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# Assessment of Ecological Status in Seawater Around Legon Bajak Port Development Plan, Karimunjawa, Central Java, Indonesia

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## ABSTRACT

The Legon Bajak port is a strategic port in Indonesia, because it is located in a busy and potential shipping lane. The port is adjacent to the Karimunjawa Marine National Park which is protected by the Indonesian government; therefore, this study aims to provide an overview of the ecological status of the Legon Bajak sea and the prediction of the impact of port activities on the ecological status of the Marine National Park. This research is a descriptive study by analysing seawater quality using atomic absorption spectroscopic methods, the status of biodiversity of seaweed and coral reefs with the transect method at 6 observed sample points and photos of underwater marine supporters. The results of the analysis of seawater quality indicate that it is in good condition, but when viewed from the analysis of seaweed conditions and coral cover <10%, this indicates that the ecological status is in a damaged condition and a category with a low functional value. An in-depth study is needed for the analysis of the environmental impact of the Legon Bajak port on the Karimunjawa National Marine Park Conservation Area.

## INTRODUCTION

Indonesia as a maritime country and the largest archipelagic country in Southeast Asia, actively build ports to connect ports in the Republic of Indonesia in increasing the level of the national economy (Karimunjawa National Park Office 2004). Legon Bajak Port is one of the potential ports located in Kemujan-Karimunjawa Village, Jepara Regency, Central Java Province, currently functioning as a place for fishing activities for local fishermen and small-capacity cargo ship activities (pier length 149.3 meters and dock capacity up to 700 gross tons). In accordance with the National Port Master Plan Road Map, the Indonesian Government will develop the port of Legon Bajak.

The development of the Legon Bajak Port is expected to be visited by ships with a capacity of up to 6,000 GT with a dock to be extended to a total length of 293 m from the initial length of 149.3 m, in addition it is also planned to increase and improve existing dock facilities, namely by adding supporting facilities on land, so that the overall plan for developing Legon Bajak Port is around 5,516.5 $m^2$. This is expected to support the target of the development plan of the national port of the Republic of Indonesia. But in its development must pay attention to the ecological conditions of the Seawaters, so as not to damage the ecological system of the waters of Karimunjawa. The Indonesian government has determined the territorial waters of Legon Bajak which are included in the conservation area of seaweed ecosystems and coral reef ecosystems protected by law (Karimunjawa National Park 2015).

The plan for port development activities needs to be supplemented by an Environmental Impact Analysis document which is a document for assessing the impact on the ecological system of the Legon Bajak Seawaters (Minister of Environment of the Republic of Indonesia 2013). To evaluate the method of analysing environmental impacts, appropriate environmental parameters are needed to produce good and sustainable studies. One of the bioindicators as parameters of marine ecosystems is the ecosystem of seaweed and coral reefs. Seaweed and coral reef commodities in an area can be used as a measure of the quality of the aquatic environment. The more is variety of seaweed and coral reefs, the better is the quality of the environment. The level of water pollution can change the structure of ecosystems and reduce the number of species in seaweed, coral reefs, plankton, benthos, and nekton communities, which results in reduced diversity (Saif et al. 2012), as well as other parameters such as wave currents, wind speed, and bathymetry can affect the ecological conditions of marine waters.

The diversity of organisms in marine waters can be expressed in species diversity at the observation site, the greater the number of species in the observation location, the better the quality of the environment (Dhruba 2015). The Legok Bajak waters environment belongs to the cate-

gory of tropical coastal environment which is biologically high in biodiversity. However, the development process in the economic and industrial sectors causes a shift in biological degradation which causes a lot of environmental damage. (Skorzeny 2010).

The development and expansion of the Legon Bajak port as a commercial port must be able to minimize the development impact on the surrounding environment, the entry of pollutants causes the marine ecosystem to be degraded and damaged. Therefore, there must be an effort to preserve organisms in the sea. This study is needed to determine the initial conditions in marine ecosystems before the development of Legon Bajak port activities so that they can predict and compare the impacts that will be caused. Research on environmental impact analysis requires a baseline and an overview of the area to be studied. Research with the title of quality of seawaters around Legon Bajak port, Karimunjawa, Indonesia can be used as a general description and basic outline of research on environmental impact analysis. Of course it involves many fields of science for the analysis process.

## MATERIALS AND METHODS

The study was conducted on 4 days, from 21 until 25 October 2016. It began with preparation until sampling was conducted. Natural condition at the time of sampling is wind speed 0.45 m/s-1.35 m/s with northwest direction of southeast. The most dominant speed is 0-5 knots as much as 43.03% and the average speed in the dominant direction of 4.9 knots, temperature 33.8-37.2°C with a relative humidity (RH) of 75 %-79 % at the sampling site. Methods of data collection and analysis will examine the quality of seawater and marine biota including seawater quality and coral cover data.

### Seawater quality

The types of data collected by seawater quality parameters are physical and chemical parameters. Seawater sampling was taken on the planned dock, port pond and drainage area. Seawater data collection location adjusted to the estimated impact that will occur with the coordinates given in Table 1.

Analysis of seawater quality was adjusted to SNI (Indonesian National Standard) with Atomic Absorption Spectroscopy method (Agilent Technologies 2017 and National Standardization Agency 2017) and according to Water Quality Monitoring - A Practical Guide to the Design and Implementation of a Quality and Freshwater Screening

Table 1: Location of seawaters quality data collection.

| No | Sampling Location | Coordinate |
|---|---|---|
| 1 | Station 1 | 110°28'39.925" E 5°47'14.827" S |
| 2 | Station 2 | 110°28'39.954" E 5°47'22.373" S |
| 3 | Station 3 | 110°28'46.884" E 5°47'18.103" S |
| 4 | Station 4 | 110°28'39.382" E 5°47'16.735" S |
| 5 | Station 5 | 110°28'50.092" E 5°47'20.220" S |

(Primary Data 2016)

Table 2: Coordinate of sampling location aquatic biota-coral reefs.

| Code | Location | Coordinate | |
|---|---|---|---|
| BK | Transects 1 | S 05°47'10.5" | E 110°28'39.3" |
| | Transects 2 | S 05°47'11.3" | E 110°28'39.3" |
| | Transects 3 | S 05°47'12.2" | E 110°28'37.9" |
| | Transects 4 | S 05°47'20.0" | E 110°28'34.1" |
| | Transects 5 | S 05°47'19.0" | E 110°28'33.8" |
| | Transects 6 | S 05°47'18.0" | E 110°28'33.9" |
| | Transects 7 | S 05°47'17.0" | E 110°28'33.7" |

Note:

BK-Transect 1: Sampling port Legon Bajak 1, BK- Transect 2: Sampling port: Legon Bajak 2, BK- Transect 3: Sampling Taka Kemujan island, BK- Transect 4: Sampling Sintok island 1, BK- Transect 5: Sampling Sintok island 2, BK- Transect 6: Sampling Cendekia island 1, BK- Transect 7: Sampling Cendekia island 2

Study Program with Atomic Absorption Spectrophotometry (Jamie & Richard 1996). The result of seawater quality analysis was analysed by comparing it with seawater quality standard, referring to Decree of State Minister of Environment Number 51 Year 2004 regarding Quality Standard of Seawater (Ministry of Environment 2004).

