Fisheries Resource and Oceanographic Survey in the North Coast of Timor – Leste by R.V. Chulabhorn

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Abstract

The survey on fisheries resource and oceanography in the North Coast of Timor-Leste was carried out by the Research Vessel Chulabhorn during 8 June – 14 July 2019. The area was divided into nine stations laid from west to east. Pelagic longline (PLL) and midwater trawl (MWT) were used for fisheries resource survey and CTD (Conductivity, Temperature and Depth recorder) was used for oceanographic survey. The results found that the catch rate of PLL was 2.77 kg/100 hooks and of MWT was 0.62 kg/hr. There were four species caught by PLL, i.e. long snouted lancetfish (*Alepisaurus ferox*), great barracuda (*Sphyraena barracuda*), black pomfret (*Taractes rubescens*) and pelagic stingray *(Pteroplatytrygon violacea*). The composition was 38.74%, 26.16%, 17.88% and 17.22% respectively. Whereas, most of the catch from MWT was juvenile aquatic fauna and identified to family and genus level. At least, 26 families of fish, cephalopod and shrimp were identified. The highest composition of MWT was eel larvae (Anguilliformes), 0.85 kg/hr accounted for 27.35% of the total catch followed by driftfish (*Cubiceps* spp.) and shortfin scad (*Decapterus macrosoma*), 19.67% and 15.48% respectively. In addition, cephalopod, shrimp and other fauna made up 20.90%, 0.68% and 4.29% of the total catch respectively.

The results of oceanographic survey showed that sea surface temperature was 26.26 – 28.64 ˚C with the average of 27.77 ˚C. Thermocline was clearly observed at Station N1, N2, N3, N5, and N6 at the depth of 50 - 188 m. Sea surface dissolved oxygen (DO) ranged from 6.16 – 6.95 mg/L with the average of 6.58 ± 0.27 mg/L. DO decreased with increasing depth level. Meanwhile, sea surface salinity ranged from 33.38 - 33.99 psu with the average of 33.58 ± 0.20 psu. Salinity increased with increasing depth level. Halocline was obviously found at Station N2, N3, N4 and N9.

Keywords: fisheries resource, oceanography, Timor-Leste, R.V. Chulabhorn

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Introduction

Democratic Republic of Timor-Leste or East Timor is a country in the Maritime Southeast Asia bordered by Indonesian waters in the north and east, Australian waters in the south and an Indonesian province in the west. The Banda Sea, which is connected to the Pacific Ocean, is situated in the north and east coast of Timor-Leste and the Timor Sea separates the island from Australia to the south. Timor-Leste is located in the eastern half of the Timor Island where the western half is Indonesian part known as West Timor (Figure 1). After a 25-year occupation by Indonesia, it became a sovereign state in 2002. The country's total land area is 14,919 km^2 with a coastline of 730 km and its exclusive economic zone is about 72,000 km2 (Angarita *et al*., 2019; FAO, 2020).

Figure 1 Map of Timor-Leste

Due to its geographical location, the country is rich with fisheries resources. Between 2009 and 2017, annual fish production from capture fisheries was estimated to be 3,200 metric tons (FAO, 2020). This amount of catch could not supply Timorese consumption. Estimates of fish consumption in Timor-Leste are low compared to regional averages. Annual per capita fish consumption for Timor-Leste was 6.1 kg (Angarita *et al*., 2019). Compared to other countries in Southeast Asia in 2011, the fish consumption of Timor-Leste was lower than Malaysia (58.1 kg/capita/year), Vietnam (33.2 kg/capita/year), the Philippines (32.7 kg/capita/ year) and Indonesia (32.2 kg/capita/year) (Firmansyah *et al*., 2019). Whereas, it was also lower than in the Pacific island countries, e.g. Solomon Islands (33 kg/capita/year), Vanuatu (20.3 kg/ capita/year) and Papua New Guinea 13 kg/capita/year) (Angarita *et al*., 2019).

Timorese fishery is characterized by subsistence and artisanal fisheries; while, semi-industrial and industrial fishing are carried out by foreign fishing fleets. In 2016, the government of Timor-Leste granted commercial fishing licenses to 18 Chinese vessels. The catch from these fleets was exported directly. However, there is currently no active foreign vessels fishing in Timor-Leste waters (Angarita *et al*., 2019). Therefore, Timor-Leste needs to import amounts of fish every year to supply domestic fish consumption. FAO (2020) reported that Timor-Leste imported an amount of 387.1 ton of fish in the recent year which is for direct human consumption. These evidences indicate that Timor-Leste waters is a potential fishing ground and fish market in the country is widely open.

In 2004, Timor-Leste and Thailand agreed on a joint research survey on the fisheries resources and marine environment in the Exclusive Economic Zone of Timor-Leste. The survey was completed by the Southeast Asian Fisheries Development Center (SEAFDEC) research vessel so-called M.V. SEAFDEC during 18 April to 2 June 2005. It covered only the South Coast of Timor-Leste. Hence, in 2018, Thai Department of Fisheries officers visited the Ministry of Agriculture and Fisheries, Timor-Leste to discuss a possible survey in the North and South Coast of Timor-Leste. Both sides agreed that "Thailand and Timor–Leste Collaborative Survey on Marine Fisheries Resources and Environment in the Territorial Waters and Exclusive Economic Zone of Timor-Leste Project" was launched in 2019.

This paper presents the fisheries resource and oceanographic survey in the North Coast of Timor–Leste which was conducted by R.V. Chulabhorn. The objectives of the survey were to study fisheries resources in order to understand the stock and biomass, species composition and catch rate in the Exclusive Economic Zone of the northern waters of Timor-Leste and to examine oceanographic information related to fisheries resources.

