Determining The Best Coral Reef Habitat in Coastal Island of Batam

1 author:

Oktavianto Gustin
Politeknik Negeri Batam
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Oktavianto Gustin, Indonesia

Key words: Coral Reefs, Habitat, Zoning, Overlay

SUMMARY

Indonesia is one of the largest archipelagic country in the world and it located at central triangular of coral reefs (the coral triangle) with high levels of diversity. On the other side the coastal climate and oceanographic conditions of batam suitable for development habitats of coral reefs. This research aims to determine the parameters that determine the living standard of coral reefs by gathering secondary data such as sea current map, bathymetry data and sea temperature while the primary data such as visibility, PH and temperature of sea water at coastal island of Batam. This research using the method of overlay analysis between spatial data and attribute data among parameters. The choice of research location based on the results of zoning secondary data with overlay analysis. The zoning secondary data then would be overlay analysis with primary data obtained from measurements in the field to obtain the best habitat for the development of coral reefs. The result of this research obtained that areas eligible living reefs include sea current velocity less than 0,9cm per second, depth less than 25 meters, sea temperature between 18°c-36°c, ph values between 7-9 and visibility of sea more than 5 meters is around the coast of tanjung piayu village with area 4.675 km2.

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1. INTRODUCTION

Indonesia is one of the largest archipelagic country in the world, with a number of about 17,508 island and lie throughout 5,120 km from east to west along the equator and 1,760 km from north to south (Dahuri, 2001). Indonesia has a long coastline of about 108,000 km, which is the longest beach in the world. The length of the coast in Indonesia and the potential of its marine resources is a substantial capital investment in building the Indonesian economy.

Indonesia located at central triangular of coral reefs (the coral triangle) with high levels of diversity. As time goes on, the condition of coral reefs in Indonesia degraded worrying. It is caused by several factors such as the high utilization of human and damage by natural disaster(COREMAP II, 2007) . Currently in Indonesia is estimated to have only 5.23% of coral reefs are in excellent condition, while 31.17% were degraded. Therefore, if it is not anticipated then the wealth and potential of coral reefs will be lost (Rudianto 2007 in Syarifuddin, 2011).

Coral reefs are unique ecosystems found in the shallow waters of the tropics, with primary productivity and high biodiversity. Although reefs can be found in various places from across the world, but only in the tropical area coral reefs can grow and flourish properly, making it the spawning ground and nursery ground for a variety of marine life (Nybakken, 1988 in Nababan, 2009). Coral reefs have a role as a food source and habitat for marine biota economically valuable aesthetic tinggi. The aesthetic value of coral reefs can be used as a tourist area and a backup source of high germplasm. It also can play a role in supplying sand for beaches, and as a barrier brunt of the waves and beach erosion. According to Sawyer (1992) in Dahuri (2003) that the coral reef identified as resources with having high conservation value because it has a high biological diversity, beauty, and provide reserve germplasm. Further said that by Ruinteenbeek in Sawyer (1992) in Dahuri (2003) that the economic value of coral reefs is estimated half of the economic value of tropical moist forests, which amounted to US $ 1,500 km^2 per year. Coral reefs habitat is affected by temperature, current velocity, pH, salinity, brightness, bathymetry and sedimentation.

Based on the final report COREMAP II in 2009 to areas Batam, the general condition of coral reefs in coastal Batam included in a category concerned. Seabed consists of sand, rubble, dead coral, dead coral covered with algae and coated fine particles on it. Coral reef are found living on the Nguan Island only about 14.88% and while on the Sembur Island less around 7.85% in the form of coral polyps, namely the types of massive coral, Acropora submassive, foliose, and slightly soft coral (COREMAP II, 2009).

For that need to do some further research on zoning or identification of coastal areas in Batam which have the potential to be used as a development area of coral reefs. So expect later after the obtained data mapping concerning the zoning determination of coral reef development

habitat in the coastal of Batam, the government through relevant agencies and society around can taken advantage.

Research problems formulation are.
    a. How does the condition of the parameters that determine the living standards of coral reefs as sea temperature, sea current velocity, sea pH, sea visibility, and bathymetry in coastal Batam Island?
    b. How do the results of zoning determination of coral reef development habitat using overlay analysis based on the parameters of temperature, sea current velocity, pH, sea visibility, and bathymetry, in coastal Batam Island?

