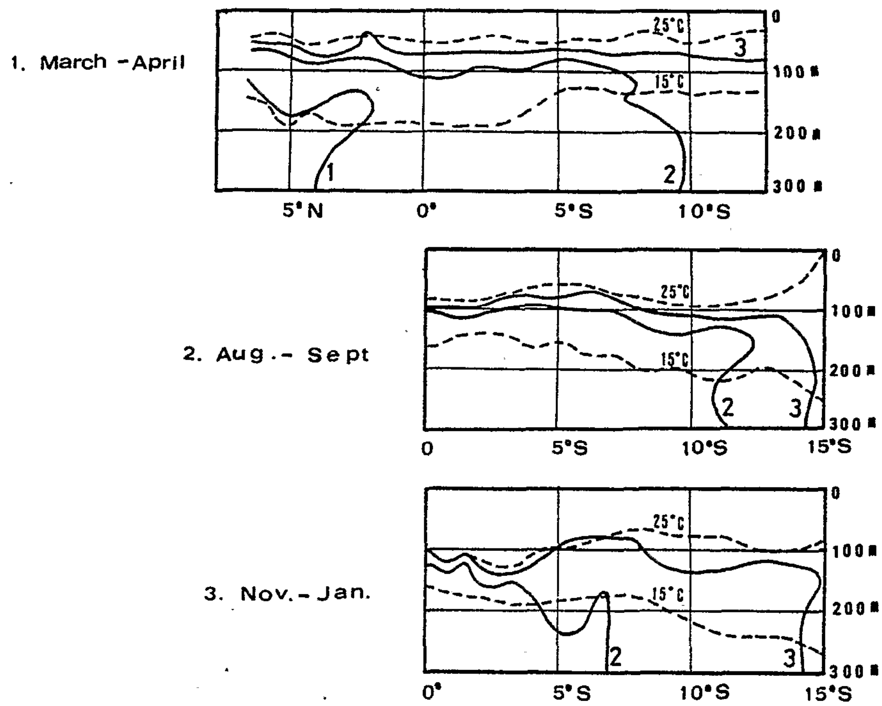


Figure 23 - Schematic representation of the thermocline and oxycline structures between 0° and 15°S, by 92°-95°E. Data from Diamantina (1), Vitiaz (2) and Koyo Maru (3). (Atlas II o E, 1971).

- Représentation schématique de la structure de la thermocline et de l'oxycline entre 0° et 15°S par 92°-95°E. Données du Diamantina (1), Vitiaz (2) et Koyo Maru (3). (Atlas II o E, 1971).

In the area South of Java, depth of bigeye habitat range between 100 to 180 m in February near the coast, becoming deeper more to the South. In July, because of the strong coastal upwelling along coast of Java and Bali, it is located more to the South 11° S to 15° S ranging there from 100 m to 250 m.

6 FISHING RESULTS OF THE JAPANESE PURSE SEINE VESSELS BASED IN JAPAN AND FISHING NORTH OF IRIAN JAYA AND PAPUA NEW GUINEA.

6.1. History.

Traditionally, japanese purse seiners were operating North of 25° N off Sauriku and near Izu Islands with small twin purse seiners. From 1969 to 1974, they have been almost all replaced by more economical autonomous purse seiners.

Tropical areas have only been explored since 1970 by JAMARC (Japan Marine Fishery Resource Center). In 1974-1975, the purse seiner "FUKUICHI MARU", 500 GT, freighted by JAMARC got very good results: 18.8 tons by fishing day in an area located between Caroline Islands and Papua New Guinea, and then, more than 10 purse seiners have been freighted by JAMARC to prospect Western Equatorial Pacific. The fleet, which had 9 units in 1976, has been increased by 5 units in 1977-1978 ; 32 units were operating in 1982, and 40 were forecasted for year 1983.

6.2. The fleet.

Japanese purse seiners are usually 500 GT with 400 tons fish hold capacity. All vessels are based in Japan where they come back for unloading the fish. Trips are generally 30 to 45 days, out of which 12 are spent in travel to the fishing grounds and come back.
The composition of the fleet in 1980 by size category is given in Table 26. Purse seiners are 1 700 to 2 400 meter long (stretched) and 240 meter deep. Mesh size averages 120 mm, usually unknoted in order to limit the weight. The more recent nets are 2 000 meter long with a 1 440 meter cork line and with a height (stretched) of 260 m.

Size category GT	Number of vessels
259	1
357	1
468	1
499	10
999	1
Total	14

Table 26 - Composition of the Japanese fleet fishing in the North of Papua New Guinea, by size category (year 1980).

6.3. Total catch and catch per fishing day.

Total catches are given in Tables 27 and 28 for the whole japanese fleet ; from 461 tons in 1970, they reach more than 35 000 tons in 1979, and probably about 60 000 tons in 1982.

The catch per day at sea averages 10 at 15 tons by effective fishing day on the fishing ground. Catches by set are 13 to 28 tons, composed of 70 % skipjack, 26 % yellowfin, and 4 % small bigeye. Total catches by species are given in Table 27, for the years 1970 to 1979 and in Table 28 for the period May 1979 to April 1980 ; data are those of unloading fish in Yaizu.

Years	Total catches (tons)	Skipjack	Yellowfin	Bigeye	Others
1970	461	338	123	-	-
1971	944	706	200	35	3
1972	782	539	188	47	8
1973	1 752	1 245	412	84	10
1974	2 261	2 159	407	36	19
1975	6 975	4 991	1 726	253	-
1976	10 539	7 509	2 756	274	-
1977	17 555	12 034	5 181	341	-
1978	32 000	25 000	7 000		
1979	36 000	26 000	10 000		

Table 27 - Japanese catch by purse seiners in the West Equatorial Pacific Ocean, from 1970 to 1979.

Months	Skipjack	Big Yellowfin	Small Yellowfin	Bigeye	Total
May	1 128	420		83	1 631
June	1 544	535		147	2 226
July	1 567	704		112	2 383
Aug.	2 927	1 313		23	4 263
Sept.	949	712	343	10	2 014
Oct.	1 133	401	520	20	2 074
Nov.	1 348	227	245	36	1 856
Dec.	1 136	233	195	29	1 593
Jan.	1 941	1 179	242	21	3 383
Fev.	2 420	643	360	12	3 435
March	1 868	1 083	112	4	3 067
April	3 506	707	568	117	4 898
Total	21 467	10 742		614	32 823
%	65,4	(21,8)	(10,9)	1,9	100

Table 28 - Quantity of tuna unloaded in Yaizu by japanese purse seiners between May 1979 and April 1980.

Different mensual indices of catch per unit effort are given in Table 29, such as the number of sets per trip, the catch per set, the catch per day on fishing ground, the average catch per trip and the number of days at sea per trip.

The full hold capacity of 400 tons is usually reached in 42 days, of which 28 are spent on fishing ground.

Months	T	C/T	D/T	F/T	S/T	C/S	C/F
May	2	420	32	20	15	28	22
June	5	416	45	31	26	16	14
July	6	397	40	28	23	18	14
August	9	348	38	23	20	21	15
September	5	403	38	27	26	15	15
October	6	346	48	33	26	13	11
November	4	463	53	37	31	15	13
December	4	398	56	39	30	13	10
January	8	424	38	26	26	16	16
February	8	429	43	28	24	18	16
March	8	383	33	21	18	21	19
April	10	451	34	21	17	27	21
Average value		407	42	28	23	18,5	15

T = number of trips
C/T = catch per trip
D/T = days at sea per trip
F/T = number of effective fishing days per trip
S/T = number of sets per trip
C/T = average catch per set
C/F = average catch per fishing day

Table 29 - Index of catch per unit effort for japanese purse seiners (May 1979 - April 1980).

6.4. Fishing grounds.

Until 1974, fishing grounds North of Irian Jaya and Papua New Guinea were only exploited from December to March, the vessels operating along the japanese coast during the summer months (April-May to September). Since 1976, fishing in tropical area occurs all year round. The fishing grounds from June 1978 to April 1980 were almost always located between 135° E and 146° E, 1° S to 6° N, so in the areas influenced by the North Equatorial Counter current usually on its Northern and Southern boundaries (Fig. 24).

6.5. Fishing methods.

Mainly, three kinds of schools are caught : those found with drifting logs, with sharks or whales and non associated schools found with birds. The porpoise associated schools of the Eastern Pacific are generally not met in the Western Pacific. Day time schools of fishes are usually difficult to set because the schools are too scattered or fast moving and because the thermocline is always deep. So japanese purse seiners set mostly just before dawn on log associated schools. The remaining time during the day is spent searching for other logs.

When drifting logs are scarce, as it was from December 1977 to March 1978 and December 1979 to March 1980, school fish sets are done during the day time on breezers or fearners or other kinds of non associated schools. Then nul sets are more frequent, but catches have usually a higher proportion of yellowfin. It is interesting to point out that since 1980 a higher proportion of sets are school fish sets with some success.

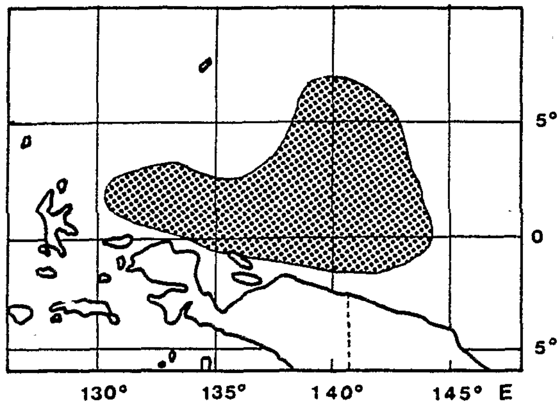


Figure 24 - Tuna fishing grounds North of the Irian Jaya and the Papua New Guinea.
- Secteur de pêche à la senne du nord de l'Irian Jaya et de la Nouvelle Guinée Papouasie.

The number of day time school fish set and night time log sets are given by month in Table 30 for the period August 1979-April 1980 as well as the average catch by category of sets. 57 % of the total sets have been done during the day time with 39 % of positive sets ; catch per set averages 14 tons or 35 tons per positive set. Almost all log sets made at dawn are positive ; production averages 24.5 tons/set with a however high mensual variability, low values from October to January and high values from February to April.

Month	Number of sets			Catch by set in tons	
	Total	School fish sets	Log sets	School fish sets	Log sets
August	177	47 (22)	130	19,3 (41,3)	17,1
Sept.	131	63 (25)	68	12,1 (30,5)	18,4
Oct.	156	40 (16)	116	8,1 (20,4)	15,1
Nov.	125	42 (25)	78	17,1 (32,1)	13,5
Dec.	120	61 (18)	59	9,1 (26,6)	17,5
Jan.	206	171 (62)	35	16,6 (43,9)	15,3
Feb.	191	159 (53)	32	11,7 (35,1)	49,2
March	146	125 (54)	21	18,5 (42,8)	35,8
April	169	91 (36)	78	16,3 (41,3)	38,7
Total	421	804 (311)	617	14,3 (34,9)	24,5

Table 30 - Catch per set for school fish sets and log sets from August 1979 to April 1980. In brakets, number of positive sets and catch per positive set.

6.6. Species composition and size of fish.

For the period August 1979 to April 1980, we present in Table 31 the composition of the catches by species and size category according to the type of set.

Species	School fish sets		Log associated sets	
	%	Size of the fishes, in kg	%	Size of the fishes, in kg
Skipjack	62,9	2,2 - 5,0	68,6	1,5 - 3,0
Big yellowfin	37,1	20,0 - 50,0	10,7	10,0 - 25,0
Small yellowfin	few	4,0 - 6,0	18,9	2,0 - 8,0
Bigeye			1,8	3,0 - 8,0
Total catch (in %)		47,3		52,7

Table 31 - Catch composition and size of the fishes caught during school fish sets and log associated sets. From August 1979 to April 1980.

From school fish sets, 37 % of the catches are big yellowfin, 20 to 50 kg. This kind of fish is not caught in log sets where the biggest yellowfins are usually 10 to 25 kg.

On contrary, small yellowfins are not caught in school fish sets but amount 19 % of the catches on logs.

Proportion of skipjack is higher during night time fishing on logs and the individual weight of the fish is lower (1.5 to 3.0 kg) than those caught during the day time on school fish sets (2.2 to 5.0 kg).

6.7. Analysis of the sets.

The prospection reports of the seiners freighted by JAMARC from 1974 to 1980 in the North of Papua New Guinea between 5° N and 2° S give some indications on the sets. The vast majority of them have been done at night on drifting logs. The seines used were mainly of two types : seines 1 430 m long (streched) with a cork line 1 275 m, and seines 1 800 to 2 000 m long with a cork line around 1 400 m long.

154 sets done at a depth inferior to 150 m allowed a catch per set of 12.9 tons. The average catch per set done between 150 and 225 m is 16.7 tons, thus 30 % greater.

Nul sets are more frequent when the reached depth is inferior to 150 m. Moreover, the reached depth becomes important as the yellowfin catch per day increases. For the skipjack, the depth would become of lesser importance, and the obtained catch per day would almost be the same for any depth (Table 32).

In fact, the variety of seines used (1 430 to 1 900 m long, with different lengths of cork line) makes the analysis delicate. For example, no increase of catch per day of yellowfin is apparent when the fishing depth is increased for the 1 275 m long cork line seine. The skipjack catches are even greater for sets done at lesser depth. On the other hand, for the 1 800 to 2 000 m long seines (streched), the catches per day of yellowfin and skipjack are greater as the depth reached by the seine increases.

The individual results of four seiners during operations between 1977 and 1980 confirm the beneficial effect to set with a net able to go deeper (Tables 32,33).

Attained depth (m)	Number of sets	Number of nul sets	Catch by set			
			Yellowfin	Skipjack	Total	YF/Total in %
50 - 75	2	2				
75 - 100	10	2	1,2	6,2	7,4	16,2
100 - 125	48	13	1,8	12,0	13,8	13,0
125 - 150	94	30	2,1	11,2	13,3	15,8
150 - 175	78	8	4,7	14,2	18,9	24,9
175 - 200	38	7	3,6	10,0	13,6	26,4
200 - 225	20	6	5,9	9,0	14,9	39,6
225 - 250	1	0		4,0	4,0	
Total	291	68	3,2	11,5	14,7	21,4

Table 32 - Distribution of the depth reached by the net, and catch per set of yellowfin and skipjack ; sets made day time and night time are included.

	Depth attained by the net	Number of sets	Number of sets whith catch superior to 10 tons	Average catch by set, in ton
- seiner 1 (1977) - corkline 1 507 m - seine 1 900 m streched	less than 150 m	36	11	7,5
	more than 150 m	10	5	18,3
- seiner 2 (1977) - corkline 1 357 m - seine 1 900 m streched	less than 150 m	38	13	12,0
	more than 150 m	9	7	17,6
- seiner 3 (1978-79) - corkline 1 285 m - seine 1 800 m streched	less than 150 m	37	19	16,9
	more than 150 m	37	18	17,6
- seiner 4 (1979-80) - corkline 1 428 m - seine 2-000 m streched	less than 150 m	27	13	11,9
	more than 150 m	22	15	20,2

Table 33 - Catch per set according to depth reached by the net, during different prospections done by JAMARC.

There is thus an advantage to fish with seine able to reach depth 150 to 180 m since the daily catch per set is there greater and at least partly composed of the more commercially interesting species. In fact, the depth reached by the net depends very much on the strength of the current in which the set is done. So we can also consider that weaker is the current, deeper are the sets and higher the catches.

For each set, the JAMARC reports indicate the temperature at maximum immersion of the seine and we were able to estimate from the hydrological measurements done simultaneously, the depth of the thermocline in the area where the set was done. The results of the analysis show that for most sets the depth of the surface homogeneous layer is situated between 130 and 160 m. Surprising fact, the average catch per set does not decrease as this layer increases but remains more or less the same for any depth (at least for dawn log sets).

Duration of a set (rings on board) is usually 40 to 70 minutes. The catch per set for skipjack seems strongly depend on the duration of the set (Tables 34 and 35). The quantity of yellofin fished at night is roughly constant for the set durations considered.

The yellowfin would be more gathered around logs and less sensitive to maneuvers around them. In fact, a shorter set duration allows increased skipjack catches and a deeper net allows increased yellowfin catches. The depth of the homogeneous layer and the value of the temperature at the maximum immersion of the seine seem to have little effect on the night catch.

Duration of the set (in min.)	Number of sets	Nul sets	% nul sets	Catch by set in tons		
				Skipjack	Yellowfin	Total
30 - 45	10	4	40 %	16,6	0,0	16,6
45 - 60	30	18	60 %	9,3	5,6	14,9
60 - 75	8	6	75 %	3,1	2,5	5,6

Table 34 - Catch per set for school fish sets, according to the duration of the set.

Duration of the set	Number of sets	Catch by set in tons		
		Skipjack	Yellowfin	Total
30 min - 45 min	27	16,7	3,1	19,8
45 min - 60 min	172	13,1	3,3	16,4
60 min - 1 h 15	68	11,8	2,8	14,6
1 h 15 - 1 h 30	7	6,0	7,6	13,6
more than 1 h 30	3	8,0	2,7	10,7

Table 35 - Catch per set for log sets, according to the duration of the set.

7 SHORT ANALYSIS OF THE CATCHES OF THE INDONESIAN PURSE SEINER "CAMAR" - JANUARY 1980 - APRIL 1982 -

7.1. Introduction.

Indonesian purse seine fishery for tuna began in January 1980 ; operations are made with a japanese built purse seiner 600 GT, 2 500 HP and 540 tons of tuna capacity. This vessel is based in Ternate and belongs to P.T. East Indonesia Fishery. Fishing grounds are located in areas North of Irian Jaya and Papua New Guinea and the main technique used is the night setting on drifting logs.

Data available which are provided by P.T. East Indonesia Fishery are the daily records of catches and the daily position of the vessel. Catches are not separated by species so that skipjack and yellowfin are confounded in a single category as tunas. Sets done without catch are not registered.

The results of fishing operations by month are given in Table 36. We indicate the number of days at sea, which does not includes days in transit between Ternate and Sorong, the total catches, the total number of positive sets, the catch per day and the catch per set.

Month	1980				1981				1982			
	Days at sea	Catch	Catch per day	Number of sets	Days at sea	Catch	Catch per day	Number of sets	Days at sea	Catch	Catch per day	Number of sets
1	25	151	6,0	3	29	27	0,9	1	23	355	15,4	11
2	20	146	7,3	5	Docking				28	437	15,6	14
3	31	300	9,7	6	Docking				17	182	10,7	3
4	17	218	12,8	6	21	136	6,5	5	14	245	17,5	8
5	21	165	7,9	2	18	308	17,1	7	Docking			
6	30	400	13,3	15	22	183	8,3	11	5	25	5,0	1
7	15	104	6,9	2	20	231	11,6	10	31	133	4,3	11
8	25	193	7,7	9	31	407	13,1	21	--	---	----	--
9	14	65	4,7	3	13	76	5,8	5	--	---	----	--
10	24	107	4,5	6	24	371	15,5	15	--	---	----	--
11	22	191	8,7	6	19	447	23,5	10	--	---	----	--
12	14	78	5,5	4	18	91	5,1	7	--	---	----	--
1-12	258	2 117	8,2	65	215	2 275	10,6	92	82 (1-5)	1 219 (1-5)	14,6 (1-5)	36 (1-5)

Table 36 - Results of the fishing operations executed by the P.T. East Indonesia Fishery purse seiner "CAMAR", from January 1980 to April 1982.

7.2. Fishing grounds.

The main fishing grounds are located North of Irian Jaya and North of Papua New Guinea between 0° N and 4° N and 139° E and 145° E.

In 1980, fishing took place usually more in the West : 48 % of the days at sea have been done West of 140° E as well as 35 % of the total catches ; 4 % of the days at sea and 4 % of the catches has been done East of 145° E and respectively 48 % and 61 % between 140° E and 145° E and respectively 16 % and 21 % East of 145° E (Fig. 25).

7.3. Catch per unit effort.

The evolution of the catch per day and the average number of positive sets per day at sea are given in Fig. 26 and 27. We can see that the average catch per day at sea is becoming higher ; from an average value of 8.1 tons/day in 1980 it reaches 10.3 tons/day in 1981 and 14.9 tons/day for the first four months of 1982. The higher values obtained in 1981-1982 could also be expected from the higher number of positive sets per day at sea as shown in Fig. 27 ; a few of the reasons may be the better knowledge of the fishing grounds, the improvement of the technique during the second year of operations or the more systematic setting on school fish. As we have no indication on the number of sets done during day time on school fish or at dawn on logs, any further analysis is not possible. For the same areas the number of positive sets was much lower during the first year of operation ; the average number of sets per day at sea was 0.23 against 0.46 during the second year.

The distribution of the production per set for the two periods is given in Table 37. The high number of sets producing 25 to 45 tons of tuna, must be noticed and may indicate the average yield of a productive log. During the years 1981-1982 a large number of set have had a low production, less than 15 tons, but we cannot know if these sets were school fish sets or log sets. At least, it may reflect the fact that during the first year of operation sets have not been made on every opportunity.

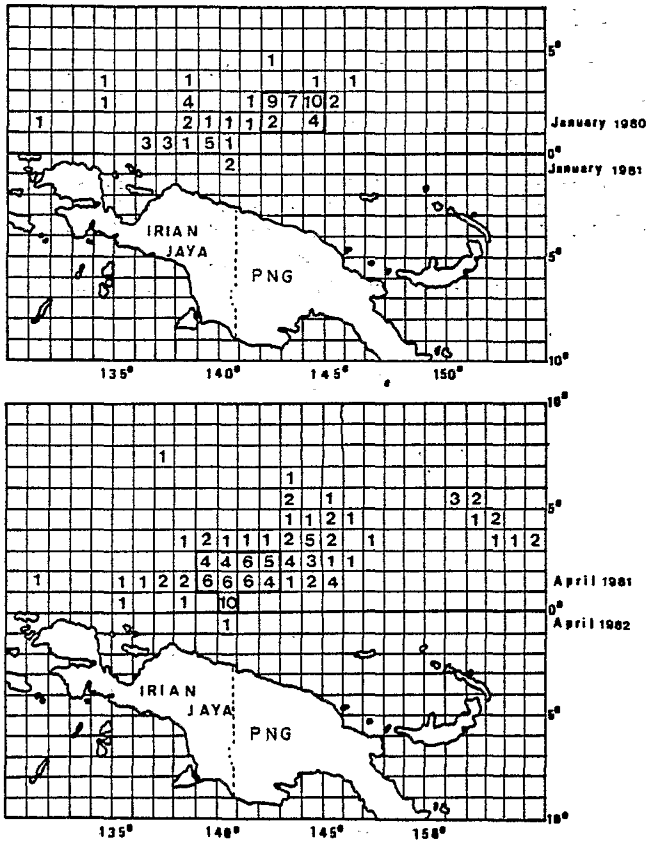


Figure 25 - Location and number of the positive sets during the two periods : January 1980 to January 1981, and April 1981 to April 1982.

- Position et nombre de calées positives durant les périodes janvier 1980 à janvier 1981, et avril 1981 à avril 1982.

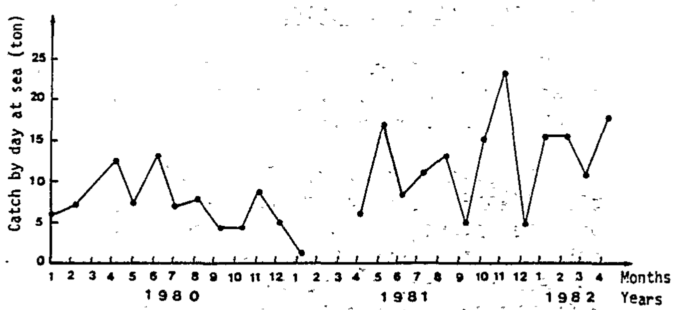


Figure 26 - Monthly catch by day at sea of the purse seiner "CAMAR" : January 1980-April 1982.

- Prise par jour de mer du senneur "CAMAR" entre janvier 1980 et avril 1982.

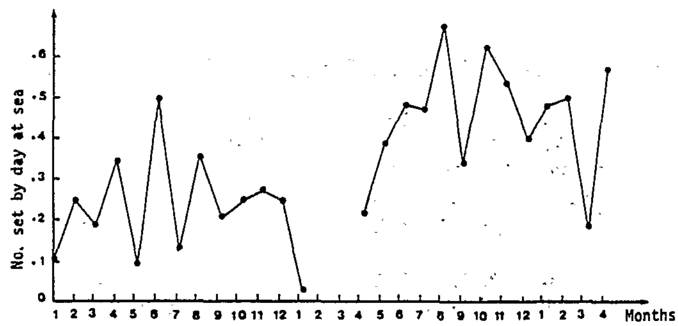


Figure 27 - Number of sets by day ay sea of the purse seiner "CAMAR" : January 1980-April 1982.

- Nombre de calées par jour de mer du senneur "CAMAR" de janvier 1980 à avril 1982.

Catch by set, in tons	Number of sets		
	1/80 - 1/81	4/81 - 4/82	Total
0 - 5	8	25	33
6 - 10	6	19	25
11 - 15	10	18	28
16 - 20	3	10	13
21 - 25	4	6	10
26 - 30	5	8	13
31 - 35	9	4	13
36 - 40	5	7	12
41 - 45	4	3	7
46 - 50	2	3	5
51 - 55	2	3	5
56 - 60	4	3	7
61 - 65	0	5	5
66 - 70	1	3	4
71 - 80	1	1	2
81 - 90	2	3	5
91 - 100	0	1	1
101 - 110	2	3	5
111 - 120	0	0	0
121 - 130	0	1	1

Table 37 - Distribution of catches per set obtained by the purse seine vessel "CAMAR", during the periods : January 1981 and April 1981 - April 1982.

7.4. Catch rate variations according to the period of the trip.

For any captain of vessel, it takes time to find the fishing ground. So that, during the first few days of a trip, catch rates are usually lower than those obtained on the fishing ground itself, especially when vessels work individually and not in fleet.

We give, in Fig. 28 and 29, the average daily catch and the number of sets per day, of the "CAMAR" according to the period of the trip given in 5 days intervals. We can see that, on the average, the catch per day during the first ten days at sea is less than half the catch rate during the remaining of the cruise ; this is well shown for the period April 1981 to April 1982, although much less evident in 1980. The average number of sets (Fig. 29) for each period of the trip gives us similar results.

In fact, "CAMAR" does not work anymore completely individually as contacts by radio with the other japanese purse seiners are received every day. So, we can assume that if the vessel work alone at the beginning of each trip, it usually works with the japanese fleet after a first week of self research in indonesian waters. This may be the main reason of the lower catch rate of "CAMAR" during its first ten days at sea and also perhaps during the first year of operation.

7.5. Importance of the fish capacity of the vessel.

It is evident that a vessel with higher autonomy and higher fish capacity can stay a longer time on the fishing grounds but spends the same time as the small ones to find them. Based on the results of the "CAMAR", we study here what benefit could be expected using vessels with higher fish hold capacity and higher autonomy which work in the area North of Irian Jaya and PNG.

We have considered in our calculation that the average catch per day at sea during the first ten days was half of the average catch rate in the fishing ground.

We give, in Fig. 30, the number of days at sea according to the fish hold capacity of the vessels for different values of the catch rate on the fishing ground. We can see that for the catch rate estimated in the fishing ground North of Irian Jaya which is comprised between 15 T/day and 20 T/day the number of fishing days of a 400 T capacity vessel must be 35 to 45 days. For a 600 T capacity, the autonomy must be 45 to 65 days at sea.

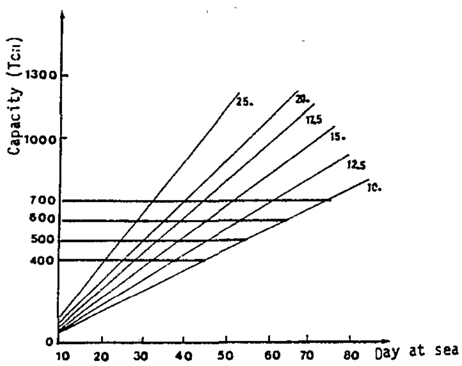


Figure 30 - Number of days at sea according to the fish hold capacity and the average catch rate in the fishing ground (from 10 tons/day to 25 tons/day).

- Nombre de jours passés en mer en fonction de la capacité du pont en thon et du rendement dans la zone de pêche (de 10 tonnes/jour à 25 tonnes/jour).