Materials and methods

1. Research vessel

The vessel R.V. Chulabhorn was used throughout the survey period. The vessel is 67.25 m length of overall with 1,424 gross ton.

2. Survey area

The survey was conducted in the Exclusive Economic Zone (EEZ) of the North Coast of Timor-Leste which is adjacent to the EEZ of Indonesia (Figure 2).

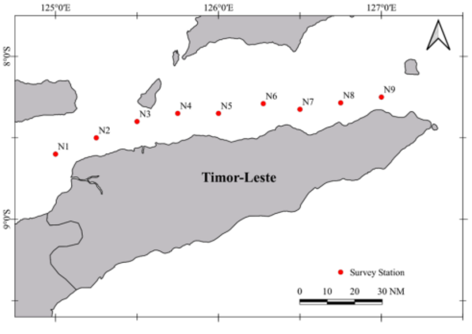


Figure 2 Survey stations in the North Coast of Timor-Leste, 2019

3. Survey period

The survey was carried out during 8 June – 14 July 2019.

4. Fishing gear

4.1 Pelagic longline (PLL)

The PLL is consisted of two main components which are gear structure and buoys. The gear structure comprises of mainline, branch line and hooks. The mainline is triple twined cremona PVA (polyvinyl alcohol) line, 6.5 mm in diameter, impregnated with oil to make it tough and durable. The strand is divided into 50 m in interval, where a branchline is fastened and tied with reef knots. The length of the strand is 600 m, consisting of 11 branch lines.

The branch line comprises 3 parts; 1) the first part made by triple twined cremona PVA line, 4 mm in diameter, which is 15 m long. 2) the second part is the same line type used in the first part but smaller, with diameter of 3 mm, 5 m length, and 3) galvanized stranded wire, size 27, which 2.5 m length. Each branch line is 22.5 m long in total. The hooks made of galvanized steel and stainless steel are attached at the end of branch lines. The shape of the hook used is J-shape and circle type (J-hook and Circle-hook). In addition, the other part of PLL are buoys which are made of PVC synthetic material, 300 mm in diameter, with a round loop for tying the mainline (Figure 3).

Fishing operations were conducted in early morning or late afternoon. The operation started by release the radar reflectors, only used when fishing in the afternoon until evening, then release the first set of the radio buoys and the flag buoys, fishing line, hooks which were baited, automatic temperature-depth recorders, and then the second set of buoy at the end of process. The hooks were left for 5 – 8 hours.

4.2 Midwater trawl (MWT)

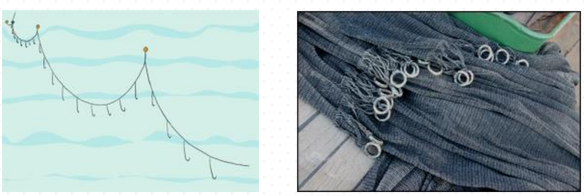
Trawl net with 2.5 cm cod-end mesh size was used in this survey. Trawling was conducted during daytime at 2.8 – 4.0 knots speed for one hour in each station.

The catches from PLL and MWT were identified into species level based on the identification guide of Ebert (2013, 2014), Nelson et al. (2016) and Smith and Heemstra (1986), and weighted in kilogram unit (kg).

4.3 Fishing assisted equipment

4.3.1 Flag buoys

The buoys were used as the symbolized location of operating fishing gear. Flag buoys consist of brightly colored fabrics flags such as red, yellow, etc., for easily spotting from far distance. The flags are 40 cm wide and 50 cm long, and tied on the end of a bamboo pole. The bamboo poles are 5 m long which has the flags tied at the end side while another side is tied with a weight of 5 - 7 kg, which also has a plastic buoy tied on the middle for floating. Normally, flag buoys are attached to the both end sides of the fishing gear such as pelagic longline, vertical longline, and deep-water traps, which are for displaying the gear locations.



a) b)

Figure 3 The fishing gears used in the survey

a) Pelagic longline

b) 2.5 cm cod-end net of midwater trawl

4.3.2 Radio buoys (Figure 4)

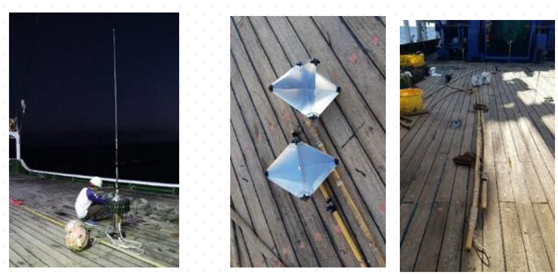
The buoy with radio transmitters is attached on one side of the flag buoys. These buoys are let floating freely during an operation. The radio buoys will emit the signal to the radio direction finder on the vessel which enable to know the location and direction of the operating fishing gear. Therefore, it helps to find and collect the gear in the sea conveniently. The radio buoys are normally equipped with pelagic longlines which are floating along the current and have long time operation.

4.3.3 Radar reflectors (Figure 4)

Its components and using method are similar to flag buoys but using a metal plate instead of fabric flags. When operating, it will be viewed from the vessel's radar screen, the radar signal sent out from the vessel hits the metal plate which will signal back to appear on the vessel's radar screen which enable to know the location of the fishing gears. Radar reflectors are normally equipped with pelagic longlines which are floating along the current and have long time operation.

