Tuna Resource Exploration with Tuna Longline in the South China Sea, Area IV : Vietnamese Waters

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ABSTRACT

The survey was designed to be carried out only in the central part of the whole area which was considered as deep sea or oceanic zone. Depth of water is mostly more than 1,000 m deep. The exploration area was covered from latitude 7º-30.0' N to latitude 16º-00.0' N and longitude 110º-00.0' E to longitude 112º-30.1' E covering around 72,000 square miles. Surface temperature varied from 27.4º C to 30.1º C, shallow thermocline layer is still the characteristic of South China Sea fishing ground. It was detached from 15-50 meters depth then water temperature decreased gradually until at the depth of 130-200 m with water temperature around 15.3º C. Three tuna were caught during the survey of M.V.SEAFDEC and many were caught on local fishing boat by both type of fishing gear tuna longline and drift gill net. They are mostly skipjack tuna *Katsuwanus pelamis* (Linnaeus, 1758) and yellowfin tuna *Thunnus albacares* (Bonnaterre, 1788) others catch were dolphinfish *Coryphaena hippurus* (Linnaeus 1758), wahoo *Acanthocybium solandri* (Cuvier, 1831), shortfin mako shark *Isurus oxyrinchus* (Rafinesque, 1809), Bigeye thresher shark *Alopias superciliosus* (Lowe, 1839), swordfish *Xiphias gladius* (Linnaeus, 1758), Bigtooth pomfret *Brama orcini* (Cuvier, 1831) and the most abundance was lancetfish *Alepissaurus borealis* (Gill, 1874). Tuna resource was found more abundance in the middle part of the survey area than the upper and lower. Their swimming layer was around 50 m to 90 m depth.

Key words : Thermocline layer, Optimum temperature, tuna longline, drift gill net, swimming layer, distribution, abundance, lancet fish

Introduction

Vietnamese waters presently cover very wide area almost more than 160,000 square miles including Exclusive Economic Zone (EEZ). The waters cover the western part of South China Sea, which is along the longitudinal line of 103°-00.0'E to 112°-30.0'E, and cover wide range of latitude from around 06°-30.0'N to 21°-30.0'N. This geographic location causes to the different fishing ground condition and fisheries resources of Vietnamese waters. Fishing ground conditions of Vietnamese waters could be separated into three different types by geographical characters. Firstly, coastal water in the high latitude fishing ground in Tonkin Bay which is shallow water and seawater temperature is a little bit cooler than the southern area (27°-28°C). Secondly, deep sea waters or oceanic zone in the central part of the area, depth of water is more than 1,000 m deep, the continental slope is very steep along the offshore of Qui Nhon to Nha Trang. And thirdly, shallow water fishing ground in the low latitude area, it is located in the southern part of Vietnam which is effected by Maekong River and the Gulf of Thailand. Sea depth is shallow and warmer than the northern part (29-30 °C). As Vietnam is located in the tropical zone of the world, so their main fisheries resource is not much different from other countries

in Southeast Asia. They may have some minor differences in the resource of northern and southern area. However, fisheries resource of Vietnam has more abundance and varied in quantity and species. Fisheries product of Vietnam in 1996 was 1,028,500 metric tons, marine fisheries was the main product total 962,500 metric tons (SEAFDEC-1998). Tuna and tuna-like fishes of Vietnam are composed of frigate tuna *Auxis thazard* (Lacepede, 1800), bullet tuna *Auxis rochei* (Risso, 1810) eastern little tuna or Kawakawa *Euthynnus affinis* (Cantor,1849), longtail tuna *Thunnus tonggol* (Bleeker, 1851) these were found in the coastal waters. And other species of tuna found in the oceanic zone are skipjack tuna *Katsuwonus pelamis* (Linnaeus, 1758), yellowfin tuna *Thunnus albacares* (Bonnaterre, 1788) and bigeye tuna *Thunnus obesus* (Lowe, 1839). Coastal tuna and tuna-like fishes were caught by purse seine, drift gill net and trolling line while the oceanic species were less caught by drift gill net and drifting longline. Generally the oceanic species are living in deep waters (oceanic zone) with the depth of water of over 200 m deep. They are usually found in the over 1000 m depth fishing ground. So that the suitable fishing ground of tuna in Vietnamese waters should be the central part which is considered by the depth contour of 1000 m. By geographical chart this area is located at the latitude between 7° N to 16° N and longitude between 110° E to 113°E, it covers about 72,000 square miles. Most of Vietnamese fishing boats are vary small and carried out fishing operation by near shore waters, a small number of bigger vessels are operating in off shore waters for oceanic squid (flying squid) angling (jigging), drift gill net and drifting long line. So it seems to be under utilization of the tuna resources in the waters for Vietnamese fishermen.

