The relationship between Oceanographic Parameters and Fish Larvae Dispersal in the Fisheries Management Area of the Republic Indonesia (FMA) 717

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Abstract. Cendrawasih Bay and the Pacific Ocean are known as potential fishing areas and as fish spawning locations in Fisheries Management Area 717. Larval dispersal in the waters is strongly influenced by oceanographic parameters. This study was conducted to examine the relationship between oceanographic parameters and fish larval dispersal in FMA 717. This research was conducted using KR Bawal Putih III in November 2019. A number of 42 stations were determined for observation. Environmental parameters included temperature, salinity, dissolved oxygen, chlorophyll-a, turbidity, and photosynthetic active radiation (PAR), were measured using SBE 19 plus V2 CTD while pelagic fish larvae were collected using a bongo net. Analysis of the correlation of oceanographic parameters with pelagic fish larvae abundance and spatial distribution was calculated using PCA (Principal Component Analysis) statistical analysis. The results showed that the pelagic fish larvae was influenced by temperature, salinity, PAR, chlorophyll-a, turbidity, and DO. Temperature and salinity have a direct interaction to the abundance of pelagic fish larvae.

1. Introduction

Government of Indonesia through the Ministry of Marine Affairs and Fisheries is targeting the development of marine conservation area of 28.1 million hectares in 2024, to reach the target, it should be in line with management effectively, so that the benefits of marine conservation area give effect towards sustainability resources of fisheries and marine as well as the welfare of society.

Based on the regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia No.18/PERMEN-KP/2014 concerning the State Fisheries Management Area (FMA) of the Republic of Indonesia to divided into 11 management areas, one of which is FMA 717. FMA 717 covers the waters of the Cendrawasih Bay and parts of the Pacific Ocean on the west side. Based on the Decree of the Minister of Forestry of the Republic of Indonesia No.8009/Kpts-II/2002 stated that the Cendrawasih Bay as marine national park and included conservation zone.

The design of marine conservation is effective generally to consider the scale of the geographic, the direction and magnitude of the spread of the larvae, for example through the use of models of hydrodynamics, and the impact of demographic and genetic in other populations [1, 2, 3]. The geographical location of 717 which is in the western part of the Pacific Ocean is oceanic waters. In addition to the dominance of the mass of oceanic water, this water is one of the entrance of masses...
of water of the Pacific Ocean to the Indian Pacific through Indonesian marine called Arus Lintas Indonesia or Arlindo.

Stock of fish is very sensitive to the changes in the deployment of spatial salinity which is caused by wind monsoon [4]. Very small changes in water temperature (±0.02 °C) can cause changes in fish population density [5]. While the current helps the movement of nutrients so that it affects the pattern and level of fertility of the waters and the distribution of planktonic organisms (phytoplankton, zooplankton, and fish larvae) that live in it. Sustainable management is influenced by the pattern and strength of the spread of the larvae which serves to protect the diversity of biodiversity and improving fisheries through recruitment [6].

Some researches that has been conducted to study the relationship larvae dispersal with the environment is done by using a variety of approaches such as modeling the biophysical [7], analytical genetic [8], and the otolith [9]. The approach that is used to put the methods of mathematics such as modeling or statistic.

Fishing activities in FMA 717, especially in pelagic fisheries, it is still possible to add more fishing effort [10], for this reason, the addition of fishing effort needs to be balanced with knowledge of spawning locations and fish larvae distribution.

Knowledge of the oceanographic parameters and fish larvae dispersal remains unclear due to the lack of data and the information is limited. This paper describes the influence of oceanography parameters on the fish larvae dispersal in FMA 717. Analysis of the relationship between the parameters of oceanography with the fish larvae dispersal and distribution of spatial uses a Principal Component Analysis (PCA).

2. Materials and Methods

2.1 Location and Time

Oceanography data and fish larvae obtained from the cruise (marine survey) using KR. Bawal Putih III in November 2019, consists of 42 observation station (Figure 1).