4.3.4 Temperature-depth recorder (TDR) (Figure 4)

The device placed instead of a hook automatically records depth and temperature data when the gear is deployed. It is used to determine the actual depth which is in the thermocline layer or not.



a) b)

c) d)

Figure 4 Fishing assisted equipment

a) Radio buoys

b) Radar reflectors on bamboo stalks

c) Radio direction finder

d) Temperature-depth recorder (TDR)

5. Oceanographic devices

The Conductivity, Temperature and Depth recorder (CTD) – model SD204 was used to collect salinity, temperature, dissolved oxygen (DO), and pressure which changes relatively to depth (Figure 5). The data were collected every second from sea surface down to 300 m depth in nine stations and then transferred to a personal computer. Thermocline layers were identified by the sudden change of temperature in water column.

Figure 5 Conductivity, Temperature and Depth recorder (CTD)

6. Data analysis

Catch rate and species composition were analyzed and reported by descriptive statistics

6.1 Pelagic longline

Catch rate by station

$$Catch\ rate_{PLL_{St.i}} = \frac{W_{St.i}}{H_{St.i}} \times 100$$

Where

$Catch\ rate_{PLL_{St.i}}$ = Catch rate of PLL in Station i (kg/100 hooks)

$W_{St.i}$ = Weight of fish (kg) in station i

$H_{St.i}$ = Number of hooks deployed in station i

Overall catch rate

$$Catch\ rate_{PLL} = \frac{\sum_{i=1}^{n} W_i}{\sum_{i=1}^{n} H_i} \times 100$$

Where

$Catch\ rate_{PLL}$ = Catch rate of PLL (kg/100 hooks)

W_i = Total weight of fish (kg) in station i

H_i = Number of hooks deployed in station i

i = Station 1, 2, 3, ..., n

Species composition of PLL

$$Comp_{PLL_j} = \frac{\sum_{i=1}^{n} w_{ij}}{\sum_{i=1}^{n} W_i} \times 100$$

Where

$Comp_{PLL_j}$ = Composition of species j caught by PLL

w_{ij} = Weight of species j (kg) caught in station i

W_t = Total weight of fish caught in station i

i = Station 1, 2, 3, ..., n

6.2 Midwater trawl

Catch rate by station

$$Catch\ rate_{MWT_{St.i}} = \frac{W_{St.i}}{T_{St.i}}$$

Where

$Catch\ rate_{MWT_{St.i}}$ = Catch rate of MWT in Station i (kg/hr)

$W_{St.i}$ = Weight of fish (kg) in station i

$T_{St.i}$ = Trawling time (hr) in station i

Overall catch rate

$$Catch\ rate_{MWT} = \frac{\sum_{i=1}^{n} W_i}{\sum_{i=1}^{n} T_i}$$

Where

$Catch\ rate_{MWT}$ = Catch rate of MWT (kg/hr)

W_i = Total weight of fish (kg) in station i

T_i = Trawling time (hr) in station i

i = Station 1, 2, 3, ..., n

Species composition of MWT

$$Comp_{MWT_j} = \frac{\sum_{i=1}^{n} w_{ij}}{\sum_{i=1}^{n} W_t} \times 100$$

Where

$Comp_{MWT_j}$	=	Composition of species j caught by MWT
w	=	Weight of species j (kg) caught in station i
W_t	=	Total weight of fish caught in station i
i	=	Station 1, 2, 3, ..., n

Results

1. Pelagic longline (PLL)

Pelagic longline was conducted in six stations, i.e. N1, N3, N4, N5, N7 and N9. The survey location ranged from latitude 08° 17.06' S to 08° 40.83' S and longitude 124° 58.03' E to 126° 52.10' E. The water depth ranged 2,007 to 3,370 m. Nine hooks were set in each basket and the total number of hooks used in operations were between 165 – 215 hooks. Indian scad (*Decapterus* spp.) was used as baits.

The total catch of PLL was 30.2 kg, with 10 fishes in total. The overall catch rate was 2.77 kg/100 hooks. The highest catch rate was found in station N5 of 7.98 kg/100 hooks while the lowest catch rate was found in Station N7 of 0.82 kg/100 hooks, and zero catch in Station N4 (Table 1). The distribution of catch rate is presented in Figure 6.

Table 1 Catch and composition from pelagic longline in the North Coast of Timor-Leste, 2019

Species (Common name)	Station												Total	
	N1		N3		N4		N5		N7		N9			
	No.	kg	No.	kg	No.	kg	No.	kg	No.	kg	No.	kg	No.	kg
Alepisaurus ferox (Long snouted lancetfish)	1	3.9	-	-	-	-	4	6.3	1	1.5	-	-	6	11.7
Sphyraena baracula (Great barracuda)	-	-	1	5.4	-	-	-	-	-	-	-	-	1	5.4
Taractes rubescens (Black pomfret)	-	-	-	-	-	-	-	-	-	-	1	5.2	1	5.2
Pteroplatytrygon violacea (Pelagic stingray)	-	-	-	-	-	-	2	7.9	-	-	-	-	2	7.9
Total catch	1	3.9	1	5.4	0	0	6	14.2	1	1.5	1	5.2	10	30.2
No. of hook	215		165		181		178		182		169		1,090	
Catch rate														
(No. per 100 hooks)	0.47		0.61		0.00		3.37		0.55		0.59		0.92	
(kg. per 100 hooks)	1.81		3.27		0.00		7.98		0.82		3.08		2.77	

