IOP Conf. Series: Earth and Environmental Science **116** (2018) 012017 doi:10.1088/1755-1315/116/1/012017

Oceanographic Factors in Fishing Ground Location of Anchovy at Teluk Cenderawasih National Park, West Papua : Are These Factors Have an Effect of Whale Sharks Appearance Frequencies?

Evi Nurul Ihsan[1,2*], Siti Yasmina Enita[2,3], Kunarso[3] and Anindya Wirasatriya[3,2]

[1]WWF Indonesia Site Teluk Cenderawasih National Park –Jln Huntap Iriati 2 Lorong 1 sebelah Kiri, Teluk Wondama 98362 Papua barat, Indonesia.

[2]Marine Diving Club, Marine Science Diponegoro University, Prof. H. Soedarto, S.H. – Tembalang Semarang 50275, Indonesia.

[3] Department of Oceanography, Diponegoro University, Prof. H. Soedarto, S.H. – Tembalang Semarang 50275, Indonesia.

Email : evinurulihsan@gmail.com

Abstract. The appearance frequencies of whale sharks in Teluk Cenderawasih National Park (TCNP) is unique because they appear throughout the year and are not related to any seasons. WWF Indonesia's monitoring results from 2011 untill now showed the appearance of whale sharks is closely related to the presence of fisherman liftnet and anchovies. This study focuses on oceanographic factors in fishing ground areas such as chlorophyll-a and satellite imagery data including chlorophyll-a, Sea surface Temperature (SST) over the last four years resulting in AQUA MODIS level 2 recording with 1km resolution in 2013-2016. The catch of anchovies and chlorophyll-a values showed a fairly good correlation during the west monsoon, 0.305, in addition the relationship between the anchovies with SST has a good correlation value starting in the transition period 1 towards the east monsoon. Based on these data, oceanographic factor conditions in TCNP provide a good opportunity for anchovies that live in warm waters to grow and reproduce. This also influences the appearance of whale sharks closely related to the presence of the anchovies where a positive correlation value is found between the catch of anchovies and whale sharks during the west monsoon and east monsoon in sequence 0,912 and 0.819. Chlorophyll-a and SST have a significant effect on fish catch of anchovies and the appearance frequencies of whale sharks even it were not in all seasons.

Keywords : Whale Shark, Anchovy, Chlorophyll-a, Sea Surface Temperature, Aqua MODIS.

1. Introduction

Teluk Cenderawasih National Park (TCNP) is the largest marine national park in Indonesia located in Nabire Regency of Papua Province (30.98%) and in Teluk Wondama Regency of West Papua Province (69.02%). One of TCNP's diversity is the presence of a unique species of shark family that is the largest

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

whale shark in the world. Whale sharks love small meals, even though they are large. The type of zooplankton which is the food of the whale shark is copepods, larvae of crab, molluscs, crustaceans, coral eggs, and fish eggs [1] In recent years, whale sharks have been reported to often roam near TCNP's coasts, allegedly as a response to the booming of *bagan* (stationary fishing vessels with lift nets) along the coast. This has resulted in TCNP gaining popularity as a tourist destination, the results of which has been both economically rewarding and potentially damaging to the whale shark population itself. The increasing frequency of whale sharks in Kwatisore waters followed by average fish catches of anchovies. Anchovies is one of the most abundant fish catches at Kwatisore area, with the percentage of 26% in 2014 and increasing in the next year to 32.1% by 2015. Based on the case, allegedly appearance of whale sharks in TCNP is closely related to the fish catch of anchovies as their main food. The distribution and abundance of biological resources in the ocean is inseparable from the conditions and variations of oceanographic parameters, so it is indispensable for the purpose of sustainable resource use management. This shows the oceanographic parameters will affect the presence of fish and the establishment of potential fishing areas. There are three environmental parameters that become the focus and core attention in this study, those are the results of fish catches of anchovies, concentration of chlorophyll-a and sea surface temperature (SST) as these two parameters are very important role in the presence of fish in the ocean [2]. This study aims to determine the oceanographic factors in the form of distribution of chlorophyll-a, SST and nutrient concentration on the appearance of whale sharks in the Kwatisore waters, Nabire regency.

