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Research Article

The Condition of Acidity, Phosphate, and Nitrate in Indonesian Seas

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ABSTRACT

This research aimed to observe the trend of acidity, nitrate, and phosphate in the Indonesia seas associated with oceanography. Analysis was done by looking at the horizontal condition from main data (acidity, nitrate, and phosphate) and ancillary data (temperature) seasonally in three-layer of depths (0 m, 50 m, and 100 m) for years 2015 using data model of INDESO. The result showed that pattern of acidity, nitrate, and phosphate vary every season. In the upper layer (up to 100 meters), acidity condition ranges from 7.5 to 8, nitrate around 0.01 – 15 mmol N m^{-3}, and phosphate around 0.001 – 1.6 mmol P m^{-3}. The value of acidity is getting lower with depth whereas the nitrate and phosphate values increased with depth. The change in acidity, nitrates and phosphate every season indicates that the monsoon also influences the spread of pH, nitrate and phosphate.

Keywords: ocean currents, Indonesia throughflow, sea surface temperature, climate change

ABSTRAK

Penelitian ini bertujuan untuk melihat tren keasaman, nitrat dan fosfat di perairan Indonesia selama tahun 2015 dan dikaitkan dengan fenomena oseanografi. Penelitian dilakukan dengan melihat kondisi horizontal dari data utama (keasaman, nitrat, dan fosfat) dan data tambahan (suhu) secara musiman pada tiga lapisan kedalaman (0 m, 50 m, dan 100 m) tahun 2015 menggunakan model data INDESO. Metode deskriptif dengan pendekatan analisis temporal dan spasial digunakan untuk metode analisis. Hasil penelitian menunjukkan pola keasaman, nitrat, dan fosfat yang bervariasi setiap musim. Perairan Indonesia lepas lapisan permukaan sampai kedalaman 100 m pada tahun 2015 memiliki kondisi keasaman sekitar 7,5 – 8, kondisi nitrat sekitar 0,01 – 15 mmol N m^{-3}, dan kondisi fosfat sekitar 0,001 – 1,6 mmol P m^{-3}. Nilai keasaman semakin rendah dengan kedalaman sedangkan nilai nitrat dan fosfat meningkat dengan kedalaman. Perubahan keasaman, nitrat dan fosfat setiap musim menunjukkan bahwa angin muson juga mempengaruhi penyebaran pH, nitrat dan fosfat.

Kata kunci: arus laut, arus lintas Indonesia, termperatur muka laut, perubahan iklim

1. Introduction

A typical of the waters will be more diverse along with the extent of the waters. As Indonesia seas located between two biggest oceans (Pacific Ocean and the Indian Ocean), resulting in characteristic differences between the waters of the region with the other. The water mass characteristics differences cause changes to the condition of the waters finally affects the level of the water's productivity (Noir P. Purba et al., 2021). In addition, wind monsoon pattern systems have the influence of circulation patterns of different water masses and vary between seasons in Indonesian waters (Utamy et al., 2015). In the northwest monsoon, the surface water generally flows toward to the east of Indonesian seas and on the southeast season mass supplies of water from upwelling in the Arafura Sea and the Banda Sea then flows toward the west part of the Indonesian waters (Kämpf & Chapman, 2016; Noir P. Purba & Khan, 2019;

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Siregar et al., 2017). This water mass movement also brought as well as the changes in the concentration of pH and other physical and chemical properties (Noir Primadona Purba & Pranowo, 2015). The degree of acidity or the level of H + ions in water is one of the chemical factors that greatly affect the life of organisms living in an aquatic environment. Based on previous research, carbon dioxide levels in the atmosphere have increased by nearly 40% in the last 250 years, from pre-industrial times having carbon dioxide levels of about 280 ppmv (parts per million volume) to reaching 384 ppmv in 2007 (Doney et al. 2009). This increase in carbon dioxide concentrations in the atmosphere can trigger the occurrence of several phenomena such as global warming and ocean acidification (Fabry et al. 2008). pH (Power of Hydrogen) is one of the important parameters for life in the sea. With the rise of the issue of ocean acidification as a form of phenomenon from climate change, pH measurement is important. Disruption of an aquatic ecosystem can be known from the fertility of waters, and indicators of aquatic fertility can be seen from the presence of phosphates, nitrates, pH. Phosphates and nitrates are needed to support aquatic organisms, especially phytoplankton, while the degree of acidity (pH) of a body of water is one of the important chemical parameters in monitoring the stability of waters (Patty et al. 2015). Naturally these three chemical compounds are present in seawater at appropriate levels. Changes in levels that occur will certainly affect the life of organisms living in waters.

