Experimental Operations of Marlin Long Lines in the Gulf of Thailand

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In four-days experimental long line operations near Samui island in the Gulf of Thailand in November 1982, black marlin was caught at a rate of 1.03 fish per 100 hooks. While the catch fluctuated by operations from 0.16 to 2.15 fish per 100 hooks, the differences in hooking rate between either hooks put on two kinds of baits (local pelagic fishes vs saury from Japan) or hooks suspended at different depths (20~40 m vs 40~70 m) were not significant. The fish caught were all small-sized, from 129 cm FL and 14.0 kg BW to 198 cm FL and 62.5 kg BW. Body weight (kg) related to fork length (cm) as $BW=6.808\ FL^{2.98}\cdot 10^{-6}$ with both sexes combined. The sex ratio was much biassed in favor of male (4.75). Although gonads of almost all the males and females were smaller than 495 g, one female of 198 cm FL had a large ovary of 4,680 g. Half of the fish caught had in their stomach some food consisting mainly of pelagic fishes.

A possibility that the waters adjacent to Samui island in the Gulf of Thailand might make a good fishing ground of long lines for black marlin was suggested by an experimental operation by the training vessel Paknam of the Training Department of the Southeast Asian Fisheries Development Center (SEAFDEC) in July 1980 (Shindo, 1980). Thereafter, efforts have been made by SEAFDEC and the Exploratory Fishing Division, Department of Fisheries, Thailand (EFDT) to study the feasibility of the fishing ground (Takahashi, et al., 1983). In course of such studies, a joint EFDT-SEAFDEC-Nagasaki University survey of the fishing ground was conducted by the training vessel Nagasaki-maru of the Faculty of Fisheries, Nagasaki University (FFUN) from October 28th to November 5th, 1982.

A part of the results of the joint survey was reported by Takahashi, et al. (1983), integrated with the results obtained in earlier surveys by SEAFDEC and EFDT. As only a part of the data of the joint survey is presented in Takahashi, et al.'s paper, we publish the present paper.

Fishing gear and operation record

Fig. 1 illustrates the arrangement and structure of components of a unit, hereafter referred to as a basket, of our long line. As a rule, we used 150 baskets for each operation, of which 50 baskets each were fitted with branch lines prepared by each of the three participant organizations. The designs of the branch lines from the three organizations had nearly the same length, although there was a little difference in details. Because of the entanglement of the line the numbers of baskets considered to have been effective ranged from 150 to 127 (Table 1).

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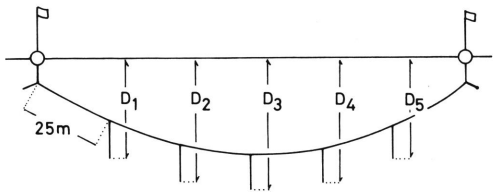

	EFDT	SEAFDEC	FFUN
	m	m	m
A	-	0.12	0.12
B	1.0	0.4	0.4
C	0.07	0.06	0.06
D	0.1	-	4.0
E	5.2	8.3	3.8
F	2.8	2.2	2.0
Sum	9.2	11.1	10.4
G	#38	#35	#38

A:branch hanger
B:vinylon cord
C:swivel
D:vinylon cord
E:compound wire
F:wire leader
G:hook

Fig. 1. Design of a unit (basket) of the long lines, 150 m long and with five branch lines, prepared by Exploratory Fishing Division, Department of Fisheries, Thailand (EFDT), Training Department, Southeast Asian Fisheries Development Center (SEAFDEC), and Faculty of Fisheries, Nagasaki University (FFUN). D_1-D_5 correspond with those in Table 1.

Four kinds of bait were used; small-sized pelagic fishes purchased at a local fish market (frozen), saury carried from Japan (frozen), live milkfish, and artificial bait. The pelagic fishes consisted of scad (*Decapterus maruadsi*), 16～19 cm FL and 68～93 g BW, and sardines (*Dussumieria acuta, D. hasseltii,* and *Sardinella jussieu*), 11.5～15 cm BL and 24～28 g BW. The saury (*Cololabis saira*) were 28～30 cm BL and 100～130 g BW. The milkfish (*Chanos chanos*), 13～15 cm FL and 40～70 g BW, were originally collected as fry at Tanegashima, a small island just south to Kyushu, in the preceding year, had been reared in the Nomo Fisheries Station, Nagasaki University, and were carried alive by T/V Nagasaki-maru. The artificial bait is a lure of polyester (Fig. 2) which was manufactured for trial by a fishing tackle manufacturer in Takeo City, Saga Prefecture, Japan.