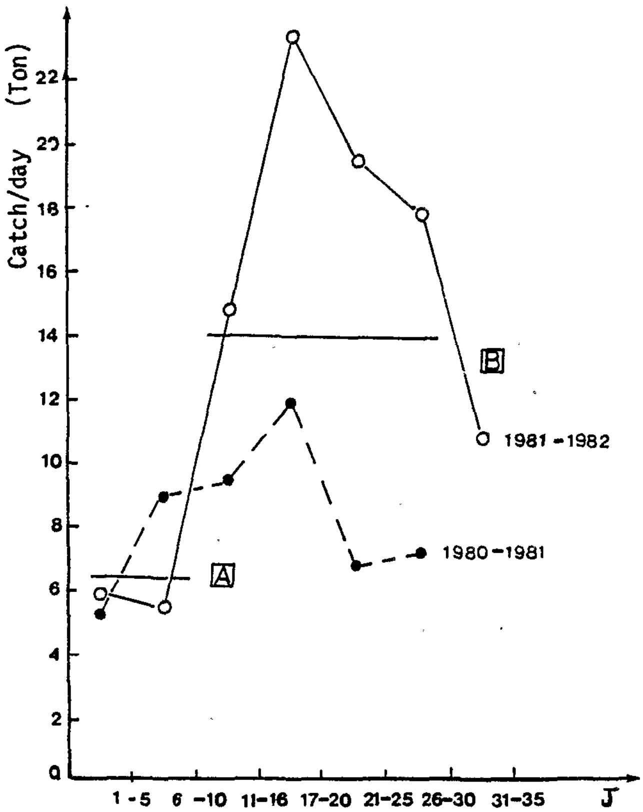


Figure 28 - Catch by day of all trips depending on the period of the trip calculated by 5 days intervals.

A - average catch by day during the ten first days of the trip for the whole period 1980-1982.

B - average catch by day during the rest of the trip.

- Prise par jour de mer en fonction de la période du voyage calculée par intervalles de 5 jours.

A - prise moyenne pendant les 10 premiers jours pour l'ensemble de la période 1980-1982.

B - prise moyenne pendant le reste du voyage.

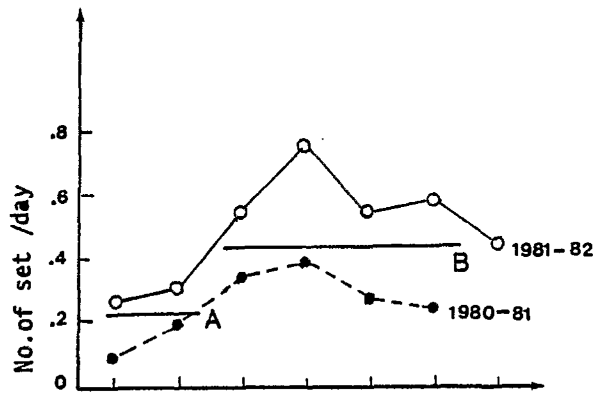


Figure 29 - Number of sets by day depending on the period of the trip.

A - during the ten first days.

B - during the following days.

- Nombre de calées par jour en fonction de la période du voyage calculée par intervalles de 5 jours.

A - pendant les 10 premiers jours.

B - pendant le reste du voyage.

In fact, the optimum autonomy depends on the relative situation of the harbour of landing and on the fishing ground, and will be higher if the place of landing is farther from the school concentrations. Fig. 31 shows the potential catch of vessels of 500 T, 600 T, and 700 T capacity relatively to a 400 T capacity vessel, for different catch rates on fishing grounds ranging from 10 to 35 tons per day, with the assumption that no vessel stays longer than 60 days at sea. We can see that the advantage of a higher capacity vessel increases as the catch rate on fishing ground increase. The advantage is very low for low catch rate of 10 T/day, (3 to 4 %) but becomes higher especially for the 600 T and 700 T capacity vessels, with higher catch rates. Average benefit may reach 10 to 15 % respectively.

We present, in Table 38, the average catch rate of the vessel "CAMAR", according to the period of the trip, and the average catch rate during the last five days of the trip. We can see that twice in 1980 and four times in 1981-1982, the vessel had to go back for loading when it was on a very productive fishing ground with catch rates over 30 T per day ; the average catch rate over the last five days of the trips during 1981-1982 reaches 24 T/day.

1980 - 1981 trips	Average catch per day			Duration of the trip in days	Reason of ending the trip
	Days 1 to 10	Remaining days	Last five days on fishing grounds		
1	(0,0)		0,0	10	*
2	6,0	11,3	0,0	35	*
3	12,1	10,5	0,0	34	*
4	18,2	2,2	33,0	31	C
5	0,0	18,2	18,0	35	C
6	(4,3)			4	*
7	6,0	9,6	0,0	35	*
8	6,5	4,6	0,0	38	*
9	12,1	4,9	8,0	36	C
10	0,0	1,8	0,0	29	*
1 - 10	7,6		7,4	287	
1981 - 1982					
1	0,0	19,7	31,6	30	C
2	(2,8)	-	(4,0)	10	*
3	4,9	16,1	4,2	22	*
4	12,9	-	14,6	15	C
5	6,2	9,3	39,2	36	C
6	7,3	16,5	8,8	36	C
7	4,9	32,0	48,4	23	C
8	4,9	19,9	13,6	33	C
9	6,9	11,5	36,6	33	C
10	3,0	27,1	8,7	29	C
1 - 10	5,7	16,9	23,9	268	

Table 38 - Average catch rate according to the period of the trip, duration of the trip, and expected reason for ending the trip:
* Unknown,
C Unloading because full capacity reached.

From those observed values, we can estimate the benefit expected from longer trips for vessels of higher capacity. An estimation of the production of vessels 500, 600, 700 T fish hold capacity relatively to the 400 T is given in Table 39, as well as the average number of days per trip to fill up the fish hold.

From Fig. 31 and Table 39, we estimate as a reasonable hypothesis catches 8 to 10 % higher for 500 T capacity and 10 % to 17 % for 600 T capacity vessels, compared with 400 T capacity vessels.

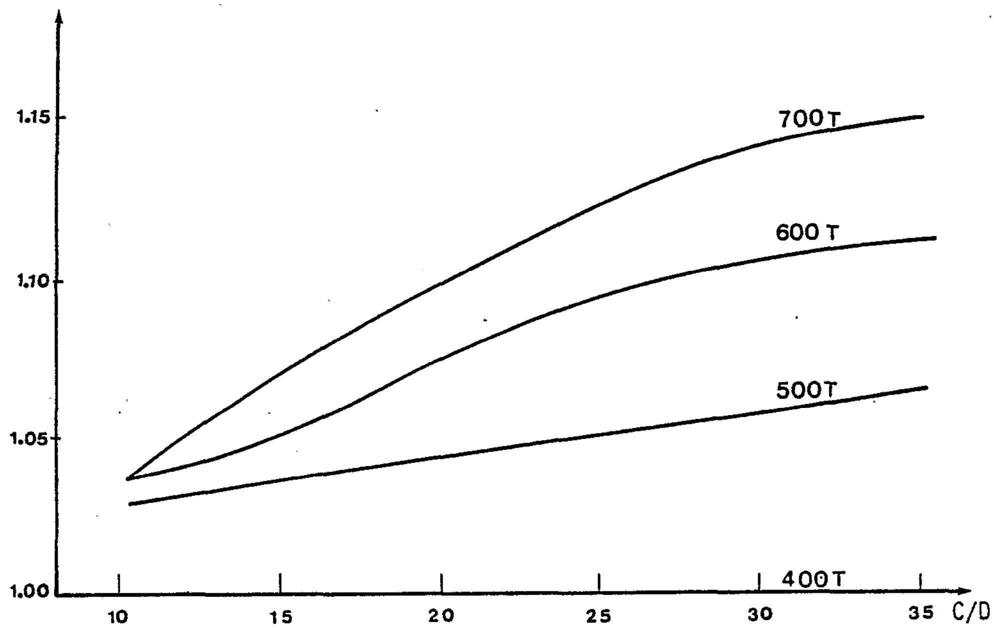


Figure 31 - Potential catch of vessels, 500 t, 600 t, 700 t fish hold capacity, relatively to a 400 t. capacity vessel, for different catch by day (C/D) in the fishing ground.

- Captures potentielles de navires de 500, 600, et 700 tonnes de capacité en thon, relativement à un navire de 400 tonnes de capacité, pour différentes valeurs de la prise par jour de pêche dans la zone de pêche (C/D).

	Fish hold capacity				
	400	500	600	700	800
Catch	1	1,10	1,17	1,22	1,24
Days/trip on fishing ground	27	31	35	39	44

Table 39 - Estimation of the annual production of vessels 500, 600 and 700 tons fish hold capacity, relatively with a vessel of 400 T fish hold capacity operating North of Irian Jaya.

7.6. Conclusion.

Because operations done by purse seine vessel "CAMAR" are very recent, the results must be taken cautiously. Results of the fishing were very poor during the first year of operation in 1980, but much better in 1981 and during the first months of 1982. Based upon this last period, we can expect for the near future, an average annual production of 2 800 to 3 000 tons, with 70 % skipjack, 30 % yellowfin for purse seiners of the category of "CAMAR" (600 GT, 430 T fish hold capacity) going 240 days at sea per year and 3 000 to 3 300 tons for vessels 750 GT with 530 tons fish hold capacity and working in fleet.

8 FISHING GROUNDS FOR PURSE SEINERS NORTH OF IRIAN JAYA.

In Figures 32 to 35 (p. 54 & 55), we present the monthly fishing grounds of the Japanese purse seiners North of Irian Jaya and Papua New Guinea from June 1976 to April 1980.

Sets appear generally to be done between 1° S - 4° N and 135° E - 145° E, and the fishing areas are usually found on a narrow latitudinal strip with a wide East-West extension. It is why it was expected that the currents which have an East-West direction in this area may be the major factor which determines fishing grounds. We give in Fig. 36, the currents charts North of Irian Jaya established by WYRTKI : the current system is composed of four major currents ; from South to North, we find :

- The current of Guinea : it flows toward South East along the coast of Irian Jaya and Papua New Guinea from November to March and created a strong upwellig along this coast during this period. From March to November, a westward current takes its place.

- The Equatorial current (EC) flows westward at the latitude of the Equator.

- The North Equatorial Countercurrent (NECC) flows eastward North of Equatorial current.

- The North Tropical Current, which flows eastward.

The boundaries of those currents may change from month to month and from year to year so does their strength, according to the strength of the North-East or South-East tradewinds.

* December - February.
The North West Pacific is caracterised by strong tradewinds which reinforce the North Tropical Current and, by a secondary effect, the North Equatorial Countercurrent. At the Equator, the tradewinds are replaced by west winds which strengthen the NECC and allow the development of the current of Guinea along Irian Jaya. This latter current may be strong in December-January : 50 to 75 cm/s. The Equatorial Current is weak and eddies may occur North of the Equator. During this period, fishing grounds may be found on the northern boundary of the current of Guinea, usually near the Equator.

* April.
The North East tradewinds predominate North of the Equator, shifting toward the South between Equator and 5° S. To North of Irian Jaya the current flows westward (25 - 38 cm/s) and the NECC is weak. The fishing grounds seems to occur between 0° and 3° N with a large variability from year to year and are located in the area of the Equatorial Current.

* June - August.
The East and South East tradewinds predominate and are very strong South of the Equator shifting toward North West North of Equator. The Equatorial Current flowing West is strong

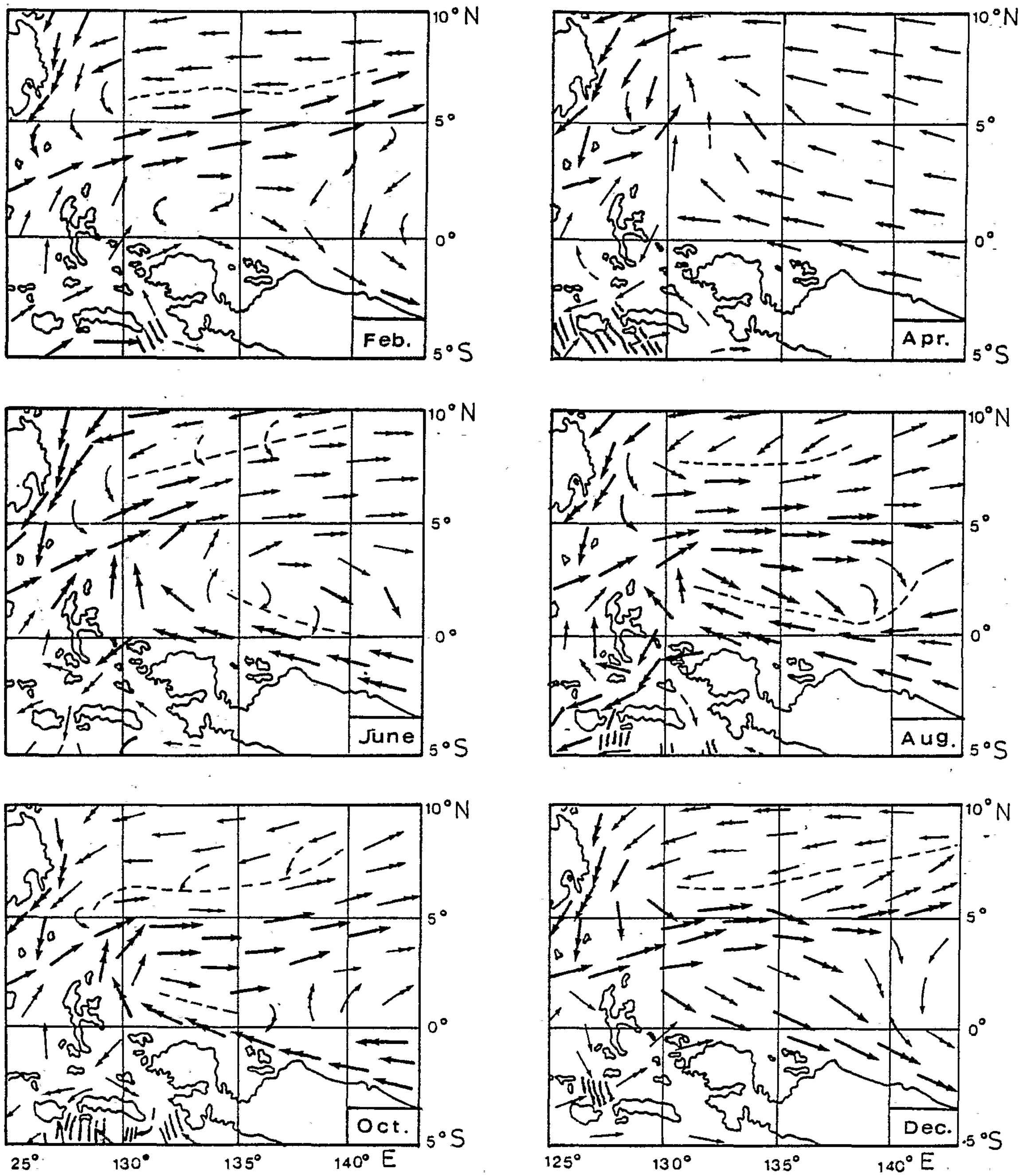
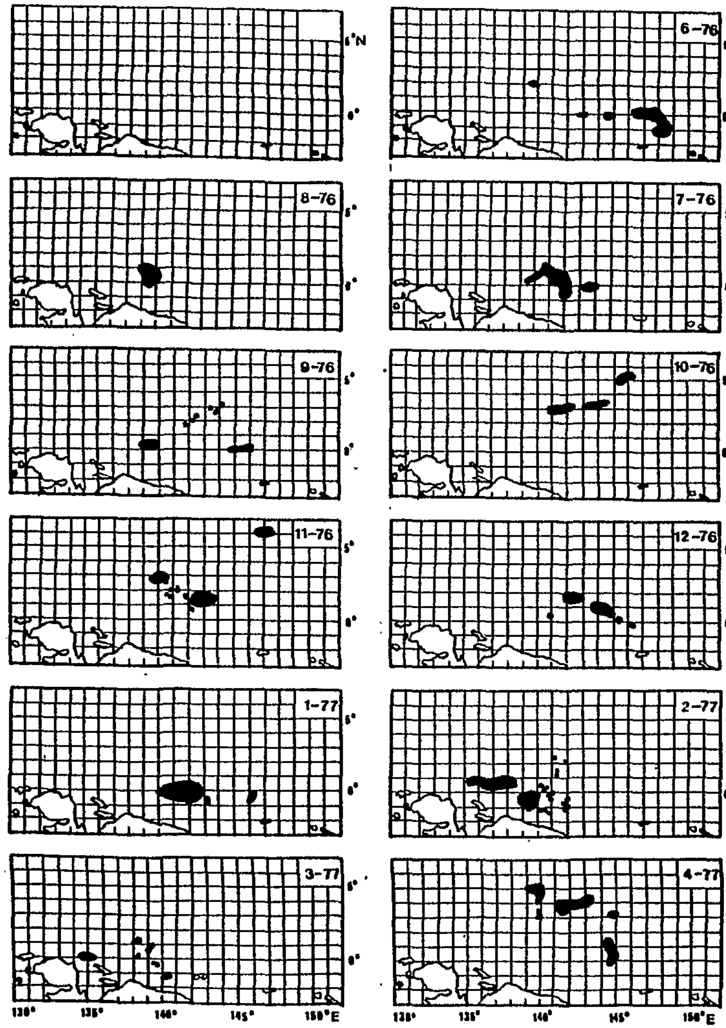
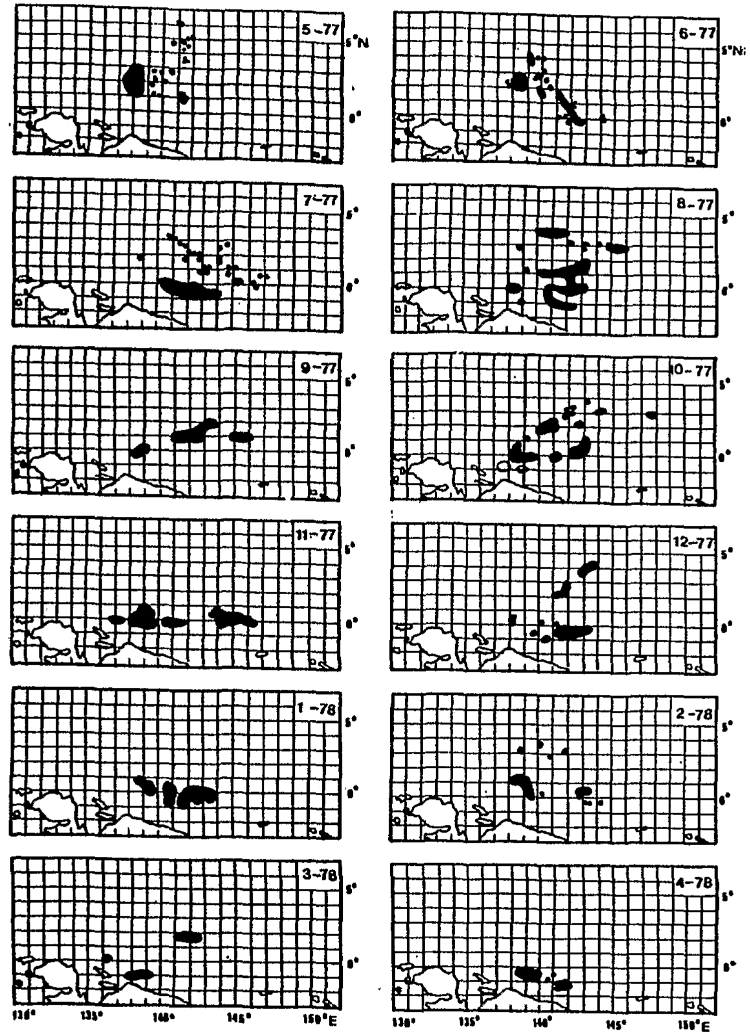


Figure 36 - Currents North of Irian Jaya (from WYRTKI).

- Les courants dans le nord de l'Irian Jaya (d'après WYRTKI).

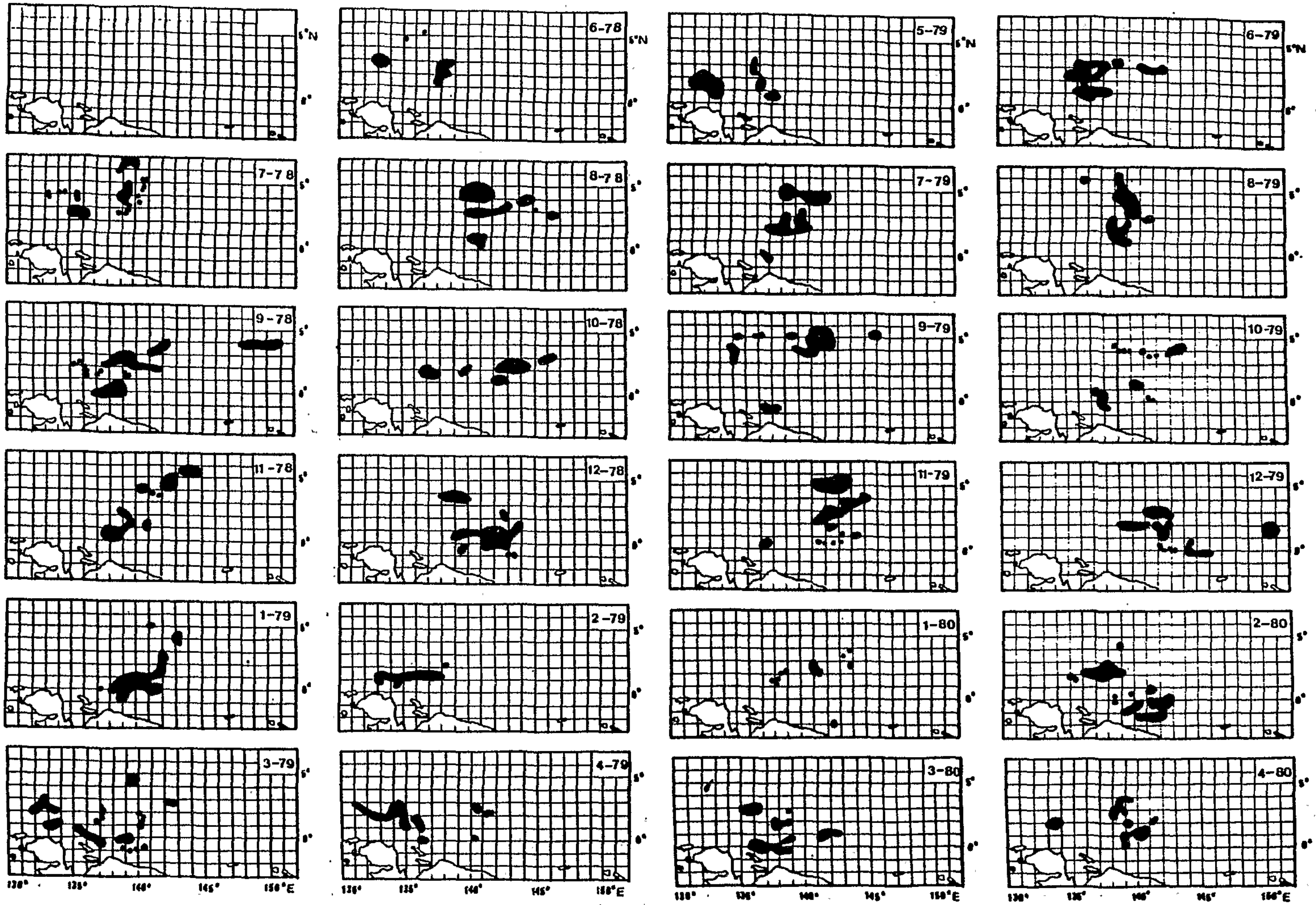




Fishing grounds of the japanese purse seiners North of Irian Jaya. Secteurs de pêche des senneurs japonais dans le nord de l'Irian Jaya.

Figure 32 - June 1976-April 1977/juin 1976-avril 1977.

Figure 33 - May 1977-April 1977/mai 1977-avril 1977.



Fishing grounds of the japanese purse seiners North of Irian Jaya. Secteurs de pêche des senneurs japonais dans le nord de l'Irian Jaya.

Figure 34 - June 1978-April 1979/juin 1978-avril 1979.

Figure 35 - May 1979-April 1980/mai 1979-avril 1980.

North of Irian Jaya and Papua New Guinea (50 - 75 cm/s). At this time, fishing grounds are located on the southern boundary of NECC near 1° N to 3° N.

* October.

The wind convergence is located North of the Equator near 10° N ; the NECC is found between 3° N and 7° N and becomes stronger. The North of Papua New Guinea Equatorial Current flows toward the West and shifts northward North of the Equator ; so, we find a strong convergence between the NECC and the northward flow from the Equatorial Current. Fishing grounds are located near this convergence on the southern boundary of the NECC near 3-4° N and sometimes, West of 140° E, near the Equator. In November, when the current of Guinea is developing, the fishing grounds shift southward on the northern edge of the this current, near the Equator.

The apparent movement of fish, in fact the change of the fishing areas can be summarized as follows :

when the current North of Irian Jaya flowing South East is well established, fishing grounds are located on its northern boundary (from December to March). In April-May, fishing grounds shift toward the North in the Equatorial Current flowing westward.

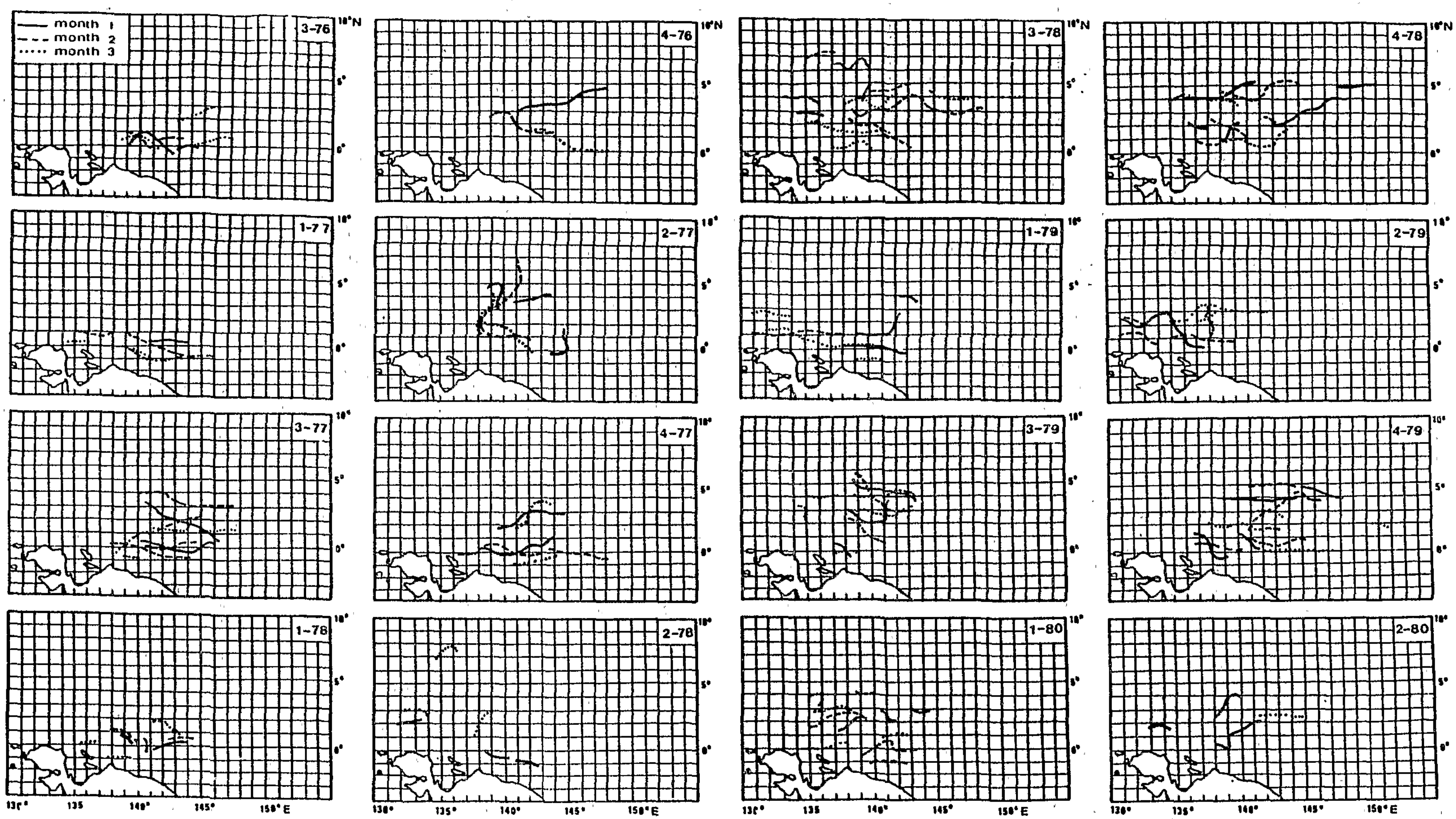
From June to August-September, fishing grounds may be found in North Equatorial Countercurrent, on its northern and southern edges and in areas where currents of various directions meet the Equatorial Current. In October-November, fishing grounds shift progressively from the southern boundary of the NECC toward the Equator near the northern edge of the current of Guinea.