In general, the ocean has natural ability to adequately support that very large to prevent changes in pH. This may cause the changes and imbalances in the level of CO2 which can be harmful to the life of the biota of the sea. Ocean acidification is the term given to the process of revelation of the level of pH sea water which is now occurred due to an increase in the absorption of CO2 in the atmosphere (Hennige et al. 2014). Along with increased CO2 concentration in the atmosphere, absorption of CO2 by sea level this may cause changing carbonate system in the ocean (Kleypas et al. 2005; Hennige et al. 2014).

Nutrients in the sea moves based on the process of physics and biology. In the euphotic zone nutrient are usually used by phytoplankton and cyanobacteria. According to research, nutrient concentration on the surface of the generally lower than in the deep sea (Chen, 2015). Nutrient concentration in the sea has an important role to the fertility of the waters about the formation of the network cell bodies in the life of the organism. Elements of nitrogen (N) and phosphorus (P) are nutrient element required by the flora (marine plants) for the growth and development of his life. The element is in the form of nitrate (NO3) and phosphate (PO4). These chemical substances together with other elements such as sulfur (S), Potassium (K) and carbon (C) also referred to as lipids. Nutrients are elements or chemical compounds used for metabolism or the process of physiology of the organism. Nutrients in coastal waters are one of the environmental factors that affect the abundance of phytoplankton. Nutrients can provide energy and used as a component to the structure of the cell (Richtel, 2007).

Indonesian waters which is relatively warm, have SST (Sea Surface Temperature) range between 28°C - 31°C and in areas often experience upwelling process such as the waters of the southern Java the surface temperature can be down to around 25°C (Khan et al., 2020; Noir P. Purba & Khan, 2019), until this time is still not many are examined regarding the variation of the value of the degree of substance which can also indicated phenomenon in the seas and the relation with the lipids in waters (Rizki et al., 2015). This research was done to know the general pattern distribution of pH and nutrients (nitrate and phosphate) in Indonesian waters in the annual period. When pH becomes acidic, the dissolved oxygen content will decrease and affect the activities of microorganisms in the process of decomposition of organic matter, one of which occurs the denitrification process which is a microbiological process that occurs when nitrates and nitrites are converted into nitrogen molecules (N2). The process produces the final production in the form of inert gas that cannot be used directly, so that the nutrient content that can be utilized will decrease.

2. Material and methods

The Data used in this research were pH, nitrate (NO_3) and phosphate (PO_4) and the temperature is obtained from the official website (http://www.indeso.web.id/) INDESO with the resolution of the 1/12°. All data is processed will produce a map within spatial and temporal from each of the variables.

Study Area research is the Indonesian waters with the coordinates of the 15°LU - 15°LS and 90°BT - 140°BT can be seen in Figure 1. The area of study is divided into five areas including the area which covers the waters off the west coast of Sumatra and the Strait of Malacca (Area 1). Area 2 which includes the waters of the southern Java, the waters of the south of Bali and

