

# Diurnal Migration of Zooplankton in Inner Ambon Bay, Indonesia

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## Abstract

The study aims to analyze diurnal migration of zooplankton in Ambon Bay. Data sampling method which is conducted stationary utilizes pontoon mooring as floating platform for acoustic data sampling. Based on the analysis, diurnal migration of zooplankton occurs at noon, zooplankton swims in water surface to epipelagic zone (0-20 m) with value of scattering volume value -90.13 dB to -100.30 dB; it indicates sparse and scattered aggregation (N=128). At night, scattering volume of -90.01 dB to -100.30 dB indicates dense and concentrated aggregation (N=75). Scattering volume is numerical expression of zooplankton density. Chlorophyll a concentration in depth of 0-10 meter having the highest value of 5.16 ppb highly affects the existence of zooplankton. It functions for food availability of pelagic fish as its carnivore.

**Keywords:** Diurnal migration, Acoustic, Zooplankton, Scattering volume

## 1. Introduction

Role of zooplankton in waters is crucial since it is one of elements in oceanic food chain. For almost four decades, scientists have discussed about challenge to utilize underwater noise measurement for marine organism research, specifically for fishes and zooplankton (Beamish, 1971; Holiday and Pieper, 1980; Stanton et al., 1998).

Diel vertical migration, also known as diurnal vertical migration, of marine organisms is familiar phenomenon which is widely documented in literature (Everson, 1982). Hydroacoustics method is so effective and fast, and it is able to detect object in high resolution. Swiftness in interpreting data becomes prominent choice in research on fish resources potential.

Inner Ambon Bay is dynamic area connected to Banda Sea where the water exchange goes across Outer Ambon Bay. During upwelling in Banda Sea, thermocline is lower than the period when the upwelling does not occur; the phenomenon streams cold current from outer bay to inner bay. Factors like tidal currents and seasonal upwelling in Ambon Bay affect nutrient concentration, temperature, salinity, and zooplankton community structure (Wagey, 2002).

Inner Ambon Bay waters is semi-closed bay when every season period, in general, does not have waves, while the current is not great. Distance of both inter-thresholds in this bay is around 74 m and current speed is <0.5 m/sec. While, the current speed of outer Ambon Bay reaches >0.5 m/sec and wind speed reaches >18 knot (Selanno, 2011).

Zooplankton functions a crucial role in pelagic system since it will determine organism life cycle above it, i.e. fish. Study on this community is crucial to be done since pelagic succession is highly affected by zooplankton. Researches on zooplankton have been conducted, one of them is Hays et al. (2005); these researchers assume that zooplankton belongs to key components of pelagic ecosystem and zooplankton is primary producer for higher trophic level.

As explained above, study on daily migration of zooplankton in Inner Ambon Bay has been undertaken. Concerning to the aim of study, it aims to analyze zooplankton daily migration in

Inner Ambon Bay. It relates firmly to zooplankton distribution pattern as one of biological indicators in determining waters condition changes. Any findings would become contribution for Ambon Bay as fishing ground of baitfish.

## 2. Methodology

The study is conducted in Inner Ambon Bay having south latitude of 3°38'46" and east longitude of 128°12'24", on September 14th, 2013. The study applies direct acoustic survey method on the object to be observed, in this concern is zooplankton in Ambon Bay. Study is conducted for 24 hours at the observed zone.