The current system as represented by WYRTKI, can be considered as an average situation and so, doesn't represent instantaneous situations which may have a wide variability from year to year. However, the importance of the currents to determine the fishing grounds very well explain the East-West development of those fishing grounds on a very narrow band as shown in Fig. 37 and 38. The variability of their latitudinal position may reflect the variability of the current boundaries.

The major importance of The North Equatorial Countercurrent flowing eastward is shown on Table 40. 63 % of the positive sets done by "JAMARC" vessels from 1976 to 1979 have been done when currents were flowing NE, East or SE. There is no indication on better catch per set for yellowfin or skipjack in one current or another. However sets were done mainly on log associated schools and so, as school fish sets are becoming more important ever since 1981, fishing grounds as reflected by school fish sets, could be slightly different.

Direction of current	Number of sets	Number of positive sets	Catch by set		
			YF	SJ	Total
North	7	5	2,6	18,7	21,3
NE	40	26	3,9	8,8	12,7
East	55	47	2,5	13,8	16,3
SE	45	35	3,9	10,2	14,1
South	15	10	3,3	4,4	7,7
SW	22	16	4,0	12,8	16,8
West	24	18	2,6	12,5	15,1
NW	21	15	2,3	12,4	14,7

Table 40 - Distribution of sets and catch per set according to the direction of surface current (source - JAMARC.Reports in MARCILLE and BOUR,)



Axis of the fishing grounds. (position of the axis is given for each month of the quarter)

Position de l'axe des secteurs de pêche. (l'évolution de la position de l'axe est donnée par mois pour chaque trimestre)

Figure 37 - From 1976 quarter 3 to 1978 quarter 2/du 3e trimestre 1976 au 2e trimestre 1978.

Figure 38 - From 1978 quarter 3 to 1980 quarter 2/du 3e trimestre 1978 au 2e trimestre 1980.

9 - INDUSTRIAL POLE AND LINE FISHERY.

We will consider as industrial pole and line fishing, fishing done with vessels over 100 GT, with freezing capacity. Four companies are using such vessels.

- P.T. East Indonesia (a joint venture) based in Ternate.
- P.T. Usaha Mina (a State enterprise) based in Sorong.
- P.N. Perikanan Maluku (a State enterprise) based in Ambon.
- P.T. Multitranspêche Indonesia (a joint venture) based in Biak.

Ten vessels were in operation in 1983, but most of them began fishing recently. (Table 41).

Company	100 GT	200 GT	300 GT
P.T. East Indonesia		2 (74)	
P.T. Usaha Mina	1 (81)		1 (80)
P.N. Perikanan Maluku	1 (82)		1 (82)
P.T. Multitranspêche Indonesia			4 (83)
Total	2	2	6

Table 41 - Pole and liners operation in Indonesia in January 1983 .
(in brackets : year of starting operations)

We will present only the results for the first two companies which are both fishing in the North and the West of Waigo Island, near Sorong (Irian Jaya).

9.1. P.T. East Indonesia.

The company P.T. East Indonesia is based in Ternate (Molluques), but the two industrial pole and line vessels used catch the fish and the bait mainly in the Waigeo area North of Sorong. The company is a joint venture between P.T. Indonesian Fishery Corporation and Nichiro Gyogyo Kaisha and Mitsubishi Corporation.

Fishing operations began in 1974 with two types of vessels : 100 GT and 190 GT japanese types. Since 1978 only vessels in operations are two 190 GT pole and liners. Caracteristics of the vessels whose names are SOASIU and SAYAFI :

length	39,5 m
width	6,5 m
GT	199 and 215 GT
HP	750 CV X 360 RPM
fuel capacity	80 m3
water capacity	12 m3
cold storage	100 tons
crew	27 to 30.

Baiting is done every day by each vessel in the bay of the Waigeo Island and fishing for tuna to the North and West of this island. Baits are caught by the classical japanese technique using boke ami. Unloading is done in Ternate in a 400 T capacity cold storage.

9.1.1. Catch statistics, effort, and catch per unit effort.

Catch statistics of tuna and bait are given in Tables 42 to 44 per month for years 1978 to 1982.

	TUNA			BAITS		
1978 Month	Days at sea*	Total catch	Catch by day (ton)	Number of buckets	Buckets by day**	kg tuna by bucket
J	37	50,7	1,4	371	10	137
F	37	47,8	1,3	351	10	136
M	50	160,1	3,2	586	12	273
A	42	170,3	4,1	379	9	(449)
M	44	169,0	3,8	1 385	32	122
J	48	145,5	3,0	1 521	32	96
J	41	164,2	4,0	1 140	28	143
A	18	116,1	6,4	592	30	214
S	40	192,4	4,8	1 295	32	148
O	39	186,3	4,8	1 159	30	161
N	41	175,2	4,3	1 290	31	136
D	20	73,5	3,7	570	29	129
Total	457	1.651	3,6	10 589	23	154
1979 Month	Days at sea*	Total catch	Catch by day (ton)	Number of buckets	Buckets by day**	kg tuna by bucket
J						
F	6	10,4	1,7	320	53	36
M	39	101,3	2,6	1 455	38	70
A	44	156,9	3,6	1 590	36	99
M	52	180,3	3,5	1 675	32	108
J	41	208,3	5,1	1 200	29	174
J	30	199,9	6,7	742	25	269
A	49	225,6	4,6	1 539	31	147
S	35	210,9	6,0	1 666	48	127
O	46	155,3	3,4	2 260	49	68
N	44	178,7	4,1	2 220	50	81
D	43	103,4	2,4	2 110	49	49
Total	429	1 731	4,0	16 777	39	103

Table 42 - Catch statistics of tuna and bait of the two vessels "SOASIU" and "SAYAFI", years 1978 - 1979.
* Number of days at sea does not include transits between Ternate and Sorong.
** Number of buckets caught by night fishing for bait.

1980 Month	Tuna			Bait		
	Days at sea*	Total catch	Catch by day	Number of buckets	Buckets by day**	kg tuna by bucket
J	49	141,8	2,9	2 030	41	70
F	37	33,8	2,0	420	25	81
M						
A	19	62,0	3,3	1 210	64	51
M	40	145,8	3,6	1 288	32	113
J	39	153,6	3,9	1 900	50	81
J	47	72,4	1,5	1 980	44	37
A	43	171,5	4,0	2 020	52	85
S	53	193,2	3,6	2 510	47	77
O	36	196,9	5,5	1 960	54	101
N	45	174,2	3,9	1 770	41	98
D	42	198,8	4,8	1 773	42	113
Total	430	1 545,0	3,6	18 861	45	82
1981 Month	Days at sea*	Total catch	Catch by day	Number of buckets	Buckets by day**	kg tuna by bucket
J	40	198,0	5,0	1 910	48	104
F	37	110,1	3,0	1 040	28	106
M	40	152,5	3,8	1 555	39	98
A	46	207,7	4,5	1 815	40	114
M						
J						
J	26	97,7	3,8	1 150	44	85
A	34	177,7	5,2	1 470	46	121
S	28	173,0	6,2	1 420	53	122
O	25	135,0	5,4	1 150	48	117
N	41	144,5	3,5	1 740	45	83
D	42	90,7	2,2	1 230	29	74
Total	359	1 486,9	4,1	14 480	41	103

Table 43 - Catch statistics of tuna and bait of the two vessels "SOASIU" and "SAYAFI", years 1980 -1981 (* and **, cf Table 42).

1982	Tuna			Bait		
Month	days at sea	total catch	catch by day	number of buckets	buckets by day	kg tuna by bucket
J	45	113,9	2,5	1 055	25	108
F	35	99,5	2,8	587	17	170
M	44	144,8	3,3	746	17	194
A	41	100,6	2,5	611	15	165
M	43	139,1	3,2	795	19	175

Table 44 - Catch statistics of tuna and bait of the two vessels "SOASIU" and "SAYAFI", from January to May 1982.

9.1.1.1. Tuna.

There is no indication on the tuna species caught because data were not available. However, it is estimated that skipjack enters for 95 % of the catches and yellowfin for 5 %. Evolution of the monthly catch per fishing day is presented on Figure 39 for the years 1978 to 1982 and the average monthly value for all years on Fig. 40. It shows us that the higher catch rate occurs from June to November sometime with some good catch rate in April-May.

Average yearly catch rates do not show any trend ; they range between 3 to 4 tons a day.

9.1.1.2. Bait.

Data on bait are not so consistant ; they are given in number of buckets and in buckets caught by fishing night. A bucket is considered to contain 3 to 5 kg of bait, but it may depend on the species caught and we have no accurate data on species composition of the bait according to the years and months.

The number of buckets caught by night fishing averages usually 40 to 50 buckets which can be considered as enough for a one day tuna fishing trip. Vessels need to catch bait every day, at night time, and so may operate only on tuna fishing grounds located very near the bait fishing grounds. Catch rates were very low in 1978 and 1982 (20 buckets/night) and much higher in 1979 to 1981 (40 buckets per night).

Average catch of tuna per bucket was 80 to 100 kg from 1979 to 1981 and much higher, 154 kg and 162 kg in 1978 and 1981 respectively. We do not know the reasons for such high differences, however as the average number of buckets caught per day was very high in 1978 and 1982, it can be expected than during those two years the average weight of bait per bucket was higher. As a bucket may contain 3 to 5 kg of bait we can roughly estimate that 25 to 35 kg of tuna are caught per kilo of bait, and that better catch of tuna per bucket may be obtained during the period June to October.

For this, we can expect of chuming rather than a higher abundance of tuna.

9.1.1.3. Size of tuna caught.

There is no accurate data on size composition of the fish. However, as the total number of fish caught on each trip is estimated, we can know average mensual weight by individual fish. It was estimated to be around 2.6 kg in 1978, 1980 and 1981 and around 3.2 kg in 1979. The lower average weights are obtained from January to April and the higher from June-July to September-October. As we do not have the composition of the catch by species we cannot know if the higher values are not the effect of higher proportion of yellowfin in the catch during those months.

9.2. P.T. Usaha Mina.

Operations with pole and line boats 100 GT and 300 GT are relativelly new for the company P.T. Usaha Mina.

In one year of operation, in 1981, the catches of the 100 GT pole and line vessel have reached 218 tons ; catches of the 300 GT vessel were 510 tons in 1980, for 134 days with an average CPUE of 3.8 tons per day, and 748 tons in 1981 for a 8 month period of continual operation and 185 days at sea. Statistics of catch and effort are given in Table 45.

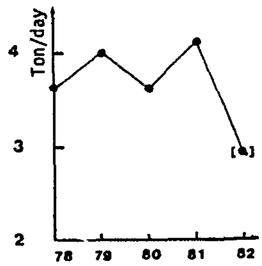


Figure 39 - Average yearly catch rate of tuna, in tons by day (vessels "Soasiu" and "Sayafi", P.T. East Indonesia) ; for 1982, from January to May only.

- Prise annuelle moyenne en tonnes par jour de mer des deux canneurs "Soasiu" et "Sayafi", P.T. East Indonesia ; pour l'année 1982, période de janvier à mai seulement.

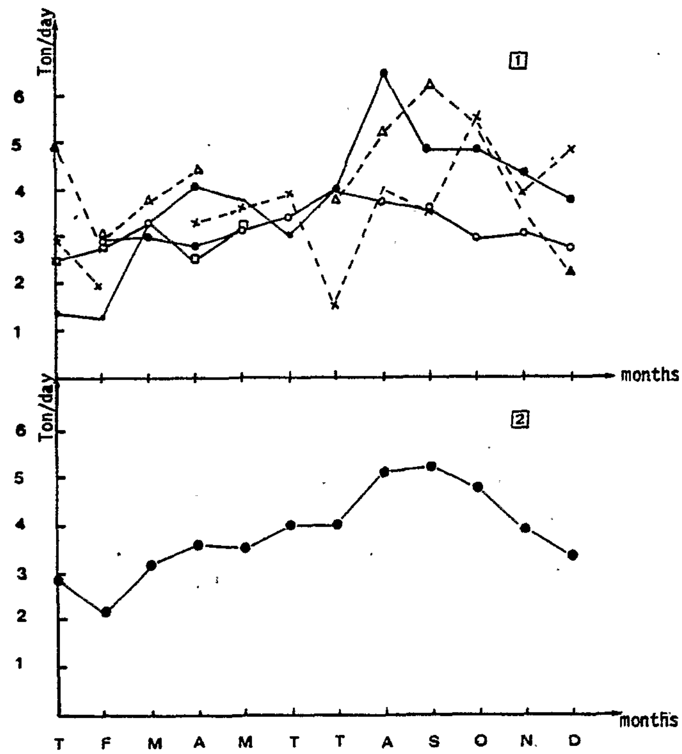


Figure 40 - Monthly catch rate of tuna in tons by day at sea by the two pole and line vessels "Soasiu" and "Sayafi" ;

1 - January 1978-May 1982, 2 - average year.

- Prise par unité d'effort mensuelle exprimée en tonnes de thon par jour de mer des deux canneurs "Soasiu" et "Sayafi" ;

1 - de janvier 1978 à mai 1982, 2 - valeur mensuelle moyenne.

Size Category		1980	1981	1982*
100 GT	Months boat operation		9	9
	Operation days		172	216
	Bait catches		8 196	7 614
	Tuna catches (kg)		216 720	225 905
	Average month production in kg		24 080	25 100
300 GT	Months boat operation	7	8	8
	Operation days	134	185	155
	Bait catches	12 327	16 095	6 529
	Tuna catches (kg)	508 322	742 511	227 802
	Average month production in kg	72 617	92 813	28 475

Table 45 - Catch statistics of the 100 GT and 300 GT pole and line boats in Sorong.
* From January to September.

10 ARTISANAL POLE AND LINE FISHERY IN IRIAN JAYA.

The first experimental pole and line fishing in North Irian Jaya has been conducted in 1971 by the japanese commpany Nichiro Gyogyo Kaisha with UNDP as contractor. Surveys were done in the areas of Sorong, Biak and Jayapura. The results show that the best place to develop pole and line fishing were the areas of Sorong and Waigeo Island, where the tuna fishing grounds are not too far from the bait fishing grounds.

The State Enterprise P.T. USAHA MINA has been created in 1973 and began its activities in 1976, with 15 pole and line vessels and with 30 vessels in 1977, all of them 30 GT and preserving the fish in ice.

In 1980, a 300 GT pole and line boat was added to the fleet and then, a 100 GT in 1981 and another 300 GT in July 1982, all freezing vessels.

The company has two 600 GT mother ships used as carriers boats. Based in Sorong, the company has there a cold storage 1 300 T capacity (- 20° C) with brine tanks 50 T at -13° C in 8 h, and an ice factory of 30 T / 24 h. at -7° C with 200 T storage capacity.

Total catches of the company are given per year in Table 46.

Years	30 GT Vessels	100 GT V.	300 GT V.	Total catches
1973	56	Experimental fishing		56
1974	69			69
1975	68			68
1976	871			871
1977	1 803			1 803
1978	4 838			4 838
1979	4 132			4 132
1980	3 668		508	4 176
1981	3 879	217	743	4 839
1982	(1 302)	(226)	(228)	(1 756)

Table 46 - Total production of tuna by the State Enterprise P.T. USAHA MINA in Sorong.
* January to September.

Caracteristics of the vessels.

We give below specifications of the 30 GT vessels all built according to the same plan.

GT	:	30 GT
length	:	20,8 metres.
width	:	4,2 metres.
draft	:	1,62 metres.
HP	:	165 HP diesel yanmar.
ice capacity	:	5 tons.
bait tank	:	45 buckets, 20 1.
autonomy	:	4 to 7 days.
crew	:	15 fishermen.

10.1. <u>Fishing operations and fishing grounds.</u>

Bait fishing is done with a basnig net, which is a boke ami modified in lift net. The size of the net is 7 X 7 m, 2 m deep for the 30 GT vessels. The same kind of net is used for the 100 GT and the 300 GT vessels but larger.

- 12 X 12 m X 4 for the 100 GT.
- 15 X 15 m X 5 for the 300 GT.

Catching the bait is done every day.

The bait fishing grounds are located near Sorong, and in the bays of Salawati, Batanta and Waigeo Islands (Fig. 41)

From February-March to May-June, when the tuna fishing grounds are close to Sorong, some bait is usually bought from the local fishermen using raft lift nets. During this period, the boats may start at 2 or 3 o'clock in the morning to buy the bait and come back around 10 a.m. after fishing when they have no more bait. From June to September, fishing is done usually North of Waigeo and the bait is taken there. From October to January-February, fishing occurs generally near the islands of Gag, Gebe and Kofiau ; duration of the trips are then 4 to 5 days and some bait is also bought from local fishermen, especially in October and November.

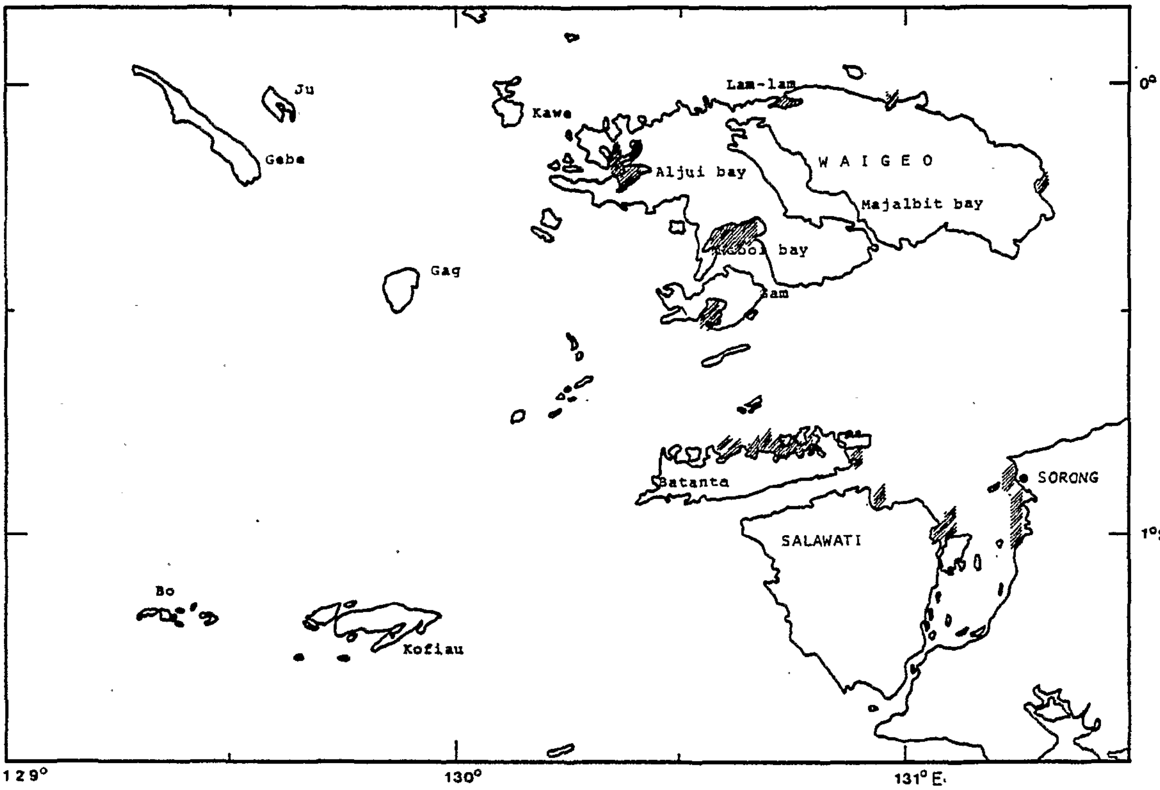


Figure 41 - Fishing grounds for tuna and bait in the vicinity of Sorong and Waigeo island.

- Secteurs de pêche du thon et de l'appât vivant dans les régions de Sorong et de l'île Waigeo.

The fishing grounds for tuna are mainly determined by the sea conditions and the weather may limit the number of days at sea between June and September. Schools of tuna are in great number North of Sorong and in the East of Waigeo Island, but the size of the schools is rather small ; the fish is usually 2.5 to 3 kg a piece.

In the North of Waigeo, schools are usualy bigger but scarcer. In the Western fishing grounds, between Waigeo and Halmahera and near Gebe island fish is usually smaller, 2.0 to 2.5 kg and according to a fishing master we met, there is no fish there in association with the logs. In the West of Waigeo and Salawati, small yellowfin, 3 to 6 kg are often met from December to March in association with whales and small forage fishes.

10.2. Catch statistics and catch per unit effort.

Statistics of the catch and effort statistics for tuna and bait are given in Tables 47 and 48 for the 30 GT fleet.

Years	Total catch tuna (tons)	Operating days	CPUE kg/day	Bait available by day (in buckets)	kg tuna per bucket	Number boats 30 GT in operation
1973	56	197	284			
1974	69	214	322	Experimental fishing		
1975	68	149	456			
1976	871	1 645	529	16,9	31,3	12,1
1977	1 803	3 910	461	25,7	17,9	22,2
1978	4 838	6 130	789	27,0	29,2	27,6
1979	4 132	5 641	732	21,5	34,0	26,1
1980	3 668	5 377	682	23,9	28,5	26,2
1981**	3 879	5 910	656	22,4	29,3	25,3
1982**	(1 302)	(3 003)	(434)	(21,7)	(20,0)	(22,3)

Table 47 - Statistics of catch and effort of the 30 GT pole and line boats of the State Enterprise P.T. USAHA Mina in Sorong.
* Average number of boats in operation each month.
** January to September.

Years	Quantity of bait caught by vessels	Quantity of bait purchased from local fishermen	Total live bait	Pourcentage caught by vessels
1976	17,2	10,7	27,9	62 %
1977	41,4	58,9	100,3	41 %
1978	82,7	83,6	166,3	50 %
1979	94,8	26,5	121,3	78 %
1980	86,9	41,7	128,6	67 %
1981	106,4	26,2	132,6	80 %
1982*	59,7	5,4	65,1	92 %

Table 48 - Catch of bait by the 30 GT pole and line boats in Sorong, in 1 000 buckets (1 bucket average 2 kg bait).
* January to September.

The average catch per boat and per year range between 3 600 tons and 4 800 tons. More than 90 % of the catches is skipjack and the remaining mostly yellowfin. Catch per day at sea was very high in 1978 after a year of very low catch rate in 1977. Since 1978, CPUE shows a regular decline until 1981 when CPUE was 656 kg/day.

The average CPUE in 1982 (from January to September) was very low, 434 kg/day and is similar to the average value of the year 1977. The evolution of the monthly values of CPUE, in kg per day, are given in Fig. 42 from April 1976 to September 1982. The variations of CPUE are very important from month to month and the reasons may be the migratory pattern of the fish since the areas where small 30 GT vessels may operate are limited, and the conditions of the sea, as those vessels cannot work easily when the wind is 3 Beaufort and up.

The main reason of the decline of the catch per day since 1978 is probably due to the lack of bait. We can see in Table 49 and Fig. 43, that the quantity of bait available per day has been steadily declining since 1977-1978, from 26 to 27 buckets per day in 1981 and 1982. During the first three years of operation 50 % of the bait was purchased from local fishermen (Table 48) ;

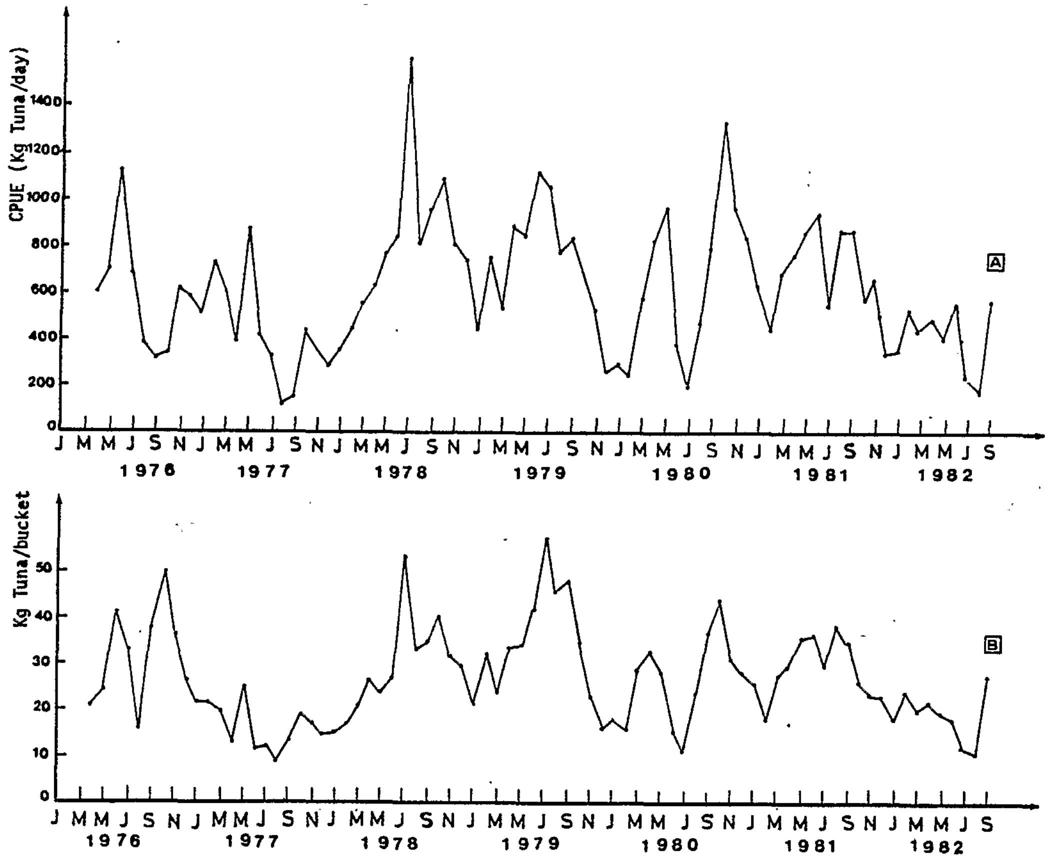


Figure 42 - Evolution of the CPUE of the 30 GT pole and line boats in Sorong.

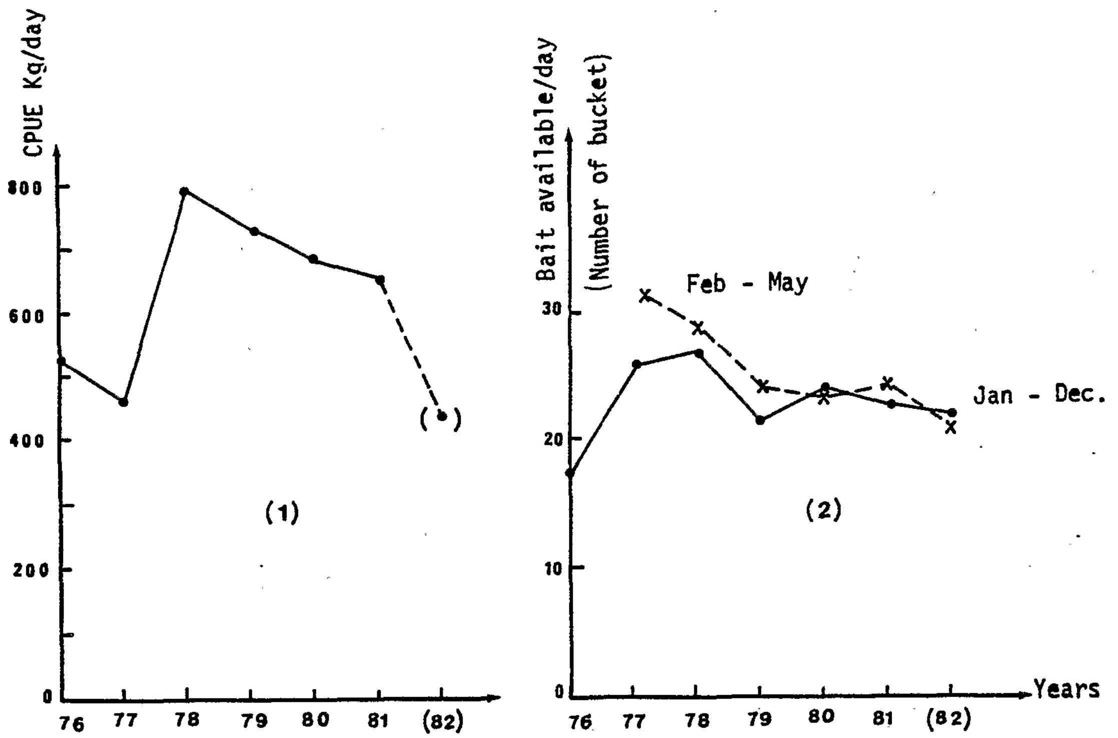
A - Catch of tuna per operation day (kg), B - Quantity of tuna caught per one bucket of bait.