2. Methods

Research was carried out in Cenderawasih Bay National Park, in the waters off the coast of Nabire Regency, Papua Province, Indonesia (approximately 2°53'04.5"S 134°50'15.4"E to 3°13'47.2"S 134°57'43.5"E), in August 2016.

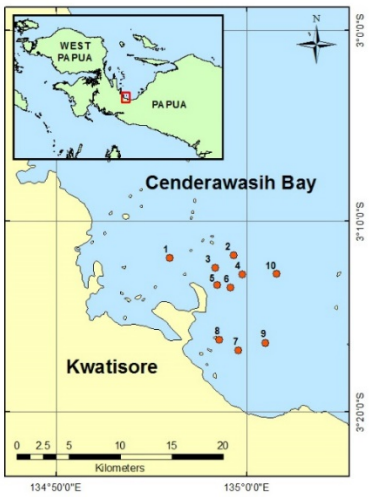

Figure 1. Approximate placement of sampling stations.

This research uses quantitative method. According Sugiyono [3] quantitative method is a research method that uses data in the form of numbers of data collection and the results of images, tables, graphics, or other display and systematic. The SST and chlorophyll-a data in this study used daily level 2 aqua MODIS (Moderate Resolution Imaging Spectroradiometer) satellite imagery with 1 km image resolution in the form of .NET Common Data File (NetCdF) format during 4-year period from January 1st, 2013 Until December 31st, 2016 downloaded from the website https://oceancolor.gsfc.nasa.gov/cgi/l3. Data on physical variables such as chlorophyll-a data and nutrient content at 10 stations were determined taking into account the results of the chlorophyll-a distribution of Aqua MODIS imagery and the largest number of appearance of whale shark location data

over the past three years [4]. The measurement of chlorophyll-a and nutrient in situ using APHA method (America Public Health Association). The results of the nitrate and phosphate solution were analyzed using a UV-Vis spectrophotometer in a chemical oceanography laboratory with 885 nm wavelength for phosphate and 543 nm for nitrate and searched for correlation value (r). The results of chlorophyll-a concentration analysis were obtained by using the formula:

$$\text{Chlorophyll-a (Ca)} = 11{,}85.(E_{664}-E_{750}) - 1{,}54.(E_{647}-E_{750}) - 0{,}08.(E_{630}-E_{750}) \quad (1)$$

$$\text{Mg Klorofil/m}^3 = \frac{C\ x\ v}{V\ x\ d} = \frac{1\ x\ 10\ ml}{3000\ ml\ x\ 1} = \frac{mg}{\text{m3}} \quad (2)$$

Information :
E = Absorbance value
C = Ca, Chlorophyll-a Concentration
V = Number of acetone used (ml)
V = Number of samples used (ml)
d = Width of cuvette (cm)

3. Results

The Effect of Oceanographic Factors on the Emergence of Whale Sharks in Kwatisore Waters

Based on the results of data processing of the emergence of whale shark with the data of fish catches in the Kwatisore waters in 2013-2016 which has been overlaid into a map of distribution shows that the emergence of whale sharks and the catch of anchovies were centered around Tanjung Paus area (fig 2). The area were bordered is the area to be analyzed. Figure 3 shows no similar fluctuation trend between the appearance of whale sharks and fish catches. Based on the correlation value (r) between the occurrences of whale sharks with the fish catch of anchovies in Table 1 shows a value of 0.090 which means it belongs to very low correlation classification.

