Distribution of sea surface temperature and chlorophyll-a concentration its correlation with small pelagic fish catch in Dodinga Bay

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Abstract. Current technology development provides us convenience through utilization of data time series to improve fish catch production, which may also be performed in Dodinga Bay through an oceanographic factor analysis on small pelagic fish catch aiming at examining the role of oceanographic factors and their correlation with the distribution of small pelagic fish. The use of fishing experimental method for data collection, image analysis, statistical analysis and their interpretation is expected to answer the research objective for optimized wild fishery production. The research finds that simultaneously sea surface temperature and chlorophyll-a significantly influence pelagic fish catch with \(F_{\text{hit}}\) value 90.403 and significance 0.000, while partially surface temperature and chlorophyll-a are the oceanographic factors which contribute to the distribution of small pelagic fish in Dodinga Bay with \(r\) square value 0.8525 for sea surface temperature and 0.6966 for chlorophyll-a.

1. Introduction

Dodinga Bay is an open bay in the west part of Halmahera Island which is relatively located in West Halmahera Regency, which is geographically at 0°50’28.93”- 0°53’33.86” North Latitude and 127°29’39.12”-127°37’42.96” East Longitude, with 84.3% of its population are fishermen [1]. Dodinga Bay has relatively high potential and productivity of small pelagic fish since it is supported with coastal ecological communities such as mangrove, seagrass and good coral reef. The study conducted by the Department of Maritime Affairs and Fisheries of West Halmahera Regency finds that the Sustainability Potential of small pelagic fish until 2018 is up to 831,614.74 tons/year, with very low level of exploitation of only 26.7% and about the remaining 609,573.60 (73.3%) of small pelagic fish resources are not exploited or wasted annually [1].

Purse seine and boat lift nets is the most active type of catching instrument in catching operation in Dodinga Bay with small pelagic fish as the main catch and local fishermen’s livelihood. Optimized production of small pelagic fish has been conducted with instrument modernization, increasing the number of catch instrument unit and fishermen’s skill improvement. However, these do not significantly influence the pelagic fish production and local fishermen’s income, since the main constraint faced by them is how to determine the catching area, which is still based on their experience. To optimally enhance the production of small pelagic fish resources in Dodinga Bay,
determining potential catching area is critical, that pelagic fish catching areas always change and move following any changes in environmental condition and the fish will naturally choose appropriate habitat to their life and growth. Such fish habitat is greatly influenced by oceanographic parameters such as sea surface temperature, chlorophyll-a concentration, water depth, DO, salinity, current speed and other oceanographic factors [2]; [3] in [4].

Studies on small pelagic fish distribution based on oceanographic factors are critical, so that in catching operation fishermen may utilize information of fish distribution using the geographic information factor (SIG). According to [5], by combining SIG and remote sensing capabilities, any environmental factors which influence fish distribution, migration and abundance may be obtained regularly, quickly and with wide area coverage, in which utilizing SIG in wild fishery may facilitate catching operation and save searching time in potential catching areas. This research was conducted to study the correlation of oceanographic parameters with fish catch to examine any oceanographic factors contributing to pelagic fish distribution in Dodinga Bay water.

2. Materials and method
This research was conducted in February-April 2020 in Dodinga Bay, North Maluku Province with 42 sampling points and a fishing base at Toniku village. The instruments used in this research were GPS, Thermometer, fish finder, TDS, compass, weighing scale and 1 computer unit equipped with spatial data processing software BEM 4.7, SPSS, SURFER 13 and Microsoft Office 2010 to process, analyze and present the data. The materials used in this research were small pelagic fish catch which were identified and weighed after catching operation.

The data were collected using an experimental fishing method, in which the primary data consist of the of fish catching positions along with catching instruments purse seine and bagan perahu (boat lift nets), oceanographic factors data and catch data. The data were collected using GPS, thermomer and digital TDS. Interviews with fishermen and related parties were conducted during the research to improve data accuracy and to cover any data uncovered in the sampling process during the research. The oceanographic data for estimated SPL and chlorophyll-a from February-April 2020 were obtained from satellite image at website https://oceancolor.gsfc.nasa.gov/.

The data of fish catch and oceanographic parameters were combined with satellite data and built in a multiple linear regression model to study the correlation of catch with the oceanographic factors, namely SST and chlorophyll-a, simultaneously with mathematical model [6]:

\[ y = a + b_1x_1 + b_2x_2 + e \]

Where : \( y \) = Catch (kg/trip), \( a \) = intercept, \( b_1 \) = SST regression coefficient, \( b_2 \) = Chlorophyll-a regression coefficient, \( x_1 \) = SST (°C), \( x_2 \) = Chlorophyll-a concentration (mg/m³)

The partial correlation of oceanographic factors with small pelagic fish catch was analyzed using polynomial and exponential regression with mathematical model \( y = ax^2 + bx + c \) and \( y = ae^{bx} \) [7].