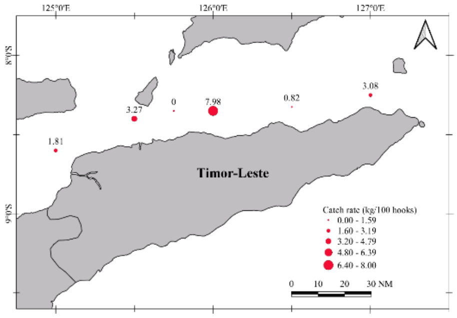


Figure 6 Catch rate of pelagic longline (kg/100 hooks) in the North Coast of Timor-Leste, 2019

The catch composed of four species, i.e. long snouted lancetfish (*Alepisaurus ferox*), great barracuda (*Sphyraena barracuda*), black pomfret (*Taractes rubescens*) and pelagic stingray (*Pteroplatytrygon violacea*). The frequently found species was long snouted lancetfish, six fish caught with the total weight of 11.7 kg (38.74% of the total weight), followed by pelagic stingray, 2 fish (7.9 kg), great barracuda, 1 fish (5.4 kg), and black pomfret, 1 fish (5.2 kg), which accounted for 26.16%, 17.88% and 17.22% respectively (Table 1). Size of the caught fish was measured. The total length of long snouted lancetfish ranged between 88 and 155 cm (average 117.9 ± 23.1 cm). The pelagic stingray body width ranged between 40 and 44 cm (average 42.0 ± 2.8 cm), while the total length of great barracuda and black pomfret were 107 cm and 72 cm respectively.

2. Midwater trawl (MWT)

Midwater trawl was conducted in five stations, i.e. N2, N4, N5, N6 and N8. Trawling distances ranged between 2.8 and 3.5 nm/haul (Table 2). The survey location ranged from latitude 08° 12.26' S to 08° 31.55' S and longitude 125° 16.56' E to 127° 00.45' E. The water depth ranged between 2,033 to 3,357 m and the operation depth ranged from 50 – 80 m.

The overall catch of MWT was 3.1 kg from all stations. The average catch rate was 0.620 ± 0.32 kg/hr. The highest catch was found in Station N8 of 1.058 kg/hr, followed by Station N9 of 0.789 kg/hr (Table 3 and Figure 7). Most of the fish caught by MWT was juvenile fishes, so typically identified to family or genus level. Hence, the catches were classified into four groups, i.e. fish, cephalopod, shrimp and other. At least, 26 families of fish, cephalopod and shrimp were identified. Eel larvae (Anguilliformes) was the highest catch of 0.85 kg (27.35% of the total catch), followed by driftfish (*Cubiceps* spp.) and shortfin scad (*Decapterus macrosoma*) of 0.53 (19.67% of the total catch) and 0.48 kg (15.48% of the total catch) respectively (Table 3 and Appendix 1)

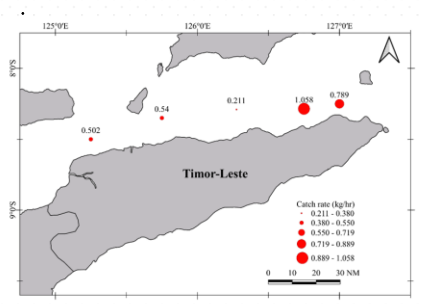


Figure 7 Distribution of catch rate of midwater trawl (kg/hr) in the North Coast of Timor-Leste, 2019

Table 2 Summary of midwater trawl operation in the North Coast of Timor-Leste, 2019

Station	Date	Time	Depth (m)		Wire out	Speed	Distance
			Bottom	Gear	(m)	(knot)	(nm)
N2	8 June 2019	17:02	3,000	80	300	2.8	2.8
N4	1 June 2019	17:41	3,370	60	250	4.0	3.5
N9	16 June 2019	13:14	2,033	50	200	2.8	3.4
N8	16 June 2019	19:20	1,587	50	200	3.0	2.8
N6	17 June 2019	16:00	3,357	50	200	3.0	3.5

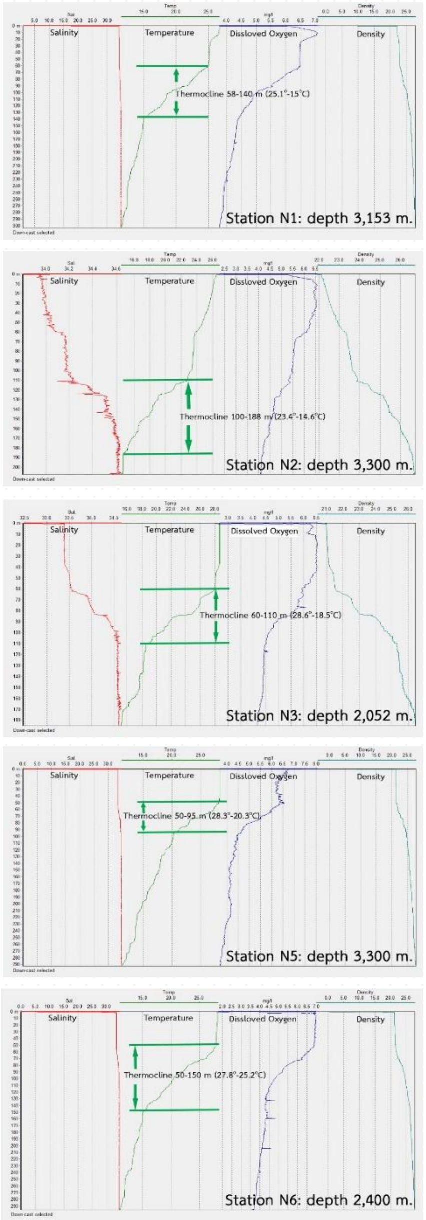
3. Oceanography

3.1 Temperature

Sea surface temperature ranged from 26.26 - 28.64 °C with the average of 27.77 ± 0.74 °C. Sudden vertical changes in temperature were observed in most of the stations and it is described as thermocline. Thermocline layers were obviously observed in Station N1, N2, N3, N5, and N6 and presented at the depth of 50 - 188 m (Figure 8).