### Aquatic Biota: Coral Reefs

The data collected is in the form of percentage of coral cover. The location of collecting marine biota data was carried out at 7 points representing the port pool, shipping lane, Kemujan island, Sintok island and Cendekia island. Data collection method is with the modification of underwater photo transports and transect methods (Kaur & Kansal 2017). In principle, this method involves two main activities of coral reef photography and transect image processing. Determination of coordinate samples with GPS research objectives by pulling 50 m transect lines parallel to the shoreline at 3-7 m depth and taking quadrant transect images every 1 m along the transect alternately on the right and left sides of the transect line. The method used to predict impacts is based on the Coral Reef Criteria, Decree of State Minister of Environment Number: 04 Year 2001 (Hill & Wilkinson 2004). Table 2 presents the coordinates of aquatic biota sampling (coral reefs).

### Aquatic Biota: Seaweed

The types of data collected were seaweed abundance and cover. The location for collecting aquatic biota data are based on the coordinates given in Table 3.

Table 3: Coordinates of sampling locations of aquatic biota of seaweed.

| Location | Coordinate | |
|---|---|---|
| Transects 1 | S 05°47'10.5" | E 110°28'39.3" |
| Transects 2 | S 05°47'11.3" | E 110°28'39.3" |
| Transects 3 | S 05°47'12.2" | E 110°28'37.9" |
| Transects 4 | S 05°47'20.0" | E 110°28'34.1" |
| Transects 5 | S 05°47'19.0" | E 110°28'33.8" |
| Transects 6 | S 05°47'18.0" | E 110°28'33.9" |

Note:

BK-1: Sampling Port Legon Bajak 1, BK-2: Sampling Port Legon Bajak 2, BK-3: Sampling Around the Island of Taka Kemujan, BK-4: Sampling Around the Island Sintok 1, BK-5: Sampling Around the Island Sintok 2, BK-6: Sampling Around the Island Cendekia

The data collection method was used to determine the condition of seaweed. The method is Transect method (Buckland et al. 2007 and State Minister of Environment, 2004). Transect method sampling is a population sample method with a sample plot approach that is on a line drawn across the ecosystem area. Fig. 1 shows the map of sampling locations, for the quality of seawater, seaweed and coral reefs.

## RESULTS

Based on observations of aerial photographic field data using the DJI Phantom 3 drone showing the morphological conditions of the Kemujan coast, especially in Legon Bajak, which is dominated by sandy beaches in the coastal

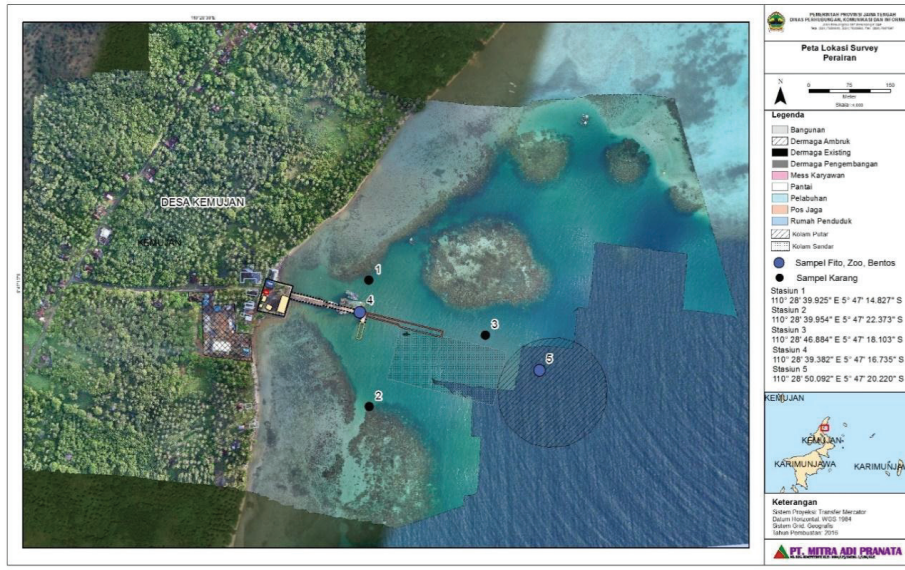


Fig. 1: Map of location of sampling of water quality, seaweed and coral (Primary Data 2017).

region. In the waters there is a coral reef ecosystem with a water base that looks sloping to the bottom of the water (Choat & Pears 2003). Coastal waters are one of the most productive ecosystems in marine waters, while based on the analysis of seawater quality, coral cover and seaweed, show the following data.

## Seawater Quality

Data of seawater quality in Legon Bajak waters, based on sampling conducted on October 22, 2016 at 6 stations, at 08.00-12.00 hours with optimum temperature conditions, the sampling temperature is 28°C, with air pressure 765 mmHg, moisture 74.8-78.9%, wind speed 0.42-1.35 m/s, northwest direction of southeast wind. Table 4 gives the results of seawater quality analysis around Legon Bajak port.

## Seawater Biota (Seaweed)

Observational data at the sampling site on seaweed were conducted on 23 October 2016 at 6 stations at 09.00-16.00 hours at optimum conditions. Temperature in place of sampling was 27.5°C, with air pressure of 765 mmHg, humidity of 75.5-78.5% and wind speed of 0.45-1.35 m/s with northwest direction to southeast.

Table 4: Seawater quality in Legon Bajak port.