2. Theoretical Basis

2.1 Research Areas

2.1.1 Geographical location

Geographically Batam Island is located at the position $0^0 25'29''$-$1^0 15'00''$ North Latitude and $103^0 34'35''$-$104^0 26'04''$ East Longitude with an area of 41,500 hectares and is bordered by (Pemkot Batam, 2015):
    a. North: Singapore Strait
    b. South: Senayang District
    c. West: Karimun District and Moro Karimun District
    d. East: North Bintan District

2.1.2 Geology

Geologically aquatic Batam included in the area of western Sumatra granite as a series of tin islands that stretchs from Thailand mainland-Malaysia to Bangka-Belitung (Usman et al, 2005). This thin pathway is known as Tin Belt of Sumatera.Pulau-islands scattered in this area are remnants of erosion or shrinkage of pre-tertiary land that stretches from peninsula Malaysia / Singapore Island in the north to the Moro Island, Kendur and Karimun Island in the south (Pemkot Batam, 2015).

2.1.3 Oceanography

Aquatic Batam included in the area of Malaka Straits with strong currents conditions, which generally move from the northwest to southeast parallel with the direction of Malaka Straits (Usman, et al, 2005). Depth on the coast varies between 10-20 meters with contrasting wall of different between the north and south, the south side has a steeper wall structure due to influence of the ocean currents movement.

2.3 Coral Reefs

Coral reefs by Supriharyanto (2007) is a collection of animal coral (coral reef) that live on the water in the form of limestone ($CaCO_3$) and has a strong capability to withstand the force of ocean waves. The animals coral generally have a limestone framework, as well as algae associated in this ecosystem.

2.3.1 Life Term of Coral Reefs

Distribution and stability of the coral reef ecosystem depends on several oceanographic parameters which are limiting factors such as water temperature, salinity, visibility, depth, and sedimentation (Dahuri, 2001).

a. Temperature

Typically coral reefs can grow in the range temperature of 18^0C-36^0C and maksimum growth occurred in the waters that has an annual average temperature between 26^0C - 28^0C (Birkeland, 1997). In some waters even coral reefs can still live with the temperature tolerance of up to 40^0C (Nybakken, 1992). The temperature rise of 2^0C - 4^0C can damage the coral tissues and increase in 4^0C - 5^0C lead to coral death.

b. Sea Visibility
The Visibility level of the water has an important correlation with depth, because of how much sunlight can penetrate the water column depends on it waters. The intensity of light in addition affected by depth also influenced by the paltikel dissolved in water (turbidity). Dahuri (2003) argued that without the availability of light with sufficient intensity, the intensity rate of photosynthesis is reduced also, where the light intensity is reduced between 15-20% of the surface intensity.

c. Depth
Coral growth is influenced by depth factor. Effect of depth usually associated with other environmental factors such as light, water movement, even at some locations is also related to the temperature and / or salinity (Supriharyono, 2000).
Most coral reefs are able to breed at a depth of 25 meters or less. The distribution of coral reefs depends on the shape and type of the reef itself. According to Ramli (2003) type of branching coral (branching) will survive at depths below 10 meters because it is able to break the waves hit, so that the branching corals dominate to depths greater than 10 meters.

d. Current
Current is required in the process of reef growth in terms of food supply in the form of mikroplankton. Current also act in the cleaning process of the deposits of material and supply the oxygen that comes from the open sea. Therefore, the current very important role in energy transfer proes (Dahuri, 2003).

e. pH
The pH scale shows the concentration of H + and OH-. The system of carbon-ascorbic acid-bicarbonate serves as a buffer to maintain the pH of seawater in a narrow range (Lewis, 2004). Sugianto (2004) suggests that pH suitable habitat for the growth of coral reefs wich range from 7 s.d 9.