Figure 1. Research location, oceanographic station, and bongo net station.
2.2 Observation of Oceanographic Parameters and Fish Larvae

Measurement of oceanographic parameters at each station used the CTD (Conductivity Temperature Depth) Seabird SBE 19 plus V2 which was lowered to a depth of 500 meters, however in this study only surface data were used. Type environmental parameter that can be measured among others: temperature (°C); salinity (PSU); dissolved oxygen (mg/l); chlorophyll-a (mg/m³); turbidity (NTU) and photosynthetic active radiation (PAR).

Fish larvae samples were taken using a “bongo net” and the calculation refers to the SEAFDEC (Southeast Asian Fisheries Development Center) standardization method [11]. Specifications “bongo net” that is use: long nets 3 m, diameter of the mouth of the net 0,6 m and the size of the mesh size 5 μm. The Bongo net was towed by obliquely through the water with a long rope reaching 150 m at the back of the boat for about 15 minutes, at a 2.0-2.5 knot speed. The volume of filtered water in the bongo net was measured with a flow meter placed in the middle of the mouth of the bongo net.

2.3 Data Processing and Analysis

The samples of larvae obtained is stored on each bottle sample of 500 ml and preserved in a solution of alcohol 95%, the next is done by counting the number of larvae in the laboratory Research Institute for Marine Fisheries (RIMF) and counting larvae refers to the larval Fish Standard Guide SEAFDEC [11].

\[ T = t \times \frac{1}{n \times N \times a} \times 1000 \ldots \ldots (1) \]

Where:

- \( T \) = number of larvae in the sample per 1000 m³ sea water volume
- \( t \) = number of fish larvae in the sample (collected number)
- \( n \) = number of revolutions of the flow meter during the tow
- \( N \) = the calibration factor in meters per revolution for a given flow meter
- \( a \) = area of the mouth of the net in square metres.

Processing of oceanography data by using the data CTD with software SBE Data Processing. Analysis and visualization of data is done by software QGIS 3.4.14, and visualized in horizontal. Each parameter is made visualization then overlay to each parameter with fish larvae data. Parameter oceanography which overlaps with the data of fish larvae then tabulated by for each parameter are generated.

To determine the relationship parameter oceanography that affect the fish larvae dispersal are using statistical methods PCA. In principle, PCA uses the measurement of Euclidean (angle), which is the sum of the square’s differences between oceanographic parameter data for the abundance of appropriate fish larvae. The smaller the euclidean between oceanographic parameters, the more similar the characteristics and vice versa. To see which factors are feasible to use for analytical component based on KMO value (Kaiser Meyer Olking statistic) with the provision that the KMO value is > 0.5 [12]. Having in mind several factors oceanography who meet for analytical component, then the data are used as forming early hypotheses in the follow-up analysis which is multiple linear analytical regression by using t-test and F-test.

3. Results and Discussion

3.1 Fish Larvae Dispersal

The spatial fish larvae dispersal in FMA 717 is shown in Figure 2 and marked by a red circle, the larger circle size indicates the more individual fish larvae. Larvae of pelagic fish were found in semi-enclosed areas, it is Cendrawasih Bay compared to the number of fish larvae obtained in open waters which directly border the Pacific Ocean. The number of fish larvae in Cendrawasih Bay from 500 until 1,850
individuals/m³ much higher than in the Pasific Ocean area, it was only 7 until 150 individuals/m³. The most locations of fish larvae were found at station number 20 with 1,850 individuals/m³ near Rumberpon and Roswar Island. The lowest of fish larvae (7 individuals/m³) was found at station number 1 where location this station is directly adjacent to the Pasific Ocean, north of Meokri the western district of Biak Island.