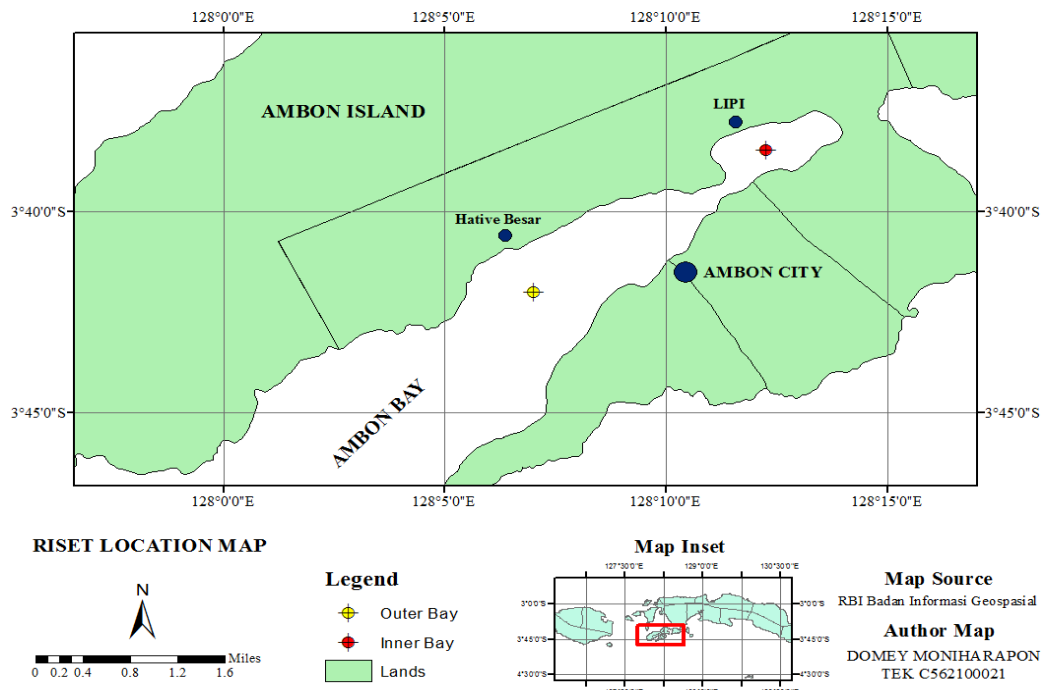


Figure 1. Map of Research Site

Cruz Pro transducer is placed next to mooring pontoon, this transducer placement in frequency of 200 kHz is by side mounted system manner. Recording is continually undertaken for 24 hours. Recording product produces ASCII file which later on will be proceed by Matlab program version R2010a. Oceanography parameter measurement is proceeded by CTD-ALEC, model ASTD-687 where the measurement is taken by down time observation of every 2 hours. Data sampling of zooplankton is taken in a range of 5 meters to the bottom of the sea with time interval for data sampling of 3 hours by utilizing Van Dorn water sampler.

Volume of back-scattering is calculated in dB, SV (Scattering Volume) depends on numerical types and abundance from scatters in volume unit which responds in form of reverse echo. Resulting scattering volume is summation of every zooplankton organism as formulated below (Stanton et al., 1994):

$$SV = N_a \sigma_a + N_b \sigma_b = \sum_{i=1}^m N_i \sigma_i \quad (\text{dB}) \quad (1)$$

Description:  $\bar{\sigma}_{a,b}$  = Back Scattering Strength (dB)

$N_{a,b}$  = Amount of species-based zooplankton

Sample of zooplankton is collected by utilizing Van Dorn water sampler, while species identification applies standard system for zooplankton identification. Abundance of zooplankton is calculated by the following formulation (Wickstead, 1965):

$$D = n \times 1/f \times 1/v \quad (\text{Ind}/\text{m}^3) \quad (2)$$

Description:  $n$  = Amount of individual zooplankton (tail)

$f$  = Utilized fraction (ml)

$v$  = Filtered water volume (l)

### 3. Findings and Discussion

#### 3.1 Aggregation Distribution of Zooplankton

Acoustic data calculation makes average Scattering Volume ( $SV_{\text{average}}$ ) based on time and depth as listed in Table 1.