2.4 Geographic Information Systems

Geographic Information System (GIS) is a useful tool for collecting, hoarding, the desired data retrieval and viewing of spatial data derived from the fact of world. Figure 1 presents a component in GIS.
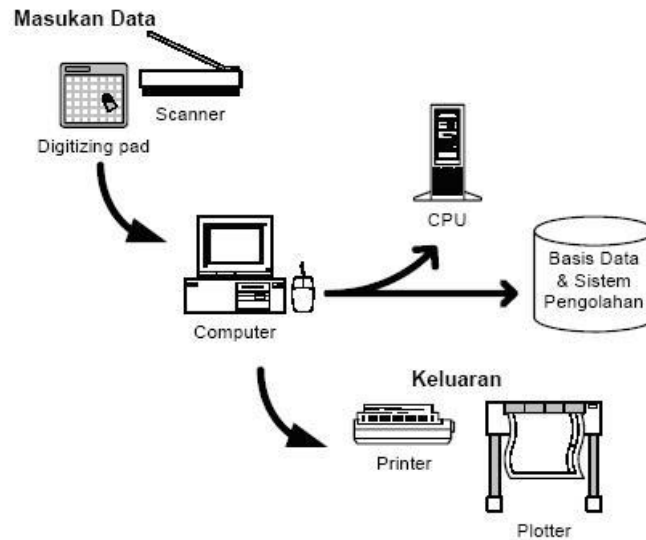
Figure 1: Components of GIS (Nuarsa, 2005)

According Nuarsa (2005), the data in GIS is divided into two kinds, ie:
  a. Spatial data, is data that describes the shape or appearance of objects on the Earth's surface.
  b. Attribute data, the descriptive data that states the value of spatial data.

There are two models of common geospatial data representation in GIS, ie:
  a. Raster data model, a model of spatial data display, placing and storing data by using a matrix structure or pixels that make up the grid. The accuracy of the data model is highly dependent on the resolution or pixel size (grid cells) on the surface of the earth. The conceptual data model is to give different values for each pixel or grid of different conditions.
  b. Vector data model, a model of spatial data display, placing and storing spatial data using points, lines or curves, or polygons and their attributes. Forms of data representation of spatial data in vector data model defined by the two-dimensional Cartesian coordinate system (x, y).

Overlay analysis techniques in GIS established through the use of overlapping each layer representing a parameter. Overlay analysis integrating spatial and attribute data is done by combining information from multiple layers to derive new information. Figure 2 presents illustrations in overlay analysis.
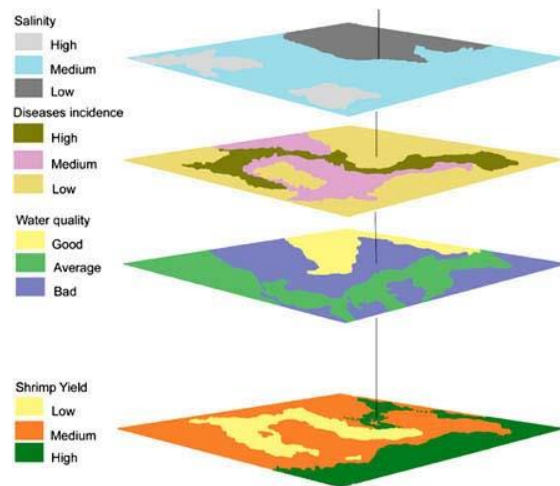
Figure 2: Analysis overlay (Graaf et al, 2003).

3. The Purpose and Benefits of Research

3.1   Research Purposes
The purpose of this study are:
   a. Knowing the condition of the parameters that define the living standard of coral reef that is sea temperature, sea current velocity, sea pH, sea visibility, and bathymetry, coastal island of Batam.
   b. Zoning determination of coral reef development habitat using overlay analysis based on the parameters of sea temperature, sea current velocity, sea pH, sea visibility, and bathymetry in coastal island of Batam.

3.2   Benefits of Research
The benefits that can be obtained from this study are;
   a. National development:
      - Accelerate the process and improve the effectiveness of development with zoning data of coral reef habitats.
      - Support programs or government policy in order to realize Indonesia as the World's Maritime Axis.
   b. Government:
      - Assist the government to provide technical studies related to zoning of coral reef habitats.
      - Assisting the government to develop nautical tourism and conservation of coral reefs, so it can increasing the country's foreign exchange.
   c. Development of science:
      - This study produces research on the condition of the parameters that define the living standard of coral reefs such as temperature, sea current velocity, sea pH, sea visibility, and bathymetry in coastal Batam.
      - Availability map zoning determination of coral reef development habitat using overlay analysis based on the parameters of sea temperature, sea current velocity, sea pH, sea visibility, and bathymetry in coastal Batam.