Presently there are some Vietnamese fishermen operating drifting longline for tuna and other pelagic species in the off shore waters of Oui Nhon down to Nha Trang Province. Their fishing boats size are about 12-17 m in length and 3-4 m in width, with main engine about 80-150 horsepower. They operate two kind of fishing gears on their vessel, surface gill net for catching flying fish in daytime is purposely for bait supply and drifting longline at nighttime. The catch are skipjack tuna, yellowfin tuna, marlin, swordfish, wahoo, dolphinfish and shark. It is quite very difficult to study on the stock assessment of tuna by using tuna longline fishing gear, because there are so many outside factors play interaction to the operation of this gear. However, the analysis of catch rates (number per hook) is still used as the best measure of effort for stock assessment purpose but it is not appropriate for economic analysis (Polacheck, 1990). South China Sea had been the main fishing ground for Taiwanese tuna longline in the previous times, it was indicated that the catch rate was around 3.4 fish/100 hook for all catches and 2.5 tuna per 100 hooks in the 1950s (Tapiador, 1952). CPUE for tuna in Zulu sea in 1983 was around 0.2 percent (Tiongson, 1983) and the last survey of MV SEAFDEC on the Western Philippines in 1998 was no catch of tuna on that survey, it may be that some fishing technique were not appropriate to that fishing ground.(Dickson, 1998) However, tuna resource in the South China Sea have shown significantly declined in the 1980s (Tiongson, 1993). Small-scale tuna longline and artisanal tuna fishing are still operated in the off shore fishing ground of Philippines and Vietnam by small-scale fisherman of the countries.

Materials and Methods

Tuna longline fishing gear used for this survey are the original gear used on MV SEAFDEC from 1994 with two different types of branchline Multifilament and Monofilament. The gear construction was consisted of 50 m of 7 mm diameter mansen rope for mainline. Two different types of branchline, 31 m of 4 mm diameter polyester rope, sekiyama and wire leader, and 23 m of 1.8 mm diameter nylon monofilament with wire leader. Buoy line was 25 m of 7 mm diameter Mansen rope connected to 300 mm diameter plastic buoy, ball shape. The gear was arranged into a basket which was consisted of 4-

6 branchlines in one basket depend upon fishing condition, mostly 4 branchlines in a basket was used in this survey, total hook numbers in each operation was about 360 hooks. (Fig.1)