- Prise par unité d'effort des canneurs de 30 GT à Sorong.

A - Prise de thon par jour de pêche (kg), B - Prise de thon par seau d'appât.

Month	CPUE kg/day	kg fish/bucket of bait	Bait available by day (in buckets)
J	429	20,0	21,5
F	520	21,6	24,1
M	567	23,4	24,2
A	652	25,5	25,6
M	772	27,2	28,4
J	767	27,5	27,9
J	660	29,9	22,1
A	516	25,5	20,2
S	639	33,2	19,2
O	738	35,5	20,8
N	649	27,2	23,9
D	510	23,0	22,2

Table 49 - Average monthly variations of CPUE for tuna and bait, for the period April 1976 - September 1982.



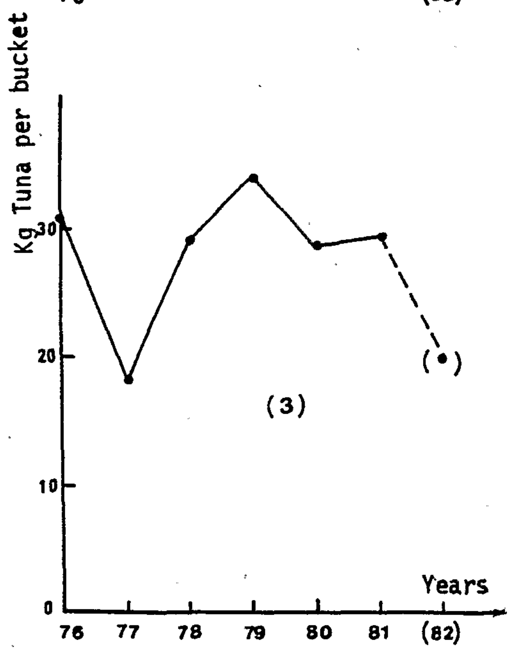


Figure 43 - Index of catch per unit effort of the pole and line boats in Sorong (P.T. USAHA MINA)

(1) - Catch of tuna per operation day in kg,

(2) bait available by day in buckets,

(3) catch of tuna per bucket of bait.

- Prise par unité d'effort des canneurs de 30 GT à Sorong (P.T. USAHA MINA)

(1) prise de thon par jour de pêche en kg,

(2) appât disponible par jour en nombre de seaux,

(3) prise de thon par seau d'appât.

in 1981 and 1982, almost all of the bait (80 % to 92 %) has been caught by the vessels themselves as the local fishermen using raft lift nets in Sorong bay prefer to sell their catch dry to the Surabaya market. The number of raft lift nets (Bagan) has increased tremendously for some years in Sorong and reached 95 units in 1981 ; their presence in the limited bait fishing ground of Sorong makes more difficult the catch of the bait for the pole and line vessels, especially when the tuna fishing grounds are close to Sorong, between February and May.

We can see from Fig. 43 (II) that the average quantity of bait available during this period, since 1977 and up to 1982, presents a higher drop than the average annual value.

Because catches of tuna depend on the amount of bait caught, the best index of CPUE is probably the average quantity of tuna caught per bucket of bait and not the total catch of tuna per day fishing. The monthly evaluation of this index is given in Fig. 42 and the evolution of the average annual value in Fig. 43.

If we disregard the very low values of this index in 1977 and 1982 (20 kg of tuna per bucket), the significant ones are near 30 kg per bucket for the years 1976, 1978, 1979, 1980 and 1981. No significant decrease is observed from one year to another exept for the two years 1977 and 1982 ; but we must note here that skipjack availability and/or abundance is subject to great annual variations all over the world.

The availability of the fish or its abundance in a restricted fishing area is also subject to high seasonal variations as it has been shown previously.
The average monthly variations of CPUE for tuna and bait, for the period April 1976 - September 1982, are given in Table 49.

High CPUE occurs generally from April to July and in October-November, however the best biting rate occurs from May to November with generally a peak between July and October, depending on the years.

When the fishing grounds present some stability with high CPUE, operations can be done in group with a mother boat on which the fish is unloaded every day. This strategy has been used during four months in 1981 and during 2 months in the end of the year 1980.

10.3. Size of the fish.

The mean size of the skipjack is 48 cm to 55 cm. Fishes are bigger than in Aertembaga and Ternate and similar to those caught in Ambon during the South East monsoon.

10.4. Conclusions.

Fishing grounds of tuna and bait seem to be very productive in the Sorong and the Waigeo areas. Average catches per year and per boat are 20 % to 40 % higher than in Aertembaga and Ambon. However, because of the increasing number of lift nets in the bay of Sorong the small pole and line boats have more difficulty to catch the bait in this area when fishing grounds for tuna are close to Sorong.

Several solutions could be tested.

- The first should be to increase the price paid to the local fishermen which is presently 500 rp/bucket, in order that they find more advantageous to sell the bait to the pole and line boats rather than to sell it dried outside.

- The number of raft lift nets should be limited to its present level.

- Another possibility is to use small boats specialized in bait fishing and to install in the bait fishing grounds traps to stock the bait.

11 ARTISANAL POLE AND LINE FISHERY IN THE MALUKU ISLANDS.

The Maluku Islands are presently the main area producing tuna in Indonesia. The total production of skipjack, yellowfin and tuna-like fishes was estimated to reach 17 868 tons in 1980 compared to 13 000 tons in 1976 (+ 37 %). From Table 50, we can see that production of tuna (yellowfin) and tuna-like fishes (others) remain at a constant level during this period ; so the increased catch only comes from one species : skipjack.

Years	Skipjack	Tuna	Others	Total
1976	7 044	1 336	4 639	13 019
1977	8 650	1 712	4 520	14 882
1978	8 665	2 090	2 592	13 347
1979	9 994	2 081	3 716	15 792
1980	12 157	2 220	3 491	17 868

Table 50 - Production of tuna in Maluku, from 1976 to 1980.

Production of each of the four districts of the Maluku Province is given per species and per gear in Table 51. 95 % of the total catches come from three districts : Maluku Utara (North Maluku), Halmahera Tengah and Maluku Tengah, which are the more populated ones.

Years	Skipjack	Tuna	Others	Skipjack	Tuna	Others
District	Maluku Utara			Halmahera Tengah		
1976	2 629	807	1 021	1 897	77	1 078
1977	4 236	1 060	794	1 848	310	1 264
1978	4 643	1 241	900	1 392	383	264
1979	3 822	912	1 044	2 308	498	591
1980	4 787	714	707	3 301	794	567
District	Maluku Tengah			Maluku Tenggara		
1976	2 263	408	2 381	353	44	167
1977	2 139	299	2 248	466	43	214
1978	2 135	407	1 115	496	60	312
1979	3 350	609	1 756	515	62	324
1980	3 534	627	1 877	535	65	337

Table 51 - Production of tuna per species and district in the Maluku Province, from 1976 to 1980.

Tuna-like fishes are caught by four kinds of gears which are "Pukat pantai", "Pukat Cincin", "Huhate" and "Pancing Tonda", that is beach seine, purse seine, pole and line and trolling respectively ; yellowfin is caught mainly by pole and line (75 %) and trolling (25 %), and skipjack by pole and line (85 %) and trolling (7 %) (Table 52).

	1976			1977		
	Skipjack	Tuna	Others	Skipjack	Tuna	Others
1			240			434
2			1 203			1 056
3	5 470	525	719	7 829	1 306	591
4	740	379	950	808	263	2 179
5	834	432	1 527	12	143	261
Total	7 044	1 336	4 639	8 649	1 712	4 520

	1978			1979		
	Skipjack	Tuna	Others	Skipjack	Tuna	Others
1			597			229
2			88			855
3	7 341	1 578	297	8 695	1 535	504
4	976	496	1 304	1 207	438	1 781
5	349	17	306	93	109	347
Total	8 666	2 091	2 592	9 995	2 082	3 716

	1980		
	Skipjack	Tuna	Others
1	320	43	889
2			211
3	10 003	1 534	356
4	833	394	1 220
5	1 002	249	817
Total	12 158	2 220	3 493

1 = Pukat Pantai = beach seine
2 = Pukat cincin = purse seine
3 = Huhate = pole and line
4 = Pancing Tonda = trolling
5 = Lainya = other gears

Table 52 - Production of skipjack, tuna (yellowfin) and tuna-like fishes in Maluku, according to the gears used (years 1976 - 1980).

Number of pole and line vessels has doubled between 1976 and 1980 from 35 to 74. They are based in the major cities of the province : Ambon in Maluku Tengah and Ternate in Maluku Utara. The number of artisanal pole and line vessels, bigger than 10 GT, is given for the four districts in Table 53. This Table does not include the "Funai", small pole and line boats usually 5 GT, which can be numerous especially in Ternate and Halmahera.

	1976	1977	1978	1979	1980
Maluku Utara	19	21	24	25	23
Halmahera Tengah	2	2	1	1	
Maluku Tengah (including Ambon)	14	11	41	41	51
Maluku Tengarra	-	-	-	-	-
Total	35	35	66	67	74

Table 53 - Number of artisanal pole and line vessels, per district, in Maluku Province (1976 - 1980).

Fish is consumed locally, smoked or fresh, but, since 1978, a larger quantity is exported frozen from Ternate and Ambon. Exports in volume and value are given in Table 54 from 1976 to 1981.

	Ternate		Ambon		Total	
Years	Volume	US $ x 10^3	Volume	US $ x 10^3	Volume	US $ x 10^3
1976	1 763	771			1 763	771
1977	1 355	725			1 355	725
1978	1 620	817	345	179	1 965	996
1979	1 535	1 134	730	534	2 265	1 668
1980	3 828	3 405	1 187	1 307	5 015	4 712
1981	5 265	4 409	2 200	2 299	7 465	6 808

Table 54 - Exports of tuna from Ternate and Ambon, in volume (metric ton) and value (10 000 US $), from 1976 to 1981.

11.1. Artisanal pole and line fishing in Ternate.

Pole and line fishing in Ternate is a very old activity. During world war II, this small island had a factory of Katsuoboshi. Ternate is now the base of a joint venture company, P.T. East Indonesia Fishery which operate with two industrial pole and line vessels, 200 GT, and one 600 GT purse seiner (see chapters 7 to 9), and which possess a cold storage 400 T capacity.

Artisanal tuna fishing is done there by two kinds of boats :

- "Huahate", which are of a same type as those based in Aertembaga and Kendari, usually more than 12 GT.
- "Funaī", which are small pole and line boats 5 GT.

"Huhate" are all based in Ternate, 20 boats in 1982, most of them are not used regurlarly ; an average of 6 to 14 boats were in regular operation each month during the period 1976-1981.

Tuna fishing is done in the vicinity of Ternate Island and Tidore and between those islands and Halmahera where bait is caught. Bait is caught by beach seine ; 25 to 30 baskets (2 kg of fish/basket) are used every day for each one day trip and come generally from one beach seine. Bait is concentrated near the beach with a lamparo before setting.

Best fishing period occurs generally from March to June and in September-October. Lower catch occurs between November and January but there are great variations from year to year.

The average yearly catch by fishing ranges between 300 and 700 kg per fishing day ; the year 1981 was considered to be particularly poor, for it was not the case in the very close area of Aertembaga. The statistics of catch and effort from the fishery office in Ternate are given in Table 55. They must be used with precautions, as we have not well understood how they were obtained.

Years	Total catch (SK + YF)	Fishing effort in days	CPUE tuna kg	CPUE bait kg
1973	860	1 414	608	
1974	923	1 311	704	
1975	1 082	2 081	520	
1976	1 356	1 960	692	51
1977	1 187	1 703	697	54
1978	1 258	1 961	641	34
1979	1 324	2 018	656	58
1980	1 153	1 874	615	44
1981	483	1 556	311	36

Table 55 - Catch and effort of "Huhate" in Ternate.

Systematic enquiries have been done in 1980 and more accurate statistical data on catch per species were obtained ; they are given in Table 56. We can see two peaks of production for skipjack in March-April and in October-November. The high catches of yellowfin were obtained in January-February.

The catches of Eastern little tuna are done all year long, particularly between October and April, but in very small quantity.

1980	Fishing days	SK	YF	Frigate T.	E.L. Tuna	Total	Catch by day
J	107	34,9	23,1	0,7	5,4	68,6	641
F	124	52,3	20,1	1,0	0,1	73,6	593
M	212	120,9	6,5	-	2,5	129,8	612
A	198	172,4	4,1	0,2	1,4	178,2	900
M	180	64,9	3,9	-	0,2	68,9	383
J	131	64,0	2,7	0,2	0,0	66,9	510
J	147	65,9	1,2	-	0,5	67,7	460
A	167	68,2	3,5	0,1	0,1	71,9	430
S	122	45,7	0,6	-	0,3	46,6	381
O	221	139,1	11,4	-	2,0	152,5	687
N	151	170,4	8,4	-	0,9	179,6	1 185
D	79	14,6	4,0	1,0	1,3	20,9	264
Total	1 839	1 013,3	89,7	3,2	14,7	1 120,9	609

Table 56 - Composition of catch per fishing day for artisanal pole and line boats in Ternate (year 1980).

"Funaï" are smaller pole and line boats 5 GT . They also do one day trip to get their bait (8 to 15 buckets of 2 kg) using beach seines on the coast of Halamera. The engines are 22 to 36 HP in board ; the number of crew is ten. The average catch per day ranges between 200 and 300 kg. No precise statistical data are available for those boats, which operate from many different bases. The principal ones are Ternate, Soasiu (Tidore Island), Jailolo, Susupu in Halmahera, Labuha in Bacam Island and Sanana in the Sulabesi Island (Fig. 44).

Statistical data of the "Funaï" landing in Ternate were available for the year 1980 and are given in Table 57. All the catches are skipjack tuna which may have a very small size as we have seen in October 1982 where almost all the fishes were 34 to 40 cm, less than 1,5 kg each.

1980	Number of trips	SK	YF	Frigate Tuna	E.L. Tuna	Total Ton	Catch by trip kg
J	7	1,42	-	-	-	1,42	203
F	11	1,96	0,04	-	-	2,00	182
M	8	1,86	-	-	-	1,86	232
A	100	38,39	0,12	-	-	38,51	385
M	178	40,00	0,47	0,01	-	40,49	227
J	150	36,28	0,08	-	-	36,36	242
J	59	14,02	-	-	-	14,02	238
A	126	34,79	0,07	-	-	34,86	277
S	46	10,46	-	-	-	10,47	228
O	23	5,41	-	-	-	5,41	235
N	55	22,42	-	-	-	22,42	407
D	34	6,67	-	-	-	6,67	196
Total	797	213,69	0,77	0,01	-	214,48	269

Table 57 - Composition of catches and catch per trip of "Funaï" in Ternate.

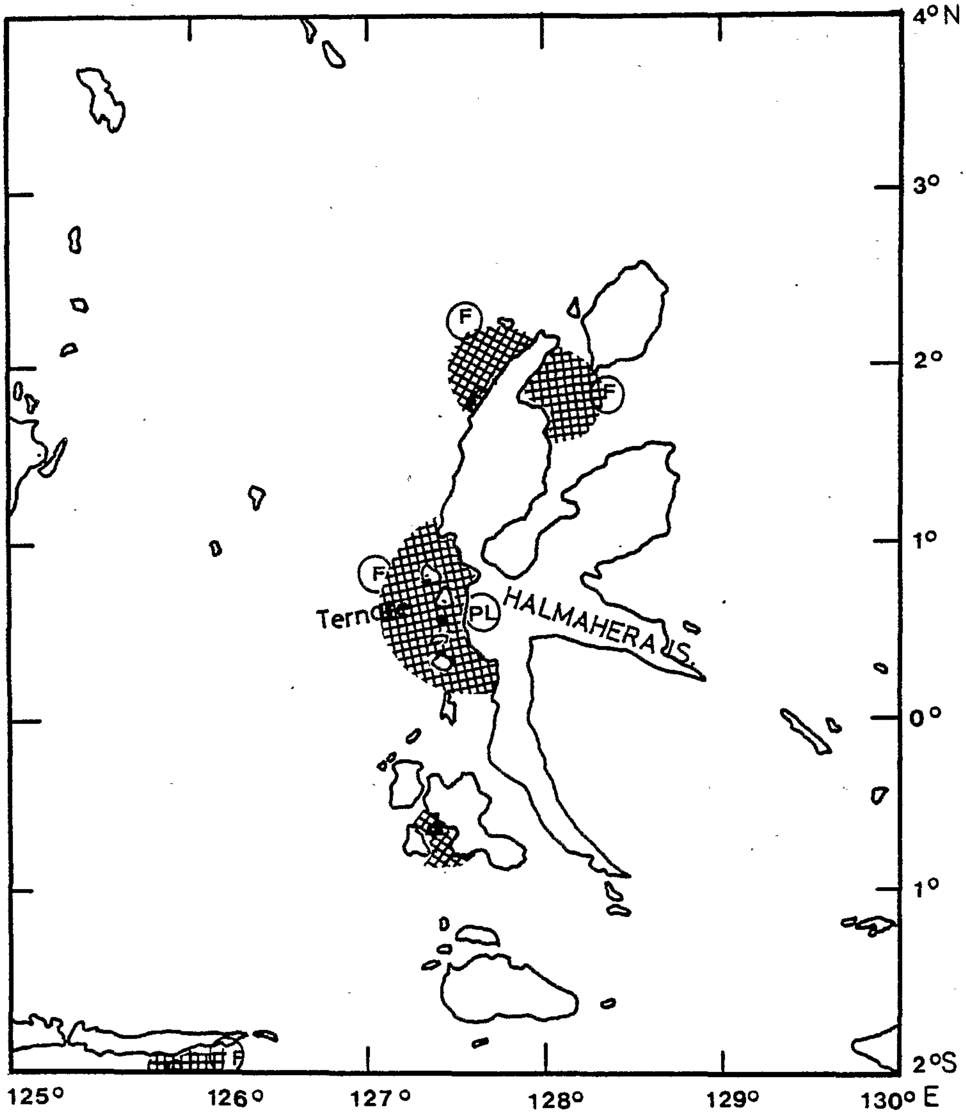


Figure 44 - Present fishing grounds for skipjack exploited by pole and line boats (PL) and "Funaï" (F) near Ternate and Halmahera.

- Secteurs de pêche de listao exploités par les canneurs du type "Huate" (PL) ou "Funaï" (F) dans la région de Ternate et Halmahera.

11.2. Pole and line fishing in Ambon.

Fishing grounds near Ambon have been known for many years. The Dutch had developed there a fishing enterprise "Stitching Voor de Zee Vissery" which became, after independence, the "Yayasan Perikanan Laut" and then the State Enterprise P.N. Perikanan Maluku. This enterprise has developed shrimp and tuna fishing ; the base is located in the Ambon bay which is an exceptional natural harbour where P.N. Perikanan Maluku possess a cold storage 500 tons capacity with two brine tanks of 2 X 25 tons per day, and an ice factory 50 tons/day.

11.2.1. The fleet.

The State Enterprise has 10 pole and line boats 30 GT since 1979 up to now and was expecting to begin operations in 1982 with two vessels 100 GT and one 300 GT to be used as mothership or catcher. Additional 10 pole and line boats belong to cooperatives and 17 to the private sector.

Almost all vessels have the same caracteristics :

length	18,5 m
width	4,0 m
draft	1,2 m
gross tonnage	30 GT
H.P.	165 H.P. in board diesel
Max speed	9 knots
bait capacity	50 buckets, 2 kg each
fish tank capacity	4 tons in ice
autonomy	6 - 7 days
crew	15

The catch and effort data of the pole and line fishery in Ambon are given in Table 58 (from J. UKTOLSEJA). Annual production was 600 to 800 tons for 6 to 7 vessels in operation during the period 1951 to 1967 with an average yearly catch by boat of 117 tons.

Year	Number of bait-boats operating	Total catch, tons	Average catch per bait-boat per year
1951	4	465,4	116,3
1952	4	485,3	131,3
1953	7	709,0	101,3
1954	8	643,6	80,4
1955	8	801,4	100,4
1956	7	692,9	99,0
1957	6	774,1	129,0
1958	6	775,4	129,2
1959	6	776,2	129,4
1960	6	811,7	135,3
1961	6	810,4	135,1
1962	6	786,1	131,0
1963	6	621,4	103,6
1964	5	634,9	127,0
1965	7	794,9	113,6
1966	8	974,3	121,8
1967	7	787,0	112,4

Table 58 - Annual catches, effort and CPUE of the pole and line fishery in Ambon, 1951-1967 (in metric tons).

Statistical data of catch and effort during the period 1968 to 1981 are given in Table 59 for the State Enterprise and the other sectors.

Years	Cooperative and private company Total catch	P.N. Perikani Maluku (State Enterprise)			Total catch
		Catch (tons)	Effort (days)	Catch by day	
1968	302	473	1 131	418	775
1969	161	450	1 011	445	611
1970	204	657	1 022	643	861
1971	755	773	962	804	1 528
1972	1 075	1 067	1 014	1 052	2 142
1973	691	944	1 258	750	1 635
1974	611	616	985	626	1 227
1975	656	546	834	655	1 202
1976	615	682	848	805	1 287
1977	996	501	748	670	1 497
1978	1 686	944	1 390	679	2 630
1979	1 557	1 069	1 577	680	2 626
1980	1 115	994	1 487	669	2 109
1981	no data	1 205	1 437	838	

Table 59 - Catches, effort and CPUE of the pole and line fishery in Ambon (number of days is number of fishing days after the bait being caught).

Data on fishing efforts were only available for the State Enterprise. Average annual catch per fishing day is 700 kg with very little variations from year to year if we except very low catches in 1968-1969 and very high CPUE in 1972 (Table 59).

The main problem that limits the catch in Ambon, as it does very often in Aertembaga, is the availability of the bait.

11.2.2. Fishing grounds.

Most of the vessels of the cooperative and of the private sector buy the bait needed from artisanal fishermen who get it at night with lampara net. However, because of the increasing number of vessels to provide and also probably because of the night fishing effort done in the bay by raft lift nets, the quantity of bait becomes not sufficient for the present fleet of pole and line boats.

It is one of the reasons why the State Enterprise vessels are more and more developing fishing in the North West coast of Ceram (Fig. 45), where good bait fishing ground can be found near tuna fishing grounds. Bait fishing is done there at night by each boat with a boke ami.

In 1980, 39 % of the catch of the State company were done near Ambon and 19 % of the bait was bought in the Ambon bay : 4.7 % of the catches and 27 % of the bait come from South Ceram Selatan, 56.3 % of the catches and 54 % of the bait come from North West Ceram.

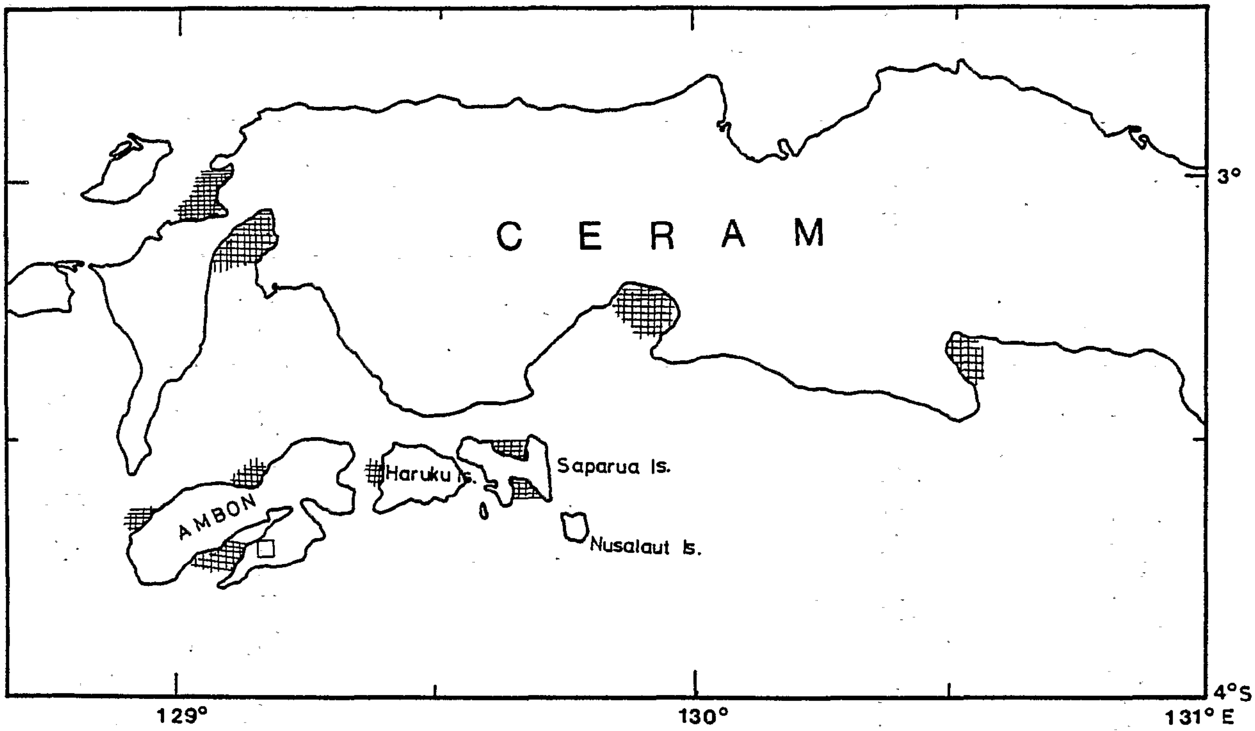


Figure 45 - Bait fishing grounds near Ambon. - Secteurs de pêche d'appât vivant près d'Ambon.

In 1981, 22 % of the bait was bought in Ambon bay, and 78 % was caught directly with boke ami, 27 % in South Ceram and 51 % in the West. Tuna catch comes for 13 % from the vicinity of Ambon, 22 % from South Ceram and 65 % from the North West coast of this island.

Usually, fishing occurs in Ambon and the South of Ceram during the North wind period, between December and March, and in the North West coast of Ceram during the South East monsoon, between May and October.

Duration of the trips for each vessel is usually 5 to 7 days, out of which 30 to 40 % is lost in transit between the base and the fishing grounds and 5 % to 15 % because the bait was not available (Table 60).

11.2.3. Size of the fish.

The fish is 47 to 55 cm long all year long therefore bigger than in Ternate, but with a lower average size during the West moonsoon period.

Fishes 30 to 40 cm long can also be caught by pole and line boats operating near Ambon and particularly between Ambon Island and Ceram.

11.3. Conclusions.

The main problem for a further development of pole and line fishery from Ambon, is the availability of the bait. Improving the catch may only be done by trying to decrease the time spent in transit. Trips are already 5 to 7 days and cannot be extended because of the limited autonomy of the vessels and because the quality of the fish would not be convenient.

Months / Years	1979	1980	1981	1982
J	45	24	35	49
F	47	22	44	49
M	48	29	43	45
A	53	33	45	47
M	48	40	40	54
J	19	39	38	58
J	37	46	38	
A	35	49	52	
S	33	28	41	
O	38	33	40	
N	37	36	35	
D	41	34	43	
Total operating days	2 637	2 276	2 440	(1 089)
Total fishing days	1 561	1 487	1 437	(545)
Lost transit and no bait: in %	1 076 40,8 %	789 34,7 %	1 003 41,1 %	(544) 50,0 %
Tuna catch by operating day	405	437	494	(333)

Table 60 - Estimation of the time lost in transit or because bait is not sufficient, per month (in %).

Improvement of the quality of the fish can easily be done by using middle size freezing carriers anchored near the fishing ground where the vessels could unload the fish every day or two. However, the use of a mother ship will only improve the catch if the duration of the trip of the catcher boats increase significantly. As bait fishing is usually not efficient during the full moon time, the optimal duration of a trip average 22 days between the two full moon periods. In order to do this, catcher boats should have to be provided in fuel, ice, and water by the mother ship.