3. Result and discussion
3.1 Type and amount of production
The small pelagic fish catch in Dodinga Bay in February-April 2020 with 42 samplings with catching instruments purse seine and bagan perahu (boat lift nets) is dominated by 6 groups of fishes of Stolephorus sp., Rastreliger spp., Leiognathus spp., Decapterus spp., Euthynnus afinis and Selaroides spp. Genus (Figure 1) with monthly production as may be observed in Figure 2, in which the production seems fluctuating with the highest production in March of 651.72 kg, followed with that in April of 578.16 kg and that in February of 377.90 kg.
Stolephorus sp.  Rastreliger spp  Caranx sexfaciatus
Decapterus spp  Euthynnus afinis  Selaroides spp

Figure 1. Types of small pelagic fish caught during research

Figure 2. Small pelagic fish production in February-April 2020

3.2. Mapping of the distribution of sea surface temperature and chlorophyll-a
Pelagic fish resources exploration activities are generally performed by observing matters related to sea water condition, such as temperature, salinity, wave, pH, DO, current and chlorophyll-a [8].

3.2.1. Sea surface temperature
Fish resources condition in a water area is closely related to oceanographic factors, such as temperature. Temperature is one of the oceanographic parameters with very dominant influence, particularly on the life of fish species and generally on sea resources [9]. The result of analysis on and interpretation of the images acquired from Aqua MODIS Satellite states that the distribution of sea surface temperature in February-April 2020 in Dodina Bay is fluctuating as presented in Figure 3, Figure 4 and Figure 5. In February, the sea surface temperature ranges between 26.30-30.00°C with average temperature 28.47°C, in March the sea surface temperature declines to 25.81-28.82°C with average sea surface temperature 27.07°C. In April, the sea surface temperature ranges from 26.30-29.80°C with average sea surface temperature 27.95°C.
The fluctuation of sea surface temperature during the research in Dodiniga Bay at the end of west season to beginning of transitional season tends to be influenced by season condition, in which during transitional season, the average sea surface temperature in Indonesian eastern territory is lower than 30°C [10]. Besides, March and April are the beginning of transitional season, thus west season is still in effect, such as fast wind, strong surface current, high rainfall and high waves causing even mixture of sea surface water, leading to relatively low sea surface temperature.

3.2.2. Chlorophyll-α
Chlorophyll-α in a water area may be taken as an indicator to determine its fertility level, since chlorophyll-α is the most commonly pigment existing in phytoplankton and an important pigment in phytoplankton photosynthesis process at sea [11]. Based on the result of analysis on and interpretation of the images obtained from Aqua MODIS Satellite in February, March and April 2020, the monthly data of chlorophyll-α distribution are presented in Figure 6, Figure 7 and Figure 8. The range of and average chlorophyll-α concentration in February, March and April 2020 is respectively 0.17 - 0.50mg/m³ and 0.357mg/m³, 0.28 - 0.56mg/m³ and 0.448mg/m³ and 0.24 - 0.54mg/m³ and 0.424mg/m³. The relatively stable chlorophyll-α average value which is higher than 0.3mg/m³ in Dodinga Bay water is caused by the bay’s semi-closed condition and its coastal ecological communities such as mangrove, seagrass and coral reef which are still in good condition as well as relatively high run off from rivers leading to Dodinga Bay [1].
3.3. Correlation of SST and chlorophyll-a with catch

The dynamic existence of fish catching areas is a problem commonly faced by fishermen. Fish will naturally choose appropriate habitat, while habitat is greatly influenced by the oceanographic condition of a water area, thus fish catching area potential is greatly influenced by the oceanographic factors of a water area. According to [12], the spread and abundance of catch are expectedly, greatly influenced by the environmental and oceanographic condition of a water area. One method to identify the distribution of fish catching areas is to regularly and continuously study the influence of and correlation of oceanographic factors on and with fish catch. The influence of oceanographic factors on catch may be simultaneous and partial. The analysis on the influence of oceanographic factors on small pelagic fish catch using multiple linear regression analysis may be observed in Table 1.

| Variable  | Coefficient | t\text{stat} | Sig |
|-----------|-------------|--------------|-----|
| (Constant)| 237.09      | 6.078        | 0.000 |
| SST       | -8.170      | 6.544        | 0.000 |
| Chlophyll-a| 67.292      | 4.571        | 0.000 |
| r²        | 0.823       |              |     |
| F\text{stat} | 90.403     |              | 0.000 |