The experimental marlin long lines were conducted on four days during the joint survey* in the waters 60～70 m deep and 60 to 90 nautical miles off the South Thai coast (Table 1, Fig. 3a). The setting of the lines started early

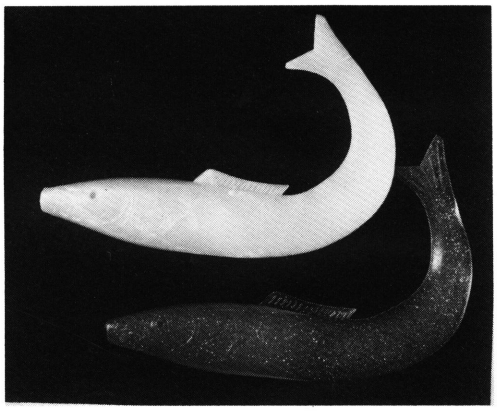

Fig. 2. Polyester lures in two different colors, white (top) and pink (bottom). When pulled in water at above a certain velocity, the tail becomes stretched backward, giving a total length of 28 cm, with undulations in the lower half of the caudal part to produce a waving movement of the tail.

Table 1. Operation records of marlin long line in the Gulf of Thailand, 31 Oct.～4 Nov. 1982.

Operation number	Date	Position	Depth (m)	No. of basket	Dist. betw. buoys (m)	Depth $D_{1,5}$	Depth of hooks (m) $D_{2,4}$	D_3
L_1	Oct. 31	09°-05.4′N 100°-38.8′E	70	150	148.2	23.4	27.1	28.3
L_2	Nov. 1	09°-32.9′N 101°-11.0′E	60	127	140.0	30.0	38.2	41.1
L_3	Nov. 3	10°-03.7′N 100°-56.2′E	60～65	142	108.3	38.7	56.3	63.9
L_4	Nov. 4	10°-30.9′N 100°-56.0′E	62	136	126.6	35.8	48.6	53.5

* The remaining days were allocated for surveys on demersal fishes, benthos, planktons, and oceanographies.

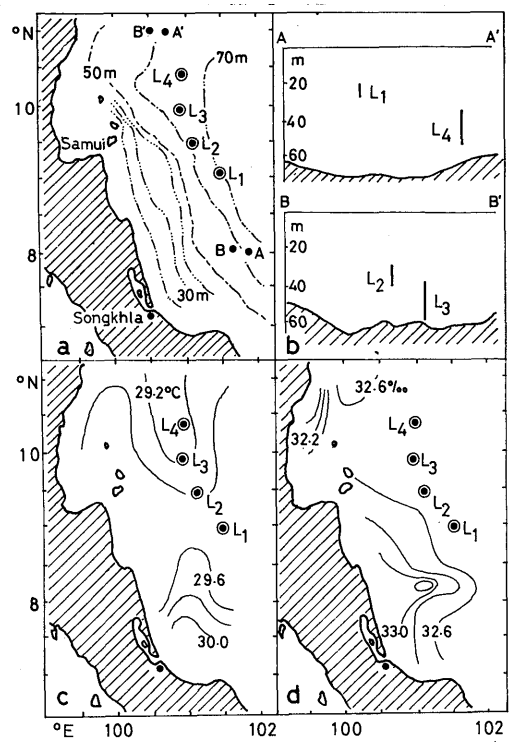

Fig. 3. Charts to show topography of the sea where four operations (L_1-L_4) were made (a), prophile of the sea and the depths at which hooks were estimated to have been kept suspended (b), distribution of water temperature at 25-m layer (c), and the same of salinity (d).

in the morning and finished at around 0830 hr. About four hours after that, we started the heaving.

The average depth below surface at which each of five hooks of a basket was kept suspended between the end of setting and the start of heaving was estimated by the formula of catenary based on the average distance between the bouys at both ends of a basket. The depths thus calculated are added to Table 1 and illustrated in Fig. 3b.