Table 1. Value of Time- and Depth-based Scattering Volume

Time	Scattering Volume (dB)				
	0-5	5-10	10-15	15-20	20-25
09:00-12:00	-96.70	-96.65	-97.10	-	-
12:00-15:00	-96.50	-96.69	-98.22	-97.54	-
15:00-18:00	-95.54	-97.07	-98.27	-	-
18:00-21:00	-96.31	-97.44	-97.92	-97.02	-
21:00-00:00	-94.88	-96.96	-97.76	-	-
00:00-03:00	-94.45	-96.92	-97.57	-	-
03:00-06:00	-96.08	-97.06	-97.40	-	-
06:00-09:00	-95.41	-96.32	-96.13	-	-

Based on the table above, distribution of scattering volume value will change over time and depth, value of scattering volume increases at 21:00-00:00 because it is affected by the nature of zooplankton which will increase and decrease along with waters column. Prior to morning to midday, there seems down movement to deeper water. Zooplankton movement to water surface is began since 18:00 by SV value of -97.02 dB and it reaches the peak at 00:00 by SV value of -94.45 dB. This aggregation will decrease at 03:00 by SV value of -96.13 dB.

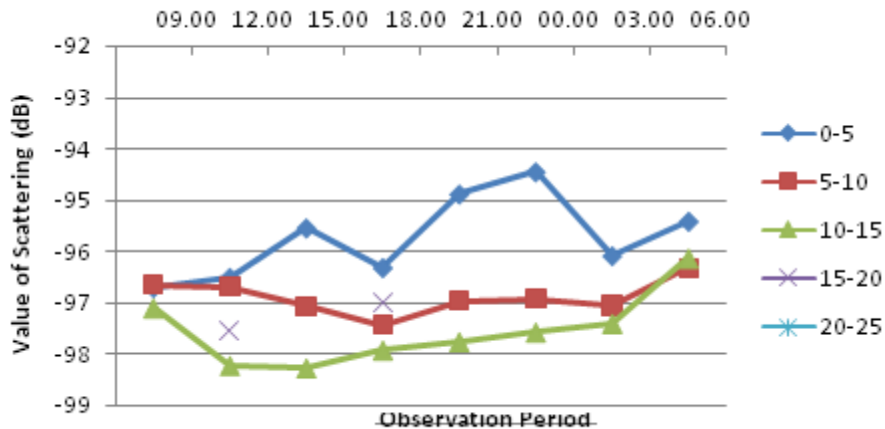


Figure 2. Value of time- and depth-based scattering volume

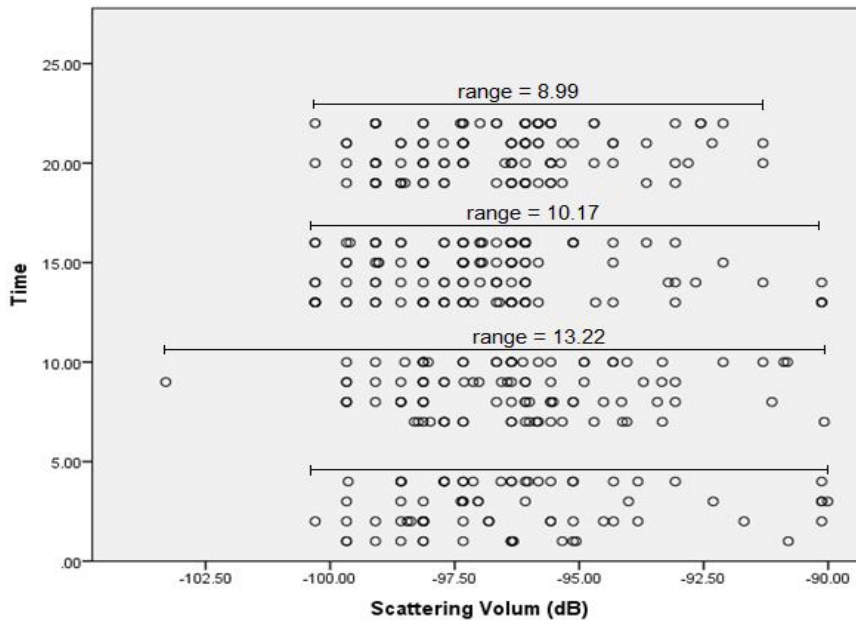


Figure 3. Value of Time-based Scattering Volume

Zooplankton will form dense layer at night and will scatter at noon. At 12:00-15:00, zooplankton will go down to depth of 15-20 m and will form multiple aggregations (Figure 2).