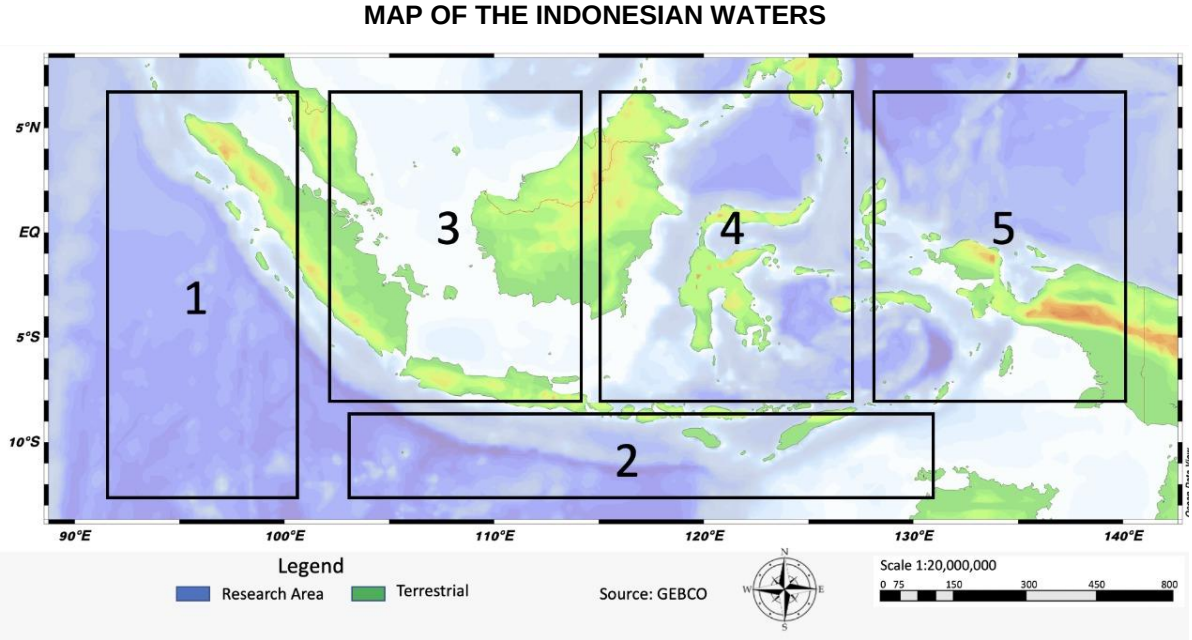

Figure 1. Research Location map

Lombok, as well as the sea East Timor. Area 3 which includes the Karimata Strait waters and the Java Sea. Area 4 which represents the Makassar Strait, Sea of Maluku and Sulawesi Sea and the area 5 which includes the Banda Sea and Halmahera Sea. The division of this region is based on the difference between the characteristics of the water. On the fifth of the area alleged to have characteristics of water that is different because of the influence of different characteristics such as Indonesia Throughflow, winds, and tide patterns (Purba et al., 2021).

The data were downloaded from INDESO (Infrastructure Development of Space Oceanography) Project recorded in 2015. INDESO given wide range of data model in Indonesia region including from surface to subsurface layers. The method used in this research with spatial analysis and the analysis of the temporal. Spatial analysis is used for data processing spatial secondary then processed using software and produces a spatial map. Spatial analysis method is used for data processing pH, nitrate, phosphate, and temperature. The temporal analysis method used to see changes in the value of each parameter in specific time, result of temporal data processing in the form of a graph.

3. Results and Discussion

3. 1. PH condition

The condition of pH in the upper layer range between 7.9 to 8 (Figure 2). In the area 1, pH value was lower on the waters off the west coast of Sumatra compared with the waters of the Strait of Malacca. While in the area 2 in the west season pH condition is slightly lower on the waters of the south of Bali and Lombok that reach the value of 7.95, while in the waters of the southern Java pH value reached 8. Area 3 has a pH condition which is relatively stable with the value of 8 only in some coastal regions value slightly lower. Area 4 also has a value of pH range between 7.95 until 8, seen that around the Makassar Strait pH values slightly higher than on the Sulawesi Sea and Maluku Sea. On the area 5 in the west season seen that pH values tend to be low in the waters of the sea Aru or around the West Irian Jaya Island, even value reached 7.8 around the coast.

At a depth of 50 meters the lowest pH value or which is sourer is starting from the area 1 exactly the western waters of Northern Sumatra and the Strait of Malacca in west season with range value 7.75 until 7.8, which then extends from the summer to the winter toward the east. Expansion of the low pH value this happens around the coastal and marine areas offshore which is not far from the coast. While the value of

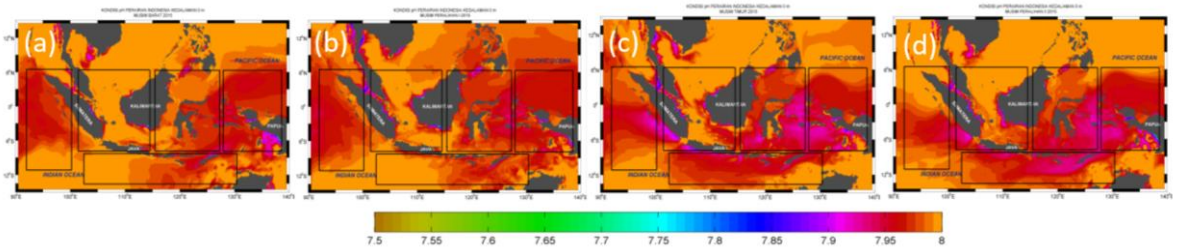

Figure 2. The condition of pH 2015 Depth 0 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season II