Figure 2. Fish larvae dispersal in FMA 717

3.2 The Relationship Between Oceanographic Parameters And Fish Larvae Dispersal

The relationship between oceanographic parameters (temperature, salinity, dissolved oxygen (DO), chlorophyll-a, turbidity, photosynthetic active radiation (PAR) and fish larvae dispersal was executed by overlapping each oceanographic parameters with fish larvae dispersal and visualized which can be seen in Figure 3 and the value for each station which can be seen in Table 1.
Figure 3. Horizontal distribution of fish larvae to environmental oceanographic
Figure 3 and Table 1 are found in station nine until 24 the number of fish larvae much higher than other station. From the picture and the table, it can be seen that Cendrawasih Bay has high sea surface temperature ranges between 29.5-30.4 °C, low salinity ranges between 32-34 PSU, and high PAR until 42. The temperature at sea is a very important factor for the life of an organism [13]. Furthermore, [14] stated that temperature is a very important physical factor in the sea. Temperature changes can have a major influence on the properties of other seawater and for marine biota. The heat received by the sea surface from sunlight causes the temperature on the surface of the waters to vary based on time.

The results of the analysis of oceanographic parameters involved in the distribution of fish larvae using PCA can be seen in the correlation matrix where the values obtained are mostly < 0.05 (Table 2),

Table 1. numbers of oceanographic parameters and fish larvae

| Station | Temperature (°C) | Salinity (PSU) | DO (mg/l) | Chlorophyll-a (mg/m3) | Turbidity (NTU) | PAR | Fish Larva (ind/m3) |
|---------|-----------------|---------------|-----------|-----------------------|----------------|-----|-------------------|
| 1       | 30.06           | 34.37         | 6.38      | 0.01                  | 0.04           | 20.90 | 7.19           |
| 2       | 29.93           | 34.11         | 4.63      | 0.06                  | 0.05           | 0.01  | 21.18           |
| 3       | 29.48           | 32.79         | 4.50      | 0.51                  | 0.19           | 6.54  | 102.87          |
| 4       | 29.46           | 33.95         | 3.99      | 0.14                  | 0.04           | 0.01  | 33.57           |
| 5       | 29.72           | 33.93         | 5.97      | 0.27                  | 0.13           | 0.01  | 121.72          |
| 6       | 29.72           | 33.92         | 5.05      | 0.06                  | 0.05           | 9.68  | 21.63           |
| 7       | 29.68           | 34.04         | 4.31      | 0.13                  | 0.07           | 0.01  | 154.50          |
| 8       | 29.68           | 34.03         | 5.53      | 0.16                  | 0.11           | 4.57  | 161.83          |
| 9       | 29.75           | 32.55         | 5.77      | 0.14                  | 0.09           | 0.01  | 542.05          |
| 10      | 29.32           | 33.55         | 5.30      | 0.06                  | 0.05           | 5.48  | 105.93          |
| 11      | 29.51           | 33.81         | 4.73      | 0.08                  | 0.07           | 35.40 | 390.19         |
| 12      | 29.27           | 33.83         | 4.07      | 0.16                  | 0.05           | 0.01  | 600.35          |
| 13      | 30.32           | 32.41         | 5.03      | 0.14                  | 0.12           | 13.80 | 658.98         |
| 14      | 29.67           | 33.01         | 4.48      | 0.09                  | 0.06           | 0.01  | 452.08          |
| 15      | 29.81           | 33.27         | 5.13      | 0.06                  | 0.07           | 2.01  | 348.50          |
| 16      | 30.38           | 32.68         | 4.93      | 0.15                  | 0.18           | 5.64  | 407.50          |
| 17      | 30.28           | 32.67         | 4.61      | 0.10                  | 0.07           | 0.01  | 530.23          |
| 18      | 29.88           | 32.32         | 5.35      | 0.06                  | 0.10           | 37.50 | 292.90         |
| 19      | 30.29           | 32.80         | 5.42      | 0.06                  | 0.09           | 42.00 | 784.46         |
| 20      | 29.99           | 33.24         | 4.81      | 0.09                  | 0.06           | 0.01  | 1848.25        |
| 21      | 29.65           | 33.73         | 5.25      | 0.09                  | 0.06           | 6.07  | 490.32          |
| 22      | 29.40           | 33.91         | 5.00      | 0.15                  | 0.08           | 12.00 | 334.74          |
| 23      |                 |               |           |                       |                |       | 419.77          |
| 24      | 29.53           | 34.07         | 5.85      | 0.21                  | 0.10           | 0.01  | 524.03          |
| 25      | 29.52           | 33.79         | 4.74      | 0.11                  | 0.07           | 0.01  | 134.85          |
| 26      | 29.58           | 34.13         | 4.33      | 0.14                  | 0.04           | 1.92  | 38.91           |
| 27      | 29.37           | 33.91         | 5.53      | 0.13                  | 0.04           | 0.01  | 41.56           |
| 28      | 29.64           | 34.04         | 4.96      | 0.15                  | 0.07           | 1.45  | 88.47           |
| 29      | 29.57           | 34.24         | 5.75      | 0.09                  | 0.04           | 0.01  | 50.10           |
| 30      | 29.61           | 33.93         | 5.64      | 0.13                  | 0.07           | 0.01  | 60.53           |
| 31      | 29.99           | 34.26         | 5.97      | 0.06                  | 0.09           | 36.50 | 40.17           |
| 32      | 29.51           | 34.25         | 5.42      | 0.05                  | 0.06           | 0.01  | 64.52           |
| 33      | 29.68           | 33.98         | 5.27      | 0.08                  | 0.10           | 1.17  | 36.64           |
| 34      | 30.17           | 34.21         | 5.59      | 0.08                  | 0.08           | 0.01  | 38.91           |
| 35      | 29.52           | 34.29         | 5.59      | 0.06                  | 0.04           | 3.51  | 18.20           |
| 36      | 30.34           | 34.27         | 5.22      | 0.13                  | 0.11           | 1.14  | 11.95           |
| 37      | 29.87           | 34.22         | 5.62      | 0.10                  | 0.17           | 0.01  | 73.31           |
| 38      | 29.65           | 34.39         | 5.97      | 0.04                  | 0.06           | 66.90 | 71.39           |
| 39      |                 |               |           |                       |                |       | 29.01           |
| 40      |                 |               |           |                       |                |       | 95.59           |
| 41      |                 |               |           |                       |                |       | 45.49           |
| 42      |                 |               |           |                       |                |       | 107.15          |

