Distributions of environmental parameters and fish at Humbold Bay, Jayapura

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Abstract. Research on the distribution of fish and plankton in waters that are equipped with environmental parameters is needed to obtain maximum results and increase accuracy also it provides comprehensive information. The research, which was conducted in Humbold Bay, aimed to map the fish and plankton distribution data both vertically and horizontally and combine it with environmental parameters in the bay. Fish and plankton's data was the volume backscattering strength ($S_v$) value obtained using the SIMRAD EK-15 device while environmental parameter data, such as temperature, salinity, and chlorophyll obtained from marine.copernicus.eu which processed in the 5-80 m depth range. The results showed that Humbold Bay had the highest average surface temperature distribution was 30 ℃, with the highest average salinity from 35.89 ppt and the highest average chlorophyll value from 0.3859 mg/m³. The horizontal distribution of plankton had an average $S_v$ value of -76.63 dB, while the fish was -56.00 dB that evenly distributed. Vertically, the $S_v$ of plankton decreased with increasing depth as well as the $S_v$ of fish which its’ also did not have a distribution pattern in certain environmental parameters.

Keywords: fish distribution, Humbold Bay, plankton, volume backscattering strength

1. Introduction
Humbold Bay, Jayapura is located at the eastern end of Indonesian waters bordering Papua New Guinea. This bay has beautiful scenery and according to research done by [1], water quality conditions are still good/normal. Even so, research conducted on the distribution of plankton and fish in this bay is still rarely done. Research on these two objects needs to be done in order to find out their sustainability and distribution in the bay area considering the existence of a ferry port in the bay.

The existence of plankton in the aquatic environment is very important where plankton, especially phytoplankton, play an active role as producers in the food chain in the waters [2]. The availability of plankton is also supported by supportive environmental factors, such as temperature and salinity. This environmental factor is very influential on the growth of plankton itself. The abundance of plankton can be utilized as a food source by small fish species, so the relationship between fish and plankton very significant [3-5]. The fish that eat plankton are small pelagic fish that generally live in the upper water column.

Detection of plankton and pelagic fish can be done simultaneously using hydroacoustic technology that utilizes sound wave propagation in the water [6]. The recorded echogram with hydroacoustic
technology will be able to provide an overview of single targets or multiple targets that are in the beam of the hydroacoustic device. The results of the echogram analysis will be able to describe horizontally and vertically at the same time of the sounding conditions of plankton and fish. Research on the detection of plankton and fish using the hydroacoustic method has been done previously by [7] and [5].

Environmental conditions can affect the presence of fish and plankton in the waters. These parameters affect both metabolism, migration, food availability for fish [8-9]. Therefore, the purpose of this study was to map the horizontal and vertical distribution of plankton and small pelagic fish in Humbold Bay, Jayapura equipped with the distribution of environmental parameters.

2. Materials and Methods

This study used acoustic data from a survey of Inter-University Cooperation Research (PEKERTI) activities on 30th April 2017 in Humbold Bay Waters. The shape of the parallel path was irregular due to the presence of small islands in the middle of the waters (Figure 1).

![Figure 1. Parallel path on research locations in Humbold Bay, Jayapura.](image)

2.1. Tools and materials

This study used a SIMRAD EK-15 single beam echosounder instrument with 200 kHz frequency, 26° beam width, and 0.16 ms pulse length to obtain acoustic data by the ship with a constant speed of 4-5 knots. Fish sampling data were obtained using gill nets. Environmental parameter data was obtained from http://marine.copernicus.eu such as temperature, salinity, and chlorophylls, while bathymetric data was obtained from ETOPO-NOAA.

2.2. Data processing

Acoustic data were processed using dongled EchoView 4.8 software with using a threshold of -90 dB to -70 dB for plankton and -60 dB to -34 dB for fish [10]. This data processed in depth range of 5-70 m with Elementary Sampling Distance Unit (ESDU) per 100 pings and depth per 5 m where the upper limit is 5 m in anticipation of noise from ships. This depth range is the depth range where orders of small pelagic fish are often found [11]. The result of this data processing was the Volume Backscattering
Strength (Sv) value of the plankton pitch and fish school. The results of fish sampling using gill nets were species identification and measurement of fish length and weight. Environmental data processing was carried out with the aim of producing a spatial distribution map to be associated with the distribution of plankton and fish.