Oceanography of the fishing ground

The upper 30 to 40-m layer of the fishing ground was covered by almost a homogeneous water of 29.1~29.3℃ in temperature and about 32.4 ‰ in salinity (Fig. 3c and d, Fig. 4a~d). The water temperature was lower on the north

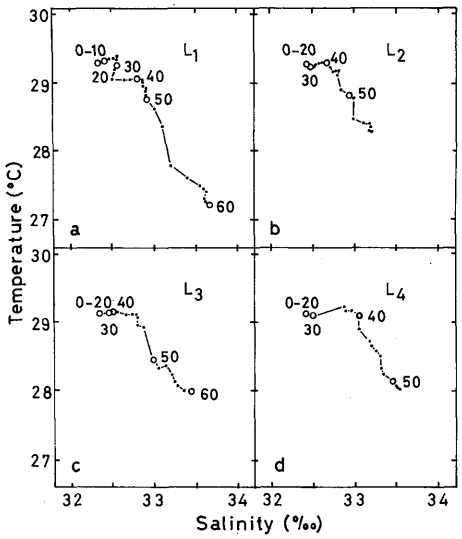

Fig. 4. T-S diagrams at four stations where the experimental long line was made.

and higher on the south of the fishing ground, while salinity was higher both on the north and south. The differences in temperatures and salinities in these areas from those in the fishing ground were small. The coastal area to the west of the fishing ground was covered by a less saline water.

Below 30 to 40-m layer, the temperature and salinity fell and rose, respectively, rather markedly with depth (Fig. 4). Comparing Fig. 3b with Fig. 4a~d, we know that the five hooks of a basket were set in almost the homogeneous water in operations L_1 and L_2, while in operations L_3 and L_4 they were in the water of a much wider ranges of temperature and salinity.

Catch of black marlin

1. Overall hooking rate

A total of 26 black marlin, *Makaira indica* (Cuvier), was caught. For the identification, the shape of lateral apophyses of central vertebrae was also examined in addition to the external characters of the fish (Ueyanagi and Watanabe, 1965; Nakamura, et al., 1968; Nakamura, 1983). None of other species of the families Istiophoridae and Xiphiidae occurred in the catch.

The catch records are presented in Table 2.

Table 2. Catch records of black marlin by operations and by baits in the Gulf of Thailand, 31 Oct.~4 Nov. 1982. In each column, the number of fish caught is followed by the number of hooks used (both separated by a slant line); the number of fish per 100 hooks is given in parentheses.

Operation number	Catch by baits				Total*
	Scad and sardine	Saury from Japan	Live milkfish	Artificial bait	
L_1	6/555 (1.08)	2/120 (1.67)	(not used)	0/75 (0.00)	8/675 (1.19)
L_2	11/521 (2.16)	2/ 70 (2.86)	0/13 (0.00)	0/35 (0.00)	13/604 (2.15)
L_3	4/553 (0.72)	0/ 70 (0.00)	0/14 (0.00)	0/65 (0.00)	4/637 (0.63)
L_4	1/395 (0.25)	0/210 (0.00)	0/15 (0.00)	0/60 (0.00)	1/620 (0.16)
Total	22/2024 (1.09)	4/470 (0.85)	0/42 (0.00)	0/235 (0.00)	26/2536 (1.03)

* The number of hooks used with the artificial bait is excluded.

Table 3. Analysis of variance of catch of black marlin (fish per 100 hooks) in four operations, L_1~L_4, with two kinds of baits, scad-sardine and saury.

Source of variation	Degree of freedom	Sum of squares	Mean square	Ratio (F)	$F_{.05}$
Operations (L)	3	7.123	2.374	10.23	9.28
Baits (B)	1	0.013	0.013	—	
Residual (LxB)	3	0.697	0.232		
Total	7	7.833			

As no fish was caught with hooks put on an artificial bait*, these hooks were omitted in calculation of the overall hooking rate. Thus we get an overall hooking rate of 1.03 fish per 100 hooks. It has been said that black marlin is coastal species rather than oceanic (Nakamura, 1938; Hirasaka and Nakamura, 1947; Morita, 1953; Ueyanagi, 1963; Koga, 1967). Still we were a little surprized at this high hooking rate.

2. Hooking rate by operations, baits, and depths of hooks

The hooking rate was the highest in operation L_2 (2.15 fish per 100 hooks), followed by L_1, while the catch was rather poor in operations L_3 and L_4 (Table 2). Paucity of the data restrains us from relating the high hooking rates in L_2 and L_1 with the extension of the warmer and more saline water from south or southwest toward the sites of these operations (Fig. 3).