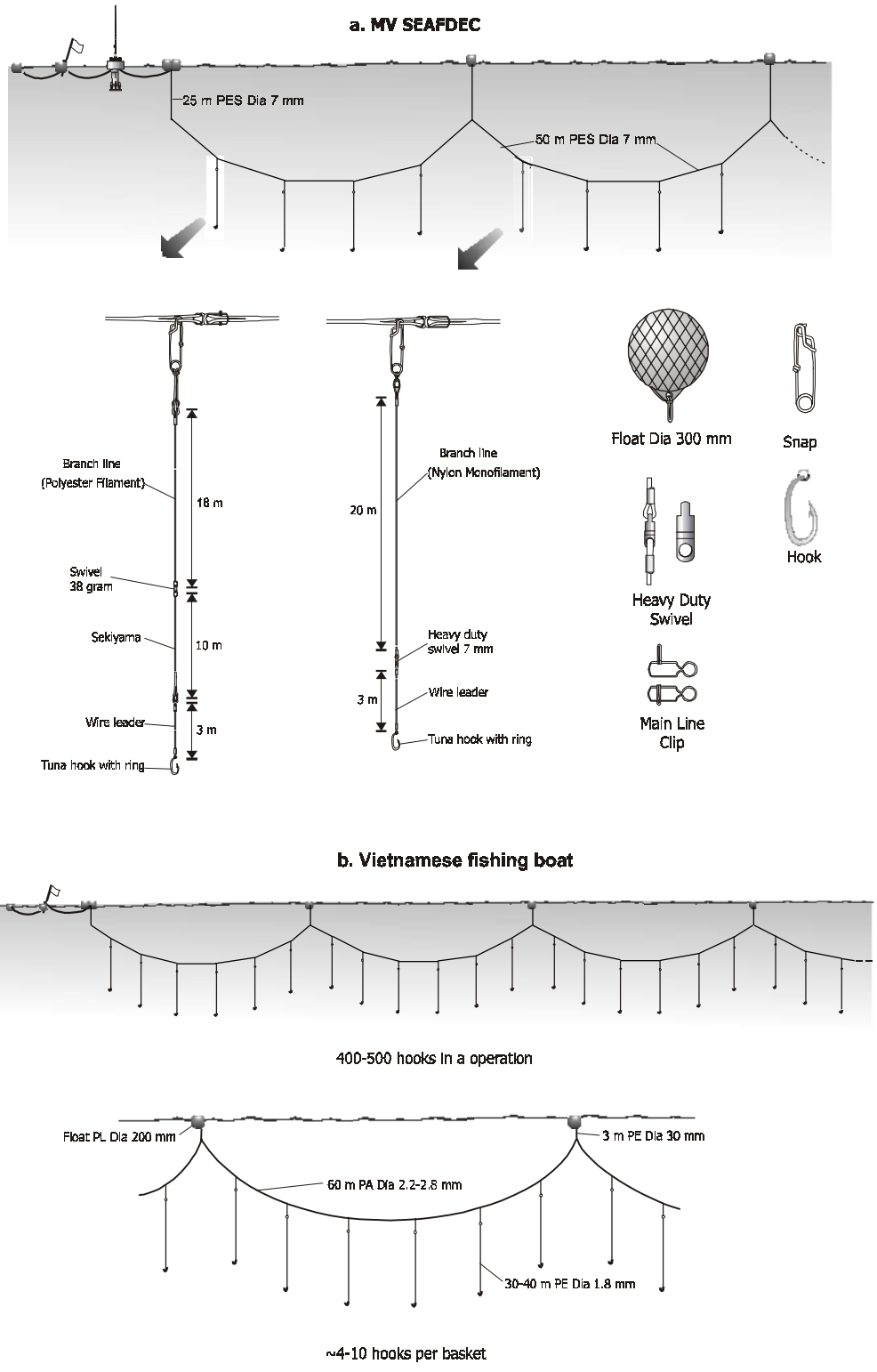

Fig. 1. (a) Fishing gear construction and arrangement of MV SEAFDEC
(b) local fishing boat of Vietnam

Dr. Chu Tien Vinh, Vietnamese fisheries biologist, provided all information and data the local fishing vessels as well as fishing gear installed onboard the local fishing boat accompanying this survey. Local tuna long line fishing gear was consisted of 60 m of 2.2-2.8 mm diameter of nylon monofilament mainline, 30-40 m of 1.8 mm diameter of nylon monofilament branchline, 3 m of 3 mm diameter polyethylene buoy line. The gear was arranged into 6-10 hooks in a basket, total hook numbers in the operation were about 400-500 hooks. The main survey was conducted on MV SEAFDEC together with oceanographic and the others of the collaborative research program, the accompanying survey were carried out on the other two local fishing boats. MV SEAFDEC is a 1,276 gross tonnage tuna purse seine training and research vessel of the Southeast Asian Fisheries Development Center (SEAFDEC), Training Department (TD). The other two local fishing vessels were Vietnamese fishing vessels, 17 m long with 120 Hp of main engine and 19 m long with 330 Hp of main engine, they carried out the survey by drifting longline and drift gill net respectively. The details of drift gill net fishing gear were not been informed but the catch was appeared in the background of this paper. (Catch data provided by Dr. Chu Tien Vinh)