Table 3 Catch and composition from midwater trawl in the North Coast of Timor-Leste, 2019

Fauna items	Weight (kg)						
	N2	N4	N6	N8	N9	total	%
Fish	0.500	0.296	0.174	0.594	0.734	2.298	74.13
Acanthuridae	0.004	0.007	0.004		0.004	0.019	0.61
Anguilliformes			0.148		0.700	0.848	27.35
Balistidae	0.002	0.010	0.004			0.016	0.52
Bramidae			0.005			0.005	0.16
Carangidae	0.480			0.040	0.003	0.523	16.87
Chaetodontidae	0.004	0.008	0.002			0.014	0.45
Fistulariidae					0.004	0.004	0.13
Gempylidae			0.003		0.004	0.007	0.23
Glaucosomatidae					0.001	0.001	0.03
Gonostomatidae		0.004				0.004	0.13
Lujanidae					0.001	0.001	0.03
Monacanthidae					0.003	0.003	0.10
Myctophidae		0.212		0.032	0.004	0.248	8.00
Nomeidae		0.006	0.004	0.522		0.532	17.16
Paralepididae		0.007				0.007	0.23
Phosichthyidae		0.010				0.010	0.32
Pleuronectiformes		0.002	0.002		0.004	0.008	0.26
Priacanthidae		0.007				0.007	0.23
Scombridae					0.004	0.004	0.13
Sternoptychidae		0.004	0.001			0.005	0.16
Syngnathidae					0.002	0.002	0.06
Tetraodontidae	0.004	0.004	0.001			0.009	0.29
Trachichthyidae	0.002	0.002				0.004	0.13
Zanclidae	0.004					0.004	0.13
Unid. juvenile fish		0.013				0.013	0.42
Cephalopod	0.002	0.224	0.011	0.400	0.011	0.648	20.90
Cranchiidae		0.006			0.010	0.016	0.52
Octopodidae					0.001	0.001	0.03
Ommastrephidae	0.002	0.218				0.220	7.10
Unid. juvenile squid			0.011	0.400		0.411	13.26
Shrimp		0.020			0.001	0.021	0.68
Oplophoridae		0.014				0.014	0.45
Unid. juvenile shrimp		0.006			0.001	0.007	0.23
Others			0.026	0.064	0.043	0.133	4.29
Jellyfish			0.018		0.026	0.044	1.42
Stomatopoda			0.002		0.004	0.006	0.19
Tunicata			0.005	0.064	0.002	0.071	2.29
Unid. juvenile lobster			0.001		0.005	0.006	0.19
Unid. crustacean					0.006	0.006	0.19
Total catch	0.502	0.540	0.211	1.058	0.789	3.100	100.00
Catch rate (kg/hr)							0.620 ± 0.32



a)

b)

c)

d)

e)

Figure 8 Thermocline, salinity and dissolved oxygen in the survey stations of the North Coast of Timor-Leste, 2019

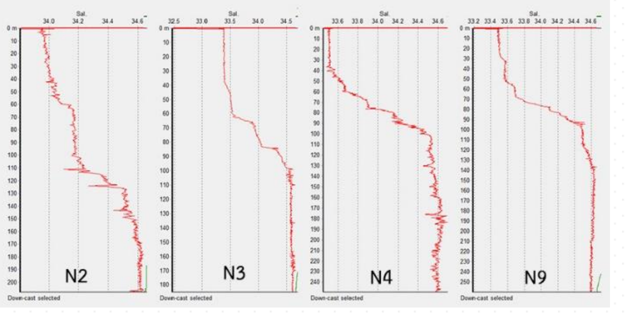
a) N1 b) N2 c) N3 d) N5 e) N6

3.2 Dissolved oxygen (DO)

DO is correlated with temperature that the vertically change of DO showed the similar trend like the temperature. Sea surface DO ranged from 6.16 – 6.95 mg/L with the average of 6.58 ± 0.27 mg/L. DO was found lower as depth increase (Figure 8).

3.3 Salinity

Salinity increased following the increasing depth. Sea surface salinity ranged from 33.38 - 33.99 psu with the average of 33.58 ± 0.20 psu. Water stratification by salinity or so-called halocline was clearly found at Station N2, N3, N4, and N9 (Figure 9).



a) b) c) d)

Figure 9 Halocline in the survey station of the North Coast of Timor-Leste, 2019

a) N2 b) N3 c) N4 d) N9

Discussion

The average catch rate of the pelagic longline in the North Coast of Timor-Leste was 2.77 kg/100 hooks while the average catch rate in the South Coast surveyed in 2005 was 15.83 kg/100 hooks (SEAFDEC, 2005). In term of commercial fishery, the average catch rate of commercial tuna longline in the Indian Ocean was 84.7 kg/100 hooks (Panjarat *et al.*, 2016). The catch rate in this survey was very low due to several possible factors.

Since this survey was conducted in June, it might not correspond seasonal migratory pattern of fishes in the area. Most of the tuna species, e.g. bigeye tuna, skipjack tuna, yellowfin tuna and some neritic tunas, are included in the list of highly migratory stocks under Annex 1 of United Nations Convention for the Law of the Sea (UNCLOS) (Maguire *et al*., 2006). These species are usually straddling stocks which migrate through more than one exclusive economic zone or between exclusive economic zone and high sea. Therefore, study on seasonal migration of tuna species and other economically important species in the region is further needed.