| No. | Parameter | Unit | Results analysis | | | | | | Quality Standards |
|---|---|---|---|---|---|---|---|---|---|
| | | | AL-1 | AL-2 | AL-3 | AL-4 | AL-5 | AL-6 | |
| | **Physical** | | | | | | | | |
| 1 | Brightness | m | 3.3 | 3.5 | 3.4 | 3.2 | 3.3 | 3.1 | > 3.0 (*) |
| 2 | Smell | - | No smell | No smell | No smell | No smell | No smell | No smell | Natural |
| 3 | Turbidity | NTU | 0.73 | 0.8 | 1.07 | 0.81 | 0.83 | 1.05 | < 5.0 |
| 4 | Total Suspended Solid | mg/L | 10 | 6 | 6 | 10 | 8 | 10 | 20.0 |
| 5 | waste | - | Nil | Nil | Nil | Nil | Nil | Nil | Nil (*) |
| 6 | Temperature | OC | 29.6 | 29.2 | 29.5 | 29.0 | 29.5 | 29.3 | Natural |
| 7 | Oil Coating | - | Nil | Nil | Nil | Nil | Nil | Nil | Nil (*) |
| | **Chemical** | | | | | | | | |
| 1 | pH | - | 8.1 | 8.0 | 8.1 | 8.0 | 8.1 | 8.1 | 7.0-8.5 |
| 2 | Salinity | ‰ | 33.6 | 33.6 | 33.6 | 33.6 | 33.6 | 33.6 | Natural |
| 3 | DO | mg/L | 7.17 | 7.63 | 7.21 | 7.56 | 7.36 | 7.56 | > 5.0 |
| 4 | $BOD_5$ | mg/L | 5.225 | 4.995 | 5.226 | 4.767 | 5.676 | 5.145 | 20.0 |
| 5 | Ammonia ($NH_3$-N) | mg/L | 0.01 | 0.011 | 0.012 | 0.016 | 0.011 | 0.011 | 0.3 |
| 6 | Phosphate ($PO_4$-P) | mg/L | 0.002 | 0.001 | 0.002 | 0.003 | 0.002 | 0.001 | 0.015 |
| 7 | Nitrate ($NO_3$-N) | mg/L | 0.039 | 0.052 | 0.058 | <0.005 | 0.056 | 0.052 | 0.008 |
| 8 | Cyanide (CN) | mg/L | 0.003 | 0.001 | 0.002 | 0.001 | 0.003 | 0.002 | 0.5 |
| 9 | Sulphide ($H_2S$) | mg/L | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | 0.01 |
| 10 | Phenolic compounds | mg/L | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.002 |
| 11 | Detergents (MBAS) | mg/L | 0.015 | 0.015 | 0.018 | < 0.010 | 0.014 | 0.018 | 1.0 |
| 12 | Oil & Fats | mg/L | 0.3 | 0.6 | 0.4 | 0.5 | 0.5 | 0.3 | 1.0 |
| 13 | Mercury (Hg) | mg/L | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.001 |
| 14 | Chromium (Cr (VI)) | mg/L | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.005 |
| 15 | Arsenic (As) | mg/L | < 0.003 | < 0.003 | < 0.003 | < 0.003 | < 0.003 | < 0.003 | 0.012 |
| 16 | Cadmium (Cd) | mg/L | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.001 |
| 17 | Copper (Cu) | mg/L | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.008 |
| 18 | Lead (Pb) | mg/L | < 0.003 | < 0.003 | < 0.003 | < 0.003 | < 0.003 | < 0.003 | 0.008 |
| 19 | Zinc (Zn) | mg/L | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.05 |
| 20 | Nickel (Ni) | mg/L | < 0.050 | < 0.050 | < 0.050 | < 0.050 | < 0.050 | < 0.050 | 0.05 |

Data Source: Primary data of measurement results in October 2016

Quality Standard *: Regulation of Environment Minister No. 51/2004, Seawater Quality Standards For Marine Biota

Table 5 gives the results of the analysis on the seaweed cover conditions at the research/sampling sites. The results of underwater observations show that there has been damage to the seaweed ecosystem as shown in Fig. 2.

### Seawater Biota (Coral Reefs)

Observation data at the sampling site on coral reefs was collected on 23 October 2016 at 7 stations at 09.00-16.00 at the optimum range. Temperature at the Sampling site was 27.5°C, with air pressure of 765 mmHg, humidity 75.5-78.5%, and wind speed of 0.45-1.35 m/s with direction northwest to southeast. Indicator of coral reef damage can be analysed by calculating substrate closure conditions in research sites (Hastuty et al. 2014). Table 6 presents the condition of substrate cover of coral reefs at research sites.

## DISCUSSION

Based on data measuring the quality of seawater in Lagon Bajak waters, it is seen that all parameters of research at all the points of measurement location meet the quality standard in accordance with the Regulation of the Minister of Environment No. 51 of 2004 for Marine Biota (Indonesian Government Regulation 1999) except for nitrate has exceeded the quality standard. Nitrate concentrations at all points of measurement, except at high AL-4 sites ranged from 0.039-0.058 mg/L. Nitrates are the chemical compounds needed by organisms as the primary source of nutrition. High levels of nitrates indicate that the Legon Bajak water condition is still quite good and there is no pollution yet. This shows that the Logon Bajak waters are still in good status and not polluted (Patty 2014).

The content of nitrate in Legon-Bajak seawaters comes from the process of degradation of organic materials either from anthropogenic activity or natural processes that occur in the sea. Nitrate is a chemical compound that is required in the process of metabolism of marine organisms, especially the growth of phytoplankton. However, if the nitrate content in excessive in marine waters can cause ecological disturbances by producing harmful algal blooms or eutrophication by algae. Eutrophication process causes oxygen needs to be high because the process of algae metabolism that requires a considerable amount of oxygen. The concentration of nitrate contained in seawater can cause algal bloom if it has a concentration of 200-1000 µg/L. The condition if no monitoring of nitrate in the waters around

Table 5: Types of seaweed and its cover in Legon Bajak waters of Karimunjawa National Park.

| Transects | Closed Cover (%) | | | | Total Closed (%) | Community Condition |
|---|---|---|---|---|---|---|
| | *Enhalus acoroides* | *Cymodocea rotunda* | *Halophila ovalis* | *Thallasia hemprichii* | | |
| 1 | 1.17 | | | 2.17 | 3.34 | Damage |
| 2 | 3.01 | 4.35 | 1.17 | 4.68 | 13.21 | Damage |
| 3 | 1.71 | 2.90 | | 4.68 | 9.29 | Damage |
| 4 | | 2.34 | | 1,00 | 3.34 | Damage |
| 5 | | 2.34 | | 1.89 | 4.23 | Damage |
| 6 | | 1.89 | | 2.17 | 4.06 | Damage |

Source: Primary data (2016)

Fig. 2: Condition of seaweed ecosystem (*Enhalus acoroides*) in Legon Bajak waters.

Table 6: Substrate closure condition at the study site.

| Location | Hard Coral | Soft Coral | Algae | Available Substrate | Mobile Substrate | Other |
|---|---|---|---|---|---|---|
| BK-1 | 54 | 0 | 10 | 22 | 12 | 2 |
| BK-2 | 54 | 0 | 1 | 40 | 5 | 0 |
| BK-3 | 64 | 0 | 1 | 29 | 4 | 2 |
| BK-4 | 59 | 0 | 13 | 9 | 19 | 0 |
| BK-5 | 57 | 1 | 0 | 42 | 0 | 0 |
| BK-6 | 48 | 2 | 2 | 23 | 21 | 4 |
| BK-7 | 25 | 1 | 0 | 32 | 40 | 2 |

Source Primary Data primer (2016).

Note:

BK-1: Observation Station On Legon Bajak Island 1, BK-2:: Observation Station On Legon Bajak Island 2, BK-3:: Observation station on Taka Kemujan Island BK-4: Observation station on Sintok Island 1, BK-5: Observation station on Sintok 2 Island, BK-6: Observation station on Cendekia 1 Island, BK-7 = Observation station on Cendekia Island 2

the Legon Bajak is done, possible eutrophication problem will occur (Donald Anderson et al. 2002).