The result of analysis in Table 1 simultaneously shows that the oceanographic factors, namely sea surface temperature and chlorophyll-a, significantly influence small pelagic fish catch in Dodinga Bay water with F\text{hit} value 90.403 and significance value 0.000 which is lower than 0.005, with regression model \( y = 237.09 - 8.170x_1 + 67.292x_2 + e \). Based on the regression model, it is clear that the coefficient of sea surface temperature is negative, which is -8.170, which means that the catch will decrease 8.170 kg if the sea surface temperature decreases or increases 1°C from the optimal condition.
and when chlorophyll-a coefficient is constant. Chlorophyll-a is positive 67.292, which means that the catch will increase 67.292 kg in case of an increase of chlorophyll-a for 0.1mg/m³ and if sea surface temperature coefficient is constant. The studies on the characteristics of sea surface temperature and chlorophyll-a concentration in some areas, such as Ireland waters and Bali Strait water ([13]; [14] and in Mediterranean waters ([15]; [14] state that SST and chlorophyll-a are important indicators to detect the fertility of a water area. Other research conducted by [17] shows that the spread of oceanographic parameters, particularly sea surface temperature and chlorophyll-a, in Maluku Sea Water significantly influence pelagic fish catch. Further, in the research conducted by [18] in Bali Strait, the statistical analysis shows that change in the parameters SST and chlorophyll-a mutually, significantly influences change in the CPUE of pelagic fish.

Further partial analysis was conducted to observe the correlation of each oceanographic factor with pelagic fish catch. Using polynomial regression (Figure 9), it is found that sea surface temperature is partially, closely related to catch, as may be observed with r square value 0.8525 or about 85.25% of the existing small pelagic fish in Dodinga Bay water is caused by sea surface temperature factor. The correlation of sea surface temperature with small pelagic fish catch is then distributed to the temperature and frequency of catch as may be observed in Figure 10. Figure 10 shows that there is a tendency of optimal range of sea surface temperature for small pelagic fish catch at 26.0 - 30.0°C and in case of fluctuation from this temperature value, the catch will decline. Surface temperature is one of the oceanographic factors which contribute to the existence, distribution and schooling of pelagic fish resources [19]. According to [3] in [19], fish metabolism activity and spread are greatly influenced by temperature even if it is only 0.03°C. Further, it is stated that knowledge of species optimal temperature will make it easier for us to predict fish concentration area, season abundance and fish group migration. According to [20], sea surface temperature significantly influences small pelagic fish catch with correlation coefficient value 0.729 in Ternate island water.

Partial analysis on catch and chlorophyll-a was conducted with exponential regression model (Figure 11), in which the regression analysis results in close relationship with r square value 0.6966 or about 69.66% of the existence of small pelagic fish is partially influenced by chlorophyll-a concentration. The chlorophyll-a value is then distributed along with catch using chlorophyll-a and catch frequency range values as presented in Figure 12, in which it is clear that the lowest catch value takes place at chlorophyll-a concentration value lower than 0.2mg/m³ and the highest catch takes place at chlorophyll-a concentration value higher than 0.2mg/m³. In addition, the chart also shows that the catch tends to increase in line with chlorophyll-a increasing value. According to [21] in [22], chlorophyll-a concentration higher than 0.2mg/m³ indicates sufficient amount of plankton to maintain the survival of importantly economic fishes. Further, according to [18], the fishes dominantly caught in Bali Strait water are pelagic fishes with their main source of food is plankton, thus change in chlorophyll-a concentration is one cause of change in the amount of catch.
The existence of phytoplankton is marked with high content of chlorophyll-a, which is followed with the existence of zooplankton, which eventually influences the existence of other water organisms such as small pelagic fish and big pelagic fish as a food chain [23]. The research conducted by [19] finds that in Ternate island water, chlorophyll-a concentration significantly influences pelagic fish catch, particularly ballyhoo halfbeak with correlation coefficient value 0.729.

**Figure 11.** Chart of partial correlation of small pelagic fish with chlorophyll-a

**Figure 12.** Distribution of small pelagic fish catch frequency with chlorophyll-a

### 4. Conclusion

The research results show that sea surface temperature and chlorophyll-a simultaneously, significantly influence pelagic fish catch with $F_{hit}$ value 90.403 and significance value 0.000, while partially surface temperature and chlorophyll-a are the oceanographic factors which contribute to the distribution of small pelagic fish in Dodinga Bay with $r$ square value 0.8525 for sea surface temperature and 0.6966 for chlorophyll-a.

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