In comparison of the hooking rates by baits, the artificial bait and live milkfish are not taken into consideration; the former did not work obviously, and the total number of hooks used with the latter was too small for any further analysis.

Analysis of variance showed that there was no significant difference in efficiency between two kinds of baits, scad+sardine and saury (Table 3).

Table 4 summarizes the catch records of

* This lure is originally designed to be pulled at above a certain velocity as in trolling. It seems that this does not work when it is drifted with current as in long lining.

Table 4. Catch records of black marlin by operations and by depths of hooks. The number of fish caught, the number of hooks used, and the number of fish per 100 hooks are given as in Table 2. The number of hooks used with live milkfish and the artificial bait are excluded. Blank spaces mean no data is available.

Operation number	Depths of hooks (m)				
	20.1~30.0	30.1~40.0	40.1~50.0	50.1~60.0	60.1~70.0
L_1	8/675 (1.19)				
L_2	6/236 (2.54)	2/237 (0.84)	5/118 (4.24)		
L_3		2/249 (0.80)		1/249 (0.40)	1/125 (0.80)
L_4		0/242 (0.00)	1/242 (0.41)	0/121 (0.00)	
Total	14/911 (1.54)	4/728 (0.55)	6/360 (1.67)	1/370 (0.27)	1/125 (0.80)

Table 5. Catch of black marlin (fish per 100 hooks) in three operations, L_2~L_4, with two kinds of baits (scad-sardine and saury) combined, in upper layers (20.1~40.0 m) and lower layers (40.1~70.0 m).

Layers (m)	Operations			Sum	Mean
	L_2	L_3	L_4		
20.1~40.1	1.69	0.80	0.00	2.49	0.83
40.1~70.0	4.24	0.53	0.28	5.05	1.68
Sum	5.93	1.33	0.28	7.54	
Mean	2.97	0.67	0.14		1.26

Table 6. Analysis of variance of catch of black marlin in Table 5.

Source of variation	Degree of freedom	Sum of squares	Mean square	Ratio (F)	$F_{.05}$
Operations (L)	2	9.031	64.515	4.041	9.55
Layers (D)	1	1.092	1.092	—	
Residual (L×D)	2	2.235	1.117		
Total	5	12.358			

black marlin by operations and by depths at which hooks were supposed to have been suspended. The fish was caught over the whole range of the depths.

The hooks in operation L_1 had been suspended in a narrow range of depth, and the distributions of hooks by depths in the other operations are biased either to shallower side or to the deeper side in Table 4 where the class interval of the depth is 10 m. The data in Table 4 are rearranged in Table 5, in which the data in L_1 is excluded and the depths of hooks were grouped into two classes, the upper and lower layers. Analysis of variance revealed that the hooking rates did not differ significantly by layers (Table 6).

Biological data of black marlin

Of 26 black marlin hooked, two escaped from

just below the gangway. All the remaining 24 fish were measured, weighed, and sexed, and the stomach contents were observed by the Thai scientists on board. For length of fish, the length from the anterior extremity of the lower jaw to the posterior end of the median caudal rays was taken as fork length (FL), which is the same as body length by Nakamura (1983). The length between the posterior margin of the orbit and the posterior end of the median caudal rays is called eye-fork length (EFL), which is used by many scientists in measuring billfishes at fish markets (Ueyanagi, 1953; Koto, et al., 1959; Nakamura, et al., 1968; etc.). This is probably because that fishermen usually cut the anterior part of the lower jaw together with the bill before stocking the fish in freezing hold. According to Nakamura (1983), eye-fork length of black marlin ranged from 85.6 to 87.9 % of fork length (=body length by Nakamura).

The black marlin caught by us were all small-sized, ranging from 129 cm and 14.0 kg BW to 198 cm FL and 62.5 kg BW (Fig. 5). The fish smaller than 157 cm FL, 19 fish, were all males, with the means and standard deviations of 143.6 ±8.1 cm FL and 18.59±3.04 kg BW. The remaining five fish, above 162 cm FL with the means and standard deviations of 177.6±15.1 cm FL and 36.74±15.00 kg BW, were females. Inclusive of all the data (105 fish) obtained in the Gulf of Thailand since 1980 by SEAFDEC and EFDT, the biggest black marlin caught was 229 cm FL and 82 kg BW, but the fish smaller than 180 cm FL and 35 kg BW accounted for 75 % of all (Takahashi, et al., 1983),

Black marlin grows to the biggest size among billfishes; a record of a 708-kg specimen is known (Nakamura, 1983). Of 2,542 and 4,448 fish landed respectively at Kaohsiung and Suou, Taiwan, in 1943, 30 % each were bigger than 100 kg BW (Nakamura, 1944). Of 36,673 fish caught by Japanese fishing boats in the East China Sea in 1952~1959, 80 % were accounted for by fish 140 to 210 cm EFL (about 163 to 244 cm FL) (Koto, et al., 1959).