- The implementation roadmap Study Center of Region Archipelago Empowerment and Border form State Polytechnic that focusing on maritime sector.
d. Public
- Provides an understanding to the public about the zoning of coral reef habitat in coastal Batam.

4. Research Methods

4.1   Research Location

The location of research carried out in coastal island of Batam with data collection done in the area based on the zoning using overlay analysis. Overlay analysis techniques established through the use of overlapping each parameter. In figure 3 below shows the location of research on the coastal island of Batam.
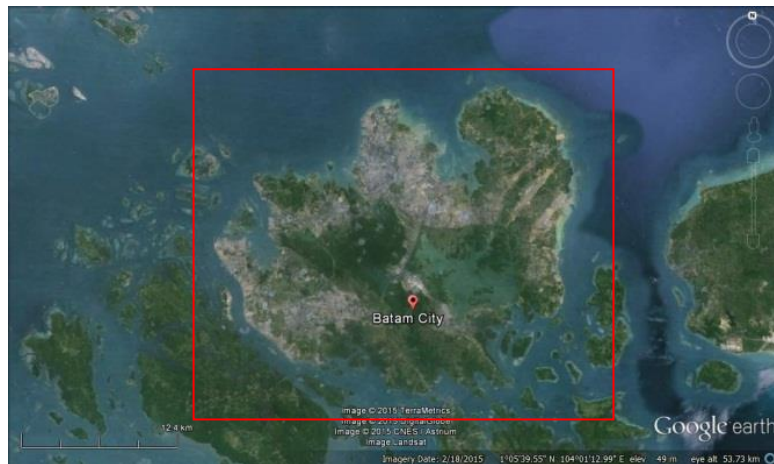

Figure 3: Location Research

4.2   Materials and Research Tools

4.2.1. Primary and Secondary Data

The data used in this study consisted of primary and secondary data.
   a. Primary data: sea visibility, pH, and sea temperature
   b. Secondary data: Sea Currents Prediction Map, bathymetry, and the Administrative Map of Area Batam.

4.2.2. Tools

The tool used in this study are:
   a. Hardware : Laptop, pH meters, GPS Navigation, Secchi disc, Current meter, Printer, and stationery.
   b. Software : OSWindows 7, Microsoft Office 2007, ArcGIS 10.1, and Global Mapper

4.3   Phases of Research Activities

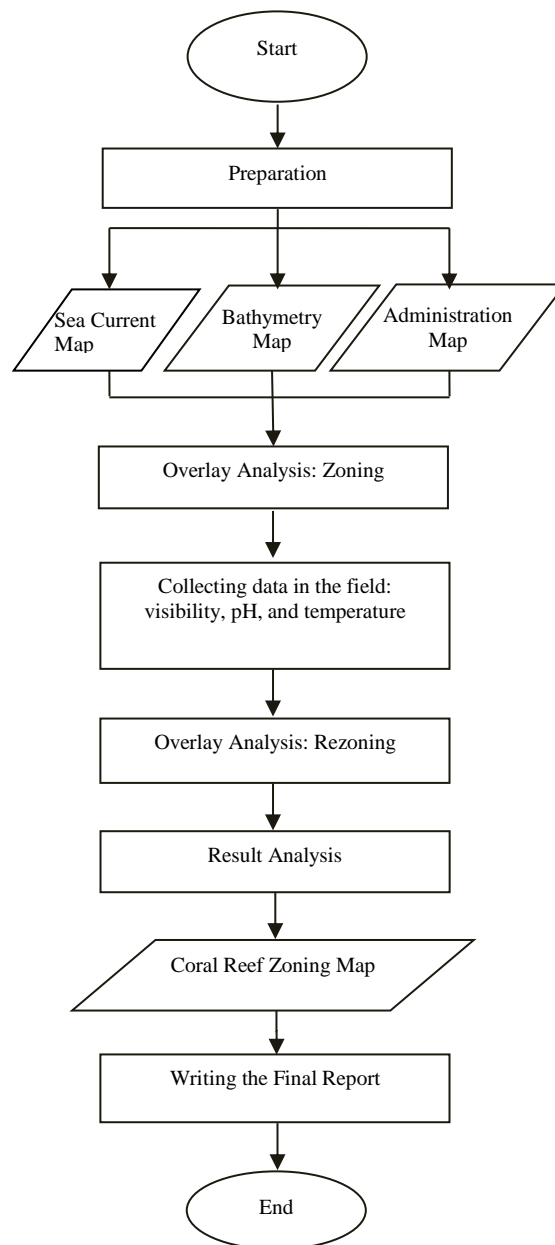Generally phases of the research presented in flow diagram Figure 4 below:

Figure 4: Research Flowchart

4.3.1 Preparation

In the preparation of research activities are collecting secondary data research that current maps, bathymetric maps and administrative maps of Batam. Data obtained from the relevant government agencies such as Hang Nadim Meteorology Station of Batam, Batam Indonesia Free Zone Authority(BIFZA)/Badan Pengusahaan Batam (BP Batam) and modeling global map GEBCO (General Bathymetric Chart of the Oceans). It also conducted a literature review on previous studies concerning the determination of the best habitat for coral reefs in various regions in Indonesia.

4.3.2 Zoning

Zoning activities by using overlay analysis is used to determine the location of first approximation areas that can be used as a coral reef habitats. Analysis overlay formed through the use of overlapping (series), each of which represents a parameter. Overlay analysis integrating spatial data and attribute data is done by combining information from multiple layers to derive new information. In this study some data will be combined to see the intersection of sea current velocity, bathymetry data, and the administrative map of Batam Island. Conclusion of the overlay analysis will indicate a good match between any data which is the point overlay (intersection) to determine the initial zoning. From the results it then be determined zoning areas that will be the primary data collection in the field (Visibility, pH, and temperature).

4.3.3 Data Measurement in the Field

Stages of field data collection is done to obtain data on the visibility, pH, and temperature of each location predetermined by the initial zoning. Figure 5 shows the location of the field data measurements.
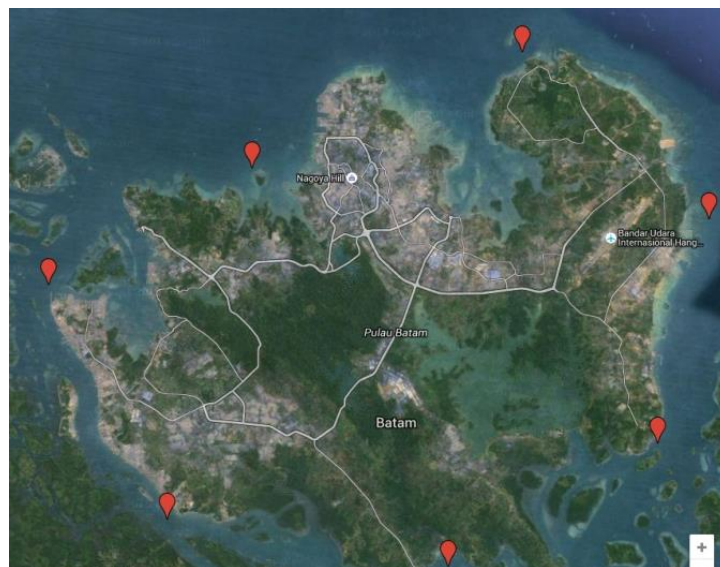

Figure 5: Location of field data measurement

4.3.4 Rezoning

Rezoning activities performed using zoning overlay analysis between the results of first approximation with the results of measurements of primary data in the field. From this Rezoning then obtained the best area of coral reefs development.

4.3.5 Results Analysis

Analysis of the rezoning result produce the zoning map of best coral reefs habitat, which serves areas that can be utilized as an area of coral reef development.

5. Results and Discussion

5.1 Sea Currents Velocity Batam Island

Sea currents Velocity around Batam Island is relatively low in the range 0-5 cm / sec, the data obtained from sea current velocity prediction map of Riau Islands from Hang Nadim Meteorological Station of Batam while the best living qualifying criteria for coral reef that is less than 0.9 cm / sec so all the areas around the island of Batam relative entry in terms of living coral reefs.