Table 2. Descriptive Statistics of Time-based Aggregation of Zooplankton

Descriptive Statistics							
Time	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
00:00-06:00	75	10.29	-100.30	-90.01	-96.3549	2.54946	6,500
06:00-12:00	99	13.22	-103.30	-90.08	-96.3645	2.28029	5,200
12:00-18:00	128	10.17	-100.30	-90.13	-96.9163	2.20222	4,850
18:00-00:00	114	8.99	-100.30	-91.31	-96.6166	1.98652	3,946

Daily migration of zooplankton will form dense aggregation at night and will aggregate

multiple numbers at noon. It is indicated by amount of N (aggregation amount) at 00:00 generating 75 groups and 128 groups at noon. At night, aggregation is formed in group with various group sizes (Table 2).

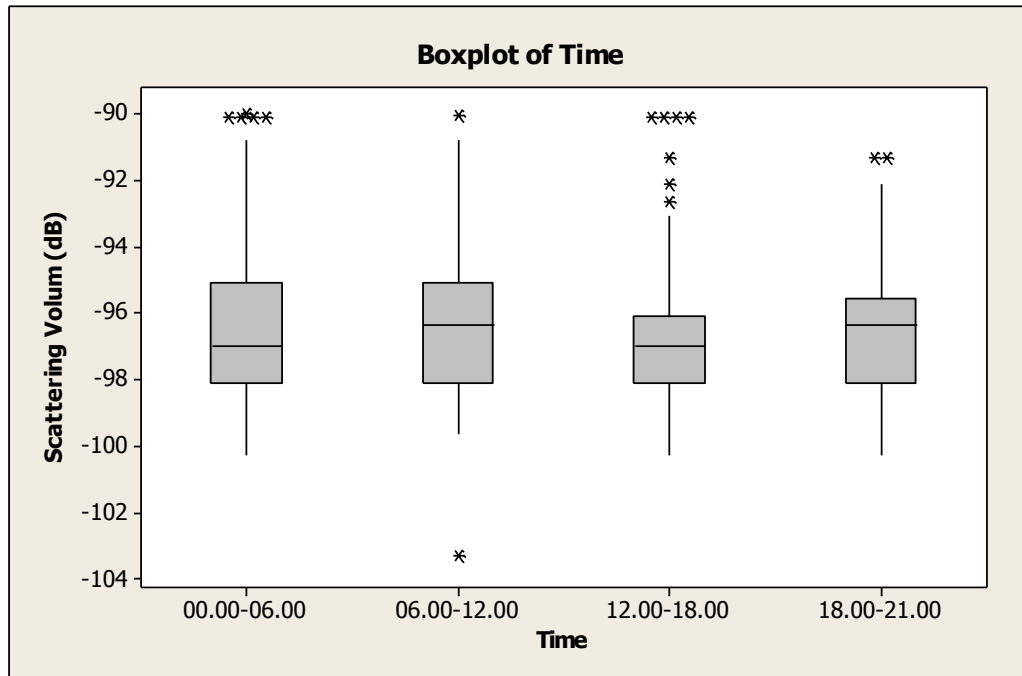


Figure 4. Scattering Volume Boxplot vs. Time.

The lowest average value occurs at 00:00-06:00, while the highest one occurs at observation time of 12:00-18:00. It indicates that at night, there exists quite dense aggregation where the size difference of inter-aggregation group may reach 2.5 dB.