The results of the analysis and observation of identified seaweed species show the presence of *Enhalus acoroides, Cymodocea rotunda, Halophila ovalis* and *Thallasia hemprichii. Halophila ovalis* is the most difficult to find, while *Cymodocea rotunda* and *Thallasia hemprichii* are the most common seaweed species found in the sampling sites. The results of the nelum to seaweed cover area showed an average percentage of 29.9%. The functional value of seaweed cover is included in the category of bad status. The higher the functional value of the seaweed cover percentage, the better, and if lower the seaweed cover, it is worse. The condition of seaweed ecosystem in the research location is seen from very low land cover condition that is <10%, indicating broken category with low functional value. No Protected Crops and Species Based on Government Regulation No. 7/1999 on plant and animal species (Indonesian Government Regulation 1999), excluding the IUCN Red Categories List of the IUCN Survival Commission, IUCN, Gland, Switzerland, 1994 (The International Union for Conservation of Nature/IUCN, 1994) and is not found in the list of Convention on Endangered Species of Endangered Species of Flora and Fauna, I, II and III. Geneva, Switzerland (The Convention on International Trade in Endangered Species of Wild Fauna and Flora/CITES, 2012). Further analysis is to look at native species of seaweed as a key species in seaweed habitat, as given in Table 7.

Coral reefs in Legon Bajak were analysed based on the percentage of coral cover conditions. The observation of coral reefs at the stations on the islands of Taka Kemojan and Sintok shows a good enough condition where coral cover is equal to or more than 50%. The observation on the island station Cendekia 1 showed moderate condition with 27% coral cover. Water quality at all the stations strongly supports coral life and coral reef recovery processes, which is demonstrated by the low algal conditions at the sampling sites. The recovery process is also supported by the availability of a substrate that is high enough above 25% (Hill & Wilkinson 2004). Table 8 explains about the genus of coral and wide coral percentage cover in the study area.

The graph in Fig. 3 shows the percentage of the coral coverage area of the observation stations on the island of on Legon Bajak 1-2, Taka Kemojan, P. Sintok 1-2 and P. Cendekia 1-2.

The coral genera found in the study area include *Acropora, Porites, Galaxea, Favia, Favites, Fungia, Isopora, Pachyseris, Montipora, Montastrea, Leptoseris, Goniastrea, Pavona, Stylloporа, Astreopora, Diploastrea* and *Millepora. Acropora* is the dominant genus of the location of the Legon Bajak 2, P.-Cendekia 1 and 2 sampling stations with a percentage of 32%, 8% and 14%. The *Porites* is the dominant genus in Taka Kemojan Station and Pulau Cendekia 1 with percentage of 43% and 8%. Other dominant genus is *Montipora* which has a closing percentage of 33% and 21% in P. Sintok 1 and 2. Other coral genera generally have a low percentage of closure, even some coral genera have very limited distribution in the study area, for example, *Galaxea, Favia, Favites* and *Pavona*. The graph in Fig. 4 shows the percentage of the coral coverage area of the observation station on the island of on Legon Bajak 1-2.

The coral genera found in the Transect Legon Bajak 1 station are *Acropora, Porites, Galaxea, Favites, Fungians, Pachyseris, Montipora, Montastrea* and *Leptoseris*. *Porites* is the most dominant coral genus in this station followed by *Pachyseris* and *Fungia*. *Porites* is coral that is very resistant

Table 7: Results of observation and analysis on the condition of seaweed ecosystem around port area and the status of ecological indigenous organisms.

| Ecosystem type | The composition of the species | Status of interest in an ecological entity | | | | Conservation status | |
|---|---|---|---|---|---|---|---|
| | | Key species | Ecological value | Economical value | Scientific value | Indonesia Government Regulation No. 7 of 1999 | International Union For Conservation of Nature (IUCN) |
| Seaweed ecosystem | *Enhalus acoroides, Cymodocea rotunda, Halophila ovalis, Thallasia hemprichii* | Not found | The seaweed cover is on average <10% so the ecological value is very low | The seaweed cover is on average <10% so the ecological value is very low | Seaweed cover is an average of <10% and existing species are the most common species so the scientific value is very low | No vegetation types included in the list of protected plants and species (appendix PP No. 7 of 1999) | *Enhalus acoroides* and *Halophila ovalis* have a low risk status (LC) |

Based on the rules of protected fauna and flora, endemic flora and fauna that are key species:

1. Government Regulation No. 7/1999 on the preservation of plant and animal species
2. IUCN Red List Categories. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland, 1994
3. Convention on the International Trade in Endangered Species of Wild Flora and Fauna Appendise I, II, and III. Geneva, Switzerland, 2012

Table 8: The genera of coral and wide coral percentage cover in the study area.

| *Genus* | Location | | | | | | |
|---|---|---|---|---|---|---|---|
| | BK-1 | BK-2 | BK-3 | BK-4 | BK-5 | BK-6 | BK-7 |
| *Acropora* | 2 | 32 | 0 | 22 | 15 | 7 | 12 |
| *Porites* | 27 | 16 | 43 | 3 | 5 | 8 | 9 |
| *Galaxea* | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| *Favia* | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Favites* | 2 | 0 | 0 | 0 | 0 | 0 | 4 |
| *Fungia* | 6 | 1 | 2 | 0 | 0 | 0 | 0 |
| *Isopora* | 0 | 0 | 0 | 0 | 12 | 2 | 8 |
| *Pachyseris* | 10 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Montipora* | 1 | 1 | 0 | 33 | 21 | 5 | 10 |
| *Montastrea* | 1 | 0 | 2 | 0 | 0 | 4 | 0 |
| *Leptoseris* | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Goniastrea* | 0 | 0 | 3 | 0 | 2 | 0 | 1 |
| *Pavona* | 0 | 0 | 3 | 0 | 3 | 0 | 0 |
| *Styllopora* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Astreopora* | 0 | 1 | 1 | 0 | 2 | 1 | 0 |
| *Diploastrea* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Millepora* | 0 | 0 | 11 | 0 | 0 | 0 | 1 |

Source: Primary Data, 2016

Note:

BK-1: Legon Bajak 1, BK-2: Legon Bajak 2, BK-3: Taka Kemujan, BK-4: Sintok 1, BK-5: Sintok 2, BK-6: Cendekia 1, BK-7: Cendekia 2