5.2 Bathymetry of Batam Island

Bathymetry around the coast of Batam Island is relatively flat and not too deep which ranges from 0-50 m so that areas around the coast of Batam Island relative entry in terms of living coral that have optimal requirement of less than 25 meters.

5.3 Sea Visibility around Batam Island

Batam island sea visibility measurements carried out at seven locations in Batam Island points, with each point of location to do sampling of 20 samples. Overall obtained 140 samples as attached with a minimum range of values 2.5 meters and a maximum 5.5 meters. The interpolation of the brightness data is done by Kriging method that produces a total nodes as much as 9400 points. The average value of the sea visibility in Batam Island at a depth range of 3.5 meters. Lowest sea visibility values mostly in the northern coast of Batam due to transportation line pass through the area. One of the supporters of the habitat parameters Coral Reef is a visibility level of water has an important correlation with depth, because of how much sunlight can penetrate the water column depends on it waters. In the absence of adequate light, the rate of photosynthesis is inhibited and also means reduced ability to produce calcium karbonat. Coral reefs hermatipik lives in symbiosis with zooxanthellae that perform photosynthesis, the light effect is important. Coral reefs can live in locations that have a sea visibility value of more than 5 meters. The results showed that the collection of field data about the location of Tanjung Piayu have adequate visibility value as a habitat for coral reef development as shown in Figure 6 Sea Visibility Map of Batam Island.
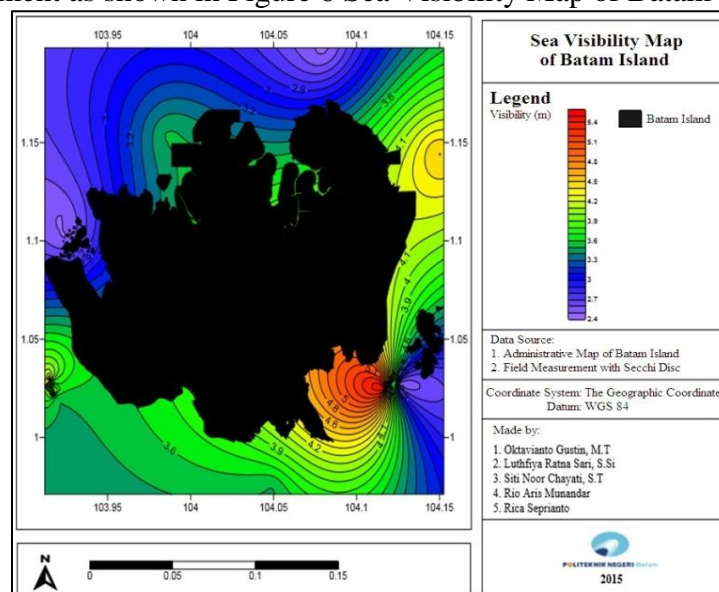

Figure 6 Sea Visibility Map of Batam Island

5.4   Sea temperature Batam Island

Batam Island sea temperature measurement performed on seven points in Batam Island locations, with each location point samples were taken as many as 20 samples. Overall obtained 140 samples as attached with a minimum temperature $30^{o}C$ and a maximum is $39^{o}c$ meters. Temperature data interpolation process performed by Kriging method that produces a total nodes as much as 9400 points. The average value of the temperature in the temperature range of Batam Island $30,81^{o}C$. Typically coral reefs can grow in the range of $18^{o}C$-$36^{o}C$. In some waters even coral reefs can still live with a temperature tolerance up to $40^{o}C$.