12. ARTISANAL POLE AND LINE FISHERY IN SULAWESI.

Tuna fishing is a very old activity in Sulawesi and especially pole and line fishing which has been probably first introduced by the Japanese in 1918 to process Katsuobushi or "Ikan Kayu" in the North of the province. At the present time, pole and line fishing is developed in two areas :

- In North Sulawesi where the main tuna fishing base is located in Aertembaga near Bitung.

- In South East Sulawesi in the town of Kendari, where this activity is more recent.

12.1. North Sulawesi.

The total number of pole and line boats was estimated to 66 in 1981, out of which 60 were based in Bitung, 3 in the district of Minahasa, 1 in Gorondalo and 2 in Manado.
The distribution of the size of the vessels for 1981 is given as follows (in GT) :

0 - 5	GT	=	1
5 - 10	GT	=	3
10 - 20	GT	=	18
20 - 30	GT	=	11
30 - 50	GT	=	32
200	GT	=	1

One 200 GT pole and line boat is used as a carrier boat. In the category 30-50 GT, all the vessels are of the same model, wooden boats of 30 GT built in Banyuwangi, and 30 of them belong to the State Company P.N. Perikani Aertembaga. The main source of data available is this company and will be presented now.

12.1.1. The fleet.

From 1967 and 1977, the State Company had 10 to 12 vessels in operations, however, from 1973 to 1978, due to mis-management the number of days of operation at sea was very low. The fleet has been increased to 20 boats in 1979 and since 1980, 30 vessels are in regular operations. All vessels have same caracteristics as follows :

length	18 m
width	4 m
draft	1,55 m
G.T.	30 GT
max. speed	9 kts
H.P.	165 H.P. Diesel
capacity	5 tons of ice
crew	18

12.1.2. Fishing operations.

The bait is collected every day from artisanal fishermen using lift nets. When bait fishing is good, one boat can obtain its needed 40 to 50 baskets (2 kg each), on the same lift net ; however, they usually need to get it from 3 to 6 different ones and sometime from as much as 10 to 20. The bait is never bought but the owners of the lifts nets get the equivalent of 20 % of the catch of the boat they supply. Trips can be 2 to 7 days long according to the quantity of tuna caught. The average number of days per trip was 3.0 in 1980, a year with a high average catch per day fishing, and 4.1 in 1982, which is a more common average annual value. Average percentage of the number of days at sea lost by lack of bait range from 13 % to 19 % depending on the year. It can be seasonally very high, especially from December to February and in July and August. Ever since 1979, the average number of days at sea per boat in operation ranges from 180 to 210. Those values are much higher than during the period 1972-1978, but could yet be improved.

12.1.3. Fishing grounds.

Fishing grounds for tuna are usually North West Sulawesi from June to August and in the South from September to May. Decision to go North or South depends on the strength and direction of the wind which may easily prevent fishing in good conditions for such small boats.
We present, in Figure 46, the main fishing grounds in 1981 according to the months ; we can see that fishing occurs almost all year long near Aertembaga in the South and East.

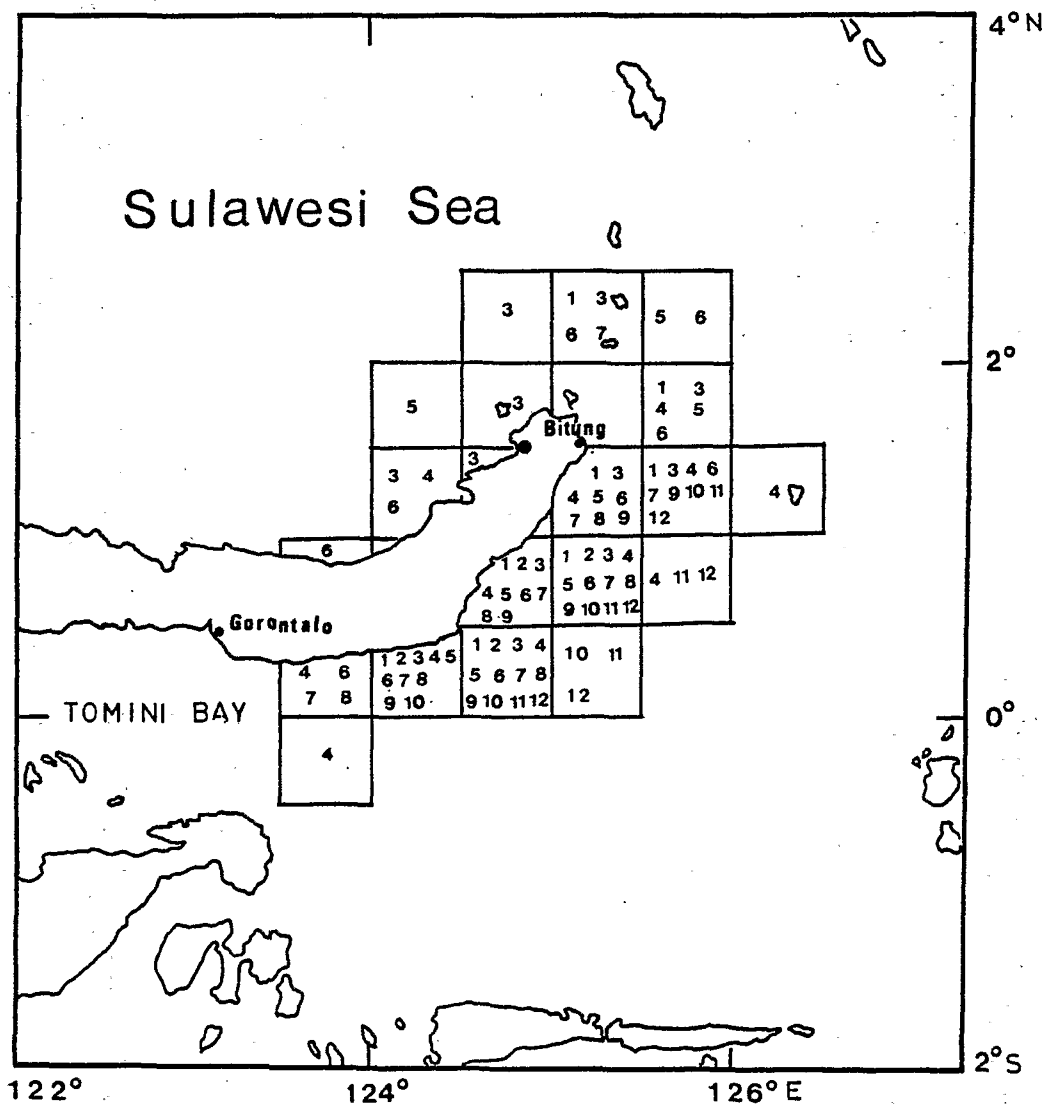


Figure 46 - Fishing grounds of the pole and line boats based in Bitung during the year 1981. The numbers indicate the months when fishing occurs.

- Secteurs de pêche des canneurs basés à Bitung en 1981. Dans chaque secteur les chiffres indiquent les mois où des pêches y sont faites.

Up to 1971, and since 1979, the major fishing grounds for bait were located near Aertembaga and Bitung and along the Western coast where the number of fixed lift nets averages 600. Between those two periods due to the bad relations between the company and the owners of the lift nets, the bait had to be purchased in Gorondalo district. As tuna is more abundant and bigger outside the Tomini Golf, a lot of time was lost during this period in non-productive trips and in transit between bait and tuna fishing grounds which also increased the mortality of the baits.

Fish aggregating devices have been experimented by the company in 1981. 13 FAD have been set and were all lost after 3 to 5 months. Since January 1982, 4 FAD are used regularly and 80 to 85 % of the total catch from January to August 1982 comes from those FAD.

12.1.4. Catch statistics and catch per unit effort.

We present, in Table 61, the yearly total catch and catch per unit effort, CPUE of all the 30 GT vessels of the State Company and, for comparison, the total catch and CPUE of the small scale companies (cooperative companies).

Years	Small scale companies			P.T. Perikanan Aertembaga (30 GT)			
	Total catch tons	Fishing days	CPUE kg	Total catch tons	Fishing days	CPUE kg	Average weight 1 fish
1966	1 151						
1967	1 650			1 283	2 421	530	2,6
1968	2 034			1 404	2 162	649	2,9
1969	1 942			1 517	1 790	847	2,5
1970	1 525			1 570	1 651	951	2,5
1971	2 246			1 332	1 762	756	2,5
1972	2 487	4 860	511	598	1 523	393	2,2
1973	3 238	5 590	579	502	1 134	442	2,1
1974	1 413	2 645	534	657	1 356	484	2,0
1975	2 119	3 552	596	613	1 144	536	1,9
1976	1 641	2 365	694	408	819	498	2,5
1977	1 513	1 872	808	339	451	752	2,7
1978	1 614	2 398	673	265	457	580	2,4
1979	2 225	2 119	952	2 149	2 964	725	
1980				3 737	3 439	1 087	
1981	1 963			2 925	4 278	684	
1982*	685	974	703	1 196	1 746	685	2,0

Table 61 - Catch and catch per unit effort of the 30 GT vessels in Aertembaga and catch and CPUE of the small scale companies (1966-1982) - January to June -

Actual total catches and CPUE may be slightly higher (5 to 10 %) as some fish is usually kept by the crew for personnal consumption an/or selling. This proportion was probably higher in the State Company during the period 1972-1978, but estimations are not possible.

The evolution of CPUE is given in Fig. 47 from 1967 to 1982. High CPUE were obtained in 1969, 1970 and 1980, and lower ones from 1972 to 1975. The average value is about 750 kg/fishing day (day with or without catch).

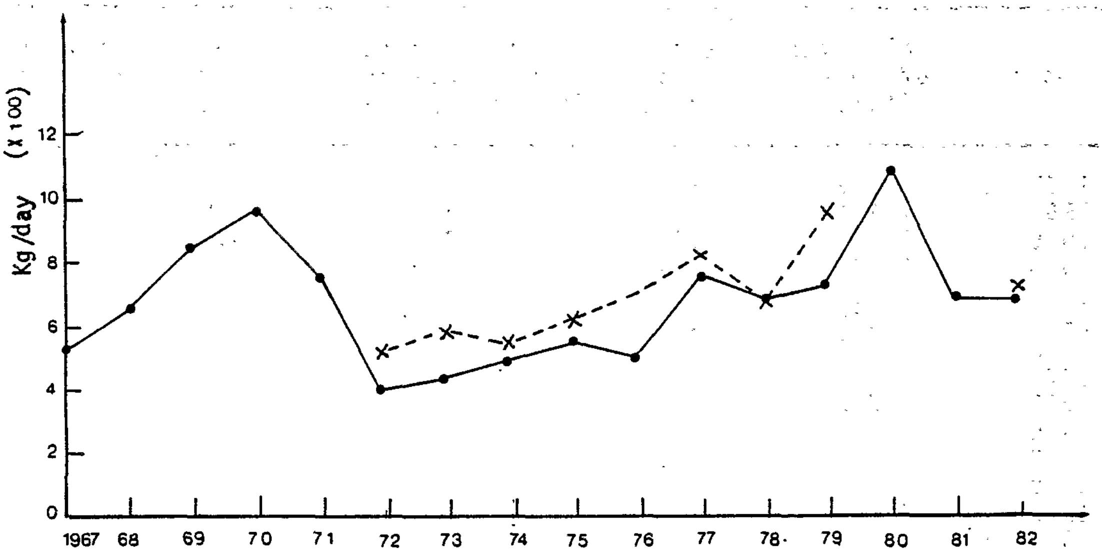


Figure 47 - Evolution of CPUE, in kg of tuna fishing day, in Bitung-Aertembaga 1967-1982

. P.N. Perikani Aertembaga (State enterprise)

x Small scale companies (private and cooperative sector).

- Evolution de la prise par unité d'effort, en kg de thon pêché par jour de pêche, à Bitung-Aertembaga, de 1967 à 1982.

. P.N. Perikani Aertembaga (entreprise d'Etat)

x autres petites compagnies privées ou du secteur coopératif.

CPUE is determined by two factors : the quantity of bait available each day for fishing and the response of the fish to the bait (good or bad biting). With this in mind, the index of the quantity of tuna caught per kg of bait could be better appreciated as an index of abundance. The yearly value of this index is given in Table 62 and Fig. 48.

As this estimation of the quantity of fish caught from 1972 to 1978, is expected to be at least slightly off, it is very difficult to analyse the resulting evolution. The index seems to slightly decrease from the period 1967-1971 to the period 1979-1982, from 8,7 to 8,0 (about 8 %). However, this is not significant since the new method of fishing on FAD has been introduced in 1981 and is now responsible for about 80 % of the catch in 1982.

The CPUE can vary widely from month to month so does the quantity of fish caught per kg of bait. These monthly variations range from 1 to 5.

The average monthly CPUE of tuna, quantity of tuna per kg of bait and average quantity of bait available per fishing day are given for the average years 1967-1980. This calculation smoothes the actual month to month variations but shows the average seasonality of the fish or bait in the area (Fig. 49).

- There are two maxima in the CPUE : one from April to June and one in October November (both subject to annual variations).
- Catch of tuna from December to March is usually lower.

Years	Total catch of tuna (tons)	Catch of bait (tons)	Quantity of bait available by fishing day (kg)	kg tuna per kg of bait	Days lost no bait in %
1967	1 283	190	78	6,8	
1968	1 404	143	66	9,8	
1969	1 517	167	93	9,1	
1970	1 570	169	102	9,3	
1971	1 332	156	89	8,5	
1972	598	137	90	4,4	
1973	502	98	86	5,1	
1974	657	120	88	5,5	
1975	613	115	101	5,3	
1976	408	65	79	6,3	
1977	339	59	131	4,9	
1978	265	54	118	4,8	
1979	2 149	289	97	7,4	15,9
1980	3 737	339	99	11,0	13,4
1981	2 925	424	99	6,9	18,9
1982*	1 796	257	115	6,8	18,8

* January to August.

Table 62 - Index of abundance of tuna and bait in Aertembaga (data from State Enterprise).

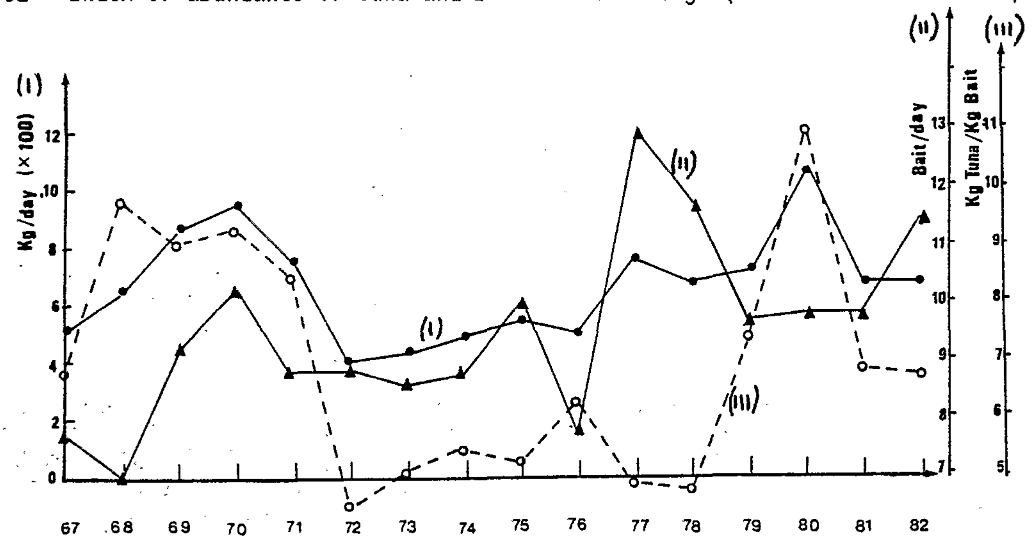


Figure 48 - Evolution of CPUE of tuna, of bait available by fishing day and of quantity of tuna caught by 1 kg of bait, from 1967 to 1982.

- Evolution du rendement en thon (en kg par jour de pêche), de la quantité d'appât disponible par jour de pêche et de la quantité de thon pêché par kg d'appât, de 1967 à 1982.

- The biting rate for skipjack is high from November to January and from April to June that is during seasonal transition periods and it reaches a low in February-March and from July to October during the West and East monsoon seasons.
- The quantity of bait caught is low from December to January ; during the period 1979 to 1982, 20 % of the days at sea were lost due to lack of bait. It is also low in July and August (on the average 19 % and 24 % days lost respectively). The best period is in September to November (12 % days lost only).

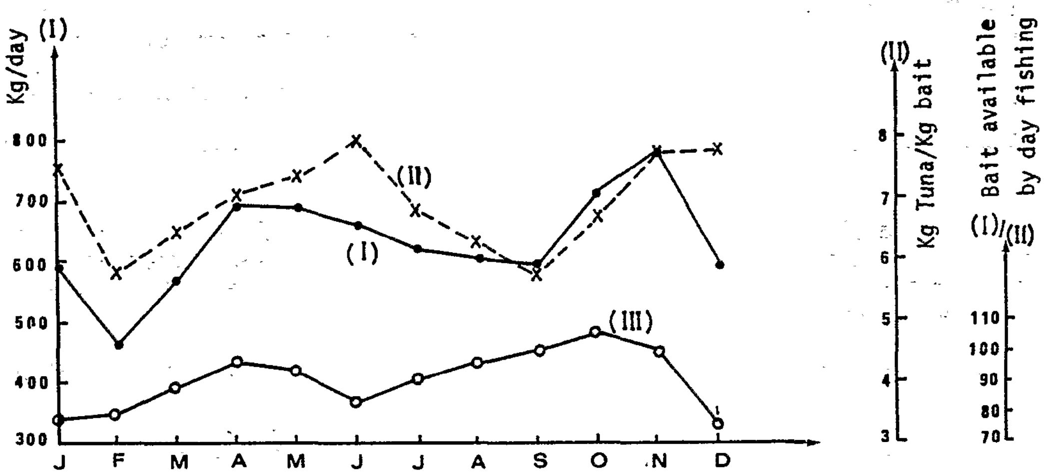


Figure 49 - Average monthly CPUE of tuna during the years 1967-1980 (I) ; average quantity of tuna caught by kg of bait (II) ; average quantity of bait available by fishing day (III).

- Prise mensuelle moyenne de thon par jour de pêche durant la période 1967-1980 (I) ; quantité de thon pêchée par kg d'appât (II) ; quantité moyenne d'appât disponible par jour de pêche (III).

The reason for the yearly and monthly variations in biting rate cannot be analized here as we have no accurate informations on either the composition per species of the bait or its size.

12.1.5. Comparison of the catch made on FAD and in the open sea.

From enquiries made in P.N. Perikani Aertembaga, it was estimated than 80 % of the catch during the period January to June 1982 had been taken from the four FAD set off Pondong. During this period, the pole and line vessels armed by small private companies or cooperatives were operating in the open sea. Both CPUE in catch per fishing day are given in Fig. 50.

No clear difference appears in terms of total catch. On the contrary, the composition of the catch is different when fishing on FAD. In the open sea almost 100 % of the fish is skipjack ; on FADs 90 % is skipjack and about 10 % yellowfin.

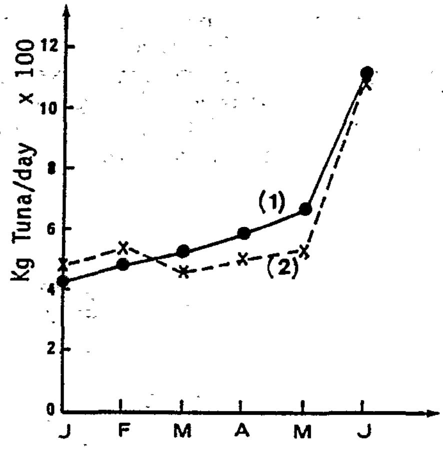


Figure 50 - Comparison of CPUE on "payao" (1) and in the open sea (2), from January to June 1982.
- Comparaison des rendements obtenus sur les "payaos" (1) et sur les bancs non associés aux payaos (2), de janvier à juin 1982.

From the data available we estimate that the average individual weight of fish is 2.0 kg on FAD and 2.4 kg from the open sea. This slight difference has a great commercial importance as, on the international market, the price of the fish weighing over and less than 2 kg is very different and lower for the smaller fish.

A fishing master of the State Company has estimated the size composition of skipjack to be :

- 80 % 1,5 to 2,0 kg, and 20 % more than 2 kg, on FAD
- 20 % --- , and 80 % --- , in the open sea.

On the basis of this composition, the introduction of FAD would reveal itself uneconomic for exports, furthermore as the yellowfin, amounting to 10 % of the catch on FAD, is a very small fish, 2 kg piece, and must be sold locally.

In fact this problem of catching too small a fish could probably be solved by setting the FAD further off shore than they are at present.

The main advantage of using FAD is the reduction of the time lost in the search for schools and the resulting lower consumption of fuel, as fishing on FAD is mainly done in the morning and allows vessels to stop activity the remaining day. This fuel saving has been estimated to reach 30 % since the introduction of FAD.

As mentionned earlier, the use of FAD may also allow simultaneous introduction of artisanal hand line fishing with small chances of catching deep bigeye tunas and yelllowfin of larger size.

12.2. Tuna pole and line fishery in Kendari (South East Sulawesi).

Kendari is located in the province of Sulawesi Tenggara. The three tuna producing districts of this province are Kendari, Bau Bau and Kolaka. The annual production of those districts are given in Table 63 for the period 1979 to 1981. Starting at 890 tons in 1979, the total catch reaches 2 000 tons in 1981. This estimation may be under estimated as the skipjack production in the Kendari auction reached 950 tons in 1980 and 1 730 tons in 1981.

The number of tuna boats has increased from 13 to 24 in 1978 and 1979 to 54 and 57 in 1980 and 1981.

The fish is usually sold locally at a very low price : 136 Rp/kg in 1980 and 146 Rp/kg in 1981. Part of it is transformed in a small Katsuobushi factory (77 tons net production in 1981) and some fish is kept in two cold storage, 350 t and 600 t capacity, for export.

Years \ Districts	Kendari	Bau Bau	Kolaka	Total
1979	234	20	638	893
1980	856	134	539	1 529
1981	1 402	71	550	2 023

Table 63 - Production of tuna per district in tons (Sulawesi Tenggara).

The bait is caught by raft lift nets but not by fixed lift nets as in Aertembaga ; one of them may provide 1 or even more boat. A few pole and line boats also use night light fishing with boke ami. Agreement exist between owners of raft lift nets and pole and line boat operators, such that, according to location of the fishing grounds, the raft lift nets may be transfered from one area to another one closer to the fishing ground.

The fishing grounds are usually located near Kendari, as no frigorific system is used, and trips are one day long.

According to enquiries done, the best fishing seasons are June-July and October to December-January. Lower catch usually occurs in August-September because of strong Eastern winds. During this period a few vessels may operate in Western areas such as Bone Gulf in the vicinity of Kolaka.

12.3. Conclusions.

Because of bait provision, problems in Aertembaga and along the South East coast of Sulawesi Utara, increasing fishing efforts in the area of Aertembaga must very cautiously be made. One mean of developing the pole and line fishing could be to operate a new kind of vessel able to stay a longer time at sea fishing its own bait, using the boke ami system, and able to operate in areas as far as the North of Sulawesi Tengah or Taliabu Island as well as the Bacan area in the South of Halmahera.

The bait seems to be more abundant in Kendari area, and there, 30 GT vessels, as those used in Aertembaga, could be introduced to develop fishing off the Buton and Muna Islands. However, an ice plant must previously be set up in Kendari. The present number of boats, about 50, could probably be doubled to similarly increase the production. As the local market is very limited, and local prices very low, production must be developed there mainly for export market.

In both areas, the use of FAD may be tested. We have seen that in North Sulawesi those systems work well and that the small fish which is caught may be sold locally. However, since the market in South East Sulawesi is much more limited, the development of FAD will slightly create problems of over production of unexportable fish.

At least, those systems, which have only been tested in areas very near the shore, should be tested further off shore in order to aggregate bigger fish. Doing so, night purse seine on FAD could be introduced in both areas as well as hand line artisanal fishing.

13 - TUNA FISHING ON "ROMPONG" IN THE NORTH OF SULAWESI.

"Rompong" is a traditional floating fish shelter used to concentrate pelagic fishes which can be caught by drift surface gill nets or by hand lines. Each Fish Aggregating Device (FAD) is made of a bamboo raft, 12 to 15 metres long, fitted by a 12 cm rattan rope and anchored with stones at a depth of 500 metres to 2 000 metres.

Tuna fishing is done with vertical hand line near the rafts. The catchers are small boats "perahu" with outboard motor 8 to 15 HP and two fishermen. One trip is usually 2 to 3 days ; fishing is done mainly at night at depth 20 to 200 m. The catches are collected by carrier boats operated throughout joint venture between P.N. Perikani Aertembaga and P.T. Sumber Mina Raya. Sometimes, non motorised pirogues may also operate.

In 1981, the number of rompongs in the Gorondolo district was estimated to be 210 units, 100 of them located off Tilamuta. From one to four boats may catch fish on one unit.

For many years, rompong fishery has been developed in the Gorondalo district, a province of North Sulawesi. Rompong are located in the North of Tomini Gulf on the Southern coast, off Popayato, Marisa, Tilamuta and Paguyaman.

The tuna catch statistics of the cooperative of Tilamuta are given in Table 64. This represent 20 to 40 % of the total tuna catch done on rompongs in district. No data on fishing efforts were available. The size of the yellowfin is 30 to 40 kg/piece.

<table>
<tr><th>Years</th><th>Bigeye</th><th>Yellowfin</th><th>Skipjack</th><th>Eastern Little Tuna</th><th>Total</th></tr>
<tr><td>1979</td><td colspan="2">151</td><td>24</td><td>31</td><td>206</td></tr>
<tr><td>1980*</td><td colspan="2">127</td><td>8</td><td>7</td><td>142</td></tr>
<tr><td>1981**</td><td>76</td><td>131</td><td>8</td><td>4</td><td>219</td></tr>
<tr><td>1982***</td><td>61</td><td>68</td><td>4</td><td>10</td><td>143</td></tr>
</table>

* 9 months
** 10 months
*** January to May.

Table 64 - Tuna production of the cooperative in Tilamuta (K. Gorondalo) (Tempat Pelelangan Ikan).

The best fishing season for bigeye and yellowfin (about half of the production for each species) occurs from February-March to May and in October-November i.e. between each monsoon period (Fig. 51).

Experimental pole and line fishing near rompongs has been developed with some success in March 1982 by two pole and line boats. According to Y. OGAWA, the rompong fishing in this area could reach 2 000 tons of skipjack and the same quantity of yellowfin and bigeye as well as some 2 500 tons of other pelagic fishes.

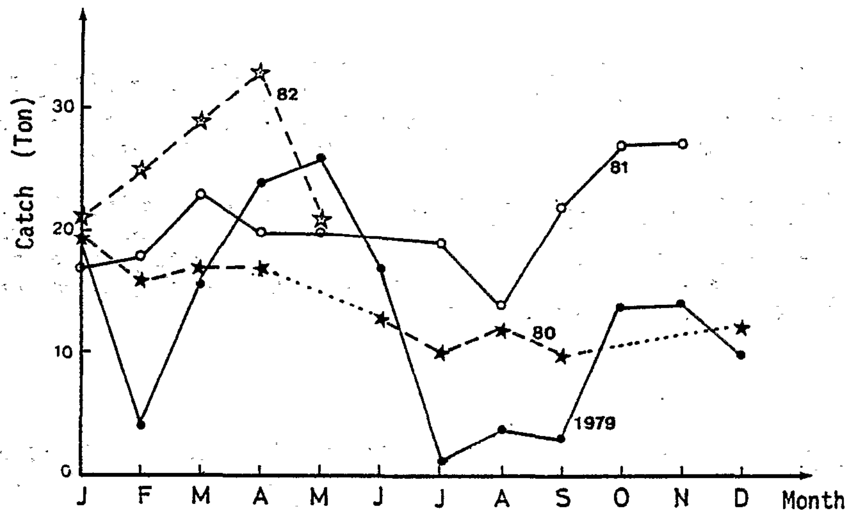


Figure 51 - Evolution of monthly catch of tuna (bigeye and yellowfin) by the hand line fishery on "rompang" in Tilamuta (from cooperative T.P.I.).

- Evolution mensuelle des prises de thon (patudo et albacore) par les pêcheurs à ligne à main opérant sur les "rompang" de Tilamuta (Source : coopérative TPI).

Fishing on rompong is also traditional in Central Sulawesi and it is the most developed method to catch pelagic fishes such as trevallies, skipjack, small and large yellowfin and round scads.