Regarding the commercial tuna longline fishery, catch rate in June was also lowest during the year. Panjarat *et al.* (2016) reported that, in 2011, catch rate of foreign tuna longliners, i.e. Belize, Indonesia and Taiwan, in the Indian Ocean was lowest in June, 9,357 kg/trip; while the annual average catch rate was 14,782 kg/trip.

Tuna species were expected to be found during the survey. All tropical tunas, i.e. bigeye tuna, skipjack tuna and yellowfin tuna, occurs at the maximum depth of 250 meters (Carpenter and Niem, 2001; Fishbase, 2020a; Fishbase, 2020b). Bigeye tuna and yellowfin tuna can be found above and below thermocline; while, skipjack is generally found above the thermocline (Carpenter and Niem, 2001). Although, bigeye tuna and yellowfin tuna occur in deeper waters because they have swim bladder which grow with age, their juvenile inhabits within narrower thermal boundary due to they do not have fully developed thermoregulation system (Moreno et al., 2016; Stequert and Marsac, 1989). Based on these tuna behaviors, the PLL was set at different depths corresponding to thermocline. Thermocline was observed in six stations in the North coast. Among these stations, the PLL was set at three stations, i.e. Station N1, N3 and N5. At Station N1, the PLL was set above and upper layer of thermocline and, at Station N5, it was set below the thermocline, although temperature-depth recorder at Station N3 was lost (Table 4). Therefore, it could be concluded that the PLL setting was consistent with vertical distribution of tunas.

Current velocity might be another factor affecting the distribution and abundance of fisheries resources. Reverdin *et al*. (1994) revealed that the South Equatorial Countercurrent (SECC), which is located between 8 °S and 11 °S in the western South Pacific, was about 20 cm s-1 eastward from January to March and about 5 cm s-1 westward from July to September. It seems that most of the PPL survey stations showed stronger velocity. For example, at Station N1, the PPL moving speed was 2.0 knot or 102 cm s-1 to south west which was more than 17 nautical miles far from the shooting location and, at Station N3, the moving speed was 1.0 knot or 51 cm s-1 to south-south west, which was more than 6 nautical miles far from the shooting location (Table 4 and Figure 10). In addition, current direction was unsteady. This could be observed in Station N7 which the PPL formed semicircle shape after seven hours soaking time. Moreover, at Station N9, the PPL moving direction was northward after shooting was finished; then, the direction suddenly turned to eastward, although the velocity was only about 12 cm s-1. Consequently, catch rate in the region might be affected by the velocity. It is important to note that the northern waters of Timor is a strait which the velocity may typically be stronger than open sea.

Table 4 Summary of pelagic longline operation in the North Coast of Timor-Leste, 2019

Station	Date	Time		Sea depth (m)	Hook depth (m)	Setting direction (Degree)	Moving direction (Degree)	Average moving speed (knot)*
		Shooting	Hauling					
N1	9/6/2019	5:04	13:41	2,583	53 – 87	270	226 (SW)	2.0
N3	10/6/2019	5:05	13:03	2,052	no data	262	196 (SSW)	1.0
N5	14/6/2019	4:58	12:23	3,351	144 – 206	282	080 (E)	0.5
N7	15/6/2019	4:58	12:27	2,167	109 – 127	280	074 (ENE)	1.2
N9	15/6/2019	17:35	23:11	2,007	74 – 115	310	352 then 090 (N then E)	0.25
N4	18/6/2019	15:16	20:06	3,370	89 – 131	230	069 (ENE)	0.43

Remark: * 1.0 knot is about 51 cm s-1.

For midwater trawl survey, eel larvae were the highest composition accounted for 27.35% of the total catch. Arai *et al*. (2001) reported that there are seven tropical eel species/ subspecies occurring in the western Pacific around Indonesia namely *Anguilla celebesensis*, *A. interioris*, *A. nebulosa nebulosi*, *A. marmorata*, *A. borneensis*, *A. bicolor bicolor* and *A. bicolor pacifica*. Most eel larvae or leptocephali can be separated into major families or genera by using a relatively limited set of basic morphological features (Miller and Tsukamoto, 2004). However, molecular techniques have been used for identification of marine organisms whose morphologies during their early life stages are not well developed. For example, Watanabe *et al*. (2004) conducted a real-time polymerase chain reaction (PCR) for a total of 44 specimens including A. japonica, A. marmorata, A. bicolor pacifica and six other anguilliform species to identify the eggs and larvae of these species. Leptocephali are transported on ocean currents from ocean spawning grounds to intertidal areas where they transform into glass eels; therefore, spatial and temporal distribution patterns of leptocephali are affected by ocean currents (Miller, 2009; Zydlewski and Wilkie, 2012). However, most life histories and eel larval recruitment behaviors remain undocumented and the abundance and ecological significance of leptocephali in the ocean appear to have been underestimated (Miller, 2009). Hence, eel larvae collected during this survey were not identified and there is a huge number of challenges to study life history of eel in this region.

The first objective of this survey focuses on biomass estimation and the initial estimation method would be swept area by using trawl based on Sparre and Venema (1992). In addition to trawl survey, the pelagic longline survey would be supplementary result. Then, the results would be used for formulating sustainable utilization plan of fisheries resources and suggesting possible management measures. However, the results were unexpected due to several factors described above and it was too soon to conclude to the results and proceed to next steps. Therefore, additional information is needed in order to develop the fisheries management plan in the North Coast of Timor-Leste. Surveys should be carried out covering at least every climatic season to observe seasonal changes. Moreover, data collection from landing sites could be supplement the information from cruise survey.