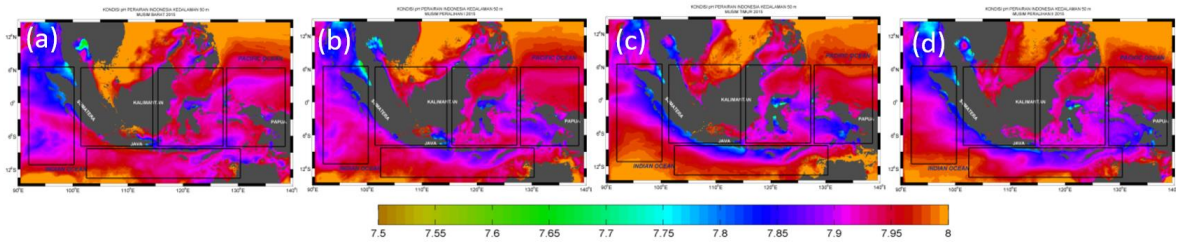

Figure 3. The condition of pH 2015 Depth 50 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season II

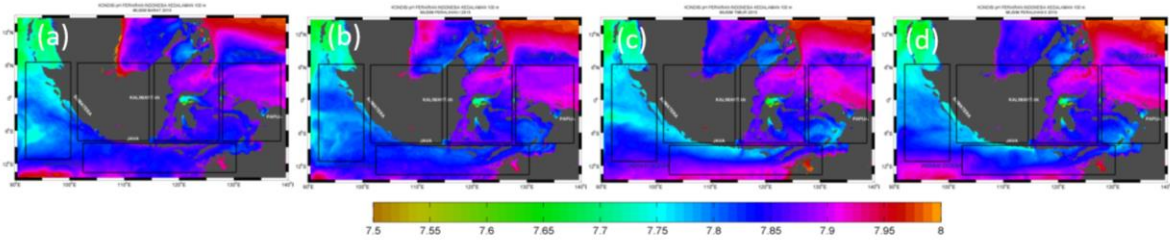

Figure 4. The condition of pH 2015 Depth 100 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season II

8 is the highest value is still can be seen in this depth, only located on the region of the sea such as the Indian Ocean and the South China Sea. In the area of 2 the condition of pH from west to east the summer season experience more acid, especially in areas not far from the coast along the south coast of Java to south Bali and Timor Sea. Next, in area 3 seen that the value of pH around the Karimata strait has not shown that is marked with the color of the waters of the likeness of the island. This is because bathymetry around the Strait of Malacca not until at the depth of 50 meters. The characteristic of Karimata strait is shallow and this affect pH value in the surrounding waters which still achieve the depth of 50 meters, such as in the Java Sea and the waters of the West Kalimantan is connected directly with the South China Sea. In both these waters, pH content of its waters - are likely to be more bases that range between 7.95 to 8.0 units of units more details are presented in the figure 3.

On the results of the data processing in the depths of the 100-meter shows that the value of pH the lower again from the conditions in the depth of 50 meters. In the Fig. 4, the value of the degree of substance with the range 7.8-7.85 looks more dominate. Waters off the west coast of Sumatra (area 1) has a lower value of around 7.75, similar value range are also available on the south coast of Java and Bali (area 2) in east season until the transition II. Around the waters of the Central Sulawesi area (4) exactly in the Gulf of Bone and Tomini bay on the east season until the transition II pH value far lower around 7.65-7.7, this may be affected by the land topography and the influence of the flow of the great river in

the area. The waters of the eastern part of the country exactly in the Banda Sea area 5) have pH values around 7.85 which this value is the value of the dominant in 100 meters. Only in the waters off Northwest Irian Jaya which is directly related to the Pacific Ocean the value of acidity slightly higher.

3. 2. Nitrate (NO_3) concentration

The whole interval from the value of nitrate surface in 2015 is 0-10 mmol N m-3 (Figure 5). In the area 1 the value of nitrate in waters off the west coast of Sumatra has increased from east season until the transition II with the value of nitrate reached 3 mmol N m-3, while on the Strait of Malacca value stable enough. Then on the area 2 which covers the south Java-Bali and Timor Sea visible improvement of the value of nitrate quite drastically and wide on the east season and began to decline on the transitional season II. The value of nitrate on the south Java-Bali until the sea East Timor has value interval 2-6 mmol N m-3 in east season and 1-5.5 in transitional season II. Next, on area 3, 4, and 5 the value of high nitrate found in many waters off the East especially on the waters of the sea Aru (area 5). The influence of the seasons is still visible around this area, especially the highest value is found on the sea Aru in east season with range value 7.0 to 10.0 mmol N m-3. On the transitional season II concentration of high nitrate values began to decline again.