According to Sutomo et al. (1994), sometimes, there exists up to three layers migrating vertically where the movement will affect value of scattering volume. This value of scattering volume indicates the density of zooplankton. Aggregation contributes value of scattering volume. The study proves that layer of dense-state backscatter is formed in upper water column at night and it will disappear at noon.

According to Falk Petersen et al. (2007), spectrum size and energy content of dominant zooplankton species in arctic ecosystem determine the value which has been known that they become food sources for higher trophic level. It means that zooplankton aggregation will form spectrum having great energy content from the dominant zooplankton.

### 3.2. Relationship between Biological Taxonomy of Zooplankton and Oceanographic Factor

Biological data processing of zooplankton generates tabulation of individual amount as presented in Figure 5, zooplankton aggregation at 15:00 begins to move to water surface with density value of 20,500 ind/m<sup>3</sup>; this condition still remains until 03:00. Species contributing dominant value is *Acrocalanus* by density value of 8000 ind/m<sup>3</sup>, while species contributing in small number is *Echinodermata* larvae by density value of 450 ind/m<sup>3</sup>.

The findings show that domination of zooplankton group found in the study is mostly dominated by zooplankton species of *Acrocalanus*, *Eucalanus*, and *Cyclopid*. There has also found a group of *Meroplankton* when become temporary plankton (larvae) in its life cycle.

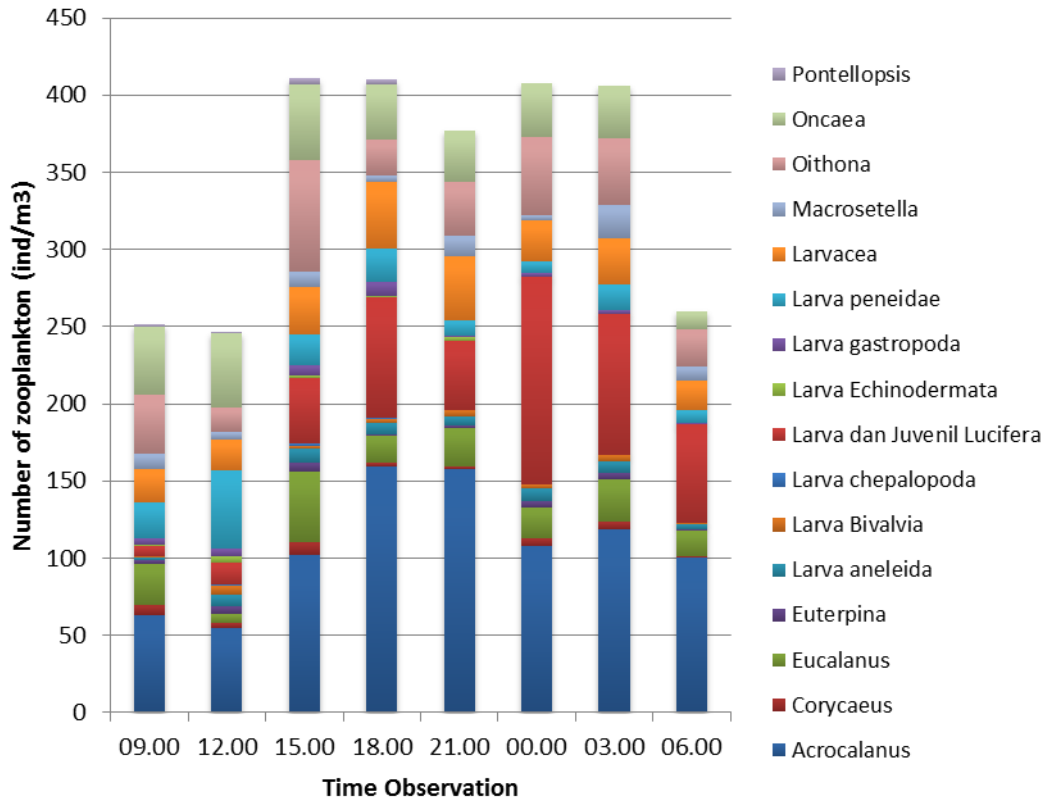


Figure 5. Composition of Observation time-based Zooplankton

Allegedly, *acrocalanus* is the greatest species which numerically becomes major contributor for the obtained value of scattering volume. This species is included in *Calanoida* since some parts of its body consist of joint hard epidermis and body segments.