2.3. Fish and plankton data analysis

The result of processing acoustic data of fish and plankton in the form of Sv value. Sv value defined as the ratio between the sound intensity reflected by multiple targets that instantaneous amplified and measured at a distance of 1 m from the target to the intensity of the sound hitting the target. According to [10] the value of Sv can be known directly through the EchoView software using the following equation:

\[ \text{Sv} = \sum_{b}^{|N.\sigma_{bs}|/|N.\sigma_{bs}|p}^2. |N.\sigma_{bs}|v \]

(1)

Where:
- \( B \) = Beam width
- \( \beta \) = Target inside beam
- \( p \) = Horizontally calculated target based on ping
- \( v \) = Vertically calculated target based on ping
- \( V \) = Volume integration (m³)
- \( N \) = Number of targets

This equation would produce the volume backscattering strength (sv) coefficient. After the smoothing was done in order to get the value \( \overline{sv} \) using the equation [12]:

\[ sv = 10^{(Sv/10)} \]

(2)

\[ \overline{sv} = \sum (sv.n)/n_{total} \]

(3)

After that, to determine the average Sv value (\( \overline{Sv} \)) that used this equation:

\[ \overline{sv} = 10 \log (\overline{sv}) \]

(4)

The value \( \overline{sv} \) of plankton and fish will be described to provide an overview of the distribution of plankton and fish both vertically and horizontally and will be associated with the distribution of environmental parameters.

3. Results and Discussion

Based on Figure 2, the research location is an open bay facing the Pacific Ocean, and in it, there is a small bay called Youtefa Bay. Yos Sudarso Bay, based on the shape of the bathymetry, is like a funnel, and it is deeper in the middle, up to 180 m, depth than near the land. Humbold Bay is a fairly deep bay, and because of its presence facing the Pacific Ocean, the bay gets its water mass directly from the ocean. The condition of water quality in Humbold Bay is still very good with the average temperature value ranges from 29-30 °C, the average current velocity is 0.2 fps, and at the river mouth is 0.6 fps [1]. [13] illustrates that waves from the Pacific Ocean greatly affect the water mass in Humboldt Bay and the closer to shore the larger waves become smaller (Figure 3).

At the time of data collection, the sun was in the northern hemisphere so that the Asian continent was hotter than the Australian continent. As a result, in Asia there are centers of low air pressure while in Australia there are centers of high air pressure which causes winds from Australia to Asia. In Indonesia, there are east monsoons in the southern hemisphere and southwest monsoons in the northern hemisphere. Because it does not pass through the vast ocean, the wind does not contain much water vapor which causes the dry season in Indonesia, except for the west coast of Sumatra, Southeast Sulawesi, and the south coast of Papua. Between the dry and rainy seasons, there is a season called the transition season, namely: Transitional Season I which is the transition from the rainy season to the dry season, and Transitional Season II, which is the transition from the dry season to the rainy season. The
characteristics of the transition season are: The air feels hot, the wind direction is irregular, and it rains suddenly in a short and heavy time.

The distribution of sea surface temperature (SST) in Humbold Bay (Figure 4(a)) is 20-30 °C which is in accordance with [14]. [15] stated that this temperature distribution is strongly influenced by the presence of the Guinea Coastal Current (NGCC). The presence of this temperature will affect the life of the fish [16]. [17] states that seawater temperature is a factor that gets a lot of attention in marine studies. Temperature data can be used not only to study physical phenomena in the ocean but also its relation to fish distribution where fish would like to be found in waters with warmer temperatures.

![Figure 2. Humbold Bay bathymetry.](image)

![Figure 3. Movement of waves from the Northeast in the waters of Humbold Bay [13].](image)

Humbold Bay's salinity in surface ranges from 33.7-35.89 ppt (Figure 4(b)). Basically, the high salinity of seawater is influenced by the mass of water from the ocean. The mass of high salinity water from the Pacific Ocean to Indonesian waters causes the distribution of surface salinity of Indonesian waters to increase from west to east, ranging from 30-35 ppt [18]. Salinity is one of the factors besides
temperature that influence the abundance of plankton. Plankton, as food for small pelagic fish, is likely to make schools in waters with low salinity levels or near coastal areas.

The presence of plankton, especially phytoplankton in waters can be described by the total value of chlorophyll in the waters. Chlorophyll has an active role in the photosynthesis process that occurs in a water area. This total chlorophyll value serves as an indicator to determine the estimated number of fish in waters [19]. The results of the distribution of chlorophyll-a in Humbold Bay (Figure 4(c)) have concentrations in the range of 0.1772-0.3859 mg/m³. NGCC plays a role in the distribution of chlorophyll which carries nutrients in large quantities in its water mass [20]. Humbold Bay waters, the concentration of chlorophyll-a in waters < 1 mg/L belongs to the category of oligotrophic water types, namely the trophic status of water containing low levels of nutrients which is Chlorophyll concentration is higher in near-surface waters [21-22]. Chlorophyll-a in the waters plays a role in the process of photosynthesis to produce a food source for planktonic fish that determines the fishing ground area [23-24].

Detection of live plankton is generally carried out by detecting pitching (swarms) of plankton in waters marked by the value of Sv. This value will increase along with the size of the detected plankton hordes. The horizontal distribution of plankton’s Sv at the study site had a very fluctuating distribution with the distribution of Sv values ranging from -82.48 dB to -75.35 dB and had an average of -76.63 dB (Figure 5(a)). This shows that the pitchiness of plankton was relatively large in the area where the Sv range of plankton generally ranges from -62.64 dB to -86.50 dB and was a planktonic organism detected in waters ranging from 5 to 200 meters [10]. The horizontal distribution of plankton was more influenced by physical and chemical factors in coastal waters because plankton lives in groups in waters with lower salinity levels compared to offshore waters to the ocean [25]. Differences in the distribution of plankton occur not only horizontally but also vertically [25]. The existence of plankton organisms in the waters

![Figure 4](image)

Figure 4. Horizontal distribution (a) Temperature (b) salinity and (c) chlorophyll on sea surface in Humbold Bay, Jayapura.
depends on the temperature, salinity, and light intensity which is quite high in these waters, this is because organisms that carry out metabolism in the waters are influenced by these factors.