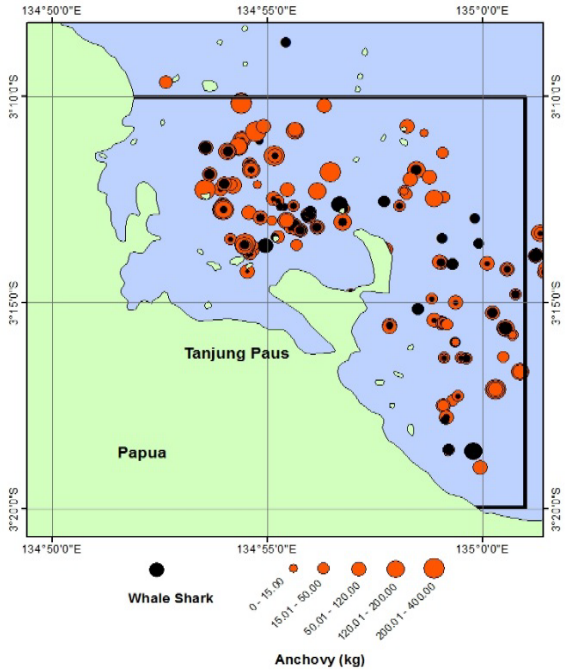

Figure 2. Distribution of anchovies and whale shark appearance during 2013-2016. Red dot shows the location of whale shark appearance, white dot shows the anchovies catch.

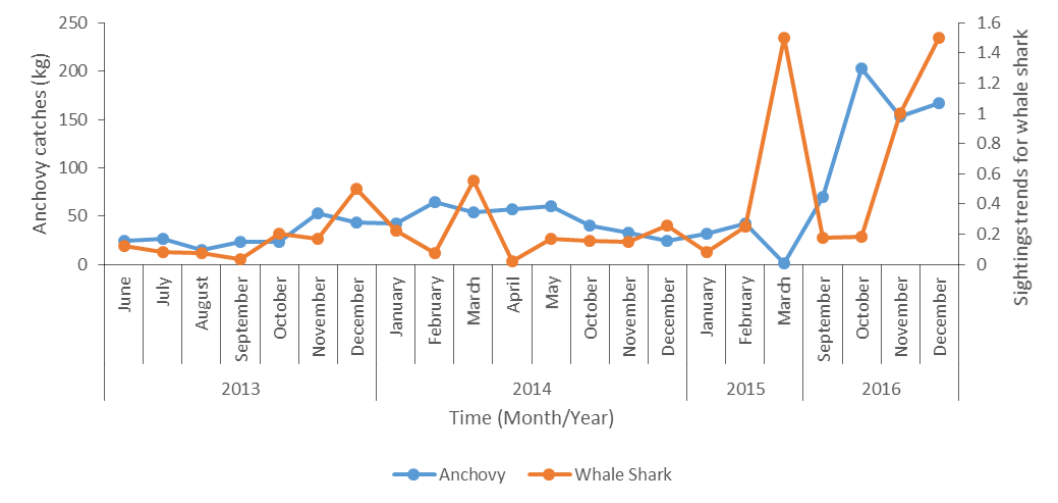

Figure 3. Fish catch and whale sharks appear temporally

Figure 4 shows the frequency of occurrence the whale sharks and chlorophyll a showing the highest occurrence being in the range of chlorophyll-a concentration of 0.38-0.48 mg / m^3 with a frequency ranging from 0.4-0.8, with a Pearson Correlation of 0.535 (Table 1). In the temporal data shown in Fig. 5, the peak of whale sharks appearance occurs frequently in December and March, followed by high chlorophyll-a concentration on these month during the 4-year period (2013-2016).