Temperature is physical parameter having a role in managing ecological condition. Temperature changes often affect physical, chemical, and biological process in the ocean. Temperature in Inner Ambon Bay ranges from 26.4°C to 27.35°C. Temperature rise greatly affects oxygen content which will directly relate to the growth of zooplankton; plankton will grow optimally at temperature range of 25°C-30°C.

Zooplankton is herbivore of phytoplankton; it will respond fast when abundance change of phytoplankton occurs. In the food chain, zooplankton will be consumed by fish as its predator (Richarson, 2001).

According to Nicholas and Young (2006), many zooplankton species conducts diurnal migration vertically based on dietary pattern. At night, zooplankton will swim to sea surface and migrate to water column at noon. Many researchers attempt to explain this phenomenon, but they come to a conclusion that zooplankton movement is undertaken to avoid predators, as

an effect of food availability, and as an environmental response (light and oxygen).

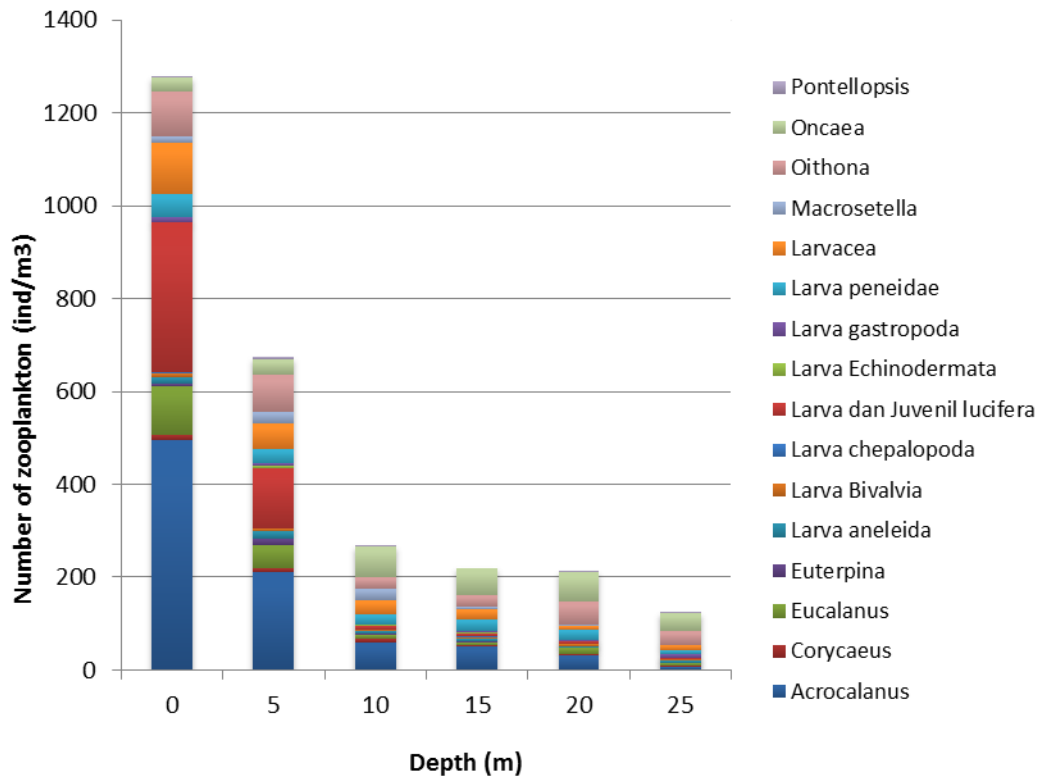
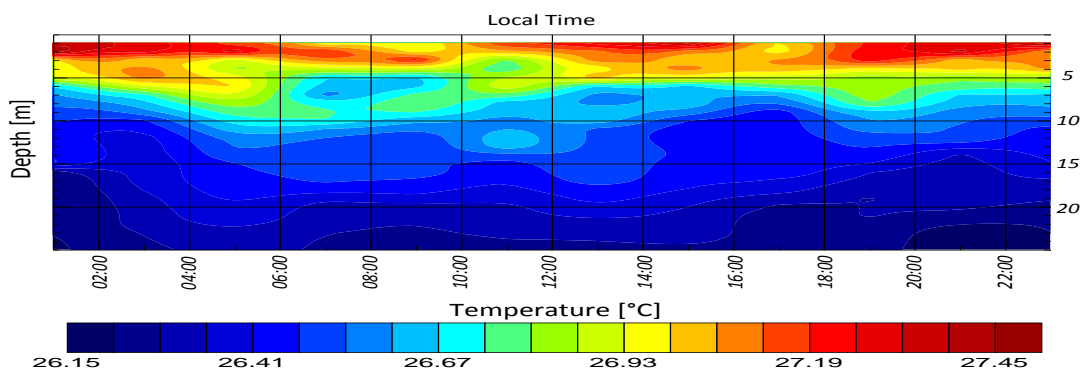