This Characteristics causes there are many coral reefs on a wide area in tropical waters. Based on the results of data collection in the field, the water area of Batam has a temperature suitable to serve as a habitat for coral reef development as shown in Figure 7 Sea Temperature Map of Batam Island.
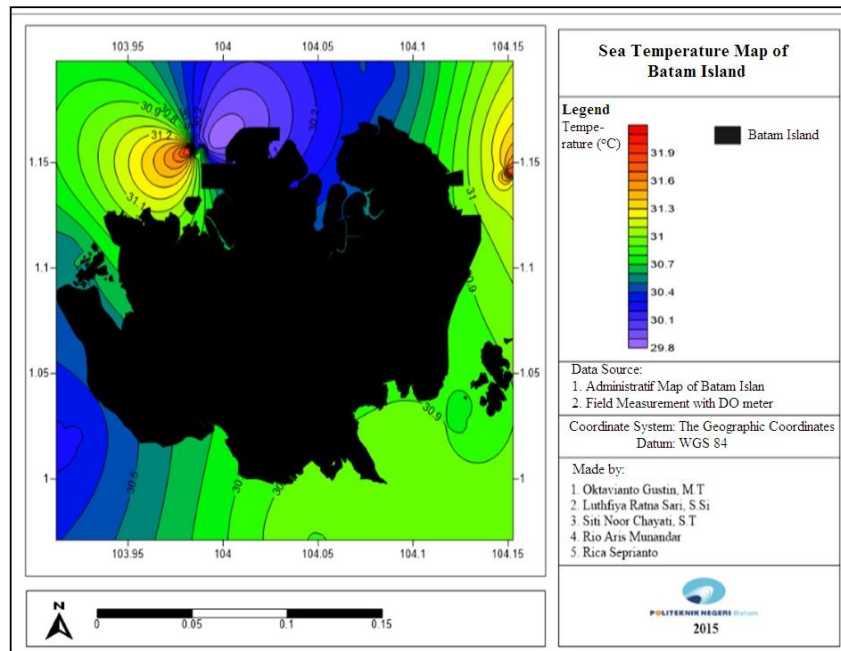

Figure 7 Sea Temperature Map of Batam Island

5.5   PH Batam Island Sea

Batam island ocean pH measurements performed on seven points in Batam Island locations, with each location point samples were taken as many as 20 samples. Overall obtained 140 samples as attached with a minimum range of pH values of 7.4 and maximum 8.2. Interpolation process of ph data performed by Kriging method that produces a total nodes as much as 9400 points. The average value of pH in Batam Island is 7.75. Sugianto (2004) suggests that pH suitable habitat for the growth of coral reefs which range from 7 - 9. By this shows that the pH conditions in the waters of Batam suitable to be used as a coral reef habitats such as the map results Figure 8 Sea pH Map of Batam Island.
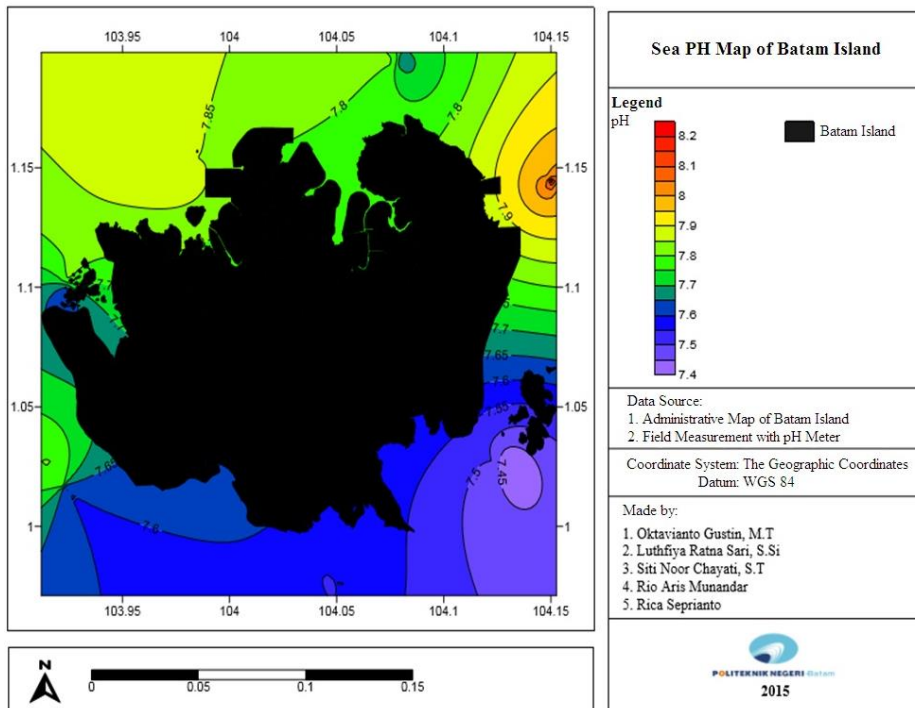
Figure 8 Sea ph Map of Batam Island