No Data
No Data
and the KMO value obtained is 0.51 with significant < 0.05. The parameters are feasible for component analysis.

**Table 2. Correlation matrix between variables**

| Variables | Temp   | Sal    | Do     | Chloro | PAR    | Turb   | Larva  |
|-----------|--------|--------|--------|--------|--------|--------|--------|
| Temp      | 1      |        |        |        |        |        |        |
| Sal       | -0.7160| 1      |        |        |        |        |        |
| Do        | 0.1119 | 0.0109 | 1      |        |        |        |        |
| Chloro    | -0.2907| 0.1152 | 0.0114 | 1      |        |        |        |
| PAR       | 0.2469 | -0.1964| 0.2672 | -0.3411| 1      |        |        |
| Turb      | 0.3520 | -0.3300| 0.3516 | 0.5126 | 0.1541 | 1      |        |
| Larva     | 0.3246 | -0.1954| -0.2203| -0.2333| -0.1896| -0.3540| 1      |

In PCA analysis, not all major components will be included in the analysis. The main component which has an eigenvalue > 1 is feasible to be selected as a component for analysis [15]. In this research, there are three factors that have an eigenvalue > 1, there are F1, F2, and F3 (Table 3), but based on the value of the squared-cosines of the variables F1 and F2 were chosen as the components of the analysis that have the largest value (Table 4). squared-cosines analysis is used to avoid interpretation errors due to projection effects. If the squared cosines of a variable associated to an axis is low, the position of the variable on this axis should not be interpreted [16].