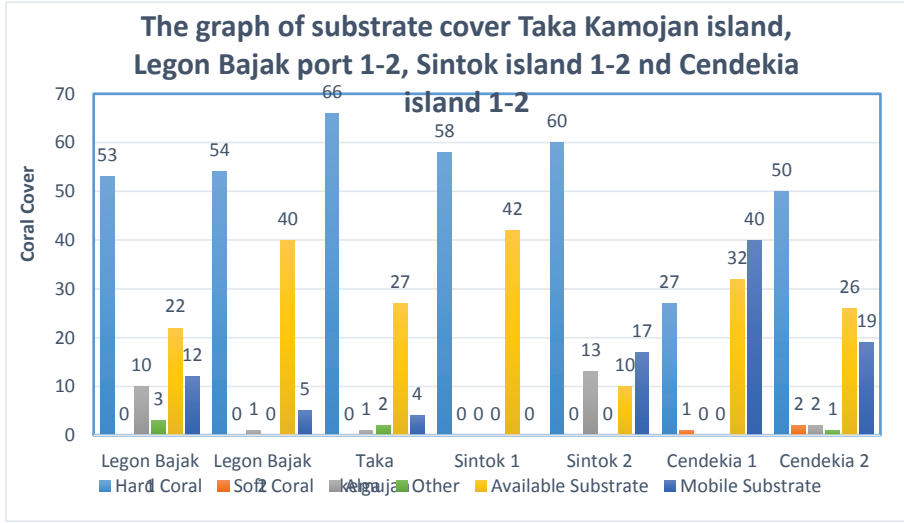


Fig. 3: Percentage of substrate cover on Legon Bajak port 1-2, Taka Kemojan island, P. Sintok island 1-2 and Cendekia island 1-2.

to environmental conditions, so it is very common in the wavy waters, whereas the *Fungia* genus is highly susceptible to strong water movement because this type of coral does not stick to the substrate. Dead coral (DC) is also common in this station with 22% cover. In the coral cover area, the Legon Bajak 2 station is dominated by the genera *Acropora* and *Porites* with a percent cover of 32% and 16%. Other types of corals in this station are *Favia, Fungia, Pachyseris, Montipora* and *Astreopora*. *Acropora* are reefs that are known to be vulnerable to poor environmental conditions but these reefs have the fastest growth rates compared to other coral species. *Porites* are the dominant coral species at the Taka Kemojan island sampling site with a cover of 43%. What is interesting is the existence of *Millepora* which reached 11% in Taka Kemojan station but not found in almost all other stations (Sweatman et al. 2005)

The graph in Fig. 5 shows the percentage of the coral coverage area of the observation station on the island of Taka Kemojan island. Stations on Sintok islands 1 and 2, although close together, have different characteristics. At Sintok island 1 station, coral species found only three species namely *Acropora, Porites* and *Montipora* with a total high cover of 58%. At Cendekia Island station 1, there is no dominant coral although the presence of coral *Acropora* and *Porites* is still higher than *Isopora* and *Montipora*. Similarly at Cendekia island station 2, no coral is very dominant. Corals *Acropora, Porites, Montipora,* and *Isopora* are the highest coral cover species on the station. *Galaxea* and *Favites* corals rarely found on other stations with 4% each cover. Based on the results of identification of coral species and the calculation of the cover, it is known that no coral species in this location, which is the key species, although because based on the average cover value >50% (good condition), the coral reef community is community key. This graph (Fig. 5) shows the percentage of substrate coral cover on observation stations Sintok 1 and 2, while at Cendekia Island 1 and 2 can be seen in the Fig. 6. The graph in Fig. 6 shows the percentage of the coral coverage area of the observation station on the island of Sintok 1 and 2.

The graph in Fig. 7 shows the percentage of the coral coverage area of the observation station on the island of Cendekia 1 and 2.

The varieties of fish and benthic organisms depend on the coral community either directly or indirectly, so that coral changes or communities will significantly bring significant changes to the coral ecosystem community. Coral communities are still a good opportunity which also have a high economic value either directly as a provider of food sources, basic ingredients of drugs, as well as indirectly such as marine tourism. Good coral conditions also have high scientific value as well as a diverse source of germplasm for exploration activities and bioprospecting of biological resources for various purposes (Sweatman et al. 2005).

Based on the conservation status analysis at locations where no species are found and coral reefs are localized as food sources, it is beneficial to the coral reef community. At coral coverage area > 50%, the country has an ecological value and a high value that supports the abundance of fish as a source of food. Coral cover > 50%, despite having high scientific value, has no protected coral reef species based on Government Regulation No. 7/1999 on plant and animal

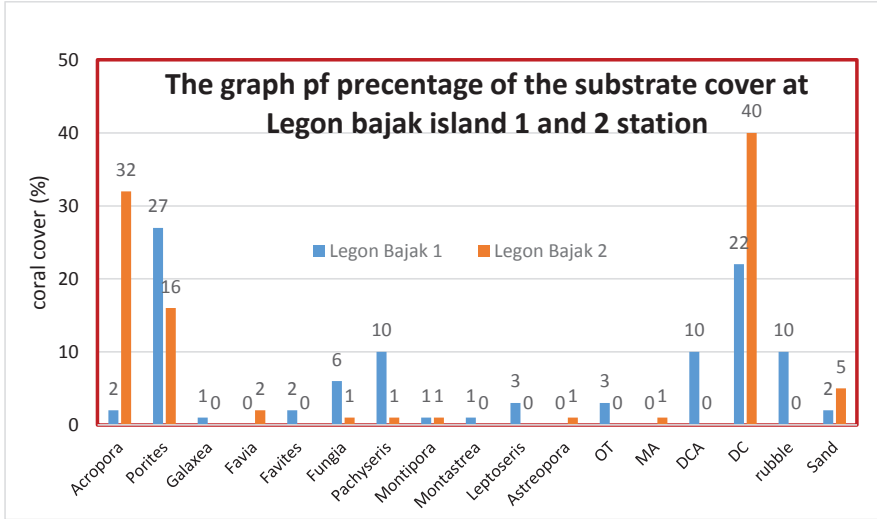


Fig. 4: Percentage of the substrate cover in the observation station Legon Bajak island 1 dan Legon Bajak island 2 (station BK-1 and BK-2).

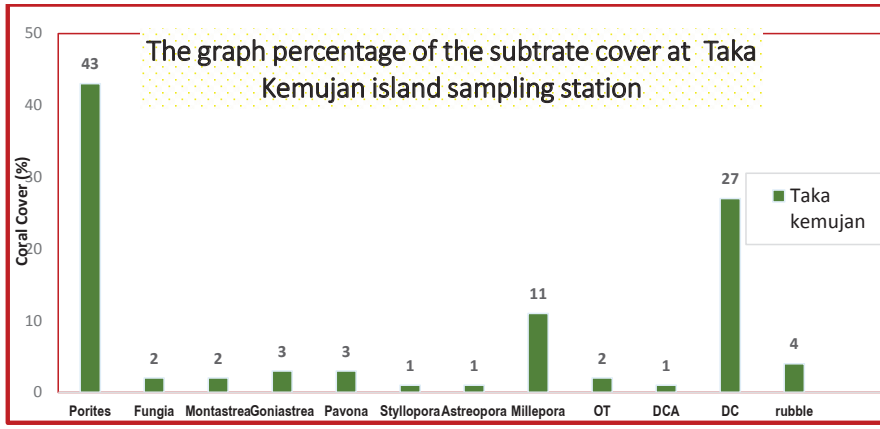


Fig. 5: The percentage of the substrate cover in the observation station Taka Kemojan island.

species (Indonesian Government Regulation 1999), excluding the Red IUCN Category List from the IUCN Survival Commission, IUCN, Gland, Switzerland, 1994 and is not found in the list of species in Endangered Species of Flora and Fauna, I, II and III. Geneva, Switzerland 2012. The status of coral interests in detail is provided in Table 9.