5.6 Best Coral Reef Habitat Zoning

The results of analysis overlay from sea current velocity data, bathymetry, visibility, temperature, and pH with certain criteria to produce the zoning of coral reefs habitat suggestion. The suggested area that reached 4.675 km^2 located around coast of Tanjung Piayu District. The zoning map of coral reef habitats advice can be seen in Figure 9 Zoning Map of Best Coral Reef Habitat.
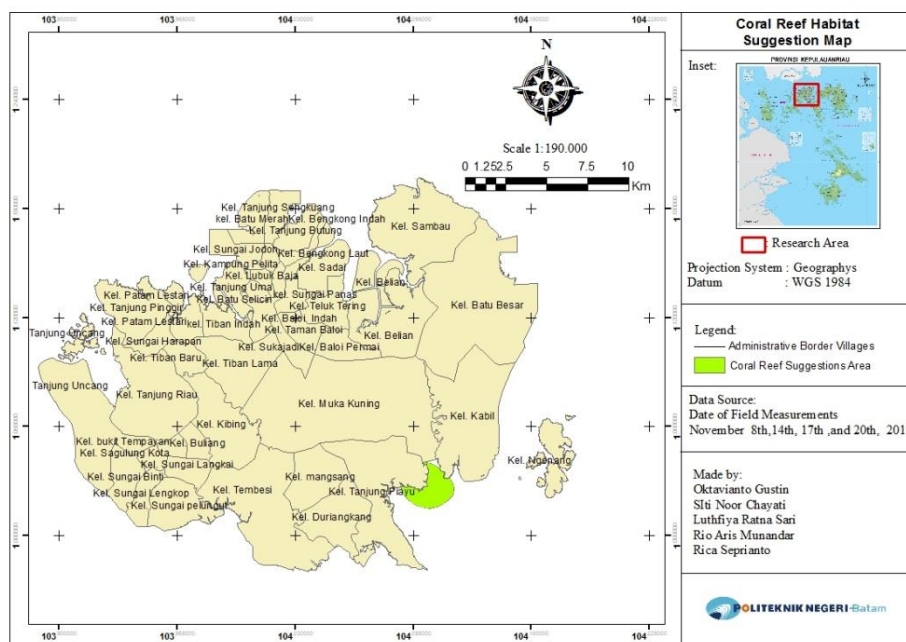

Figure 9 Zoning Map of Best Coral Reef Habitat

6. Conclusion and Suggestion

6.1 Conclusion
Physical oceanographic parameters which include sea currents velocity, bathymetry, temperature, and sea pH around the Batam Island accordance with the terms of coral reef living conditions. As for the parameters of visibility just around the Piayu headland are eligible, ie more than 5 meters. North coast of Batam relatively more turbid due to many transportation lines pass through the area.

The results of analysis overlay from sea current velocity data, bathymetry, visibility, temperature, and pH with certain criteria to produce the zoning of coral reefs habitat suggestion. The suggested area that reached 4.675 km2 located around coast of Piayu Headland.

6.2 Suggestion
Zoning study coral reef habitats need to be developed further with more complex parameters and with a more accurate tool. The parameters are recommended to be added include sediment and nutrients contained in water. Better add the latest satellite imagery data that can be used for other research (Gustin O. et al, 2013).

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BIOGRAPHICAL NOTES

Since 2015 author worked as a Lecturer in Geomatics Engineering Studies Program of Batam State Polytechnic. He previously worked as a Team Leam Leader in the field Project and as a Surveyor in Project Monitoring Consultant.

Author has graduated from Geomatic Engineering Master Degree in 2013 and Bachelor in 2011 at the Sepuluh Nopember Technology Institute of Surabaya by taking Thesis on Remote Sensing.

Nowadays he has a wife named Lylla Roseldy and has been blessed with a daughter named Arsyila Kira Alaian.

CONTACTS

Oktavianto Gustin, M.T
State Polytechnic of Batam
Ahmad Yani St, Batam Kota
Batam
INDONESIA
Tel. +62 – 778 469856 – 569860 ext. 2510
Fax +62 – 778 463620
Email   : oktavianto@polibatam.ac.id
              oktaviantogustin@gmail.com
Web site : www.polibatam.ac.id