**Table 3. Root values and percentage diversity of each parameters**

|       | F1     | F2     | F3     | F4     | F5     | F6     | F7     |
|-------|--------|--------|--------|--------|--------|--------|--------|
| Eigenvalue | 2.1733 | 1.8900 | 1.3282 | 0.7493 | 0.4483 | 0.2950 | 0.1159 |
| Variability (%) | 31.0471| 27.0001| 18.9746| 10.7039| 6.4050 | 4.2138 | 1.6555 |
| Cumulative %  | 31.0471| 58.0472| 77.0218| 87.7257| 94.1307| 98.3445| 100.0000|

**Table 4. Squared-cosines of the variables**

|       | F1     | F2     | F3     | F4     | F5     | F6     |
|-------|--------|--------|--------|--------|--------|--------|
| Temp  | **0.7943** | 0.0481 | 0.0389 | 0.0037 | 0.0075 | 0.0705 |
| Sal   | **0.6691** | 0.0182 | 0.1066 | 0.0384 | 0.0246 | 0.1411 |
| Do    | 0.1022 | 0.2350 | 0.1807 | **0.4552** | 0.0078 | 0.0186 |
| Chloro| 0.0636 | **0.4803** | 0.3323 | 0.0000 | 0.0798 | 0.0173 |
| PAR   | 0.2658 | 0.0057 | **0.4634** | 0.0824 | 0.1794 | 0.0025 |
| Turb  | 0.2598 | **0.5725** | 0.0758 | 0.0010 | 0.0047 | 0.0449 |
| Larva | 0.0185 | **0.5303** | 0.1305 | 0.1685 | 0.1445 | 0.0001 |

The results of the F1 and F2 analysis to see the relationship between the components are shown in Figure 4 where the oceanographic parameters that have a direct relationship with each other are temperature and salinity with eculidean between the two being very close compared to other parameters.
The six oceanographic parameters were then t-test with a 95% confidence interval, from the hypothesis obtained that the t-test results stated that H1 was accepted. Its mean the seven oceanographic parameters had a significant impact on the distribution of fish larvae. T-stat values for each parameter were temperature 4.065; salinity 3.996; oxygen 4.495; chlorophyll 4.584; turbidity 4.584; and PAR 4.433 which the values greater than t-table value (2.028).

To see simultaneously the oceanographic parameters affecting the presence of fish larvae used F-test with a 95% confidence interval. The results of the F-test obtained that the calculated F value of 203.484 (Table 5) is greater than F-table value (2.134), from these results it can be concluded that the H2 hypothesis can be accepted. Its mean that together the main components significantly affect the dependent variable or oceanographic parameters affect the presence of fish larvae in FMA 717.

Table 5. F-test results from dominan main component to bound component

| Source    | DF | Sum of squares | Mean squares | F       | Pr > F |
|-----------|----|----------------|--------------|---------|--------|
| Model     | 6  | 41868.772      | 6978.129     | 203.484 | <0.0001|
| Error     | 252| 8641.891       | 34.293       |         |        |
| Corrected |    |                |              |         |        |
| Total     | 258| 50510.663      |              |         |        |

The magnitude of the influence of these parameters is expressed in the close relationship between the parameters (R-square) which is 0.829 or can be expressed in the percentage of 83%

The presence of fish larvae in FMA 717 spread in several locations with the highest abundance found in Cendrawasih Bay. Oceanographic parameters have their own part in the presence of fish larvae. The spatial correlation between oceanographic parameters and distribution of fish larvae, the oceanographic parameters that have dominan are temperature and salinity. They are components that affect the density, where the density can form the occurrence of water mass movements or ocean currents. Fish larvae have passive motion where their movement is influenced by water mass movements [17]. Swimming and
even random chance arising from the turbulent nature of ocean flows can all affect the probability that larva will be transported to a particular destination [18].

4. Conclusions
The distribution of fish larvae in FMA 717 was mostly found in Cendrawasih Bay with an abundance of 1,850 Individu/m³. Oceanographic parameters that have a direct interaction with fish larvae distribution are temperature and salinity. These two factors were the main factors in the presence of fish larvae in FMA 717 while the other four factors (oxygen, chlorophyll, turbidity, and PAR) were spatially correlated with the presence of fish larvae.

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