Although black marlin is known to be rather coastal species among billfishes, it seems that the fish migrating into the shallow waters such as the Gulf of Thailand are only a part of young fish.

The clear-cut difference in size by sexes in our data must be attributable to a mere chance. About 7 % of males in the data presented by Takahashi, et al. (1983) were larger than 200 cm FL. On the other hand, the sex ratio much biassed in favor of male (4.75) seems a genuine one. Of 79 black marlin caught by experimental long line fishing in the Gulf of Thailand in 1982, 69 were males (Takahashi, et al., 1983).

Fig. 5 also shows the relationship between fork length and body weight. Although the two regression equations for male and female look quite different, the both give the same body weight (23.4 kg) at 160 cm FL. If the data for both sexes are combined, we get

$BW=6.808FL^{2.98}\cdot10^{-6}$.

The means and standard deviations of the condition factor, $BW(kg)\cdot FL(cm)^{-3}\cdot10^{6}$, were 6.3 ±0.6 for males, and 5.8±0.5 for females. The difference by sexes is not significant ($t=1.823$, $t_{.05}=2.074$).

According to Koto, et al. (1959), the condition factor of black marlin in the East China Sea tended to increase from 11 at 130 cm EFL (ca. 150 cm FL) to 12 at 200 cm EFL (ca. 233 cm FL). These values of condition factor which were calculated on eye-fork length are equivalent to 6.0 and 6.8, respectively, calculated on fork length, putting the former length at 86 % of the latter. We can consider that the condition factors of black marlin in the Gulf of Thailand and in the East China Sea are almost the same.

The gonads of all the male were in immature stage; their weight ranging from 52 to 370 g, with the mean of 213 g. Of females, four had undeveloped ovaries weighing from 192 to 495 g, with the mean of 348 g. The remaining and biggest female, 198 cm FL, however, had a large ovary of 4,680 g. While Koto, et al. (1959)