In this research, an analysis of the environmental parameters of the Legon Bajak port as supporting data to complement the research on the assessment of ecological status of the seawater around the Legon Bajak development plan, Karimunjawa.

### Wind Speed and Wind Direction

The conditions of wind speed and direction based on secondary data from the Maritime Meteorology Station of Semarang, the Meteorology, Climatology and Geophysics Agency show that the dull waters have wind speed and wind direction in the period 2010 to 2015 as given in Table 10.

The dominant wind direction is from the east, which is as much as 31%, the second dominant direction from the northwest is 17.2%. The most dominant speed is 2-4 knots as much as 27.6% and the average speed in the dominant direction is 4 knots.

Fig. 8 shows windrose data and dominant wind direction data and average speed. Table 11 gives the data of dominant wind direction and average speed for 2005-2015 in the area around the research area.

The conditions of wind speed and wind direction are very influential on tidal patterns and surface currents. Strong wind speed and heavy rain also caused changes in

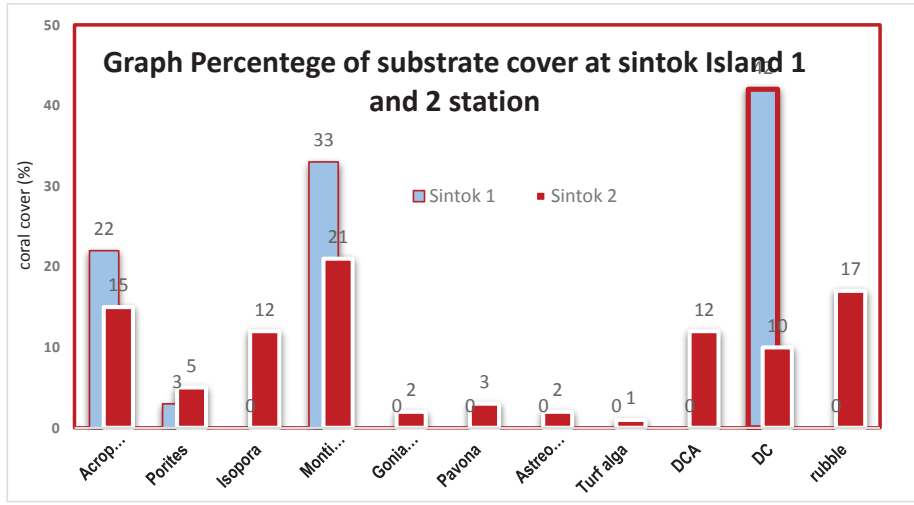


Fig. 6: The percentage of substrate cover at Sintok island 1 and 2 stations.

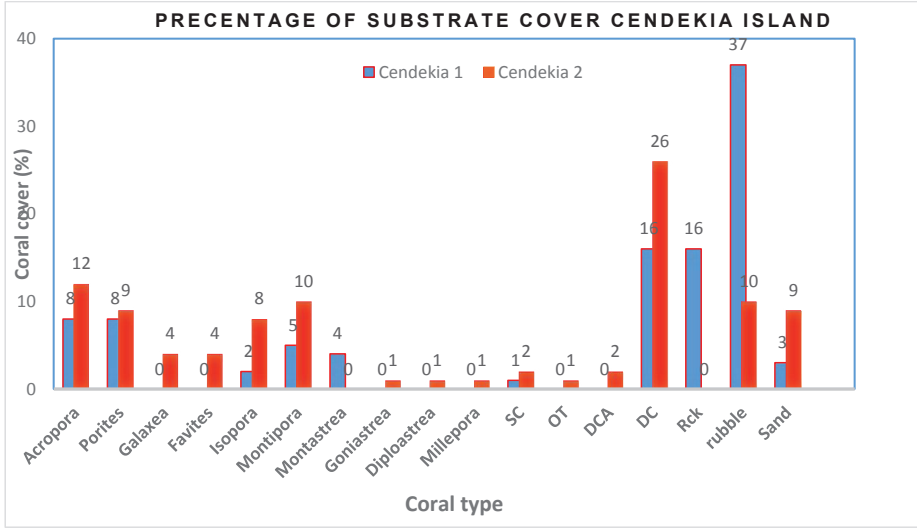


Fig. 7: Percentage of substrate cover at stations Cendekia island 1 and 2.

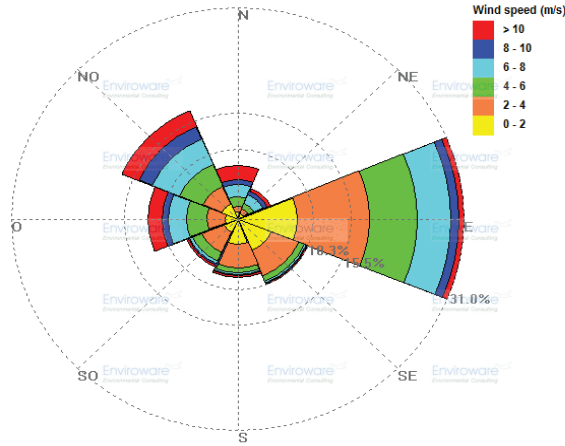


Fig. 8: Windrose data for Legon Bajak waters in 2005-2015.

Table 9: Condition of coral ecosystems in the area of the port based on the analysis of the extent of coral cover and the type of protected flora/fauna.

| Ecosystem Type | Composition of Species | Status of Interest in Ecological Indigenous | | | | Conservation Status | |
|---|---|---|---|---|---|---|---|
| | | Key Species | Ecological Value | Economic Value | Scientific Value | Government Regulations N0 7, 1999 | IUCN |
| Coral ecosystem | Reef Acropora Porites Galaxea Favia Favites Fungia Isopora Pachyseris Montipora Montastrea Leptoseris Goniastrea Pavona Styllopora Astreopora Diploastrea Millepora | It is difficult for species to determine key species but is a key community for many reef fish and other species whose lives depend on the coral community | Coral cover> 50% so it has high ecological value | Coral cover> 50% so it has a high economic value because it supports the abundance of reef fish which is partly a type of consumption | Coral cover> 50% so it has a high scientific value | No coral species were included in the list of Protected Plant and Species (appendix PP No. 7 of 1999) | The exact status can not yet be determined but many members of this coral genus encountered a red list with various statuses. |

Source: Primary data, 2016

Table 10: Dominant Wind Average Speed Data for 2005-2016.

| Speed (Knots) | Amount of Wind | Speed Data (%) |
|---|---|---|
| 0 – 2 | 1820 | 25.117 |
| 2 – 4 | 2002 | 27.629 |
| 4 – 6 | 1307 | 18.038 |
| 6 – 8 | 1122 | 15.484 |
| 8 – 10 | 395 | 5.451 |
| >10 | 600 | 8.280 |
| Jumlah | 7246 | 100 % |

Data source: Maritime Meteorology Station, Semarang, 2016

Table 11: Dominant wind direction data and average speed for 2005-2015.

| Direction | Dominant Wind Direction (%) | Average Direction Speed (Knots) |
|---|---|---|
| North | 7.853 | 7.445 |
| Northeast | 4.885 | 6.085 |
| East | 31.024 | 4.425 |
| Southeast | 10.406 | 3.001 |
| South | 8.529 | 3.316 |
| Southwest | 7.673 | 4.067 |
| West | 12.421 | 6.300 |
| Northwest | 17.210 | 6.518 |

Data source: Maritime Meteorology Station, Semarang, 2016

tidal patterns and ocean currents. So changes in oceanographic parameters in these shallow waters have triggered an increase in sedimentation due to the occurrence of nearshore breaking waves and increased longshore current flows, thus further decreasing the quality of the coastal marine environment resulting in damage to coral reefs and seaweed conditions. This can make the condition of the status of coral reefs and seaweed worse (Anand Kumar Varma 2013).