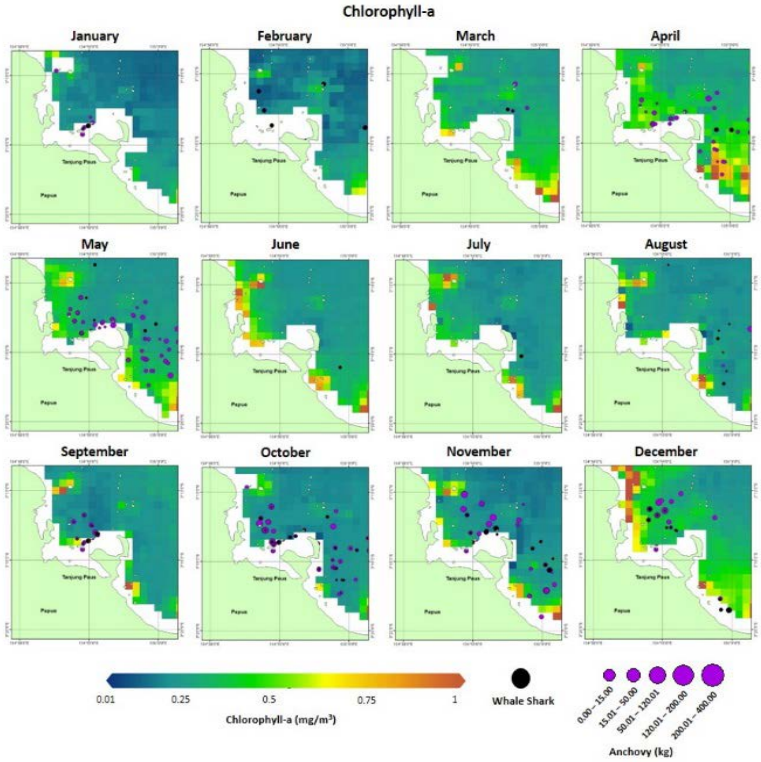

Figure 4. Overlaid map of chlorophyll-a distribution, the appearance of whale sharks and the fish catch at Kwatisore waters.

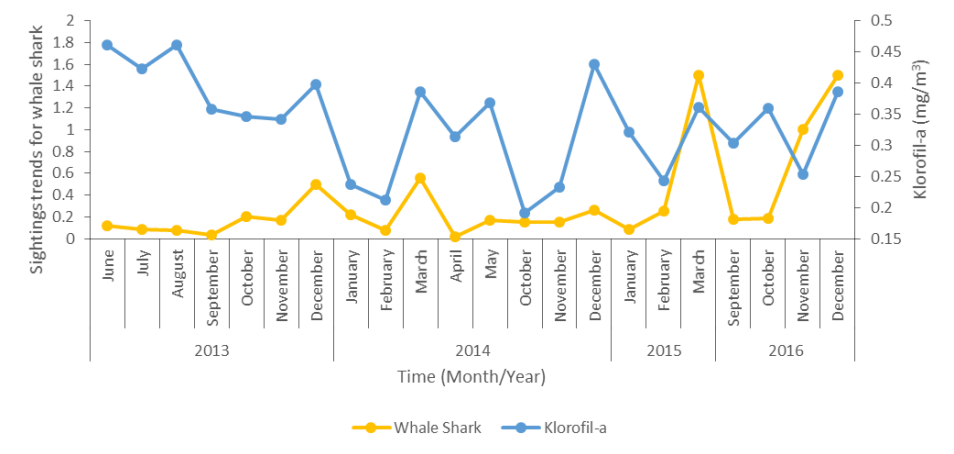

Figure 5. The appearance of whale sharks and the concentration of chlorophyll-a temporally.

Figure 5 shows a good relationship between the appearance of whale sharks with a concentration of chlorophyll-a in the waters of Kwatisore. The appearance of whale sharks to the surface usually coincides with the hordes of small fish on the water surface [5]. The presence of small fish on the surface indicates that the plankton concentration which is also the food is abundant enough and then the energy produced will be utilized by tropical top level organisms in this example is the anchovies [6]. Whale shark feed in Mexico consists of ~ 85% Copepods. In Australia, whale shark feed consists of krill shrimp (*Pseudeuphausia latifrons*), Copepods, and small fish hordes [7]. In Tanzania, the composition is over 50 percent of the sergestid shrimp species (*Lucifer hanseni*) [8]. Copepods include the main constituents of various types of zooplankton on the coast and the high seas and the presence of Copepods is closely related to food availability (phytoplankton) [9]. Based on the above reference it can be said that the association of the appearance of whale sharks and chlorophyll-a concentration in this research indicates the occurrence of food chain process in normal Kwatisore waters with intermediate tropic level suspected of krill shrimp, Copepods and or sergestid shrimp.