The informations on the technics presented here come from a study done in 1980 by Ir. H.R. BARUS in the area of Parigi and Poso, where the number of rompongs is respectively 68 and 50.

13.1. Description of a rompong.

The principle of a rompong in Parigi and Poso is a little different from those set in Tilamuta because they are composed of a trap and of an aggregating device which is the raft, when those in Tilamuta have no trap.

Description (see also Fig. 52)

- The trap is 2 to 3.4 meters long, 0.8 to 1.2 m large and 1.5 m deep. It is made with wooden sticks 5 to 6 cm diam., or with rattan 0.5 to 1 cm diam. tressed, and with gaps of 1 cm wide ; a door is opened on each side of the trap.

- The raft is used to aggregate the fish and to hold the trap. It is composed of two rafts fixed on each side of the trap, build out of bamboo 15 cm diam. and 8 to 12 metres long. The number of bamboo is 10 to 14.
The life expectancy of raft and trap is 4 to 5 months.

- The anchorline is made of weaved ratan "Taik ayam" quality, or if the ratan is strong enough, with one ratan 3 cm diam.. The anchorline is usually 1 800 metres long, with an average life of one year.

- The anchor is made with stones 3 X 50 kg fixed with ratan.

- Rompongs are set 5 to 15 miles off the coast line.

13.2. Fishing method.

The small pelagic fishes such as round scads, selars and mackerels aggregate near the raft and enter the trap in order to protect themselves against the larger pelagic fishes such as skipjack, tuna or marlin. Usually, those small pelagic fishes enter the trap at noon, in the evening (6-7 p.m.) and in the morning. No fish enter the trap during the night.

The fishermen use different kinds of boats, motorised or not, and collect the fish caught in the trap with "Serok" at dawn. During the night, they light on 4 "Petromax", in order to aggregate the fish, 100 metres off the rompong and they catch tuna, skipjack, selar or round scad with a hand line, sometimes with a gillnet. In the early morning they switch off the light and collect the fish from the trap before going back.

13.3. Catch statistics.

In Table 65, we give the estimated production per species of the traps of 13 rompongs, between February and September 1979. The main species collected are trevallies and round scads and the average monthly production of a trap is 100 kg of fish.

Months	Selar Trevallies	Layang Round scads	Kembung Rastrelliger	Total catch	Catch by rompong
February	700	1 300		2 000	154
March	635			635	49
April	735	925		1 660	128
May	1 000	750		1 750	135
June	865	500		1 365	105
July	465			465	36
August	735	460	400	1 595	123
September	600	500		1 100	85

Table 65 - Production (in kg) of the traps of 13 rompongs in Parigi (February to September 1979). (from Ir. H.R. BARUS)

Production by hand line fishing is given in Table 66. The average production per rompong per month is 490 kg with 36 % of skipjack, 18 % of big yellowfin, 19 % of small yellowfin, 3 % of tuna-like fishes and the remaining 24 % composed of trevallies and round scads. No data were available on either the actual fishing efforts or the number of day/boat fishing on each rompong.

Months	Skipjack	Big YF	Small YF	Tuna-like fishes	Others (trevallies, round scads, etc...)	Total catches	Catch by rompong
February	2 050		1 160	240	300	3 750	288
March	3 000	240	810		1 150	5 200	400
April	4 000	6 600		700	2 040	13 340	1 026
May	1 250	1 000	3 000	200	3 450	8 900	685
June	2 400		1 080	190	1 700	5 370	413
July	2 600	600	1 200		1 715	6 115	470
August	1 500		270	210	1 000	2 980	229
September	1 800	800	2 400		700	5 700	438
Total	18 600	9 240	9 920	1 540	12 055	51 355	3 950
%	36 %	18 %	19 %	3 %	24 %		

Table 66 - Production (in kg) of handline fishing on 13 rompongs in Parigi (February to September 1979). (from Ir. H.R. BARUS)

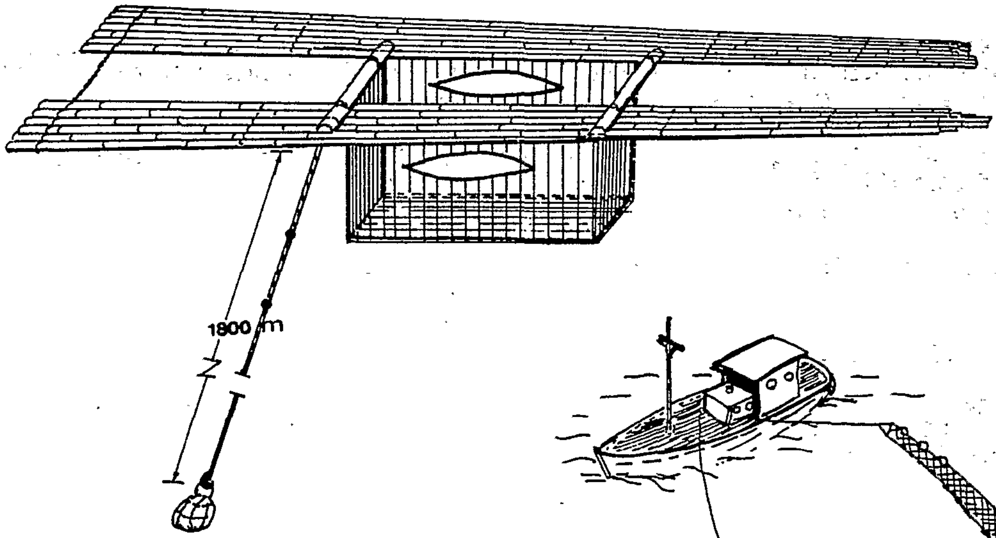


Figure 52 - Typical "rompang" in Parigi and Poso.

- "Rompang" à Parigi et Poso.

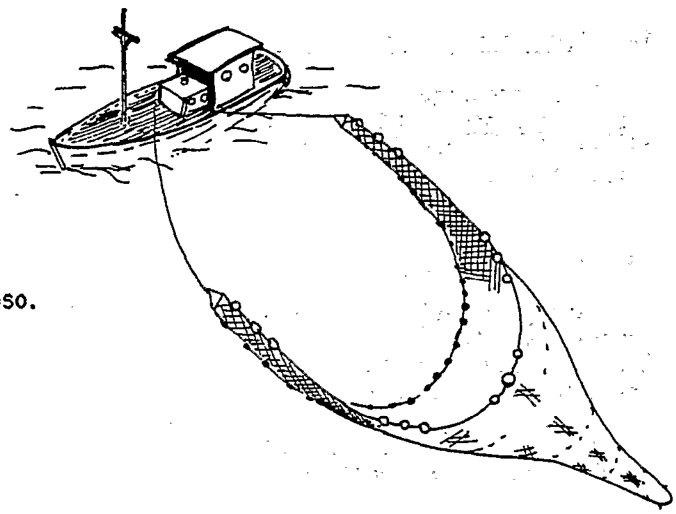


Figure 53 - Typical "payang"

- "Payang".

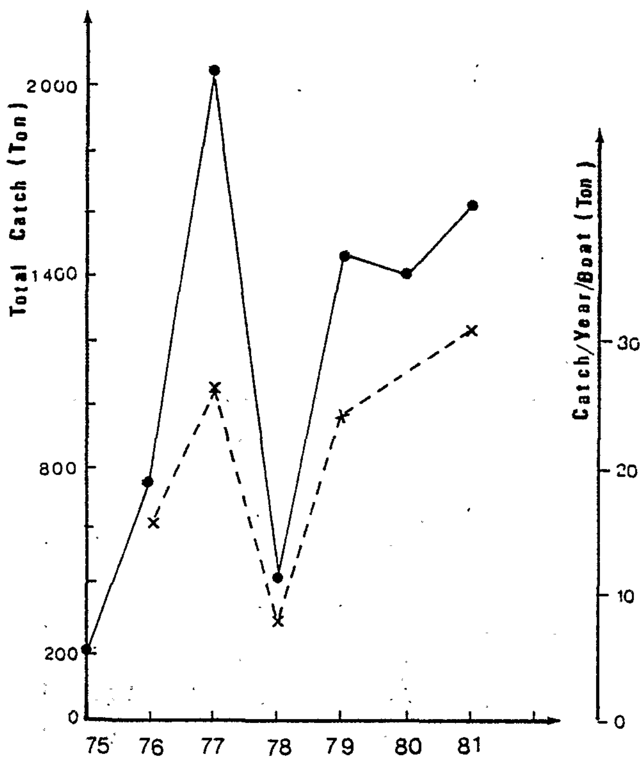


Figure 54 - Evolution of total catch by "payang" vessels and average annual catch by operating vessel, from 1975 to 1981, in Pelabuhan Ratu.

- Evolution des prises totales des "Payang" et prise annuelle moyenne par bateau, de 1975 à 1981, dans le port de Pelabuhan Ratu.

14 ARTISANAL FISHERY WITH "PAYANG" AND GILL NETS IN PELABUHAN RATU (SOUTH WEST OF JAVA).

Pelabuhan Ratu is a very active fishing harbour located South of Java, 120 km South of Jakarta, in a wide bay open on the Indian Ocean. Its main activity is tuna fishing which have been developed for a long time with two original techniques :

- fishing with "payang" which is a kind of danish seine used from a boat to catch pelagic fishes (Fig. 53),
- fishing with gill nets.

The fish production is usually sent to Jakarta, fresh or boiled and salted.

14.1 Tuna fishing with "Payang".

This technique is mainly used to catch "Tongkol" which is here usually longtail tuna (*Auxis thazard*) and a smaller proportion of skipjack and yellowfin ; by-catches of other fishes like "Petek", "Eteman", "Tengiri", "Lemuru" or "Kembung", may represent 10 to 20 % of total catches.

14.1.1. The fleet.

Payang vessels are 12 to 18 GT, 12 to 15 meters long and 3.0 m wide. They use outboard motors, 40 to 50 HP. The net 300 to 500 metres long. The total number of boats in Pelabukan Ratu is 120 but only 50 to 80 are used in regular operations. The trips are one day long starting 3 to 5 a.m. and ending around 5 p.m. The number of crew is 20 to 28. No ice is used.

It usually takes two hours to reach the tuna fishing grounds. The total duration of a set is about 30 to 40 minutes and the number of sets per trip may be 8 to 10.

14.1.2. Total catch and catch by unit effort.

In Tables 67 and 68, we give the total catches and average number of payang vessels operating in Pelabuhan Ratu, per month from 1975 to 1981. Those statistics come from the auction and may not cover the total real landing as an unknown proportion of the catches may be sold directly on the beach.

Months	1975	1976	1977	1978	1979	1980	1981
J	2	2	2	19	12	24	48
F	13	9	7	11	83	35	32
M	16	7	6	77	23	42	74
A	16	60	36	70	108	46	59
M	14	44	64	65	145	143	50
J	15	73	68	30	130	153	58
J	22	113	375	45	214	309	41
A	70	204	146	48	392	197	85
S	22	110	225	27	134	113	531
O	9	80	781	20	101	121	254
N	3	22	229	34	89	94	324
D	2	21	100	8	40	131	65
Total	207	744	2 039	455	1 470	1 408	1 620

Table 67 - Total catches by payang in Pelabuhan Ratu from 1975 to 1981 (in tons)

Months	1975	1976	1977	1978	1979	1980	1981
J	50	28	30	15	27	37	18
F	50	30	20	45	35	(40)	20
M	50	18	30	55	50	43	40
A	50	31	45	140	65	48	56
M	58	53	75	135	70	68	36
J	100	63	75	35	70	70	44
J	95	65	75	56	80	97	45
A	95	63	105	60	90	69	49
S	84	68	105	60	75	35	98
O	75	63	126	55	75	36	106
N	50	60	126	45	49	38	83
D	10	50	126	15	49	34	41
Total	767	592	938	716	735	615	636
Average	64	49	78	60	61	51	53

Table 68 - Average number of operating payang vessels per month from 1975 to 1981, in Pelabuhan Ratu.

This is probably the reason for the great variations in the yearly total catch estimations presented in Table 67 and Fig. 54. Catch per year and per boat is around 25 to 30 tons, but for the reason mentionned above, this is probably underestimated.

We consider as a reasonable estimation an annual catch of 35 to 45 tons for a payang vessel operating all year long.

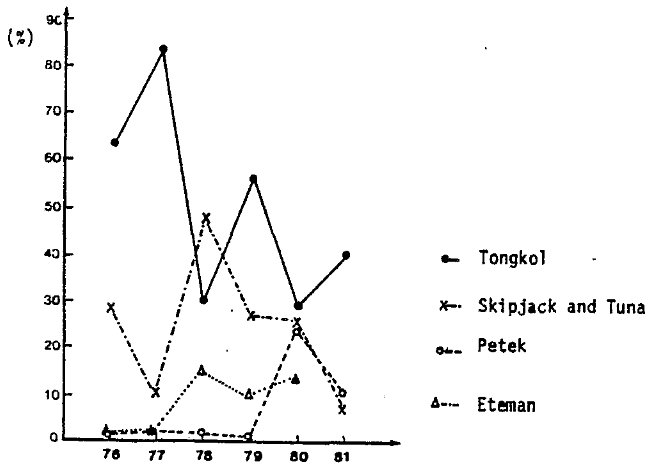
The catch composition per species, from 1976 to 1981, is given in Fig. 55. The main species caught is tongkol (longtail tuna) with an average 40 % of total catches ; skipjack and yellowfin average 20 to 30 % and eteman 10 %.
As seen from Table 69, which gives an estimation of the total catch of skipjack and yellowfin by payang vessels from 1975 to 1981, the monthly and annual values show a great variability.

Months	1975	1976	1977	1978	1979	1980	1981	1975-1981
1	1,2	0,3	0,9	4,8	7,2	1,2	2,9	2,6
2	4,3	4,9	2,0	3,7	76,2	5,0	12,4	15,5
3	5,8	4,8	4,6	38,9	14,7	12,6	20,0	14,5
4	8,9	32,3	24,4	43,8	15,6	17,9	15,3	22,6
5	9,7	19,2	3,2	34,3	23,2	9,1	4,6	14,8
6	0,7	4,2	17,2	10,4	4,4	13,3	2,5	7,5
7	7,4	0,3	70,1	27,7	106,4	91,8	5,4	44,3
8	12,5		42,7	31,9	43,0	114,8	17,4	37,4
9	8,3	20,4	-	2,1	24,1	50,0	16,2	17,3
10	4,5	47,2	-	-	27,0	33,1	8,0	17,1
11	-	15,5	33,5	13,4	37,8	11,5	6,5	16,9
12	0,6	15,0	-	4,1	6,6	20,1	6,0	7,5
Total	63,9	164,1	198,6	215,1	386,2	384,4	117,2	

Table 69 - Total catch of skipjack and yellowfin by payang boats 1975-1981 (statistics from auction, in tons)

Figure 55 - Catch composition (in %) by species of "payang" vessels from 1976 to 1981.

- Composition par espèce des prises des "payang" de 1976 à 1981.



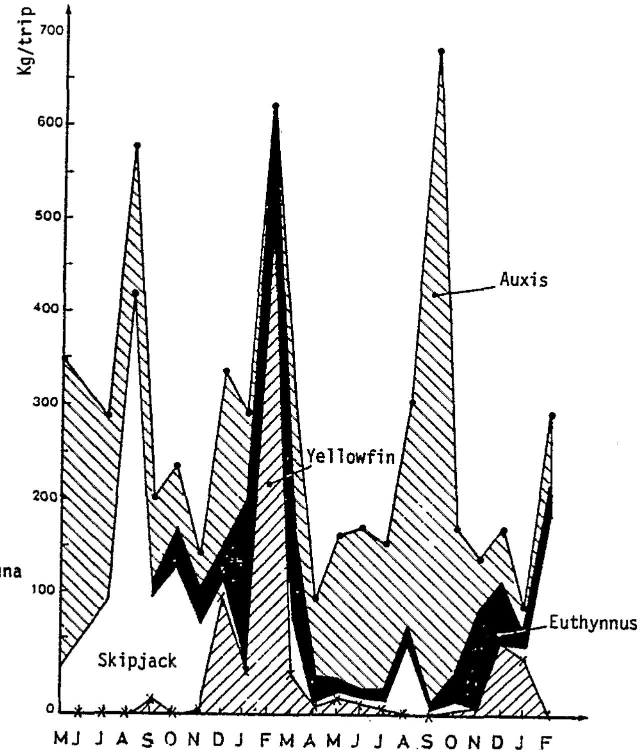


Figure 66 - Average monthly catch by trip of tuna and tuna-like fishes for payang vessels, in Pelabuhan Ratu : May 1980-February 1982.

- Prise moyenne mensuelle de thon par voyage des "payang" à Palabuhan Ratu : mai-février 1982.

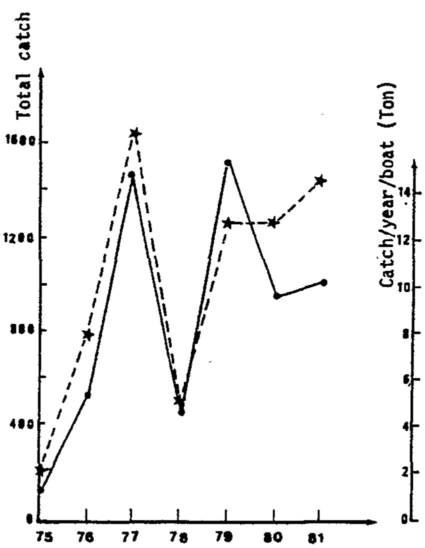


Figure 57 - Evolution of total catches of tuna by gillnet boats and average yearly catch by operating boat, from 1975 to 1981.

- Evolution des prises totales de thon au filet maillant et prise moyenne annuelle d'un bateau, de 1975 à 1981.

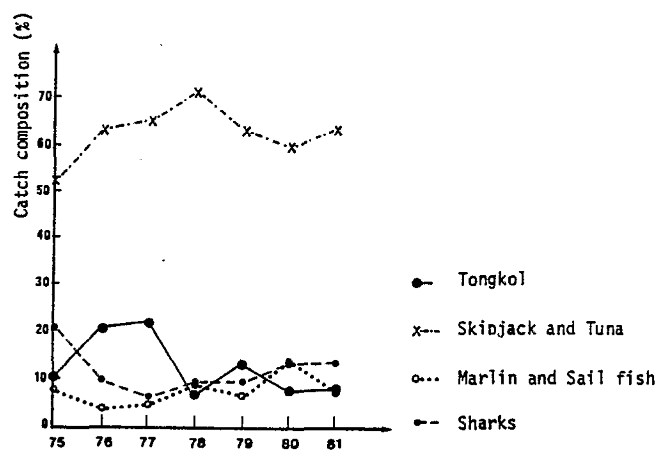


Figure 58 - Catch composition (in %) by species of gillnet vessels from 1975 to 1981.

- Composition, par espèce (en %), des prises faites au filet maillant de 1975 à 1981.

The higher values are generally obtained in July and August (years 1978 to 1980), but very low incidental catches may be obtained all year long as in 1975 and 1981.

Starting July 1980 more accurate estimations of the tuna and tuna-like fish catches are collected under supervision of BPPL. Results of enquiries are given in Table 70 and Fig. 56.

Months	Trip	Catch per trip (kg)	Composition of catch in %			
			SK	YF	Auxis	Euthynnus
May	131	385	16,4	0,2	83,2	0,2
July	486	321	39,1	6,2	60,3	-
August	157	604	74,0	-	26,0	-
Sept.	128	234	68,8	9,4	17,3	4,6
Oct.	173	265	59,9	0,2	25,5	14,4
Nov.	120	171	51,8	4,6	24,0	19,6
Dec.	140	366	3,4	35,1	51,0	10,5
Jan.	62	319	-	15,1	27,0	57,9
Febr.	22	647	-	79,1	0,8	20,1
March	135	331	16,1	15,4	40,0	28,4
April	137	124	3,6	6,6	70,5	19,3
May	190	189	2,8	10,8	78,8	7,7
June	196	196	4,0	5,9	85,9	4,3
Jul.	120	184	6,9	2,7	83,4	7,0
Aug.	182	335	24,1	0,3	71,3	4,4
Sept.	479	705	1,2	0,3	98,2	0,2
Oct.	247	201	4,0	4,1	76,5	15,4
Nov.	72	170	0,0	5,1	31,6	63,3
Dec.	47	197	0,0	40,5	25,1	34,4
Jan.	13	120	12,6	49,3	25,8	12,3
Febr.	37	323	67,0	0,3	23,6	9,1
Total	3 274	344	21,4	5,4	66,4	6,8

Table 70 - Monthly catch per trip of tuna and tuna-like fishes (excluding other species), and composition in % of tuna catches for payang vessels. May 1980 - February 1982.

The catch per trip of tuna and tuna-like fish averaged 344 kg. However, this value is over estimated as trips which produce no catch are not registered.

A very high proportion of skipjack is observed from July to November 1980 with peaks around August and September when we have the full East monsoon, and in February 1982.

Catches were very low in 1981 as it was estimated from the auction data, in Fig. 55.

Yellowfin represents no more than 5 % of the total tuna and tuna-like fish catches, however, catches were significant from December to February in 1980-1981 and in December and January 1982.

Longtail tuna is caught all year long, but higher values are obtained from July to October, which can be considered as the main fishing season for payang vessels.

14.2. Tuna fishing with gill nets.

This technique has been developed in Pelabuhan Ratu in order to catch mainly skipjack or "Cakalang" and yellowfin. However, by catches of sharks and rays, sail fishes or marlins may represent 35 to 40 % of total catch.

14.2.1. The fleet.

The gillnet boats are slightly smaller than payang ones, usually 10 to 12 metres long, 2 m wide and 0.9 m draft. They use outboard motors 40 H.P.. Trips are usually one day long but can last 2 to 4 days during the period extending from April to October, when the fish is far from the bay. 18 to 20 nets, 100 metres long, 18 metres high are set every day during night, 4 m below the surface. The mesh size is 5 to 6 inches. The crews are 3 to 4 men.

Depending on the duration of the trip, the boats may or may not carry ice. For one day trip the boat leaves harbour at noon, sets the net at the end of the afternoon and comes back in the morning at 6 a.m.

There were 155 gillnet boats in 1982, of which 20 to 80 % operate depending on the season.

14.2.2. Total catch and catch by unit effort.

In Tables 71 and 72, we give the total catches and average number of operating boats per months from 1975 to 1981.

Months	1975	1976	1977	1978	1979	1980	1981
J	6	6	20	46	32	22	50
F	12	8	29	20	30	39	49
M	9	7	15	35	33	65	60
A	8	41	15	38	37	36	44
M	8	48	41	27	272	183	115
J	23	89	32	35	157	70	66
J	12	141	170	73	200	69	84
A	34	62	323	35	252	109	66
S	11	69	214	76	153	123	136
O	4	13	338	23	144	108	120
N	3	41	193	26	142	43	128
D	4	24	78	21	59	79	76
Total	135	547	1 467	454	1 520	942	994

Table 71 - Total catches by gillnet boats in Pelabuhan Ratu from 1975 to 1981 (in tons)

The number of boats in operation averages 60 to 120 for each month. The fishing efforts were increasing until 1979 and have been decreasing in 1980 and 1981. The evolution of total catches and catch per year and per boat is given in Fig. 57.

The catch per year and per boat averages 12 to 14 for the last three years (1979 to 1981) and was very low in 1978 and before 1977. However, those values must be taken cautiously as the boats may not sell all their catches to the auction and as a majority of them do not operate regularly.

Months	1975	1976	1977	1978	1979	1980	1981
J	95	25	60	60	51	54	44
F	95	25	65	68	86	(60)	28
M	95	60	65	68	120	67	35
A	95	66	65	150	80	66	48
M	100	81	85	150	107	87	69
J	92	81	85	81	107	83	74
J	90	82	85	110	140	120	82
A	65	81	97	96	160	110	90
S	67	86	97	96	165	93	96
O	70	85	107	98	165	86	108
N	65	83	107	80	160	34	99
D	25	70	134	40	109	31	56
Total	954	825	1 052	1 097	1 450	891	829
Average	79	69	88	91	121	74	69

Table 72 - Average number of operating gillnet boats per month from 1975 to 1981 in Pelabuhan Ratu.

In Table 73, we give the catch and effort of a gillnet boat which has operated continuously from July 1981 to June 1982. Here, total catch reaches 17.7 tons for 107 one day trips, and 35 trips of 2 to 4 days. The average catch per trip was 125 kg and catch per day 83 kg.

Months	Total catch, kg	Number of one day trips	Number of 2-4 days trips	Average catch by day	Average catch by trip
J	2 759	20		138	138
A	2 062	23		89	89
S	1 497	23		65	65
O	900	16		56	56
N	1 922	1	6	101	274
D	972		5	65	194
J	818		4	68	204
F	900	1	4	69	180
M	947		5	63	189
A	1 012		6	56	169
M	2 539	14	3	110	149
J	1 359	9	2	91	123
Total	17 687	107	35	(83)	125

Table 73 - Catch and effort of a gillnet boat, from July 1981 to June 1982, in Pelabuhan Ratu.

Since May 1980, more accurate catch and effort data are collected under the superevision of BPPL. They are given in Table 74. The only catch of skipjack, yellowfin and tuna-like fish are registered : catch of skipjack per trip ranges between 80 and 120 kg and for yellowfin, between 5 to 20 kg.

Months	Trips*	Catch by species			
		Skipjack	Yellowfin	Auxis	Euthynnus
May	656	95,5	18,6	-	-
July	331	20,6	1,3	-	-
Aug.	303	34,9	1,2	-	-
Sept.	995	70,5	4,5	0,9	0,5
Oct.	801	59,0	5,3	1,7	0,2
Nov.	295	22,8	3,6	0,6	0,1
Dec.	422	46,7	9,9	0,9	1,0
Jan.	282	23,4	6,9	0,4	0,4
Feb.	259	32,3	2,7	0,1	0,4
March	369	29,5	4,3	0,1	1,1
April	257	16,2	3,7	1,5	1,2
May	572	75,2	4,9	1,6	0,5
June	448	50,7	2,4	1,7	0,3
July	610	68,7	3,4	0,4	0,0
Aug.	476	33,7	1,9	1,8	0,4
Sept.	645	67,7	5,5	5,6	0,2
Oct.	370	38,2	2,9	0,4	0,8
Nov.	277	38,8	3,3	0,2	0,8
Dec.	249	31,5	3,2	-	1,2
Jan.	126	14,9	1,2	-	-
Feb.	131	15,3	2,2	0,3	0,2
Total	8 874	886,1	92,2	18,2	9,3
%	100	88,0	9,2	1 8	0,9

* number of trips with catch.

Table 74 - Monthly catch of tuna and tuna-like fish per species for gillnet boats. May 1980 - February 1982.

In Figure 58, we present the average yearly composition per species of gillnet catches from 1975 to 1976.

We can see that marlin and sail fish represent 5 to 10 % of total catch, sharks about 10 % as well as "Tongkol" which is here mainly Auxis and Euthynnus. In Table 74, the estimation of "Tongkol" in 1980 and 1981, is much lower, 2 to 3 % of total tuna catch.

The main season for skipjack fishing usually begins in May and ends in November ; it is during this period that the higher landings are registered in the auction (Table 75).

However, depending on the year, very high monthly peaks of production may occur as in August, October, November 1977, or as in May and August 1979, or may be absent as in 1978, or may be rather low as in 1980 and 1981.

Months	1975	1976	1977	1978	1979	1980	1981	1975-1981
1	2,2	3,0	16,1	36,0	17,5	8,5	33,4	16,7
2	5,3	2,6	24,9	14,6	24,5	21,6	41,4	19,3
3	4,6	4,4	8,0	22,9	26,7	23,9	41,1	18,8
4	2,1	21,9	8,0	29,0	26,8	12,9	25,5	18,0
5	5,4	20,3	31,6	21,2	193,9	117,2	89,6	68,5
6	11,7	38,1	19,3	23,7	112,3	33,3	48,5	41,0
7	5,1	51,1	110,1	59,7	81,9	38,3	62,9	58,4
8	12,9	26,4	265,6	20,9	182,2	69,2	41,1	88,3
9	5,2	40,3	86,4	40,0	76,5	82,6	83,5	59,2
10	0,9	6,4	163,4	13,8	80,3	71,2	62,1	58,0
11	0,9	33,1	161,7	15,2	73,6	26,1	69,9	54,3
12	1,2	17,0		13,9	33,4	60,4	37,7	27,2
Total	57,5	264,6	895,1	310,9	929,6	565,4	636,8	

Table 75 - Total catch of skipjack and yellowfin by gillnet boats in Pelabuhan Ratu 1975-1981 (statistics from auction, in tons)

For the period July 1981 to June 1982, we can see that the average monthly catch per fishing day was rather regular, with one peak in November and one from May to July. Depending on the average duration of the trips, we can see that one day trips occur mainly from May to October, and that trips of 2 to 4 days occur from November to April-May.