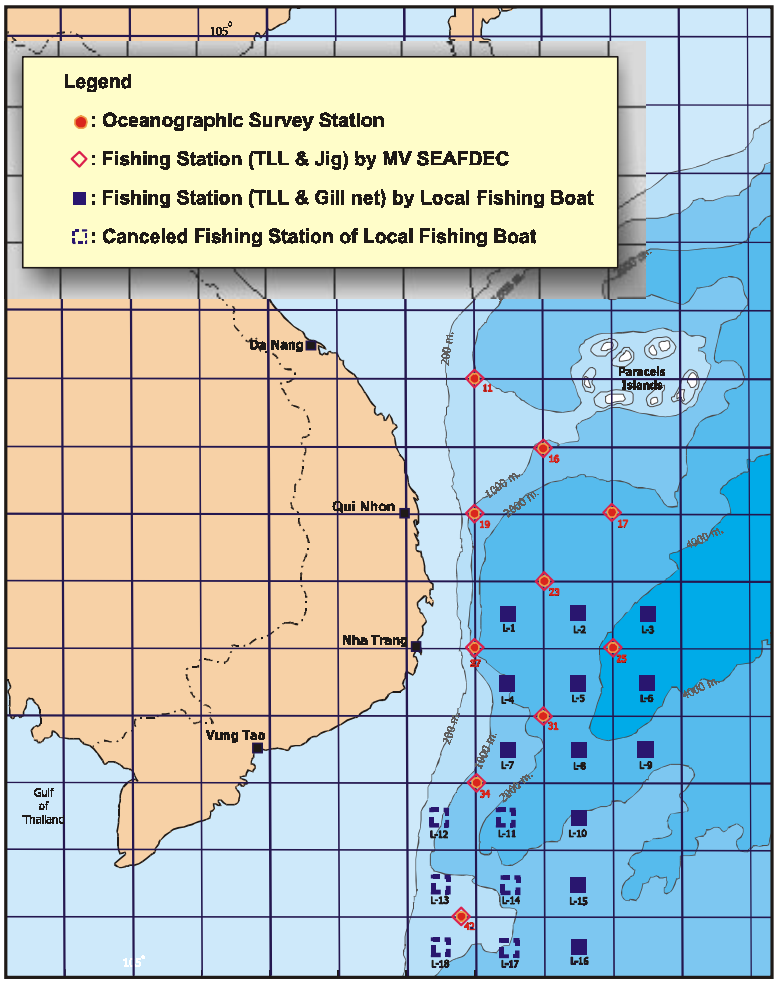

Fig. 2. Fishing survey station during the cruise by MV SEAFDEC and local fishing boat.

Ten fishing survey stations were planned along the stations of Oceanographic survey, they were designed mostly beyond the depth contour of 1,000 m deep, these for MV SEAFDEC. The designed of 18 accompanying survey stations by local fishing boats were distributed among the ten stations of

MV SEAFDEC with around 45 miles interval. However, the fishing survey had been conducted in 12 stations and the rest of 6 stations in the southern area were cancelled. (Fig.2)

Fishing Operation

Indo-pacific mackerel and Indian mackerel were prepared for bait of tuna longline on MV SEAFDEC while flying fish was used on the local fishing vessel. The first two fishing stations were used for fishing survey and checking the swimming layer of tuna at the same time. So fishing gear arrangements of the first two fishing operation on MV SEAFDEC were 6 and 5 branchlines in one basket. Depth of hooks layer were 134-155 m and 70-110 m deep, there was no tuna catch at that time. Then the gear arrangement of 4 branchlines was used for the remained 8 fishing survey stations, they were designed to operate in the two different periods of time, daytime and nighttime, four by four stations. In order to check water temperature at hooks layer, two set of depth meter and temperature meter recorder (RMD&RMT) were fixed at the lowest branchline of the basket number 20 and 60 of the line (total 85 baskets). Daytime operation was carried out from 0500 hrs. to 1500 hrs. While nighttime operation was conducted from 1800 hrs. until 0600 hrs. of the next day.

Fishing operation on board local fishing vessel was carried out only at nighttime (1500 hrs.-0500 hrs.) during the period of 17-28 May 1999.

Fishing Ground Conditions

Oceanographic data of fishing ground were detached and recorded by ICTD before and after the fishing operation, they were water temperature from surface to 1,000 m, salinity, dissolved oxygen, and transparency. At some station, XBT was operated to check the water temperature profile of fishing ground. Those data were used to identify thermocline layer, and also RMT&RMD device were used to confirm water temperature and depth of hooks layer at the same time of operation. (Table.1) Record of water temperature at hook layer compared to water temperature profile was shown in Fig. 3. Prior to any fishing operation, discussion among researchers had been made on the results which had caused effect to the previous operation as to fishing ground conditions, hooks layer and catch.

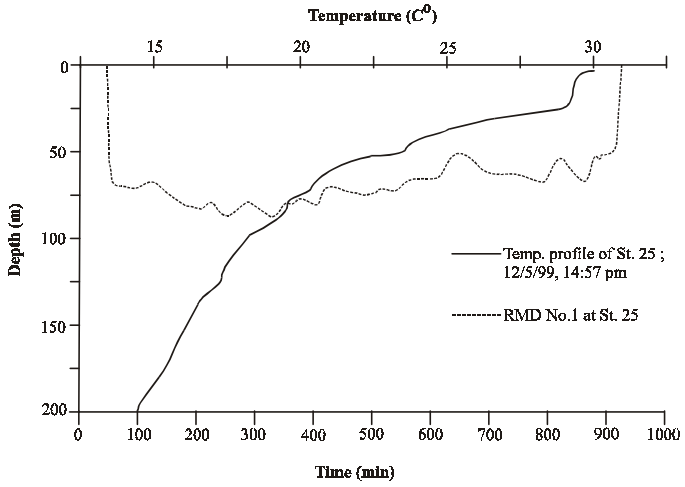

Fig. 3. The respective depth of hooks layer (from RMD) in comparison with the temperature profile of fishing ground from ICTD at Station no. 25.