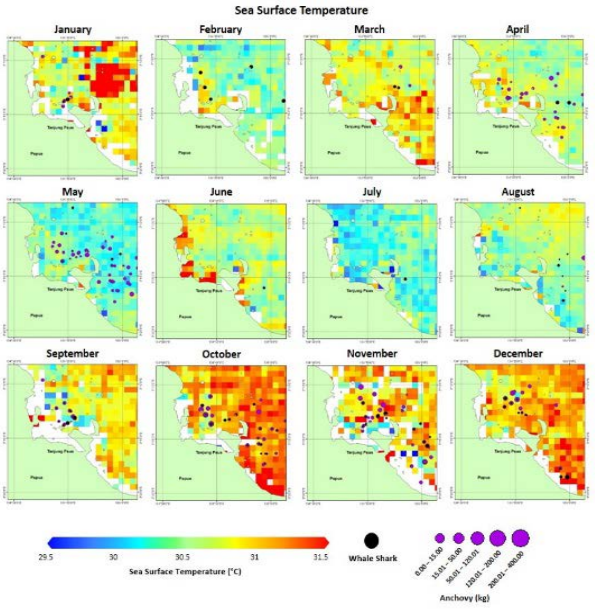

Figure 6. Map of SST distribution, the appearance of whale sharks and the catch of anchovies in the Kwatisore waters.

Figure 6 shows the highest climatological frequency of whale sharks in the SST range of 30.5 to 31.3 ºC. Pearson correlation results between the appearance of whale sharks with SST showed a value of 0.53 (Table 1). Figure 7 shows that the rise in whale shark frequency is not always accompanied by an increase in SST, but the peak of whale sharks increases at an SST above 30.5 ºC. The range is between of tropical areas that are the habitat of whale sharks. The data indicate a link between the appearance of whale sharks and SST in the Kwatisore waters.

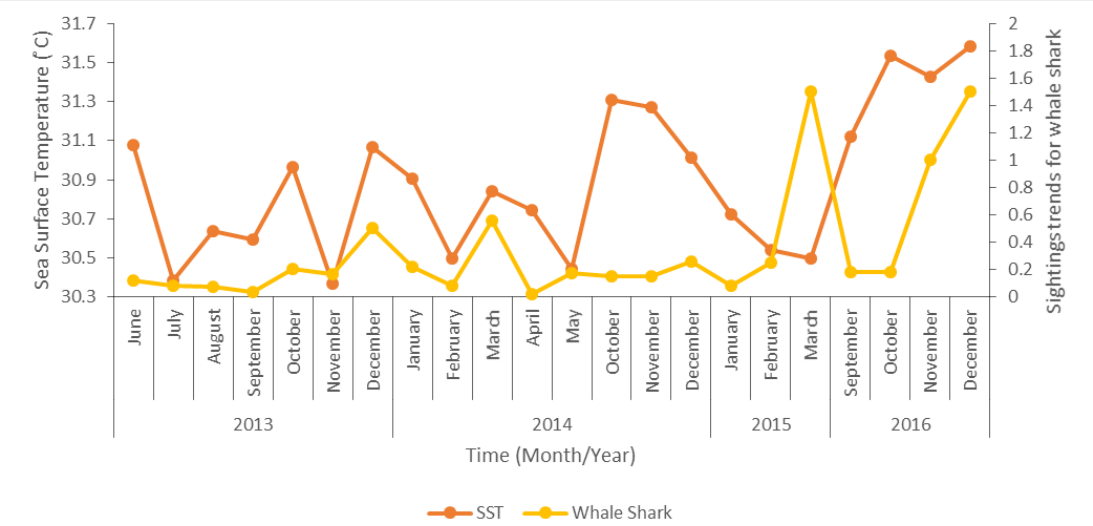

Figure 7. The appearance of temporary whale sharks and SST concentrations.

Table 1. Bivariate Correlation between monthly climatological variables in Kwatisore waters (N = 12)

N = 12	Chlorophyll-a	SST	Whale Shark	Anchovies
Chlorophyll-a	1			
SST	0,201	1		
Whale Shark	0,548	0,543	1	
Anchovies	0,227	-0,105	0,090	1

Table 2. Results of field data from 10 stations in Kwatisore waters

Station	x	y	Chlorophyll-a	Phosphate	Nitrate
1	134.9328	-3.1987	4.057711	0.006572	0.003584
2	134.9882	-3.19646	0.335064	0.003348	0.002492
3	134.9723	-3.20727	0.417528	0.004309	0.002744
4	134.9962	-3.21341	0.865244	0.003255	0.001554
5	134.9737	-3.22265	1.859378	0.006014	0.001946
6	134.9856	-3.22469	1.212439	0.003441	0.002002
7	134.9922	-3.27972	0.739933	0.004371	0.00154
8	134.9758	-3.2705	2.913667	0.004402	0.001806
9	135.0161	-3.27283	0.680173	0.003038	0.001274
10	135.0258	-3.2129	1.93666	0.003224	0.001176