Nitrate content in the upper layers of 50 meters (Figure 6) has a higher value when compared with the surface layer, but the content

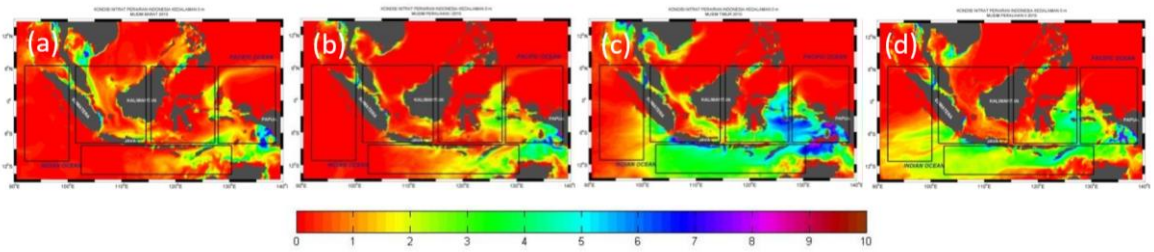

Figure 5. The condition of Nitrate 2015 Depth 0 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season II

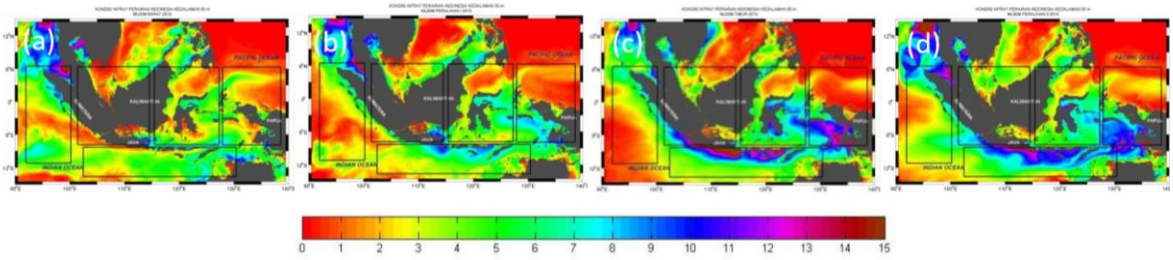

Figure 6. The condition of Nitrate 2015 Depth 50 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season II

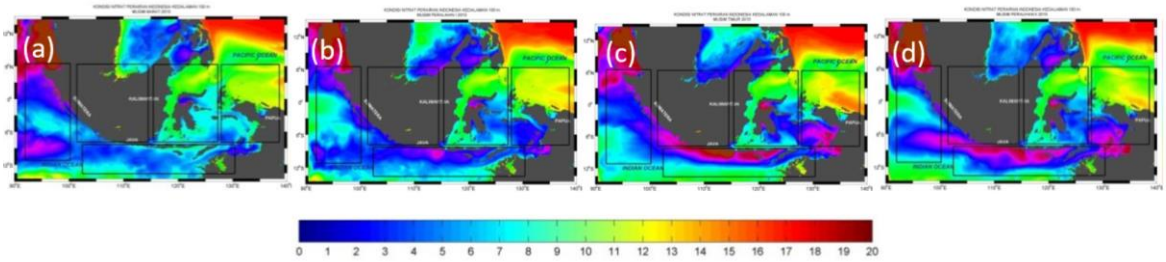

Figure 7. The condition of Nitrate 2015 Depth 100 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season II

of nitrate in layers of 100 meters have a higher value when compared with the content of nitrates both layers. At 100 meters nitrate distribution shows that the content of the higher nitrate found in the Malacca Strait waters region which is located in an area of 1, until the coastal waters off southern Java and Bali-Lombok (area 2) on east season, the gulf of Bone and the gulf Tomini on area 3 on the east season until the transition II, and the waters of the Banda Sea and sea Aru in east season until the transition II, this high value ranges between 15.0 - 20.0 mmol N m-3. The content of nitrates low in this depth is generally spread in almost every area. The results of the spread of the value of nitrate in 100 meters can be seen in Figure 7.