## Hydrooceanography

Legon Bajak waters are located in the Java seawaters which have relatively calm characteristics, can be seen from the dynamics of tides, currents, waves and morphology.

### *Tides*

Based on the results of tidal measurements in the waters of Legon Bajak in March 2017, it shows that tides in the Legonbajak waters are diurnal tidal types where the Formzhal value is 3.03 (F > 3). Single (diurnal) daily tides have a tidal period of 24 hours 50 minutes, so that one day there is one tide and one time low tide. Tidal charts on the Legon Bajak waters, Karimunjawa are presented in Fig. 9 (Parker 2007).

***Seawaters Flow Pattern*:** Field investigations include current velocity measurements and current directions carried out from 1 to 4 April 2017 at Legon Bajak, Karimunjawa (Table 12).

### *Sea Wave*

Based on the results of processing, the ADCP station data presented in Figs. 3-4, the following can be concluded.

The current velocity varies with the average speed in all water columns ranging from 1.71-3.1 cm/s, the minimum current speed is 0.0-0.1 cm/s, and the maximum current speed is 5.8-27.2 cm/s, with the smallest current velocity evenly at each depth (0.0-10.0 meters) and the largest current velocity in cell depth 1 (8.0-10.0 meters) (Fig. 10).

The largest current velocity at average depth is 6.8 cm/s with an average speed of 2.1 cm/s. Current speed in each cell depth can be seen in Fig. 11.

From the results of the analysis of current observation data using current rose, it can be concluded that a number of things are:

(a) The direction of the dominant current is towards the southeast to the north.
(b) The direction of the dominant current at the average depth is to the southeast and south with the frequency of occurrences of 14.75% and 13.82%. The dominant current velocity is > 0-10 cm/s with an event frequency of 100%.

The maximum speed that occurs is> 0 cm / s - 10 cm / s with an event frequency of 100%. The dominant direction at the cell-cell depth can be seen in Fig. 12. The distribution of the depth of the current average from 1 April 2017 to 4 April 2017 are given in Table 13.

Based on the results of the processing of observational flow data April 1, 2017 - April 4, 2017 at an average depth in the form of a scatter the plot addressing the direction of the current is almost in all directions with the dominant movement towards the southeast to the north, the current movement occurs at all depths. It can be concluded that the current velocity and direction are dominated by tidal factors and at the surface depth or cell 5 (0.0-2.0 meters) influenced by non tidal factors, one of which is wind. Based on current modelling data using numerical modules on the condition of moving current tide averages from north to south, while at low tide the current moves from south to north (Sofian 2010).

## Wave Pattern

### *High Raw Data and Wave Period*

Based on the results of ADCP station data processing presented in Figs. 13, following can be concluded.

(a) The maximum wave height that occurs is 13.8 cm with a period of 5.1 seconds on the second day measurement or April 2, 2017.

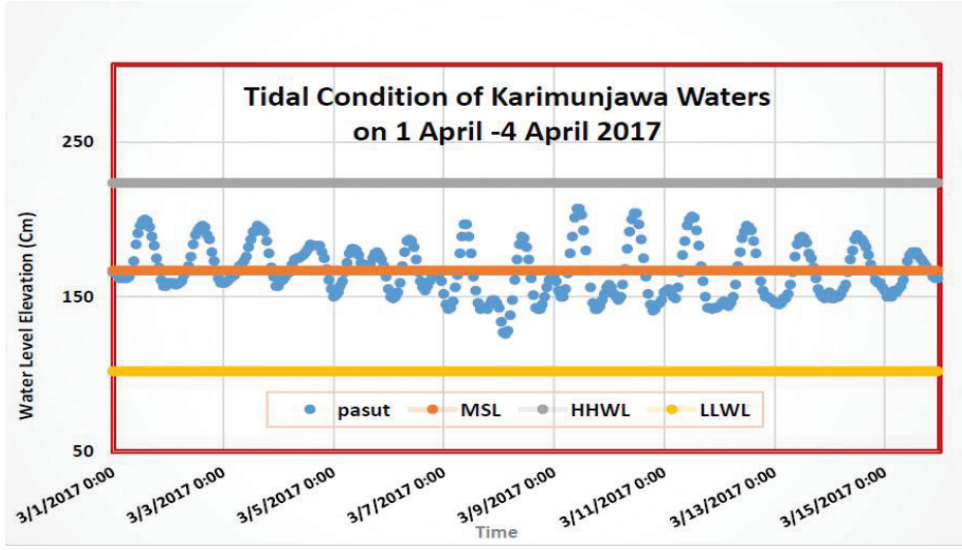


Fig. 9: Sea level elevation in Karimunjawa region (Realtime Data Geospatial Information Agency, 2017).

Table 12: Type and location of measurement: speed, current direction, wave height and wave period in Legon Bajak Waters, Karimunjawa.

| Station | Coordinate | Location | Activity |
|---|---|---|---|
| Acoustic Doppler Current Profiler (ADCP) | S 05°47'15.5" E 100°28'54.3" | Marine waters | Measurement of speed, current direction, wave height and wave period with ADCP, is carried out for 3×24 hours. |

(b) The wave height that occurred during the measurement was carried out in the range of 2.3-13.8 cm.
(c) The wave period that occurs during measurements is carried out in the range of 4.2 seconds to 5.5 seconds.
(d) The maximum wave period that occurs is 5.5 seconds with a wave height of 12.4 cm on the measurement of the fourth day or April 3, 2017.

The results of wave analysis based on wind data from the Meteorology and Geophysics Agency, Semarang in 2005-2014 in the Legon Bajak waters region were relatively low with a maximum of 50 annual waves around the pier reaching 1.50 m, it is estimated that ships can dock throughout the year. Whereas from waverose, waves occurring around Karimunjawa Port more than 0.50 m are estimated for 5 days in August, 4 days in May, June, September while other months are less than that. This regulation needs to be made appropriate if the development of Legonbajak port is in the construction and post-contraction stages because it can significantly affect the ecological conditions of the coast, especially the conditions of coral reefs and seaweed.