Table 3. Bivariate correlation between stations (N = 10)

N = 10	Chlorophyll-a	Nitrate	Phospate
Chlorophyll-a	1		
Nitrate	0,402	1	
Phospate	0,683	0,644	1

4. Discussion

There are many whale sharks found at sea surface temperatures above 29ºC. Particularly for unfamiliar or non-clumped whale sharks found around 90% of the Indian Ocean are found in waters with sea-surface temperatures ranging from 25ºC to 35ºC [10]. Whale sharks can still tolerate temperatures up to 10ºC during whale sharks to dive in and also found whale sharks in Fundy Bay on the east coast of North America with a sea surface temperature of 44ºC [10]. So it can be said that the appearance of whale sharks in the waters of Kwatisore more in October until December due to SST in waters Kwatisore is in accordance with the habitat of whale sharks basically, it is also supported by the high concentration of chlorophyll-a in those months.

The assumption that the puri fish is a whale shark food in Kwatisore is allegedly due to a change in feeding habits on the whale shark at Kwatisore. According to field observations and interviews with the chart fishermen it is known that throwing the fish from the catch to the sea can provoke the whale shark to rise to the surface. The existence of the anchovies on the surface becomes a sign for whale sharks to feed, where the presence of small fish indicates the high concentration of zooplankton in waters which is a food for the anchovies and also the whale shark. While the anchovy fishing takes place throughout the year in Kwatisore, it is thought to be the factor of changing the habit of feeding on the whale sharks in Kwatisore.

There is the possibility that the anchovies became one of the main food of whale sharks in TNTC area. However, it is also possible that the appearance of whale sharks in locations where abundance of anchovies is due to both species has similar preference types of diet [11]. The high biomass of the anchovies caused by the abundance of primary producers, in this case phytoplankton which is also an abundant zooplankton food. Thus the catch of the anchovies on the chart is thought to be strongly influenced by the water fertility factor. The abundance of the anchovies is highly dependent on the abundance of food [12].

Based on analysis of Fig. 4, it appears that chlorophyll-a in coastal waters is higher than offshore. This is indicated by the range of chlorophyll-a in coastal waters being between 0.5-1 mg / m^3. The range of chlorophyll-a in offshore waters is between 0.01-0.5 mg / m^3. The distribution of chlorophyll is higher concentration in coastal and coastal waters, and low in offshore waters. The high distribution of chlorophyll-a concentration in coastal waters is due to the supply of nutrients in large quantities through run-offs from the mainland, whereas the low concentration of chlorophyll-a in offshore waters in the absence of direct supply of nutrients from the land [13].

Table 2 shows the results of data from 10 stations, 4 points located near the coast i.e: point 1, 3, 5 and 8, while the other 6 points are more toward the high seas i.e: point 2, 4, 6, 7, 9 and 10. Phosphate concentration At 4 points are in the range of 0.0043-0.0065 ppm where the range is higher than the 6 points located in the high seas with a range of 0.0032-0.0043 ppm. Nitrate concentration at 4 points is in the range of 0.0018-0.0035 ppm where the range is higher than the 6 points located in the high seas with a range of 0.0011-0.0024 ppm. This suggests that nutrient concentrations are affected by the innate nutrients of the land. The concentration of chlorophyll-a and the concentration of nitrate and phosphate (Table 3) shows the correlation (r) values of 0.402 and 0.683, respectively, the correlation rate is moderate to strong.

This indicates a similar fluctuation trend, where as the phosphate content increases the concentration of chlorophyll-a also increases. The high correlation value indicates that phosphate is the main indicator

of Kwatisore water fertility. High nutrient concentrations supported by sufficient sunlight intensity will increase primary productivity, as evidenced by indicators of elevated chlorophyll-a levels. Chlorophyll-a is often used as a measure of phytoplankton abundance and primary marine productivity. Nitrate and Phosphate are the nutrients that serve as the material for photosynthesis. The nutrient supply is thought to come from the mainland through the river [14].