So, we can see that skipjack enter the bay during the former period which is also the period of high catches by payang vessels, but is still abundant outside the bay during the remaining months.

Yellowfin is caught all year long by gillnet boats, with higher catch from November to June when the boats operate outside the bay ; during this period and especially from November to January, yellowfin may however enter the bay and be caught there by payang.

14.3. <u>Conclusions.</u>

Artisanal fishery in Pelabuhan Ratu is very developed and the number of vessels, 120 payang vessels and 155 gillnet boats is already very high. Because pelagic and highly migratory fishes such as skipjack, yellowfin, and even longtail tuna do not enter the bay very regularly, catches of payang vessels have great fluctuations from one year to another.

When the fish enter the bay, there is also a great competition between the vessels for a limited number of schools. So, even if the stock, which has off shore great reserves, is not over exploited, we can fear that any increase of fishing effort (number of operating boats) will only very marginally increase the total catch of this fishery, as the vessels, too small to do more than a one day trip, may not fish far outside the bay, and compete in a very restricted area.

For gillnet fishery, fishing effort is already high. This technique is much more efficient than the former in terms of average catch/man/year: 4.5 tons versus 1.7 for payang, and in terms of catches ; because the fishing area is wider, the yearly catches seem more regular. However, due to the high present fishing effort any subsequent increase must be done cautiously in order to prevent high competitions in the same fishing grounds which should slightly decrease the catch per unit effort.

We have seen that Pelabuhan Ratu is located near very good fishing grounds for yellowfin and bigeye fishing with deep long line gears. So, we can propose two ways to develop the tuna fishing activities in this harbour.

- The first way would be to experiment with the efficiency of fish aggregating devices to catch big yellowfins and bigeyes, with the hand line fishing technique from small artisanal vessels ; however, because of the seasonally rough conditions of the sea, those FAD may not be kept together long enough at sea, so experiments with different types of FAD has to be done.

- The second way would be to develop from Pelabuhan Ratu an industrial long line fishery able to operate South of Sumatra and Java, according to the season.

Abundance of marlin and sail fish in this area, should also make possible the development of sport fishing activities.

15 ARTISANAL PURSE SEINE FISHERY IN ACEH - (NORTH SUMATRA) -

At the time of the trip we did in Banda Aceh in September 1982, there were 100 artisanal purse seine boats in this town for a total of 240 for the whole province ; about half of them were operating. The main bases are located in the North coast of Sumatra (Aceh Utara), in the town of Aceh (Aceh Besar) and in Sabang (WE Island).

15.1. The fleet.

The evolution of the number of purse seine boats in the Aceh Province are given by districts for years 1977 to 1981 in Table 76.

Boats are 12 to 16 GT, 18 metres long, 3.5 m wide and 1.5 m draft. The engines are 45 HP inboard yanmar or Ford. The number of crew members is 18 to 20. The typical net is 1 000 to 1 200 metres long (streched) 2 000 to 2 400 inches deep with an average weight of 5 tons, including 600 kg of sinkers. The numbers of floats is 1 500 (one every 60-80 cm). Because the height of the net is small, the rings are only set on one half of the net ; their number is about 60.

Districts	1977	1978	1979	1980	1981	1982
Aceh Besar	72	64	64	64	93	100
Pidie	12	8	12	12	11	-
Aceh Utara	10	41	72	83	96	-
Aceh Timur	2	2	2	4	10	-
Sabang	6	6	17	17	16	-
Aceh Selatan	-	-		-	2	-
Total	102	121	167	180	228	-

Table 76 - Number of purse seine boats in Aceh Province by district from 1977 to 1981.

15.2. Fishing grounds(Fig. 59).

The trips are done during the day from 4-6 a.m. to 4-6 p.m. with some varation in Banda Aceh according to the tide. Catches are made on school fish sets and the species caught are skipjack, yellowfin or tuna-like fish (mainly fregate mackerel and eastern little tuna) according to the area where fishing takes place. The time spent to reach the fishing grounds is usually less than 2 hours, so about 18 miles from the landing place. For vessels based in Banda Aceh, the fishing grounds for yellowfin and skipjack are located West of the Breveh Island and those for longtail tuna, mainly East of this island and between Sabang and Banda Aceh in shallower waters. In Sigli (Aceh Utara), some purse seine boats use baits before setting schools, but this method is not really developed elsewhere.

Some good fishing grounds are known to be located in the Southern part of the province on the continental shelf, but they are not yet exploited because of their distance from Banda Aceh.

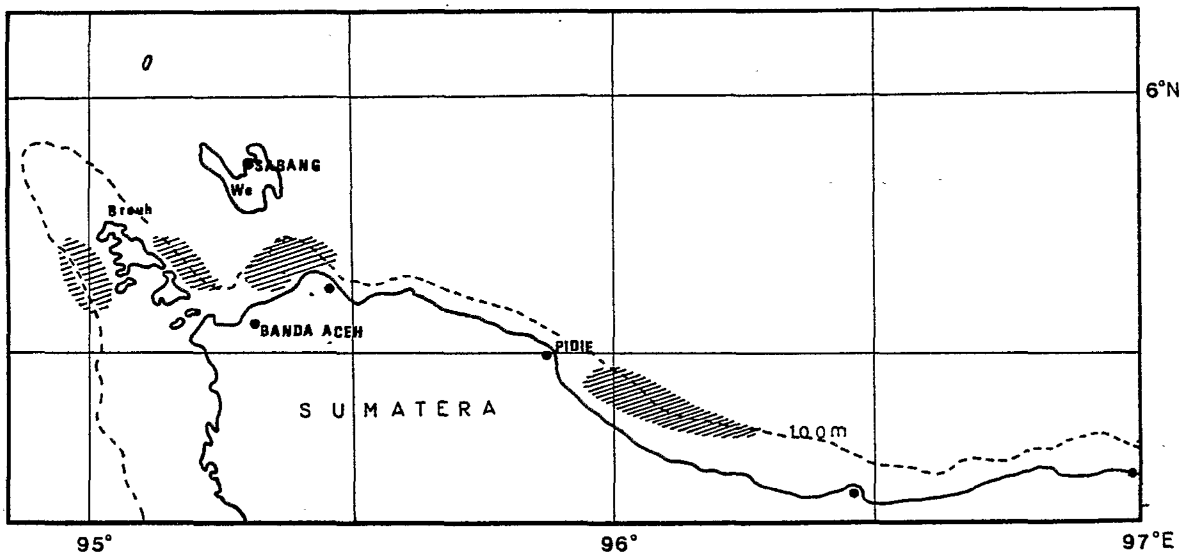


Figure 59 - Major fishing grounds for the artisanal purse seiners operating North of Sumatra.

- Principaux secteurs de pêche des senneurs artisanaux en opération dans le nord de Sumatra.

15.3. Catch statistics and catch per unit effort.

In Table 77, we give statistics of tuna and tuna-like fishes unloaded in Lampulo (Aceh Besar) from January 1981 to July 1982.

Total catch reaches 1 804 tons in 1981 ; the proportion of each species is not known from February to August 1981 but skipjack and yellowfin represent 53 % of the total catch between September and December and 12 % from January to July 1982. There is a great variation in the production from month to month and this must be due to the migrations of the fishes inside or outside the very limited area where the vessels operate.

Data on catch per unit effort are not available because the boats registered each day are only those which have taken some fish. 40 to 50 % of the vessels operate each day except on friday where there is no operation. Taking this into account, we can estimate that the average annual production by boat reaches between 35 to 40 tons.

Enquiries made in 1978 on two boats which have operated all year long 303 and 277 days respectively gave a total production of 56.1 and 58.5 tons.

Average catch per day is then estimated to reach 180 to 210 kg with great day to day variations.

1981	Tuna (Yellowfin)	Cakalang (Skipjack)	Tuna like fishes	Total
Jan.		10	228	238
Feb.				285
March				287
Apr.				230
May				42
June				20
July				38
Aug.				47
Sept.	22	48	53	123
Oct.	1	91	45	137
Nov.	2	38	28	68
Dec.	1	17	71	89
Sept.-Dec. %	6,2 %	46,5 %	47,2 %	1 604
1982				
Jan.		8	70	78
Feb.		9	318	327
March	3	11	151	165
Apr.	1	14	120	135
May	2	58	76	136
June	2	5	226	233
July	1	18	11	30
Jan.-Jul. %	0,9 %	11,1 %	88,0 %	1 104

Table 77 - Tuna and tuna-like fish unloaded in Lampulo (Aceh Besar) by artisanal purse seine boats fishing during the day. January 1981 - July 1982.

15.4. Conclusions.

The number of artisanal purse seiners in Banda Aceh, fishing for tuna and tuna-like fish is already very high ; very often several boats operate on a same school. So, because of the very restricted area where vessels may operate on a one day trip, any further increase of the fishing effort may decrease the average catch per boat, even if the stock is under exploited. Two ways to increase the catches may be considered.

The first is a possible increase of the size of the vessels in order to exploit fishing grounds not yet reached ; however, it could then be difficult in this province to find crews for more than one day trip.

The other way to improve the catches would be to set up fish aggregating devices (FAD). FAD could be set up in off shore areas at depth from 1 000 to 3 000 metres ; however, existing purse seines seem not deep enough to prevent skipjack and yellowfin to escape from the net and the vessels are too small to allow the use of deeper purse seines.

With the same length, the solution could probably be found by using, with the same kind of vessels, 15 to 20 GT, purse seines 400 to 500 metres long and 100-150 m deep. The technique to be applied should be the one used in Philippines where one purse seine boat work night time on deep anchored FAD with the help of one or several light boats.

Tuna-like fishes are usually caught in shallow waters less than 100 metres, so, deep purse seines cannot be used to catch those fishes ; however, here also, FAD could be tested in shallow waters and fishing could be done on them with the same kind of gear used at present.

16 TROLLING FOR TUNAS IN PADANG.

Trolling is the most common technique developed in Western Sumatra to catch tuna. Almost 500 boats are registered in this province. Most of them are based in Padang, unloading the fish near this town in the Bangus auction, and in Parianam, 50 km North of Padang. The total production of tuna and tuna-like fish in the Province "Sumatere Barat" was estimated to reach 5 415 tons in 1979 and 6 851 tons in 1980 (Table 78).

Years & gears		Tuna	Skipjack	Tongkol	Total
1979	Payang	12	13	258	283
	trolling	1 688	2 585	1 142	5 415
	other gears	21	10	10	41
	Total	1 721	2 608	1 410	5 739
1980	Payang	18		405	423
	trolling	1 532	2 994	2 325	6 851
	other gears	23		13	36
	Total	1 573	2 994	2 743	7 310

Table 78 - Production of tuna and tuna-like fishes in West Sumatra, by category of gears, years 1979 - 1980.

50 % of the catches are skipjack tuna and 30 % "tongkol", usually Auxis thazard. Catches of "tuna" (yellowfin) average 20 %, but this category may sometimes include an unknown proportion of rainbow runner (Elagatis bipinnulatus). Almost all the catches are made by trolling vessels, (Fig. 60), if we except some "tongkol" caught by payang gears.

16.1. The fleet.

The number of trolling fishing units for each district of "Sumatra Barat" is given in Table 79. The two main bases are Padang and Parianam with respectivily 218 and 139 boats registered in 1981. The trolling vessels are of the same type, 15 to 20 GT, 15 metres long with 33 HP in board yanmar diesel engine.

The trips may be 4 to 15 days long, according to the catch and the season. The fish is preserved with ice in a 2.5 to 3 tons capacity hold. For each trip vessels take 2.5 tons of ice (50 blocks of 50 kg) and come back for unloading when they have 600 to 700 kg of fish. Fishing is done with 15 lines at a speed of 5 to 6 knots. During the night boats stop operations and usually anchor in sheltered areas near the islands. The number of fishermen is 5 to 7 per boat.

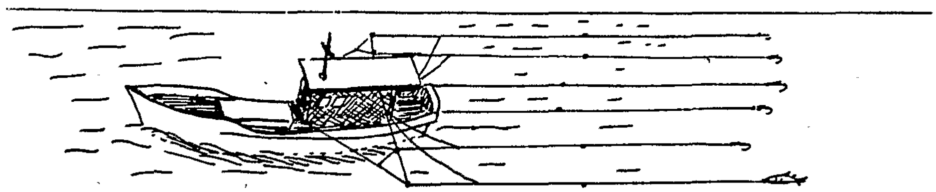


Figure 60 - Troller in Padang

- Ligneur à Padang.

Districts	1979	1980	1981
Pesisir Selatan	80	80	57
Padang Parianam	133	110	139
Kotamadya Padang	201	196	218
Agam	25	40	40
Pasaman	33	46	(50)
Total	472	472	(504)

Table 79 - Number of trolling fishing units by district in Sumatra Barat (Fishery Service in Padang).

16.2. Fishing grounds.

Fishing grounds are located off Padang near the Mentawaï Islands. So, it usually takes 10 to 12 hours to reach them.

From October to December, fishing occurs mainly on the North West of Padang near Telo and Simuk Islands in the West of Tanah Masa and Tanah Bala, and between Tanah Bala and Siberut Islands. Fishing may be done on drifting logs which are sometimes very numerous rather far West of those islands from November to March-April.

From May to August, fishing occurs mainly South-West of Padang ; from March to May, a good fishing ground for skipjack is located North of Sipura and East of the Siburu Islands.

From July to August-September fishing is usually poor because of strong South winds, but rather scattered schools are found South of Siberut and West of Sipura.

According to the fishermen we met, the best season is from December to May-June. During this period, many "jumpers" can be found near logs (Idan Batang) 40 to 60 miles off the islands in the West ; then, a trip may be 4 or 5 days only versus an average 7 to 10 days or even 15 days during the bad season.

16.3. Total catch and catch per unit effort.

In Tables 80 and 81, we give the total production per month and fishing effort, in number of trips, for the two main auctions located in Bangus and Parianam, where 50 % of the total catch of the province is unloaded.

1981	Production (tons)	Trips Nb.	Catch per trip (kg)	Tuna (tons)	Skipjack (tons)	Others (tons)
J	278	396	702	36	119	123
F	339	337	1 004	(48)	(131)	(160)
M	317	388	818	52	105	161
A	294	383	768	53	132	109
M	285	363	785	70	188	27
J	272	361	753	52	179	41
J	214	398	537	27	108	78
A	188	307	612	23	125	39
S	229	391	585	18	75	136
O	271	370	734	46	17	208
N	243	358	680	41	155	48
D	331	363	911	66	188	76
Total	3 261	4 415	739	(532)	(1 522)	(1 207)
1982						
1	294	379	775	93	188	12
2	238	330	722	71	142	25
3	240	350	687	71	144	26

Table 80 - Catch and effort of trolling boats in Bangus (Kotamadya Padang) in 1981-1982). These detailed data are not available, estimated catches have been bracketed.

Months	Catch in tons			Trips Nb.			Catch per trip (kg)		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
J		82	31		111	50		739	620
F		52	52		93	81		559	642
M	54	64	61	114	95	81	474	674	753
A	72	70	51	107	91	86	673	769	593
M	70	73	34	94	90	51	745	811	667
J	87	43	37	114	84	47	763	512	787
J	89	50	38	120	84	63	741	595	603
A	51	27	17	86	46	35	593	587	485
S	51	38	32	76	66	51	671	575	627
O	65	35	47	97	61	64	670	573	734
N	74	31	26	94	58	54	787	534	481
D	86	17	44	107	34	59	804	500	746
Total	699	582	470	1 009	913	722	693	637	651

Table 81 - Production and effort, in number of trips, of trolling vessels in Parianam auction, 1979-1981.

Three species are mainly caught : yellowfin (tuna), skipjack (cakalang) and frigate tuna (tongkol). In the statistics, the category "tuna" may include rainbow runners which can be seasonnaly very abundant, especially when fishing is done on logs located very close to the shore.

Catch per trip averages 650 to 740 kg all year long, but this index cannot be used as a representation of a catch per unit effort because the durations of the trips may be quite different from month to month.

For a sample of ten boats from March 1980 to July 1982, we present in Fig. 61, the average number of trip per month and per operating boat in Bangus, and in Fig. 62, the average total catch per boat and per month. We can see that the higher catch per month are obtained from January to June (2 tons per boat per month) and the lower from July to November (1 to 1.5 ton per month).

The average catch of skipjack and yellowfin, in number of fishes, by operating boat and per month in Bangus is given in Fig. 63. The catches of skipjack seem very low in 1980 and 1982 compared with the year 1981 ; variability between months seems lower than between years. On the contrary, catches of yellowfin seems regular from year to year with a clear seasonality and very low catch between July and November.

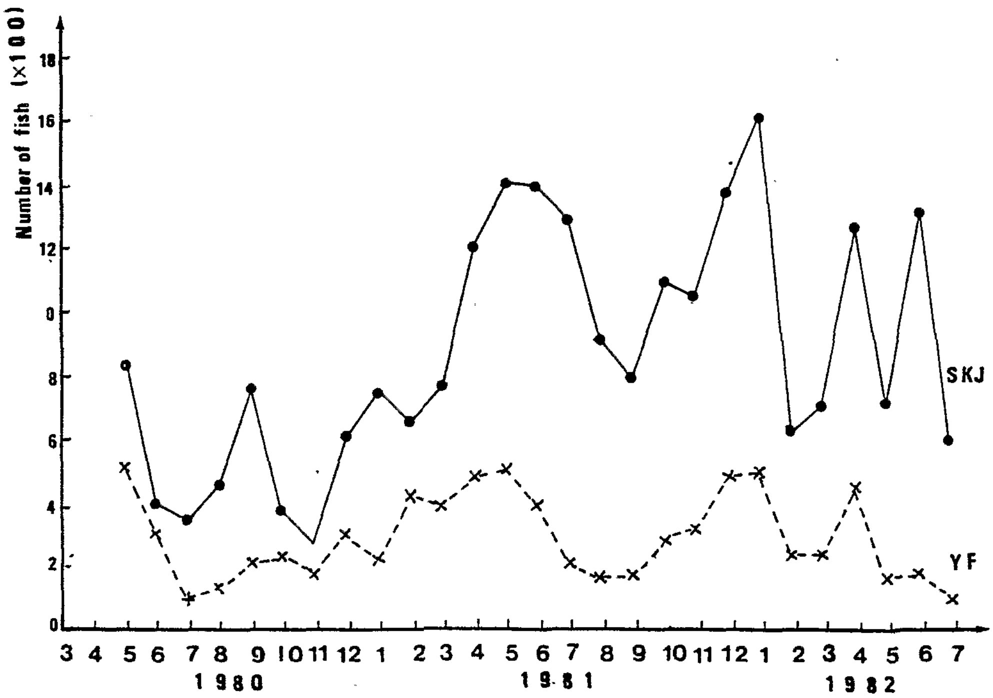


Figure 63 - Catch of skipjack and yellowfin, in number of fishes by boat and by month in Bangus, March 1980 - July 1982.

- Prise de listao et d'albacore, en nombre de poissons, par bateau et par mois à Bangus, de mars 1980 à juillet 1982.

We must however keep in mind that abundance index used in Figures 61 to 63 are strongly biased because the proportion of effective fishing days during a trip is lower when the trip is short, so during the good season. A better index of abundance, such as catch per fishing day, would probably show higher seasonal variations.

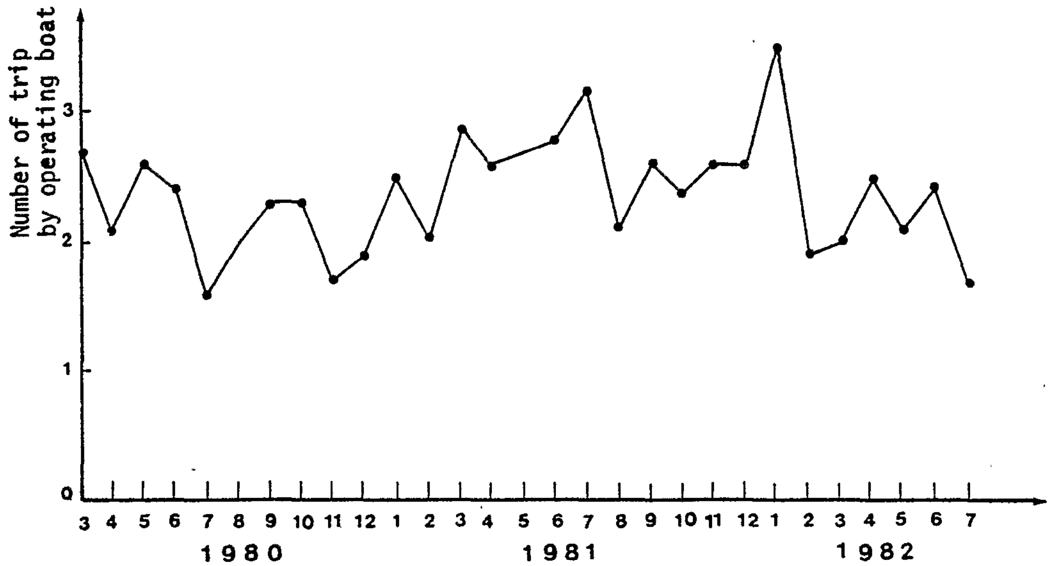


Figure 61 - Number of trip by month and operating boat in Bangus, March 1980 to July 1982.

- Nombre de voyages effectués par mois et par bateau à Bangus, de mars 1980 à juillet 1982.

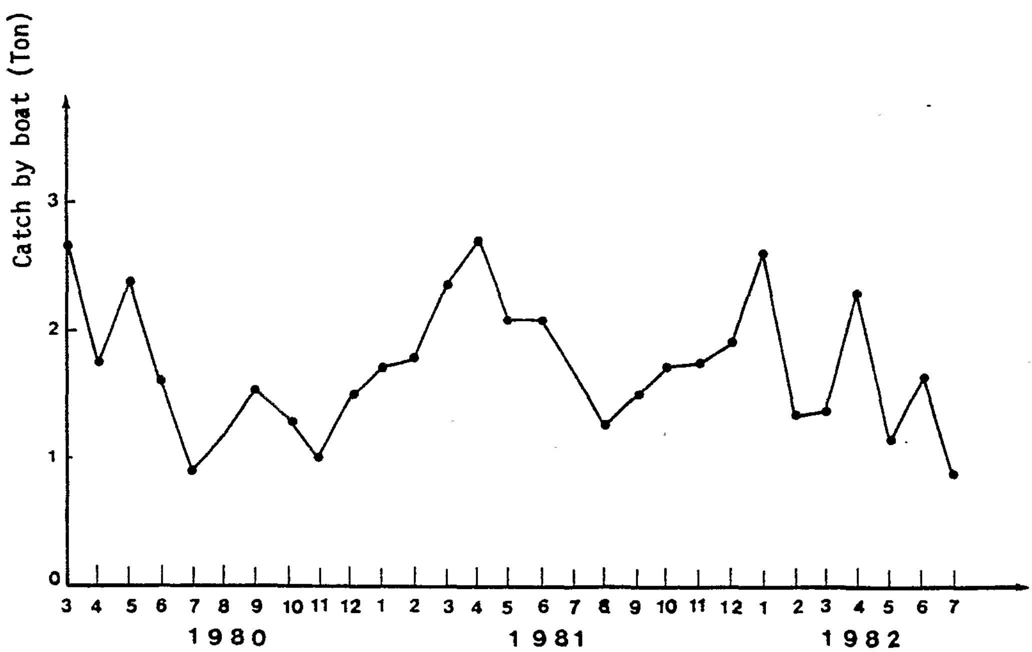


Figure 62 - Catch of tuna by month and by operating boat in Bangus, March 1980 to July 1982.

- Prise mensuelle moyenne de thon par bateau à Bangus, de mars 1980 à juillet 1982.

On the other hand, low catch per unit effort from July to October may not reflect a lower abundance of fish in the area, but rather a poor hook biting rate during this season because the seasonal upwelling of the West coast of Sumatra make natural food more abundant for the fishes.

At least, bad weather during Southern winds may also be a reason for the poor catches of skipjack and yellowfin during this season ; fishing may then be done near the islands on the continental shelf, to catch frigate tuna (Auxis thazard).

16.4. Annual production by vessel.

From enquiries made in Padang in August 1982, we can expect that the yearly production of a troll boat ranges between 18 to 25 tons. From log books of three boats, KM Tuna 01, KM Tuna 02 and KM Bracung, S. MERTA estimated that the average yearly production was 27 tons/boat for 240 days at sea in 1978-1979.
In Bangus, the production in 1981 was 3 260 tons for the 218 boats registered but only an average of 160 boats were in regular operations.

So, a production of 20 tons/boat/year seems to be a reasonable estimation. From Figures 61 and 62, we estimated the average production per vessel (from a sample of 10 of which 6 were operating all year long) to be 22 to 23 tons in 1981. Skipjack and yellowfin weight usually 1 to 1.5 kg per fish.

16.5. Conclusions.

One of the limitation of the trolling fishery in Padang comes from the fact that the fishing grounds are very far from the unloading facilities. Boats need to carry large quantity of ice and long trips have a bad effect on the quality of the fish, especially during the poor season when trips are longer. 30 % only of the fish caught is of first quality and 70 % is quality two or three. This could be improved by setting cold storage and ice plants in Pagaī, Siberut or Tanahmasa Islands.
Improving the total catch and catch per vessel would be accomplished by setting fish aggregating devices (FAD) off the Pagaī Islands, South of Siberut or further off the Northern Islands especially in areas near cold storage facilities. Such FAD would allow better catch and less fuel consumption (at present 100 liters per day), especially during the season from July to October when the fish is present in the area but does not bite to the hooks. FAD could allow a simultaneous development of hand line fishing for big tunas such as yellowfin ; this kind of fishery could be developed with smaller artisanal vessels as it is done in the Philippines and in many others Pacific Islands.

The type of FAD cannot be an artisanal model similar to those used in Tomini Gulf in North Sulawisi but models as those developed in the Central Pacific Islands (Hawaī, Samoa, Fidji) which would be more resistant during the strong Southern wind period.

17 TROLLING IN BENOA (BALI)

Trolling has been a common practice since the 1950's. Although motorized boats have been used since 1980, fishing operation are still limited to about 10-20 miles South of the coast, mainly in the Badung Strait, located between the Islands Bali and Nusa Pomido. The fishing season is mostly during the East monsoon period. The fishermen have been dependent on artificial bait made of goat-hair and only recently they started using plastic baits. There has beew a decline in the use of sail boats as more motorized boats have become more popular (Table 82).

The monthly catch in the last 3 years is shown in Table 83, while the catch per unit of effort for several months in 1981 and 1982 are in Table 84. Here, also the East monsoon plays an important role in tuna and skipjack landings.

Years	1975	1976	1977	1978	1979	1980	1981	1982
Sail boat	256	256	256	256	256	181	175	51
Motor boat	-	-	-	-	-	75	81	115

- Source : TPI "Astitining Samudra", Tanjung Benoa.

Table 82 - Statistics of sail and motorized trolling boats in Tanjung Benoa.

Months	1979		1980		1981	
	1	2	1	2	1	2
J	-	-	-	-	-	-
F	2 018	1 464	-	-	-	1 469
M	450	1 281	-	-	-	-
A	300	4 581	-	-	2 624	2 686
M	-	4 097	-	-	-	23 648
J	3 110	5 627	3 711	3 799	-	16 221
J	1 405	6 333	4 720	4 552	-	10 673
A	10 963	4 488	3 499	2 593	-	525
S	4 891	7 840	-	-	4 670	2 659
O	5 781	2 304	-	-	3 172	9 894
N	14 778	4 298	151	752	-	8 748
D	-	505	-	-	-	-
Total	43 696	42 818	12 081	11 696	10 466	76 523

- 1 Tuna
- 2 Tuna-like (mixed with skipjack)

Source : TPI "Astitining Samudra", Tanjung Benoa.

Table 83 - Monthly catch by trolling boats in Tanjung Benoa (kg).

18 EFFECT OF THE INDUSTRIAL PURSE SEINE FISHERY ON THE POLE AND LINE FISHERY IN AERTEMBAGA AND SORONG.

Tuna fishing by pole and line is of a great importance in Indonesia even if the amount of catch obtained using this technique remains at a rather low level of 13 000 to 16 000 tons/year.

Since 1978, purse seining has been considerably developed in two areas located near the traditional Indonesian pole and line fishing grounds.