Results

The tuna survey by tuna longline was carried out by two vessels, MV SEAFDEC and local fishing boat of Vietnam. Twenty-two fishing operations were conducted, 10 operations by MV SEAFDEC and 12 operations by the local one, 3,408 hooks and about 6,000 hooks were set by those two vessels. There were not so many tuna caught, two large sized yellowfin tuna *Thunnus albacares* (Bonnaterre, 1788) and one big sized skipjack tuna *Katsuwonus pelamis* (Linnaeus, 1758) were taken by MV SEAFDEC while 55.9 kg of yellowfin tuna and 73.4 kg of skipjack tuna were taken by local fishing vessel. Other catch by MV SEAFDEC were wahoo *Acanthcybium solandri* (Cuvier, 1831), dolphinfish *Coryphaena hippurus* (Linnaeus, 1758), swordfish *Isurus oxyrinchus* (Rafinesque, 1809), bigeye thresher shark *Alopias superciliosus* (Lowe, 1839), Blue shark *Prionace gluca* (Linnaeus, 1758) black ray and lancetfish *Alepissaurus borealis* (Gill, 1874) while other catch of local fishing boat were. Spanish mackerel, Tripletail, dolphinfish, bigtooth pomfrect *Brama orcini* (Cuvier, 1831), shark and others (Table 2 and 3).

There was no difference between the catch by daytime and nighttime of the operation on MV SEAFDEC, even through there was 5 to 6 hours different in the immersion time, 8-9 hours for daytime operation and 14 hours for night time operation. Almost of the operation on board local fishing vessel were conducted at nighttime for 13 hours immersion times.The hook rate for overall of this survey by MV SEAFDEC was 0.88 percent and only 0.09 percent for tuna (yellowfin and skipjack tuna) but it could not be compared with the catch of local fishing boat because the informed data was only available in total weight of the catch. However it was found that there were yellowfin and skipjack tuna distributed in the oceanic zone at the central part down to southeastern part of Vietnamese waters. This could be more clear understood, when it was compared to the catch of drift gill net which had been operated in the area at the same time (see Table 3 and Fig. 4)

Fishing ground condition of the central area of Vietnamese waters was determined station by station of the fishing survey. It was found that the vertical temperature profile of the fishing stations show a mixed layer of about 10 to 50 m deep after that the water temperature starts to decrease gradually. The thermocline layer is evidently not prominent with temperatures of around 16 °C to17 °C and 15 °C to16 °C at 150 and 200 m, respectively. The level of dissolved oxygen in the upper layer (60 m deep) was about 3.22 –3.88 ml/l, salinity levels were 33.89 to 34.44 ppt. at 60 m deep. (Table1) Base on RMT and RMD data which was recorded at fishing station number 25, 74 kg yellowfin tuna was caught with one blue shark *Prionace glauca* (Linneaus,) one wahoo and three lancetfish. Depth of hooks layer was recorded at 50-80 m deep with the water temperature at 20.5 °C to 23.5° C and depth of sea was over 4,000 m. (Fig. 3) It was similar to the hooks layer of the operation at station number 19 which the result was 56 kg yellowfin tuna, 8.2 kg skipjack tuna, one shortfin mako shark, one dolphinfish, one black ray and one lancetfish. So that according to the information of this survey it could be assumed that the swimming layer of tuna in this area are around 50-90 m deep from the surface.

Table 1. Fishing ground condition of the survey station.