In addition to nutrient factors, other factor that is likely to cause high concentrations of chlorophyll-a is the light factor. In certain seasons sunlight in the waters of Kwatisore has a high intensity and good water brightness, it is used by phytoplankton to produce their food through the process of photosynthesis. Light is one of the factors that determine the distribution of chlorophyll-a at sea. On the high seas, on a mixed surface layer is available enough sunlight to process photosynthesis. In addition to high-chlorophyll a-concentrations in coastal areas, in offshore waters are also found areas with high chlorophyll-a concentrations, although in general they have low chlorophyll-a concentrations in the absence of nutrient supplies derived from mainland. The high concentration of a-chlorophyll in offshore waters due to the high concentration of nutrients produced through the physical process of water mass, for example upwelling process [15].

5. Conclusions

Based on the results obtained from the research, it can be concluded that the frequency of appearance of whale sharks has no significant correlation with the abundance of fish catches of anchovies with a correlation of 0.09. The occurrence of whale sharks has the same fluctuation trend with the concentration of chlorophyll-a and SST in Kwatisore waters with the correlation of 0.548 and 0.543 respectively. The appearance of whale sharks and chlorophyll-a concentrations increased in December and March, with the range of chlorophyll-a concentrations of 0.38-0.48 mg / m^3 with SPL above 30.5 ºC. The range is a range of tropical areas that are the habitat of whale sharks.

Acknowledgments

The authors would like to thank Oceanography Departement Diponegoro University for helping make this study comes true, Teluk Cenderawasih National Park Autorithy and for all the people at Kali Lemon Resort and Kwatisore Village for helping at the field.

References

[1] Tania C 2015 *Pemantauan dan Studi Hiu Paus di Taman Nasional Teluk Cenderawasih: Laporan Pemantauan Tahun 2014–2015* (Taman Nasional Teluk Cenderawasih/WWF Papua)
[2] Gaol JL and Sadhotomo B 2007 *Journal of Indonesian Fisheries Research* **3** (1): 201-211.
[3] Sugiyono. 2012. *Qualitative and Quantitative Research Methods R & D*. (Bandung: Alfabeta)
[4] Sudjana. 2005. 6th *Statistical Method*. (Bandung: Tarsito)
[5] Noviyanti, S.N. 2015. *Characteristics of the Whale Shark Habitat Rhincodon typus Smith, 1828 (Elasmobranchii: Rhincodontidae) in Probolinggo Coastal District, East Java*. Bogor Agricultural University: Bogor.
[6] Nelson JD and Eckert SA 2007. *Fisheries Research* **84** (1): 47-64.
[7] Taylor JG, 2007 *Fisheries Research* **84** (1): 65-70.
[8] Rohner CA, Armstrong AJ, Pierce SJ, Prebble, CE, Cagua EF, Cochran JE, Berumen ML and Richardson AJ 2015 *Journal of Plankton Research* **37** (2): 1-11.
[9] Folt CL and Burns CW 1999 *Trends in Ecology & Evolution* **14** (8): 300-305.

[10] Stacey N, Karam J, Dwyer D, Speed C and Meekan M. 2008. *Assessing Traditional Ecological Knowledge of Whale Sharks (Rhincodon typus) in Eastern Indonesia: a Pilot Study with Fishing Communities in Nusa Tenggara Timur*. (Canberra: DEWHA)
[11] Marliana SN 2016. *Ecological Studies of Natural Shark Feed (Rhincodon typus) in the Context of Fishing Activities in Cenderawasih Bay National Park*. Wasior: WWF-Indonesia.
[12] Dinisia A and Adiwilaga EM 2016 *Journal of Marine Fisheries* **6** (2): 143-154
[13] Rashid A 2009 *Journal of Science & Technology* **9** (2): 125-132.
[14] Rousseaux, C.S. and Gregg, W.W., 2012 *Journal of Geophysical Research* **117** (C10006): 1-10.
[15] Ridha U, Muskananfola M R, and Hartoko A 2013 *Diponegoro Journal Of Maquares* **2** (4): 53-60.