The catches of skipjack in Philippines made by purse seiners increased from 3 000 tons in 1976 to 50 or 60 000 tons in 1981 (from official estimations, but probably much more).

Catches of skipjack by japanese purse seiners North of Irian Jaya and Papua New Guinea increased from 1-000 tons in 1973 to more than 50 000 tons in 1981 ; in this same area, american, korean and taiwanese purse seiners also operate, mainly since 1979 and 1980. The total number of purse seiners is already 44 with a total skipjack production probably near 80 000 tons in 1981 against 20 000 tons in 1978 and 5 000 tons in 1975.

Months	Total		Species							
	Catch	Effort	1	2	3	4	5	6	7	8
1981										
J	13 713	617	12,0	7,2	0,4	1,7	0,3	0,0	0,0	0,4
J	11 305	705	8,2	3,9	0,1	2,9	0,1	0,3	-	0,7
A	3 545	266	6,1	5,3	0,0	1,2	0,2	-	-	0,5
S	3 792	249	4,7	5,9	0,4	3,2	0,6	-	-	0,3
O	5 548	403	7,3	5,8	0,2	0,3	0,0	-	-	0,2
N	4 179	309	4,1	9,2	0,0	0,1	0,1	-	-	0,0
D	No activies due to bad weather									
1982										
J										
F										
M	3 834	207	4,8	13,5	-	0,2	-	-	-	-
A	4 311	210	8,4	12,2	-	-	-	-	-	-
M	1 823	96	6,8	10,7	0,3	0,0	-	1,1	-	0,4
J	3 574	462	-	-	-	7,7	-	-	-	-
J	2 267	574	-	-	-	4,0	-	-	-	-
Range	1 823 13 713	96 705	4,1 12,0	3,9 13,5	0,0 0,4	0,0 7,7	0,0 0,6	0,0 1,1		0,0 0,7
Average	5 263	373	6,9	8,2	0,2	2,1	0,2	0,5		0,4

- 1 Yellowfin tuna (<u>Thunnus albacares</u>).
- 2 Skipjack (<u>Katsuwonus pelamis</u>).
- 3 Eastern little tuna (<u>Euthynnus affinis</u>).
- 4 Bullet/frigate mackerel (<u>Auxis spp.</u>).
- 5 Spanish mackerel (<u>Scomberomorus commerson</u>).
- 6 Marlin (Istiophoridae).
- 7 Sailfish (<u>Istiophorus platypterus</u>).
- 8 Dolphinfish (<u>Coryphaena hippurus</u>).

Source : Research Institute for Marine Fisheries.

Table 84 - Monthly catches and catch per boat per day, by trolling boats in Tanjung Benoa, June 1981-July 1982 (in kg).

As the Philippines purse seine fishing grounds are very close the North Sulawesi where indonesian pole and line boats are based, it is interesting to look at the evolution of the total catch in the Philippines. For the pole and line fishery in Aertembaga, we give two indices of CPUE, the catch per day at sea and the average quantity of tuna caught per kg of bait (Tab. 85).

The average value of CPUE for the years 1967 to 1971 can be considered as the index of abundance when there were no purse seine operations in the Philippines. We cannot see any decrease of CPUE (catch per day) during the period 1978-1981 when the catches obtained by the Philippines purse seiners increased so much.

We have seen in chapter 12 that the average value of the quantity of tuna caught per one kg of bait gives a better index of the abundance of tuna. The value of this index was 8.7 for the average years 1967 to 1971, it droped to 7.4 in 1979, increased to 11.0 in 1980 and droped again to 6.9 in 1981 ; so, its average value for years 1979 to 1981 is 8.4 which is not significantly different with the value calculated for the years 1967-1971. In 1982, both CPUE remain at a relatively low level but those values are not really significant as they were calculated only for the first 6 months of the year.

Because of the wide natural annual fluctuations in the availibility and/or the abundance of skipjack, it is difficult to detect any significant effect of the skipjack fishery in the Philippines on the abundance of this fish in North Sulawesi.

Years	Philippines purse seine catch, in tons	(1) CPUE - pole and line: Aertembaga, kg/day	(2) CPUE - Aertembaga kg Tuna/kg bait
1975	2 761	746*	8,7*
1976	3 181	-	-
1977	29 174	808	-
1978	55 090	673	-
1979	49 730	725	7,4
1980	(65 000)	1 087	11,0
1981**	(60 000)	684	6,9
1982	-	685	6,8

* average value for years 1967-1971.
** first six months only.

Table 85 - Catch of skipjack by purse seiners in Philippines waters, and CPUE in Aertembaga.

In North Papua New Guinea, and Irian Jaya, purse seine operations also has considerably increased, as seen in Table 86, and especially since 1979.

We have seen in chapter 10 that in Sorong the index of catch per day may not give a good representation of the abundance of the fish, because of the increasing difficulty to obtain the bait. So, the quantity of tuna per kg of bait is given as index of abundance.
Considering the annual variations of this index, no precise evolution of CPUE can be detected presently. The evolution of the average annual catch per fishing day of the 200 GT pole and line boats operating near Waigeo Island has also stayed very constant from 1978 to 1981.

Years	Japanese purse seine fleet	Other purse seiners	Total purse seine	CPUE (1) Sorong kg/bucket	CPUE (2) P.T. East Indonesia pole line boat (tons/day)
1973	1 245		1 245		
1974	2 159		2 159		
1975	4 991		4 991		
1976	7 509		7 509	31,3	
1977	17 010		17 010	17,9	
1978	20 712		20 712	29,2	3,6
1979	25 541	(6 000)	(31 500)	34,0	4,0
1980	48 000	(20 000)	(68 000)	28,5	3,6
1981	(50 000)	(30 000)	(80 000)	29,3	4,1

Table 86 - Catch of skipjack by purse seiners North of Irian Jaya and Papua New Guinea, and CPUE of pole and line boats near Sorong.

Conclusions.

The increasing catches of skipjack by purse seiners in the Philippines waters and in the North of Irian Jaya and Papua New Guinea, have not presently affected the abundance of the fish in the Indonesian pole and line fishing grounds in the North of Sulawesi and the North West of Irian Jaya.

19 POSSIBLE DEVELOPMENT OF ARTISANAL AND INDUSTRIAL TECHNIQUES FOR CATCHING TUNA IN INDONESIA.

Catches of tuna fishes in Indonesia has reached in 1979, 127 000 tons.

This value includes catches of big tunas like yellowfin, bigeye, marlin and sailfish (18 000 tons), those of skipjack (42 500 tons) and show the predominance of the catches of small tunas like frigate mackerel, longtaiil tuna, eastern little tuna, frigate and bullet tuna which have been estimated at 66 000 tons in 1979.

One of the purposes of this report and more particularly of this chapter, is to study the possibility of increasing catches and exports of tuna from Indonesia ; so we will examine the possibilities of developing artisanal, semi-industrial or industrial techniques in order to increase tuna catches of exportable value mainly skipjack and yellowfin.

Increasing tuna catches can be imagined using two ways :

- Increasing number of artisanal or half industrial units as small artisanal longliners, handliners, trollers, gillnetters or middle size pole and line and purse seine boats.
- Increasing the number of industrial fishing units of large longliners, pole and line boats or large purse seiners.

Each solution has its own advantages and drawbacks, which would be too long to develop ; so, we will give here a quick revue of those different techniques and our opinion on the possibility to develop them.

19.1. <u>Artisanal and semi industrial techniques which can be developed or introduced.</u>

Many artisanal techniques can be developed such as trolling, handline, longline or pole and line. Efficiency of some of these techniques could be increased with simultaneous introduction of aggregating device as it exists in the Philippines.

19.1.1. <u>Handline fishing on payaos.</u>

This method is very old in Indonesian waters and presently exists in North Central and South Sulawesi as well as in the Moluccas (Ceram), under the name of rompong. It could be developed in other areas where systems should be set up. In the Philippines outriggered handline boats used are 2 GT with inboard engine, and one crew using two handlines of one hook each. The bait used is round-scad, small tuna or squid. The catch rates are 2 or 3, 40 kg yellowfin per fishing day and 200 kg/trip (one trip is 3 to 5 days). This technique of handlining on aggregating device has also been developed for a few years in Hawaii where the bait used is squid.

Fishing is done during the day time in the Philippines, but can also be done by night as it is in Hawaii. This technique has the advantage of obtaining a high price product (big yellowfin) for a low investment which can be done by individual people.

On the other hand, the method is only possible in areas where the payaos should be set up in deep waters ; because of the high price of the payaos (2 000 to 4 000 US $ depending on the depth) this could be organized only on payaos yet set up by industrial enterprises which could invest in payaos. Catches done by those handline fishermen could then be sold back to those industrial enterprises with, as a result, among others, a better price for them.

19.1.2. Surface trolling.

This technique is well developed near Padang (West Sumatra) where there are more than 350 troll boats, 15 to 20 GT, 30 to 40 HP engine using 10 to 15 lines each. Average catch rates are 600 fishes per trip (one trip is 6 to 9 days). Catches are preserved in ice but the quality of the product, mainly skipjack is usually poor. Catches are made on surface schools located by birds, or near drifting logs.

Main fishing grounds are off Pagaï and Siberut Islands. But because of brittle mouth of skipjack, trolling, it is well known, is not the most convenient technique to catch this fish and so can only be developed in area where surface yellowfin are abundant.

19.1.3. Deep trolling near payaos.

There too, the technique has become popular in the Philippines for some time and has been developed in areas where payaos are set up. Small outriggered boats 1 to 2 GT, 16 HP with 6 hooks, used one troll line 300 m long, weighted with 10 kg of load. The bait used is squid or milkfish ; fishing speed is 1.5 knots. The average catches, mainly yellowfin are 10 fishes of 25 to 50 kg each, per fishing day.

Similarly to handlining, this technique could be very simple to develop in Indonesia but can only be started in areas where payaos are yet to be set up.

19.1.4. Artisanal long line.

This method is already developed to catch tuna in South West Sulawesi, but there also, the method used in the Philippines waters could be implemented and tested as a model. In this country, small tuna long liners 13-18 meter long, 18 to 30 GT, 100 HP, can set 100 baskets of 5 to 6 secondary lines. Bait is made with milkfish alive and catch rate reach 3 to 5 %, including 70 % of yellowfin or bigeye of 25 to 60 kg. Duration of trips is 7 days and longliners fleet generally work with a mother boat.

The lines are short and total duration of a set is about 6 hours in order to prevent fish damage by sharks. Fish is preserved with dry ice because its destination is sashimi market. This technique could be developed in Indonesia, especially in area North of North Sulawes from Manado, in North East Kalimantan and from Ambon (Maluku) which is close to the fishing grounds of Banda Sea. It could also be developed in the North of Irian Jaya, from Sorong, where good catch rate of yellowfin tuna can be obtained from April to September.

19.1.5. Pole and line fishery with live bait.

Small pole and liner boats, 12 GT to 30 GT with 50 to 165 HP engine and 15 to 26 crew members catch mainly skipjack. Fish is preserved in ice for the bigger boats which make 4 to 7 days trips, the smallest generally performing daily trips. Catch rates are usually depending on the season, 600 to 800 kg per boat and per fishing day.

This technique is the more used and the more productive to catch skipjack in Indonesia ; so, as it is very well known, one would be tempted in order to increase the catches, to consider only increasing the total number of pole and line vessels. However, in this case, we can fear that the problem of catching the bait will be more and more difficult and will become a major limitation of having good catch rate of tuna. Such problems already occurs in Manado, Ambon and Sorong. At present, abundance of bait is enough only in Kendary allowing further development of this fishery.

Because of bait problems, it is now often necessary to exploit areas far from the base which makes more complex the logistics and the conservation problems for small boats.

Better catches and catch rate per individual boat could be obtained by using mother boats (200 to 300 GT) as cold storage near the fishing grounds. This technique has already been started in Ambon and Sorong.

Another possibility would be to set up payaos near fishing bases in coastal areas in order to increase catches and lower fuel consumption. However, the result may be the obtention of higher proportion of very small skipjack not big enough to be exported on the international market, as we have seen in Aertembaga. An advantage of using payaos is that it simultaneously allows development of big yellowfin fishing by handline and deep trolling.

19.1.6. Purse seine fishery with small purse seiners.

Artisanal fishery of tuna and tuna-like fish using this method, is alreasy developed in Indonesia, mainly in Aceh and in Pelabuhan Ratu (South West Java). Two kinds of fishing gear are used : payang and ring net (pukat cincin) ; the first one is used in Pelabuhan Ratu, the second in Banda Aceh.

A great proportion of catches is, in fact, not skipjack but tuna-like fishes such as frigate mackerel, eastern little tuna and longtail tuna as well as scads and mackerels. Tuna fishing is done during the day time on surface schools. The total production of tuna and skipjack using these gears averages 3 000 tons/year in Aceh Province and 1 000 tons in South West Java.

In the Philippines waters, tuna catch using small purse seine (ring nets) is well developed. The number of boats is about 300 units with total yearly catch near 30 000 tons. The catches are made on payaos set up near the shore. Boats are 20 GT, 65 HP using ring net 400-500 m long X 120 m. Fishing is done at night using one light boat to concentrate the fish. The catch rate averages 0.5 ton/set.

This method could be developed in Indonesia, especially in the Eastern provinces, but we can fear it would take many very small fishes not tradeable on the international market. However, for local consumption, this technique could be adapted on some of the existing units. The composition of the catches and the size of the fish may depend on the distance between the shore and the aggregating device set up.

19.1.7. Conclusions on the possible development of artisanal and semi-industrial techniques to increase the catches of tuna.

We have seen that many methods could be used and tested to increase tuna catches in Indonesia :

- Artisanal longliners, in conjunction with mother boat could be used in the Banda Sea, in the area North of Sorong and with good probability of success in the Sulawesi Sea (area North of Sulawesi and North East of Kalimantan).

- Handlining and deep trolling could be developed in all areas where payaos would be set up.

- Pole and line fishing on payaos, set up far enough from shore in order to restrict catches of too small yellowfin and skipjack, could be implemented near present fishing bases, to increase catch rates and lower fuel consumption.

The generalization of the use of the mother boat will help to find an answer to the lack of bait near the main bases and will readily allow to get better quality fish.

Even by increasing artisanal techniques, the increase of catches of skipjack and yellowfin will remain very limited if we develop only such techniques. So it appears that Indonesia also need to implement industrial methods of catching tunas in order to increase export trade.

19.2. Industrial techniques to develop.

There are mainly three industrial methods to catch tuna :

- Longlining with big longliners, able to move out to better fishing grounds according with the season, is used to exploit stock of large yellowfin and bigeye as well as marlin, sailfish and sharks found in deep waters.

- Pole and line and purse seine vessels catch shools of skipjack and yellowfin found in surface or subsurface.

19.2.1. Longlining.

In Indonesia, this technique has been developed from Bali for 10 years. The fleet, 20 longliners 110 GT, 365 HP, catch 100 to 120 tons/year per vessel, South Java and Bali and in Banda Sea, according to the season.

In Ambon, a new company has begun this fishing in 1981 using 5 modified trawlers 300 GT. According to the reports of effort and catch statistics by area on japanese tuna longline fishery, very good catch rates of yellowfin can be obtained all year long in the sea of Sulawesi and in the Pacific Ocean North of Irian Jaya. Bigeye tuna is abundant in the South West of Sumatra and in the Banda Sea, and we have seen in chapter 3, that benefits could be expected when introducing in Indonesia, for those two areas, deep tuna longliners.

19.2.2 Impact of industrial pole and line and purse seine fisheries on the resources available to the artisanal pole and line fishery.

Before developing industrial pole and line and purse seine techniques, it is advisable to pay attention to the impact of the introduction of those methods on the surface stock already exploited by the present pole and line fishery in Indonesia.

Therefore, we need to examine what the stock exploited by long range pole and line and purse seine vessels is, for the two species : skipjack and yellowfin.

19.2.2.1. SKIPJACK.

During long time, it has been considered that in the same area there were only largely migratory stocks of skipjack, being shared by different countries and different EEZ. The facts seem more complex.

Tagging done by South Pacific Commission in the South West Pacific shows a very wide migration of fishes from one area to others, confirming that skipjack can be a very migratory species but, on the other hand, we can see that from the many fishes tagged in Papua New Guinea, for example, a weak proportion has ever been recaptured very far from the tagging area ; the major recapture has been done near the area of tagging, sometimes after a long period at sea.

- So we can imagine the existence of local stocks, remaining near the same islands and archipelagos, and more largely ones usually living more off shore or sometimes melted with the local ones.

- This hypothesis of "local stocks" and "largely migratory ones is making its way, at present time, for many scientists.

- This can explain the fact that in some areas the average catch are obtained all year long on the "local stock" with high peak of production during "migratory ones" crossings. It is not impossible so far for the "local stock" to be renewed by migratory ones during that crossing, or that some fishes from "local stocks" leave the area with the migratory ones of the same size.

- The importance of melting between stocks could be very variable according tothe areas and latitudes considered.

In higher latitudes (Japan, Australia, New Zealand) fishes arriving there are all highly migratory ones, going back in tropical areas for spawning, explaining that in those areas fishing seasons are usually well defined in time.

In middle latitudes (Hawaii, New Caledonia, Fidji) local stocks tied up with islands and shallow waters could be periodically renewed when crossing of the migratory fishes.

In lower latitudes and in Equatorial areas (as in Indonesia) local stocks tied up with islands could be less melted with the stock of migratory origin which should remain more offshore.

- In the Western Pacific, the hypothesis of a mainly "local stock" in Philippines can be made, taking into account that though 100 000 to 150 000 tons are annually caught there, no indication of lower fishing catch rated in Sorong or Manado is noticed although catch of skipjack in Philippines have decreased in 1980-1981 in spite of increasing fishing effort (chapter 18).
The other hypothesis is that only a part of the whole "migratory stock" from which migrant fishes come, migrate seasonally in higher latitudes.

Conclusions are that in offshore areas in the North of Irian Jaya and Western Sumatra, exploitation with purse seine vessels or long range pole and line boats most possibly should not affect the artisanal pole and line fishery operating in Sorong, Ambon, Kendari or Aertembaga, and so can be widely developed.

So are the stocks South of Java and the Nusatenggara Island. In the interior seas of Indonesia, as the Maluku Sea, the Ceram Sea and the Banda Sea, the relations between the near shore stocks and the offshore ones are not known but the very weak leves of present skipjack exploitation in those areas and soma similarity with the Gulf of Mindanao area allow us to expect large possibility of developing tuna fishing both with artisanal and industrial techniques.

19.2.2.2. YELLOWFIN.

The development of industrial techniques must not affect the catch rates of yellowfin by longliners. As a matter of fact, the proportion of yellowfin in total catches by pole and liners and purse seiners will probably remain low and will be done on young fish with high natural mortality rate.

On the other hand, the introduction of purse seine or/and pole and line fishery on aggregating device in the interior sea will ease the development of artisanal handlining and longlining fisheries, as it happened in the Philippines.

Purse seine can be introduced in the interior seas of Indonesia, if fishing effort is not too high (5 to 10 vessels) and with only some limitations as, for example, a limitation of the fishing grounds outside the 10 miles off the shore.

19.2.3. Industrial pole and line.

There are presently four industrial pole and liners in operations in Indonesia with an average catch of 700 to 800 tons per boat and per year, mainly skipjack, and with an average catch by fishing day of 2.6 to 4.1 tons, depending on the season.

The fishing grounds are located East or South West and West of the Waigeo Island, where the bait is caught. The bait is usually found in small quantity (35 to 50 buckets per fishing night) and has to be caught every night, thus restricting tuna fishing grounds to those located near the bait fishing grounds. The catch of tuna per bucket of bait averages 100 kg.

In the Sorong area, the bait is often difficult to obtain from May to August. However, the main advantage of pole and line fishing with freezing industrial boats (over 100 GT) is being able to obtain bait in areas far from the existing bases of small pole and liners, usually less or not yet exploited.

This kind of fishing can be developed in the near future, but there too, it will be interesting to develop new fishing strategies in order to lower the need of bait or to increase the catches of bait for each unit, using small boats specialized in night bait catching with lampara and lift nets.

19.2.4. Industrial purse seine fishery.

North of Irian Jaya and Papua New Guinea, purse seine fishery is yet very active and the Japanese fleet catch there almost 60 000 tons a year (72 % skipjack, 26 % yellowfin and 2 % bigeye). The technique used is night fishing (just before dawn) on drifting logs, but the day time school sets have become more successful for the past two years. According to KEARNY, the potential should there still be very important but still barely known.

The main problem for developing industrial purse seine fishery is a technical one. Purse seining is not possible when schools are too small or too scattered. This is the reason why purse seine cannot operate in the fishing grounds of the small pole and line boats which may prevent any conflict. We present briefly, here, areas where purse seining can be introduced in Indonesia : we consider four main areas :

19.2.4.1. North of Irian Jaya.

That area is well known to japanese and american purse seine fishing companies. Trials have been done by JAMARC for the past ten years and the technique of night fishing on drifting logs is now being used. We must notice however that for two years, a higher proportion of catches has been done on fish school set during the daytime. Catch rate by japanese purse seine averages 20 tons per set, 10 tons per day at sea and 15 tons per effective fishing day. Japanese purse seiners come in the area from Japan, making 30 to 40 daytrips on which 10 days are lost in travels.
So, we can expect better annual catches for vessels based in Ternate, Sorong or Biak which are very near the fishing grounds.
However, because the fishing grounds are wide and the schools available for purse seiners always difficult to find, we recommend the companies in order to be efficient, to operate with, at least, 2 or 3 vessels.

19.2.4.2. West of Sumatra.

Areas North West and South of Sumatra are yet completely inexploited and largely inexplored for their tuna resources. Only small scale fisheries based in Padang and Banda Aceh catch 2 500 to 4 000 tons of skipjack and yellowfin. Schools are met all year long off Siberut and Pagaï Islands but these schools are usually scattered.

From January to April-May, hydrological structures, are convenient between 5° N - 5° S and from coast line to 85° E (a homogeneous layer of 100 m or less with a temperature gradient of 2° to 3°C/10 metres in the thermocline). During this season school fish sets could be possible during the daytime. More over, drifting logs are numerous off shore in November-December and from March to June and could allow the setting on drifting logs.

Using this method, purse seiner "LADY SUSHILL" has caught 517 tons in 50 days in the area 0 - 2° S, between 87° E and 90° E, in January-February 1980. During this period, we note a strong convergence at this latitude. In March 1982, a Japanese purse seiner has been observed by local fishermen doing trials on drifting logs off Pagai Islands.

From April to October, we can also observe a strong convergence of surface current between 8° S - 10° S and 85° E - 100° E. From August to October, this convergence may be very close to Southern Sumatra about 6° S to 8° S.

19.2.4.3. South of Java and Nusatenggara Islands.

Convenient hydrological conditions may occur in those areas from July to September because of coastal upwelling in South of Java and Bali. At this time coastal sea surface temperature may be 1.5° to 2°C below offshore temperature, and frontal areas could be convenient for purse seining. A longline vessel captain confirmed to us the abundance of active skipjack schools in this area from May to August.

So, during this period, we could expect a season for purse seining on daytime fish schools. A well recorded thermocline (even if a little too deep, 100-120 m) has been observed in South and South West Java during the "Jetindofish" cruises done in February-March. During this period, many drifting logs can be encountered offshore and could allow night logs setting, if those logs have fish, which must be verified. Consequently, there is in Southern Indonesia (Indian Ocean) two complementary fishing seasons for purse seine : one from January to May in South West Java on drifting logs and another from June to August-September in South of Bali and Nusatenggara. During the period October to December, fishing could occur either in West Sumatra or in Ceram and Buru Seas.

19.2.4.4. Conclusions.

If we except the North coast of Irian Jaya, we can say that the purse seine fishing grounds of Indonesia are yet to be discovered.

This is why we recommand experimental surveys by commercial boats particularly in the Indian Ocean West of Sumatra and in the South of Java and Nusatenggara Islands.

20 RESOURCE ASSESSMENT AND NATIONAL AND INTERNATIONAL IMPLICATIONS.

20.1. Western Pacific Ocean.

Skipjack are highly fecund, fast growing and relatively short lived, if compared to larger tunas. Stock assessments made by the South Pacific Commission (SPC) indicate that the present fishing level in the Western Pacific, probably near 500 000 to 600 000 tons in recent years, is very low, offering a considerable potential for increased catches.

SPC scientists calculated the Western Pacific stock to be about 10 millions tons with a turn over of 20 % a month (that is 20 % of the stock is replaced each month). If 50 % of this turn over was caught, a potential annual catch of 12 millions tons is possible. These calculations are yet to be confirmed as they greatly exceed the previous estimations but they indicate, at least, that there is no overfishing problem for this species at the present time.

Areas where the vessels may operate are usually limited during a given period, so, the stock available to purse seining is also limited. Even if there is no global overfishing a too large number of vessels in the area where the fish is catchable means a higher competition between them and so lower the catch rates for each vessel. On the other hand, as it always takes time to find the concentration of schools or logs, the number of vessels operating in one area, must not be too low. Individual vessel should not loose too much time finding grounds so, the interest of the companies is to work in fleet of two or three vessels at least.

Big oceanic purse seiners cannot usually operate in areas very close to the shore where the schools are too small or too scattered (there are some exceptions) ; and so they need to be able to operate seasonally in different areas and often in different EEZ. This is of great importance if we consider the national and international resources management.

Since the oceanographic conditions in the area North of Irian Jaya may change from one year to another, and because some of the fishing grounds usually found in the Indonesian EEZ may be found, according to the season or the year, in neighbouring waters and vice versa, we think that a mutual agreement between those countries would be of a great interest for the future Indonesian purse seine fleet.

In tuna fishing, especially with purse seine, a better mobility and a wider choice between fishing grounds mean a better catch. We consider that 10 to 20 purse seiners, at least, may operate from Indonesia in Indonesian EEZ and international waters of Eastern Indonesia.

We have seen that the risk is very small to overfish skipjack , whose potential is very high. It is the reason why we do not find any sign of an hypothetic effect of the purse seine fishing on the abundance of the stock available to the small scale pole and line fishery (chapters 18, 19). As artisanal pole and liners and purse seiners do not compete in the same areas and for the same schools, there is no restriction to develop both kinds of fishery simultaneously.

The problem of resource management which has been sometimes pointed out in the Western Pacific comes from the fact that juvenile yellowfin constitute significant proportion of the catches of purse seiners (about 15 %). Adult yelllowfin are caught by long liners and are considered to be fully exploited, so, in order to protect yellowfin tuna stock, skipjack purse seining might have to be restricted. In order to know the real effect, we can see what happened in the Atlantic Ocean when yellowfin surface fishery was introduced ; before its introduction the Maximum Sustainable Yield (MSY) calculated from the catch and effort of the longline fleet was estimated to be around 45 000 tons ; at the present time, the catches by purse seiners have reached 120 000 tons and the longline catches have become stable at a lower level of 35 000 tons. So, the total catches of yellowfin has been multiplied nearly by three, with the introduction surface fishing.

20.2. Indian Ocean.

Presently, the main species caught in the Indonesian waters of the Indian Ocean are yellowfin and bigeye, both fished by longline fleets. According to SUZUKI (1979), the estimated MSY for yellowfin is about 40 to 60 000 tons. In recent years, the total production by the longline fishery was around 30 000 tons and it has generally been agreed that, even if the fishing effort by the longline fishery was increased, no marginal increase in the catch could be expected (FAO, 1969 ; HONMA and SUZUKI 1972, SUZUKI 1979).
However, the development of the surface fishery may potentially increase the total production.

With the introduction of deep long line, it appears that the stock of bigeye tuna in the Indian Ocean offers scope for further exploitations. According to RIGGS, 1981 (in SILAS and PILLAI, 1982), the yield curve shows increasing catch with effort. As stated by FAO, an increase in the total catch could be obtained by increasing the longline fishery effort, but the CPUE will probably tend to decline gradually. However, the increased use of deep long line gear might further the production of bigeye without lower CPUE, at least in a short future (see chapter 3).

As already seen for the Western Pacific, the main potential in the future remains the skipjack. The total potential for this species is not known ; estimates recently discussed in IOFC give a potential of 225 to 400 000 tons with present catches no more than 30 to 60 000 tons. If we exclude the possible development of the small scale sector, which catches the fish close to the coastal and insular areas, one way to increase the catches of skipjack is to introduce there purse seiners fishing offshore. As seen for the Western Pacific, the introduction of this technique will not, most probably, have any effect on the existing artisanal fishery. However, as the resources are little known, we consider that it could be of great interest for the country to favour experimental fishing, there.

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