Station No	Location		Sea Depth(m)	Surface temperature (°C)	Transparency (m)	Water quality at 60 m. depth		Thermocline layer				Hook layer			
								Upper		Lower		Monofilament		Multifilament	
	Latitude	Longitude				Salinity (ppt)	DO(ml/l)	Depth(m)	Temp(°C)	Depth(m)	Temp(°C)	Depth(m)	Temp(°C)	Depth(m)	Temp(°C)
11	15°55.0 N	111°20.8 E	847	27.4	29	34.28	4.14	51	26.4	165	16.7	135-145	17.0-18.5	145-155	17.0-18.0
16	14°55.1 N	111°02.7 E	1230	28.6	36	34.05	4.12	40	27.3	140	16.0	100-110	18.0-20.0	70-110	19.0-21.0
17	13°56.9 N	112°01.2 E	2100	29.2	38	33.89	3.83	15	28.8	130	17.3	55-65	15.0-26.0	60-85	23.0-26.0
19	14°00.0 N	109°59.8 E	653	27.9	27	34.44	3.82	30	27.5	110	19.6	55-90	21.0-23.0	55-75	23.0-24.0
23	13°05.0 N	110°58.8 E	2703	29.3	33	34.16	3.69	15	28.8	130	17.2	55-65	*	50-65	24.0-25.0
25	12°02.5 N	112°02.4 E	4117	29.7	30	34.44	3.31	20	29.2	110	17.6	50-75	20.0-22.0	55-80	20.0-23.0
27	11°58.2 N	109°59.7 E	1734	28.3	31	34.39	3.62	15	28.0	200	15.3	50-75	23.0-24.0	55-65	23.0-24.5
31	10°56.0 N	110°59.0 E	2940	28.8	31	34.39	3.77	10	28.7	145	16.4	45-85	21.0-23.0	45-65	22.0-23.0
34	09°55.1 N	109°56.8 E	1614	30.1	33	34.08	3.22	30	29.3	195	15.4	85-90	21.5-23.0	90-110	21.0-22.5
42	07°57.0 N	109°49.5 E	628	29.7	24	34.26	3.70	25	29.4	200	15.8	75-105	22.0-23.0	80-105	20.0-23.0

* RMT was out of order.

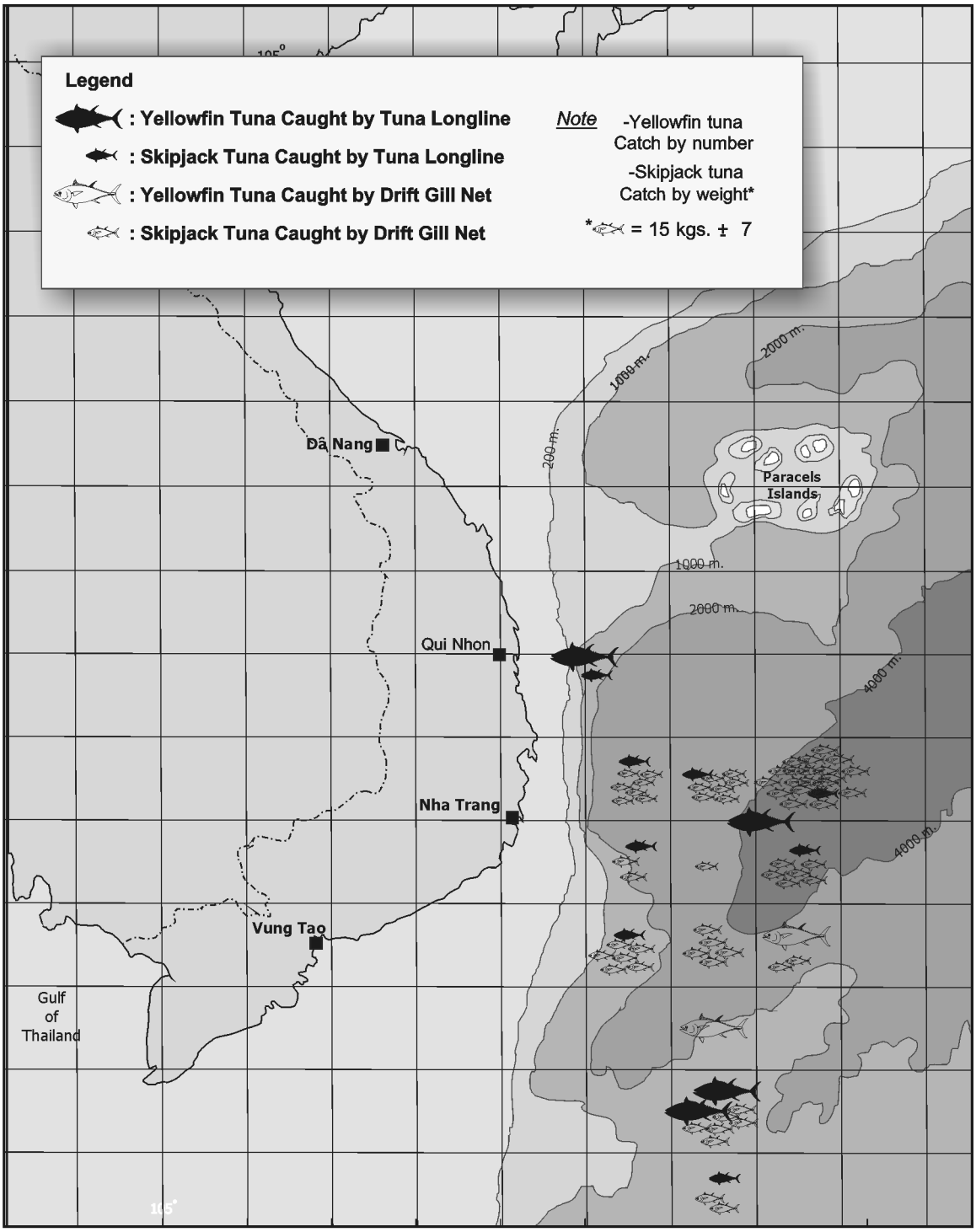

Fig. 4. Result of the survey.