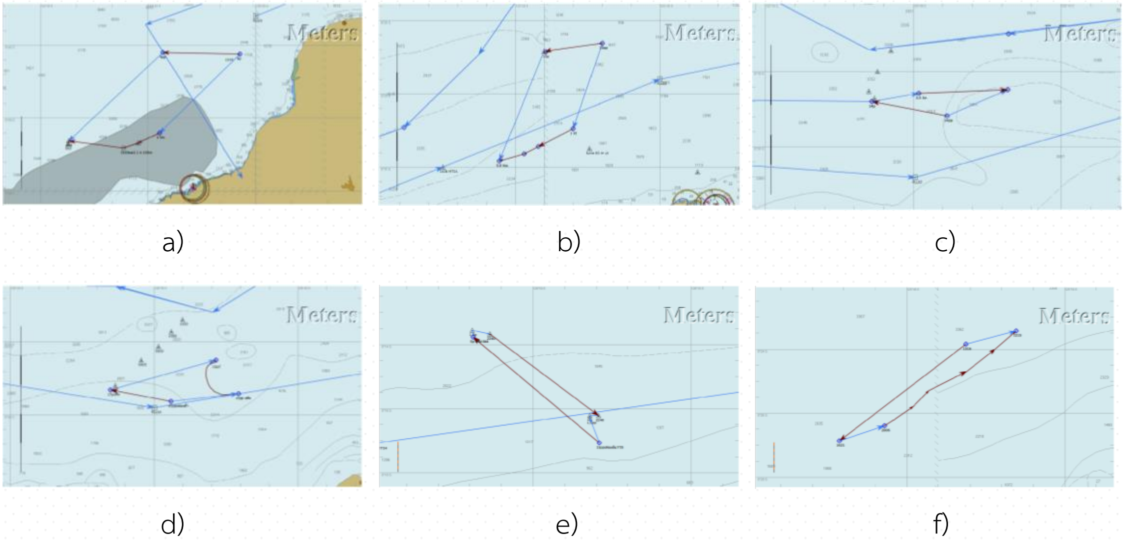


Figure 10 Setting direction and moving direction of pelagic longline

a) Station N1 b) Station N3 c) Station N5 d) Station N7 e) Station N9 f) Station N4

Remark: ← Longline setting direction → Moving direction

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Appendix 1 Catch and composition from midwater trawl survey in the North Coast of Timor-Leste, 2019

Group	Family	Species	N2	N4	N6	N8	N9	Total	%
Fish	Acanthuridae	Acanthuridae	0.004	0.007	0.004		0.004	0.019	0.61
	Anguilliformes	Eel larvae			0.148		0.7	0.848	27.36
	Balistidae	Balistididae juvenile	0.002	0.01	0.004			0.016	0.52
	Bramidae	Brama sp.			0.004			0.004	0.13
		Bramidae			0.001			0.001	0.03
	Carangidae	*Decapterus macrosoma*	0.48					0.480	15.48
		Decapterus sp. juvenile				0.04	0.003	0.043	1.39
	Chaetodontidae	*Chaetodon* sp.	0.004	0.008	0.002			0.014	0.45
	Fistulariidae	Fistulariidae					0.004	0.004	0.13
	Gempylidae	Gempylidae - juvenile			0.003		0.004	0.007	0.23
	Glaucosomatidae	Glaucosomatidae					0.001	0.001	0.03
	Gonostomatidae	*Triplophos* sp.		0.004				0.004	0.13
	Lujanidae	Lujanidae					0.001	0.001	0.03
	Monacanthidae	Monacanthidae - juvenile					0.003	0.003	0.1
	Myctophidae	*Diaphus* sp.		0.048				0.048	1.55
		Diogenichthys sp.		0.086		0.012	0.003	0.101	3.26
		Myctophidae		0.078		0.02	0.001	0.099	3.19
	Nomeidae	*Cubiceps* sp.			0.004	0.522		0.526	16.97
		Psenes sp.		0.006				0.006	0.19
	Paralepididae	Paralepididae		0.007				0.007	0.23
	Phosichthyidae	*Photichthys* sp.		0.01				0.010	0.32
	Pleuronectiformes	Pleuronectiformes		0.002	0.002		0.004	0.008	0.26
	Priacanthidae	Priacanthidae		0.007				0.007	0.23
	Scombridae	*Scomberomorus* sp.					0.001	0.001	0.03
		Scombridae sp - Juvenile					0.003	0.003	0.1
	Sternoptychidae	*Sternoptyx pseudobscura*		0.004	0.001			0.005	0.16
	Syngnathidae	Syngnathidae					0.002	0.002	0.07
	Tetraodontidae	*L. lagocephalus*	0.002					0.002	0.06
		Lagocephalus sp.	0.002					0.002	0.06
		Lagocephalus spadiceus		0.004				0.004	0.13
		Tetraodontidae			0.001			0.001	0.03
	Trachichthyidae	Trachichthyidae	0.002	0.002				0.004	0.13
	Unid.juvenile fish	Unid. juvenile fishes		0.013				0.013	0.42
	Zanclidae	Zanclidae	0.004					0.004	0.13
Cephalopod	Cranchiidae	Cranchiidae		0.006			0.01	0.016	0.52
	Octopodidae	*Octopus* sp.					0.001	0.001	0.03
	Ommastrephidae	Ommastrephidae		0.218				0.218	7.03
		Sthenoteuthis sp.	0.002					0.002	0.06
	Unid.juvenile squid	Small squids			0.011	0.4		0.411	13.26
Shrimp	Oplophoridae	*Oplophoris* sp.		0.014				0.014	0.45
	Unid.juvenile shrimp	Shrimps, small, non comm.		0.006			0.001	0.007	0.23
Other fauna	Jellyfish				0.018		0.026	0.044	1.42
	Stomatopoda				0.002		0.004	0.006	0.19
	Tunicata				0.005	0.064	0.002	0.071	2.29
	Unid. Juvenile lobster				0.001		0.005	0.006	0.19
	Unid. Crustacean						0.006	0.006	0.19
Total			0.502	0.54	0.211	1.058	0.789	3.100	100.00