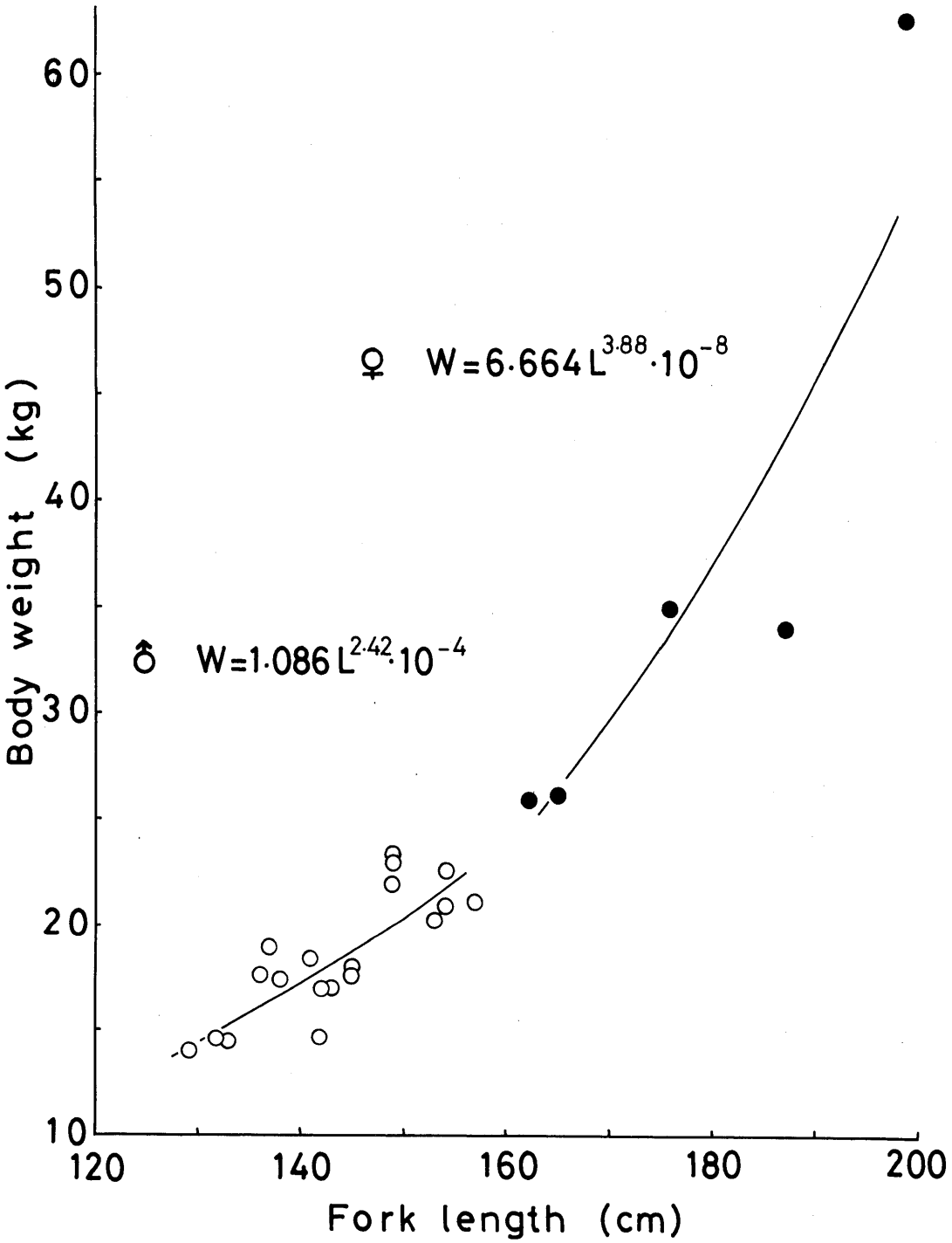

Fig. 5. Fork length and body weight of 19 male (open dots) and five female (solid dots) black marlin caught during the survey.

supposed that the fish takes part in breeding after reaching 200 cm EFL, Nakamura (1975) wrote that the age of the first sexual maturity was not known. As we did not examine the ovary histologically, it is not sure if the female with the large ovary was to spawn before long.

Although half (12 fish) of the fish caught had some food in their stomach, the amount found

was generally little, ranging from 10 to 150 g. Food items mostly consited of fishes, especially pelagic ones; *Decapterus* occurred in five stomachs, *Caranx* in two, and *Thunnus tonggol, Trichiurus* and *Alutera* in one each. Two demersal fishes, *Nemipterus* and *Priacanthus,* were also found in one stomach each. As for decapod mollusks, only species encountered was *Euprymna* (Sepiolidae) which was found in one stomach.

Acknowledgments

We express our heartfelt gratitude to Mr. Virat Charusombat, Director of Exploratory Fishing Division, Department of Fisheries, Thailand, and Dr. Shigeaki Shindo, Deputy Secretary General, SEAFDEC who took every trouble to implement the present joint survey. Our thanks are due to all the Thai scientists who took part in the survey and the crew staff of T/V Nagasaki-maru, especially to Mr. Dhummasakdi Poreeyanond from EFDT who acted as the leader of the Thai team as well as a liason officer for the participants from the three organizations.

We express our sincere gratitude to Dr. Shoji Ueyanagi, Dr. Izumi Nakamura, and Dr. Tsutomu Koto for their kindness of helping us in obtaining valuable pieces of literature.

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シャム湾におけるカジキ延縄試験操業結果

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岡座輝男・千田哲資

1982年11月にシャム湾のサムイ島東方水域において，4日間にわたりカジキ延縄の試験操業をおこない，26尾のシロカワカジキを捕獲した。鈎百本当りの釣獲率は日により0.16～2.15尾の間で変動し，4日間を通じて平均1.03尾であった。餌の種類（現地購入のイワシ類とアジ類，および日本から運んだ冷凍サンマ），または鈎の垂下層（20～40m層と40～70m層）による釣獲率には有意な差はみられなかった。漁獲魚はすべて小型魚で，尾叉長129cm，体重14.0kgから尾叉長198cm，体重62.5kgの範囲であった。最大の個体は雌で，重量4,680gの卵巣をもっていた。