Discussion

The most important factor in tuna longline fishing is determination of the swimming layer (suitable depth) of the target species caught. (Dickson, 2000 refer to Hanamoto, 1974; Nishi, 1990; Boggs, 1992) Dickson, 2000 was also refer to Nagano *et.al.*, 1997 that the comparison between shallow and deep longlines, it was indicated that the albacore, bigeye tuna and lancetfish having catch rate increased with depth while yellowfin, swordfish, mako shark and the blue shark had no clear catch rate trend with depth. Comparing to the deep longline, the shallow longline has also been observed to have higher percentage yellowfin tuna (Suzuki *et.al.*, cited in Nakano *et.al.*,1997 referred by Dickson ,2000) So, at the first two station (St. 11 and St. 16) the gear arrangement of 6 and 5 branchlines in one basket were trial in the fishing operations, depth of the hook was reached at 135-155 m and 70-100 m with the range of water temperature at 17.0-18.5^{o}C and 18.0-21.0^{o}C, respectively. Catch at two stations were only lancetfish, black ray and bigeye tresher shark. It was considered that hook layer (hook depth) was too deep at this fishing ground condition, water was a little bit cooler than the optimum temperature for yellowfin and skipjack tuna, 21.0-24.0^{o}C and 20.0-22.0^{o}C (Laenastu and Rosa, 1963 cited in Stretta, 1991). Then the remained eight fishing survey stations were carried out by four branchlines in a basket arrangement of the fishing gear. Under this fishing condition, hook layer was displayed from 50 m depth to 110 m depth which the water temperature varied from 21.0-26.0^{o}C. Finally, two yellowfin and one skipjack tuna were caught at station number 19 and 25. Therefore, consideration only temperature could not be used as the determinant of CPUE, other environmental parameters has strongly effect too (Andrade and Gracia, 1999). Other parameter such as salinity, dissolved oxygen, relative irradiance (total light) are also effect to tuna distribution, the maneuvering sphere of tuna was located just above the combined layer of thermocline, halocline and oxycline, they corresponded to slightly above or just within the high-turbidity water layer (Morinaga *et.al.*, 1992). Fishing ground condition of the survey area at 60 m depth was 33.89-34.44 ppt. of salinity, 3.22-4.14 ml/l of dissolved oxygen and 20.0-24.0^{o}C of water temperature, it should be good for yellowfin tuna and skipjack tuna distribution when compare to study of Morinaga *et.al.*,1992.

However, 340-360 hooks in one operation was too small, the hooks may be not much distributed to the suitable area and layer of tuna. So it has made small size of samples from the survey too. The result from the local fishing boat survey was a little bit better than MV SEAFDEC in total catch, but the data was not clearly identified. By the rough gear construction information, it could believe that their hooks depth were around 30-80 m deep. When their catches were taken into consideration, many spanish mackerel and dolphinfish had been caught in five stations and also one tripletail *Lobotes surinamensis* (Bloch). Those were shallow layer pelagic habitat of the oceanic. Also bait is the one of the important factor of the line fishery, flying fish which is the natural bait in this waters was used on local fishing vessel.

It could be confirmed that there are many tuna and skipjack distribution in the above thermocline layer (50-90 m depth) off the survey waters.

Table 2. Fishing Operation condition and catch on each survey station of MV SEAFDEC.