From the results of visualization of three depths (Figure. 5-7) seen that the concentration of nitrate on average higher in the base of the waters or waters more in compared with on the surface. This trend is assured by the opinion of Hutagalung and Rozak (1997) stated that the levels of nitrate are higher when the depth is increased meanwhile for horizontal distribution of the level of nitrate higher toward the beach. The concentration of nitrate in the surface layer is lower than in layers near the basis caused by nitrate in surface layer more used or consumed by phytoplankton. In addition, the concentrations of nitrate slightly higher near the base of the waters also influenced by sediment. In the sediment nitrate produced from biodegrades organic materials to ammonia which then is being

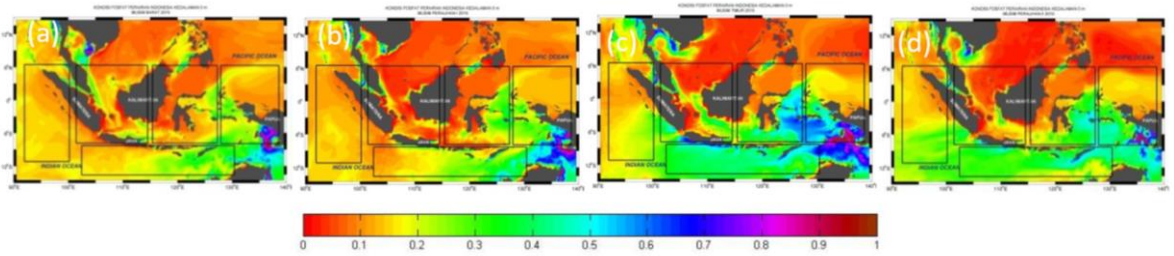

Figure 8. The condition of Phosphate 2015 Depth 0 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season II

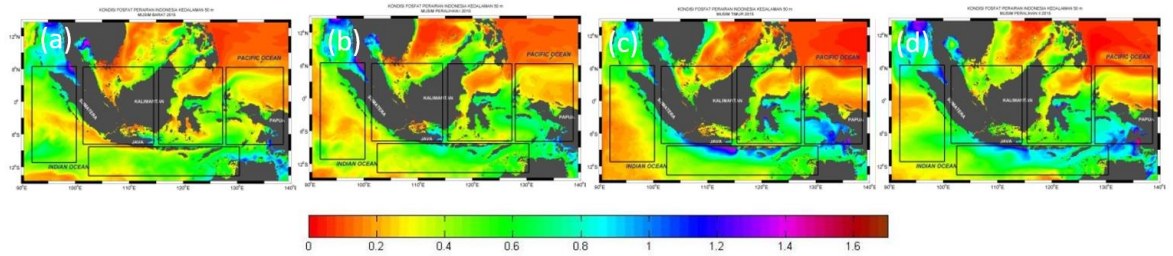

Figure 9. The condition of Phosphate 2015 Depth 0 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season II

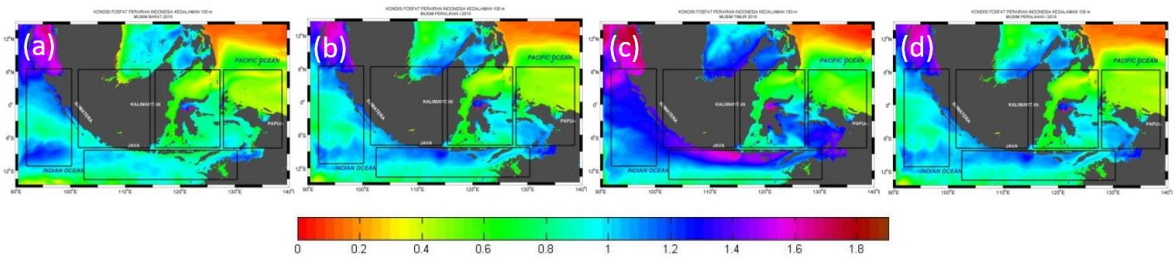

Figure 10. The condition of Phosphate 2015 Depth 0 m; (a) West season, (b) Transitional Season I, (c), East season (d) Transitional Season I

oxidized to nitrate (Hutagalung & A., 1997; Seitzinger, 1988; Risamasu & Prayitno, 2011).

3. 3. Phosphate (PO_4) concentration

The concentration of phosphate in the waters of the sea that normal range between 0.01 - 4 mg/l (Brotowidjoyo et al., 1995 in Arifin dkk., 2011). In general, the value of phosphate in Indonesian waters varies in each area and from summer to winter. More details about the condition of the phosphate Indonesian waters on 2015 can be observed in the results of processing the data presented in Figure 8.