Appendix 2 Details of oceanography observation in the North Coast of Timor-Leste, 2019

Station	Date	Time (local)	Latitude	Longitude	Bottom depth (m)	Sampling depth (m)	Temperature (°C)	Thermocline (m)	DO (mg/L)	Salinity (psu)	Transparency (m)
N1	13/7/2019	944	8°38.865'S	124°54.244'E	3,153	5	26.70	58-140	6.62	33.91	17.9
						15	26.31		7.00	33.97	
						30	25.22		6.49	34.05	
						50	25.15		6.47	34.05	
						70	23.48		6.15	34.16	
						100	19.16		5.04	34.42	
						130	16.05		4.54	34.62	
						200	13.71		4.16	34.61	
						250	12.44		3.91	34.62	
						300	11.64		3.77	34.62	
N2	13/7/2019	1515	8°38.865'S	124°54.244'E	3,300	5	26.26	100-188	6.19	33.99	13.23
						15	26.02		6.52	33.97	
						30	25.60		6.52	33.99	
						50	24.72		6.25	34.03	
						70	23.67		5.61	34.17	
						100	23.28		5.47	34.15	
						130	19.01		4.70	34.50	
						200	14.62		4.11	34.61	
N3	10/6/2019	0730	8°38.865'S	124°54.244'E	2,052	5	28.64	60-110	6.30	33.38	24.77
						15	28.65		6.49	33.38	
						30	28.65		6.51	33.39	
						50	28.13		6.30	33.50	
						70	26.03		5.79	33.92	
						100	20.44		4.62	34.55	
						130	18.21		4.41	34.58	
						180	15.28		4.18	34.60	

Appendix 2 (Cont.)

Station	Date	Time (local)	Latitude	Longitude	Bottom depth (m)	Sampling depth (m)	Temperature (°C)	Thermocline (m)	DO (mg/L)	Salinity (psu)	Transparency (m)
N4	18/6/2019	0714	8°38.865'S	124°45.582'E	3,370	5	27.99	60-100	6.16	33.52	18.56
						15	28.00		6.17	33.51	
						30	28.00		6.15	33.52	
						50	27.24		5.94	33.63	
						70	25.40		5.60	33.89	
						100	20.12		4.68	34.46	
						130	18.68		4.33	34.46	
						200	13.61		4.03	34.63	
						240	11.49		3.77	34.62	
N5	14/6/2019	0649	8°16.791'S	125°57.430'E	3,300	5	28.25	50-95	6.70	33.45	18.52
						15	28.25		6.35	33.46	
						30	28.26		6.29	33.46	
						50	28.13		6.44	33.49	
						70	25.24		5.56	34.00	
						100	20.24		4.45	34.47	
						130	18.17		4.34	34.58	
						200	14.84		4.19	34.58	
						250	13.59		3.89	34.60	
						290	11.42		3.69	34.54	
N6	17/6/2019	1454	8°14.917'S	126°18.333'E	2,400	5	28.20	50-150	6.95	33.48	15.43
						15	28.16		6.98	33.48	
						30	28.01		6.95	33.50	
						50	27.86		6.88	33.53	
						70	26.18		6.22	33.78	
						100	20.40		4.79	34.46	
						130	17.67		4.29	34.63	
						200	13.63		4.13	34.62	
						250	12.01		3.86	34.60	
						290	11.24		3.70	34.59	

Appendix 2 (Cont.)

Station	Date	Time (local)	Latitude	Longitude	Bottom depth (m)	Sampling depth (m)	Temperature (°C)	Thermocline (m)	DO (mg/L)	Salinity (psu)	Transparency (m)
N7	15/6/2019	0650	8°17.976'S	126°27.288'E	2,167	5	28.28	35-180	6.66	33.45	11.39
						15	28.28		6.67	33.45	
						30	28.28		6.64	33.46	
						50	28.13		6.59	33.48	
						70	24.88		5.77	33.99	
						100	21.98		4.79	34.35	
						130	18.95		4.32	34.57	
						180	14.44		4.05	34.60	
N8	22/6/2019	1820	8°15.018'S	126°55.215'E	1,587	5	27.71	70-240	6.87	33.56	15.99
						15	27.71		7.10	33.56	
						30	27.64		7.08	33.56	
						50	27.59		6.99	33.58	
						70	26.46		6.47	33.75	
						100	22.06		4.73	34.45	
						130	19.03		4.35	34.58	
						200	13.88		4.03	34.63	
						240	12.41		3.83	34.60	
N9	16/6/2019	0720	8°11.567'S	126°59.403'E	2,061	5	27.95	68-140	6.75	33.49	21.81
						15	27.96		6.76	33.51	
						30	27.74		6.80	33.54	
						50	27.38		6.63	33.57	
						70	26.46		6.16	33.77	
						100	21.06		4.59	34.50	
						130	18.72		4.54	34.59	
						200	14.00		4.00	34.62	
						250	11.64		3.70	34.60	