The highest plankton’s Sv values ranging from -77.05 dB to -75.35 dB (red) were found close to the mouth of the Anafre river which carried nutrients from the mainland. The discovery of pitch plankton with low Sv values in several locations with a value range of -82.48 dB to -79.42 dB (green) which was thought to be in less fertile locations, [26] explained that there are many pollutants that enter the waters due to waste disposal. This condition is caused by an increase in development and an increasing population on the shores of this bay. In the bay also found 30 families and 44 species of plankton dominated by the plankton type Mycrocyatis sp [27].

The distribution of fish’s Sv values horizontally ranged from -42.79 dB to -59.97 dB with an average Sv value of -54.96 dB (Figure 5(b)). The values were dominated by the range of -60.00 dB to -54.01 dB (red). In addition, the largest Sv value was in the range of -48.60 dB to -42.00 dB (purple), and the range of Sv values was -54.00 dB to -48.70 dB (yellow). This showed that the density of the fish Sv value in this bay was quite low because it was dominant in the range of -60.00 dB to -54.01 dB which illustrates that tropical water had a high diversity of fish species but had small biomass.

![Figure 5. Sv value horizontal distribution of (a) plankton (b) fish in Humbold Bay, Jayapura.](image)

The results of fish sampling carried out at the research location found the types of fish Selar crumenophthalmus, Gerres oyena, Parupeneus barberinus, Siganus spinus, Hemiramphus far, Lutjanus fulvus with different sizes (Table 1). This showed that the fish caught included pelagic fish and demersal fish caused by shallow water so that the fish had the same area for activity. Looking at the average length of the respondents, it seemed that there was not much difference, namely in the range of an average length of 16-20 cm, except for the Hemiramphus far species, which had an average length of 29.34 cm. The comparison between the horizontal distribution of the Sv values of fish and plankton showed a high Sv value for plankton followed by a high Sv for fish, and no schools of fish were found in locations with a low Sv value for plankton.

The vertical distribution of plankton’s Sv shows the small value of plankton with increasing depth which was indicated by the presence of Sv values between -80.00 dB to -78.00 dB at depths of more than 60 m (Figure 6(a)). This condition described the availability of sunlight which is used as a condition for the growth and development of plankton to reach that depth. The vertical distribution of fish’s Sv showed that the fish’s Sv values were spread in the range of -60.00 dB to -42.00 dB with small Sv values (-60 dB to -55 dB) spread at every depth (Figure 6(b)). Based on the figure, it was found that a large
number of schools in the water column near the surface were thought to be small pelagic fish which feed on phytoplankton and were found in the surface area [28].

**Table 1.** Fish average length and weight sampling results.

| Species                  | \( L \) (cm) | \( W \) (gram) |
|--------------------------|--------------|----------------|
| *Selar crumenophthalmus* | 20.66        | No Data        |
| *Lutjanus fulvus*        | 19.15        | 182.18         |
| *Gerres oyena*           | 16.28        | 81.35          |
| *Parupeneus barberinus*  | 19.36        | 114.71         |
| *Siganus spinus*         | 19.51        | 143.27         |
| *Hemiramphus far*        | 29.34        | 54.48          |

**Figure 6.** Vertical distribution of (a) plankton’s and (b) fish’s Sv value in Humbold Bay, Jayapura.

### 4. Conclusion

The horizontal distribution of temperature, salinity, and chlorophyll on the surface was seen as getting into the bay area values of these three parameters had decreased. The highest value of surface temperature, salinity, and chlorophyll are 30 °C, 35.89 ppt, and 0.3859 mg/m³, which is in the optimal range for marine life.

The horizontal distribution of Sv values for plankton ranges from -82 dB to -75 dB with an average of 76.63 dB, followed by the Sv value of fish with a range from -42.79 dB to -59.97 dB with an average Sv value of -54.96 dB. The distribution of Sv plankton and fish generally spreads evenly throughout the waters following the oceanographic conditions of the waters. The types of fish found in the bay were *Selar crumenophthalmus, Gerres oyena, Parupeneus barberinus, Siganus spinus, Hemiramphus far,* and *Lutjanus fulvus.* The vertical distribution of Sv for plankton shows that the Sv value of plankton in the deeper waters had a smaller Sv value. This condition is followed by the Sv of fish with low Sv values found in every depth range. The distribution of Sv of fish based on the distribution of temperature, salinity, and chlorophyll-a did not show any fish concentration at a certain value.

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