The value of phosphate in this surface layer seen vary in each season and area. If seen on the area 1 which represents the waters off the west coast of Sumatra and the Strait of Malacca phosphate value increase on the east season until the transition II. On the area 2 high phosphate values are located throughout the south coast of Java especially on east season, in addition to the influence of monsoon and upwelling high phosphate values in this region is suspected because of influence from the mainland, this assured by Arifin dkk. (2011) stated that the reservoir of phosphate is not air but the stones or sludge and other deposits. Phosphate is in the rocks will be swept into the sea through run off or when the rain occurs. Next, on area 3 phosphate conditions began to rise in around the Java Sea and some Karimata strait in east season, this allegedly because of the influence of the flow of Monsoon Indonesia across the region. The area 4 and 5 is a region of Eastern Indonesia waters, in this region the value of phosphate tends to be higher than with the west coastal waters of Indonesia.

At a depth of 50 meters phosphate value increases with the highest concentrations located in the area close to the coast as in the waters of the southern Java (area 2) and the Strait of Malacca (area 1), coastal area south of West Irian Jaya (area 5), and the coast of the island of Sulawesi (area 4). More details, phosphate conditions on 50 meters depth is presented in Figure 9.

From the Figure 9, phosphate value at a depth of 50 meters and 2015 in Indonesian waters ranged between 0 - 1.6 mmol P m^{-3}, with most of the concentration range between 0.2 to 1.0 mmol P m^{-3}. This shows that the value of phosphate in this layer increased compared to the surface layer that most valuable from 0 - 0.6 mmol P m^{-3}. To show that the more in the higher phosphate waters, then presented visualization of phosphate at a depth of 100 m, such as in the Figure 10.

Conditions phosphate on the depth of 100 meters in 2015 worth lower than the surface layer and the depth of 50 meters. Naturally, phosphate is distributes from the surface until the basis. The more to the base of the waters of the higher its concentration, as a result of the bottom of the sea that is rich in nutrition and specialized the lower the further toward the sea. The low serum phosphate in surface layer can probably also due to phytoplankton activity. According to Purba & Pranowo (2015), nutrient concentration on the surface are lower because marine plants use it in the process of photosynthesis.