Figure 6. Composition of Depth-based Zooplankton

Figure 6 shows that zooplankton in Ambon Bay tends to swim in depth of 0 to 5 meter, and amount of this zooplankton will decrease along with the depth increase. Main cause of this phenomenon is that there are a lot of chlorophyll a in this depth as well as other oceanography factors.

Oceanographic transverse distribution in Inner Ambon Bay can be seen in Figure 7. Inner Ambon Bay is semi-closed waters when in certain time, dynamics of oceanography is relatively stable. In season in which winds come from the East, influence of Banda Sea will greatly affect the dynamics in this waters.





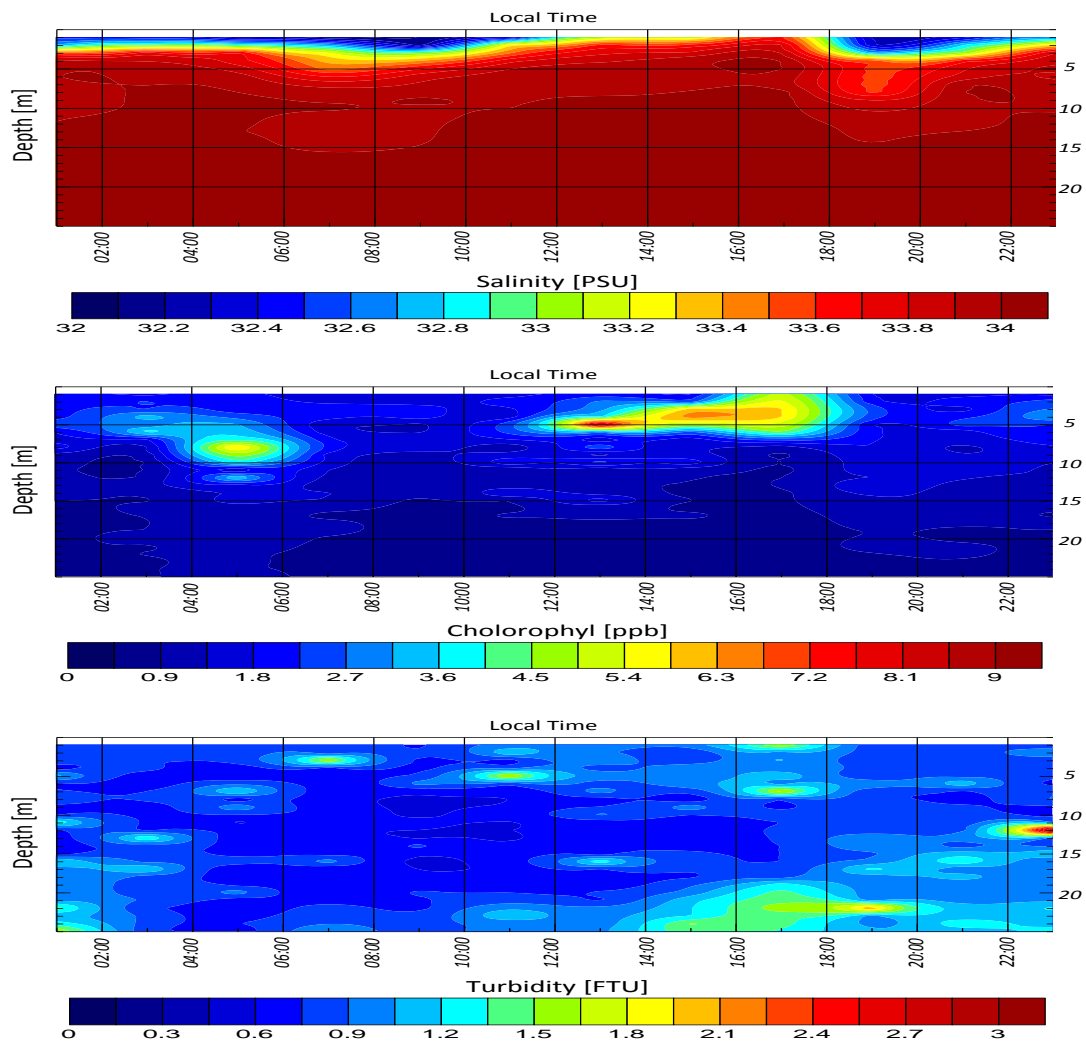


Figure 7. Oceanographic Transverse Distribution in Inner Ambon Bay

When the study is undertaken, maximum turbidity value is 2.1 FTU (Frequency Turbidity Unit) and the lowest value is 0.7 (FTU). This turbidity value is triggered by high concentration of chlorophyll a 5.16 (ppb). Boyd (1979) states that turbidity may be triggered by particle suspension, which directly or indirectly will affect waters organisms. It can be seen in movement pattern of zooplankton at 15:00 to 03:00 indicating quite dense amount. This amount is dominant at depth of 0-5 meter (Figure 4). Zooplankton is predator of phytoplankton, while abundance of phytoplankton will firmly relate to chlorophyll a. One of stimuli in aggregation behavior is availability of food.

Salinity distribution in September is 34.04 PSU (Practical Salinity Unit) where the increase of salinity will increase waters density. Salinity variation will temporarily or spatially change over times along with the influence of local variation from transportation rate through hydrological cycle. Inner Ambon Bay waters is estuary of some rivers running off to this bay, so salinity fluctuation will be firmly affected on how hydrological process occurs. According to Nontji (1987), salinity distribution in the sea is affected by multiple factors like water circulation pattern, evaporation, rainfall, and river current or surface runoff surrounding the

waters.

#### 4. Conclusion

Diurnal migration of zooplankton at noon is almost dispersed evenly to the entire waters by value of scattering volume -100.30 dB to -90.13 dB indicating sparse aggregation. While, at night, value of scattering volume ranges from -100.30 dB to -90.01 dB indicating dense aggregation.

Chlorophyll a concentration in depth of 0-10 meter having value of 5.16 ppb highly affects the existence of zooplankton. It is in consequence of aggregation and behavior of zooplankton which highly relate to food availability.

Ambon Bay waters is still proper for fishing ground of baitfish since this zooplankton-rich ocean has abundance value of 138,250 ind/m<sup>3</sup>. The amount is quite rich as food sources for pelagic fishes as the following trophic level in a food chain.

#### Credits

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