Station No	Number of gear (basket)		Number of hook per basket	Total hook	Operation time		Hook layer		Type of bait	Catch	
	Mono	Multi			Immersion time (hrs)	Daytime Nightime	Depth(m.)	Temp(°C)		Species	Weight (kg.)
11	30	30	6	360	8	Daytime	135-155	17.0-18.5	Chub Mackerel	Black ray Bigeye thresher shark	6.5 20.0
16	32	32	5	360	8	Daytime	70-110	18.0-21.0	Chub Mackerel	Black ray 3 Lancetfish	5.3 8.8
17	42	43	4	340	8	Daytime	55-90	23.0-26.0	Chub Mackerel Flying squid	Shortfin mako shark Wahoo	85.5 8.0
19	42	43	4	340	8	Daytime	55-90	21.0-24.0	Chub Mackerel Flying squid	Yellowfin tuna Dolphinfish Skipijack tuna Black ray Shortfin mako shark Lancetfish	56.0 5.0 8.2 3.6 30.0 5.6
23	41	43	4	336	9	Daytime	50-65	24.0-25.0	Chub Mackerel	Black ray	5.1
25	42	41	4	332	14	Nightime	50-80	20.0-23.0	Chub Mackerel Flying squid	Yellowfin tuna Blue shark Wahoo 3 Lancetfish	74.4 70.0 5.5 4.3
27	40	43	4	332	9	Daytime	50-70	23.0-24.5	Chub Mackerel Flying squid	Black ray 2 Lancetfish	6.0 5.0
31	41	42	4	332	14	Nightime	45-85	21.0-23.0	Chub Mackerel	Blue shark	38.0
34	43	42	4	340	14	Nightime	85-110	21.0-23.0	Chub Mackerel	Snake mackerel	0.4
42	42	42	4	336	14	Nightime	75-105	20.0-23.0	Chub Mackerel	3 Bigeye thresher shark Swordfish	212.0 23.5

Table 3. Fishing condition and catch of local fishing boat compare to the catch of drift gill net.

Date	Station No.**	Location		Total hook	Operation time		Type of bait	TLL Catch		Drift Gill Net Catch*	
		Latitude	Longitude		Immersion time (hrs)	Daytime /Nighttime		Species	Weight (kg.)	Species	Weight (kg.)
17/5/99	L-7	10°30.0 N	110°30.0 E	500	13	Nighttime	Flying fish	Shark	59.9	Devil ray	140.9
								Skipjack tuna	9.5	Skipjack tuna	97.2
								Others	3.6	Others	10.6
18/5/99	L-6	11°30.0 N	110°30.0 E	500	13	Nighttime	Flying fish	Dolphinfish	5.3	Skipjack tuna	33.8
								Skipjack tuna	16.0	Wahoo	11.9
										Others	6.2
19/5/99	L-1	12°30.0 N	110°30.0 E	500	13	Nighttime	flying fish	Shark	16.0	Skipjack tuna	102.5
								Skipjack tuna	10.1	Others	10.1
								Tripletail	2.9		
20/5/99	L-2	12°30.0 N	111°30.0 E	500	13	Nighttime	flying fish	Skipjack tuna	14.0	Skipjack tuna	115.2
										Black marlin	51.2
										others	16.4
21/5/99	L-3	12°30.0 N	112°30.0 E	500	13	Nighttime	flying fish	Skipjack tuna	14.0	Skipjack tuna	430.7
										Black marlin	110.6
22/5/99	L-4	11°30.0 N	111°30.0 E	500	13	Nighttime	flying fish	Skipjack tuna	12.6	Skipjack tuna	88.7
										Black marlin	161.8
										others	10.4
23/5/99	L-5	11°30.0 N	111°30.0 E	500	13	Nighttime	flying fish	Spanish macke	7.0	Skipjack tuna	15.2
										Black marlin	66.5
										others	11.3
24/5/99	L-9	10°30.0 N	112°30.0 E	500	13	Nighttime	flying fish	Shark	21	Yellowfin tuna	8.2
								Spanish macke	8.4	Skipjack tuna	31.1
										others	11.7
25/5/99	L-8	10°30.0 N	111°30.0 E	500	13	Nighttime	flying fish	Pomfret	0.8	Skipjack tuna	79.1
										others	6.9
26/5/99	L-10	09°30.0 N	111°30.0 E	500	13	Nighttime	flying fish	Shark	4.5	Yellowfin tuna	5.5
								Spanish macke	2.0	Spanish mackere	6.9
										Marlin	9.4
										Others	5.8
27/5/99	L-15	08°30.0 N	111°30.0 E	500	13	Nighttime	flying fish	Yellowfin tuna	55.9	Skipjack tuna	85.8
								Others	1.7	Black marlin	7
28/5/99	L-16	07°30.0 N	111°30.0 E	500	13	Nighttime	flying fish	Skipjack tuna	6.2	Yellowfin tuna	6.6
								Spanish macke	2.6	Skipjack tuna	36.4
										Others	34.5

* Drift gill net operated by another local fishing boat

** Local fishing boat survey station

*** Information by Dr. Chu Tien Vinh

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