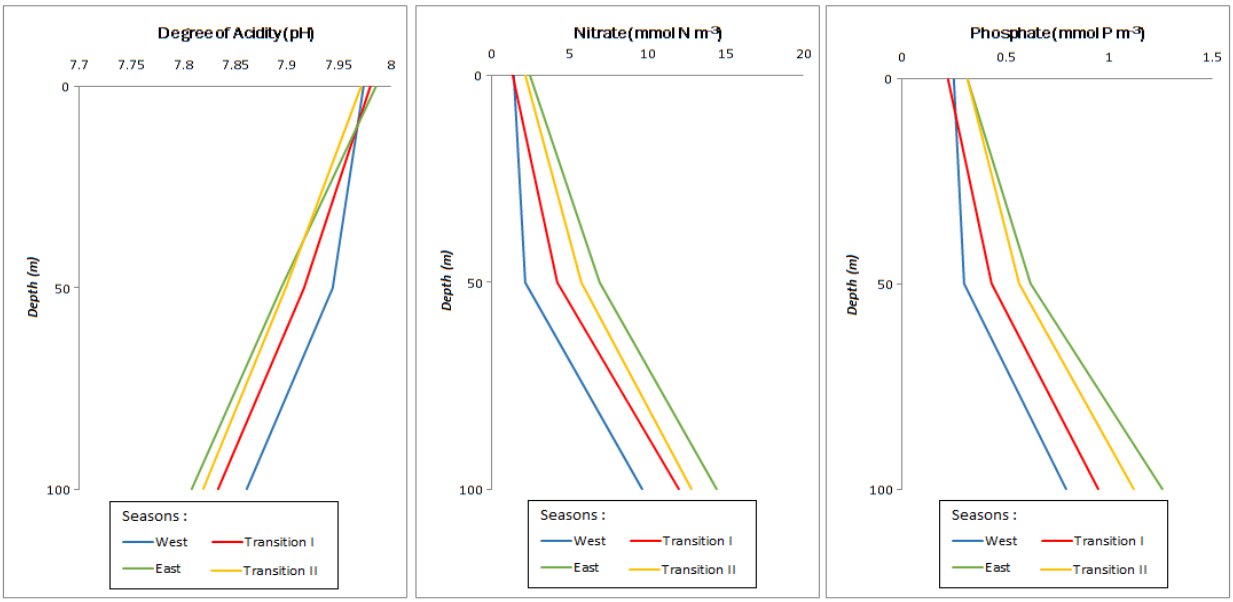

Figure 11. The pH profiles, nitrate and phosphate to the depth

3. 4. The relevance of pH, NO_3, and PO_4

Graph of pH conditions and nutrients (nitrate and phosphate) in Indonesian waters made to know the relation between the two variables with how to get the average value - average each season so that it can be seen the value of pH, nitrate and phosphate and its amendments to the seasons and the depth during the year 2015. As the depth increased, the value of pH declining, rather nutrient value (phosphate and nitrate) thus increasing increases with depth. This can be proved from the Figure 11.

The value of pH (Figure. 11a) in Indonesian waters ranged between 7.8 to 7.98 which occur from the surface of the waters (depth 0 m) to a depth of 100 m. As the waters increased the value of pH more acid. The value of the nitrate found in Indonesian waters from the surface to a depth of 100 meters ranged between 0.1 mmol N m-3 until 11 mmol N m-3, where the concentration of nitrate increased increases with into. The concentration of phosphate in Indonesian waters in the range of the value is not much different from every season or can be said almost stable, namely on 0.0001 mmol P m-3 up to 1 mmol P m-3. Just as with the nitrate, phosphate also increased concentration increases with depth, only amendments thereto is not evident as the concentration of nitrate found. In general, it can be said that the condition of a degree and lipids and the rate of the depth is inversely. This is shown in the graph of pH conditions, nitrate and phosphate on three-layer depth and looks very real on some of the seasons. The condition of pH and nutrients that most shows the differences in the depth of 0 m is when the east season 2015, where in the time of nutrient conditions appear to increase as the condition of pH thus decreasing. In addition, on the depth of 50 m in east season 2015 decrease nutrient value is quite clearly seen with accompanied with the increase in the value of pH and when entering West season 2015 occur increasing the value of nitrate and phosphate which then accompanied with the decline in the value of pH. Then on the depth of 100 m pH conditions and nutrients stable enough or not too fluctuating between the season, but on 2015 nutrient value both phosphate and nitrate increased quite sharply from west to east the summer season and falls on the transitional season II, this is accompanied by a degree of conditions that decrease from west to east the summer season.

In some locations can occur because of the existence of the mass movement of water from the lower layers to the surface or commonly known by the term of upwelling. This is assured by the statement from Martono (2016) stated that the mass of the water up to the surface has the cold temperatures, salinity and rich will be the womb of nutrient substances such as phosphate and nitrate found. The researchers in the field of marine have stated that the phenomenon of El Nino has occurred in the year 2015 and was the strongest compared to 1997. The influence of the El Nino effect to the increased intensity of upwelling in the waters of southern Java until Bali-Lombok is closely related to the current transport system across Indonesia (ARLINDO). Previous research shows that during the phenomenon El Nino, currents transport across Indonesia slowed and gained during periods of La Nina (Meyers, 1996; Ningsih, 2003; Safitri, et al. 2012 in Martono, 2016). A weaker currents transport across Indonesia was the cause of the decrease in the face of the high sea's of the south of Indonesia and cause Sagara Anakan Lagoon depth of the thermocline in the waters of southern Java. Sagara Anakan Lagoon depth of thermocline layer this then increase the intensity of upwelling in waters south of Indonesia. This mechanism due to nutrient conditions have increased during the period of the El Nino (Martono, 2016). Other factors that can affect the spread of the value of the nitrate in the surface including the flow of the surface, wind, bathymetry and many other physical factors, besides chemical factor will also greatly be affected

4. Conclusions

The pattern of pH, nitrate and phosphate concentration in Indonesian waters during 2015 in each area has a variety. PH conditions have the interval from 7.5 - 8.0 units of the unit, nitrate conditions have the interval between 0 - 25 mmol N m-3, and phosphate conditions have the interval between 0 - 1.8 mmol P m-3, where the interval occurs from the depth of 0 m to 100 m. The deeper waters, value degrees while pH the lower while the value of nitrate and phosphate increased. The changes of the pH degree, nitrate and phosphate on each season indicate that the monsoon factor has influenced the spread of pH, nitrate and phosphate.

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