## Beach Morphology

Based on the results of observations of visual field data using aerial photographs of the DJI Phantom 3 beach type Kemujan island, especially in LegonBajak, it is dominated by sandy beach in the foreshore area. Furthermore, in the

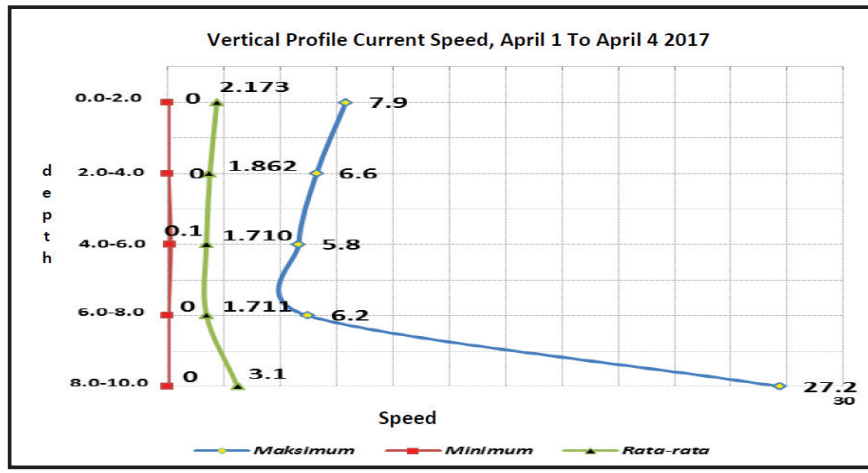


Fig. 10: Vertical profile maximum, minimum and average current speed, April 1, 2017-April 4, 2017.

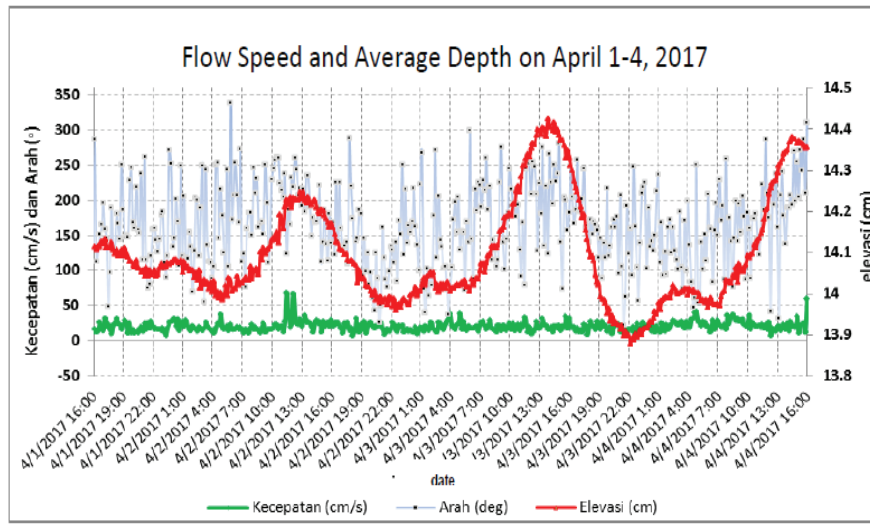


Fig. 11: Average depth current speed, April 1, 2017-April 4, 2017.

backshore area or behind the stretch of sand, the land cover is in the form of trees. In waters there is a coral reef ecosystem with a bottom of the water that looks sloping based on the depth contours resulting from bathymetry analysis (Wolanski & Elliott 2015). The coastline can change with the development of the famous Legonbajak port at the operational stage (post construction) and affect the ecological conditions of the coast. Fig. 14 shows the coastline of the waters around the port of Legonbajak (Karimunjawa waters).

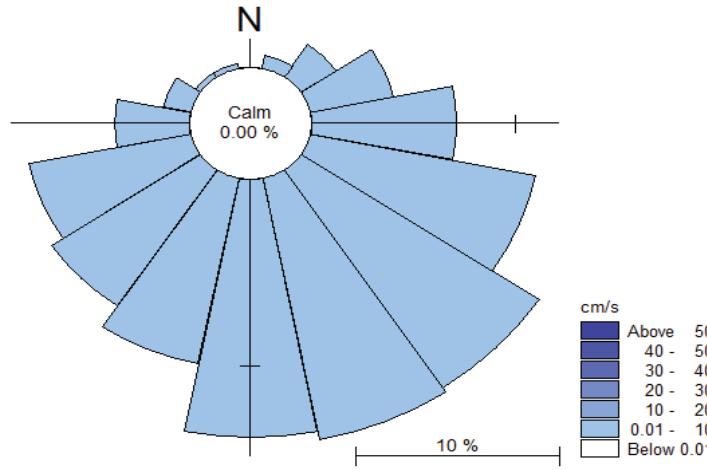


Fig. 12: Current rose depth average April 1, 2017-April 4, 2017.

Table 13: Average depth current velocity distribution April 1, 2017 - April 4, 2017.

| Frequency of Current Flow in Percent (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Direction | | Flow Speed (cm/det) | | | | | | | | Jumlah |
| | | Calm | >0-10 | >10-20 | >20-30 | >30-40 | >40-50 | >50-60 | >60 | |
| - | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | U | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22.5 | UTL | 0.00 | 0.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.69 |
| 45 | TL | 0.00 | 2.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.07 |
| 67.5 | TLT | 0.00 | 4.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.15 |
| 90 | T | 0.00 | 7.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.14 |
| 112.5 | TTg | 0.00 | 11.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.06 |
| 135 | Tg | 0.00 | 14.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.75 |
| 157.5 | TgS | 0.00 | 13.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.82 |
| 180 | S | 0.00 | 13.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.82 |
| 202.5 | SBD | 0.00 | 10.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.14 |
| 225 | BD | 0.00 | 8.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.99 |
| 247.5 | BDB | 0.00 | 7.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.83 |
| 270 | B | 0.00 | 3.92 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.92 |
| 292.5 | BBL | 0.00 | 1.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.15 |
| 315 | BL | 0.00 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 |
| 337.5 | BLU | 0.00 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 |
| Total | | 0.00 | 100 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100 |
| Kumulatif | | 0.00 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Prediction of Coastline Changes in the Baseline Condition of the Initial Environment around the Port of LegonBajak**

Based on the observations of visual field data using aerial photography from the DJI Phantom 3, the type of Kemujan island beach, especially in Legon Bajak, it is dominated by sandy beaches in the foreshore area. Furthermore, in the coastal area or behind a stretch of sand, land cover is in the form of trees. In the waters, there is a coral reef ecosystem with a water base that looks sloping based on the contour of the depth of the results of the sound of bathymetry. Prediction of coastline changes in the basic conditions of environmental conditions initially around the port of Legon Bajak which existed prior to development in 2016 compared to the environmental conditions in 2003, a coastline shift had occurred, predicted to be largely due to activities in the surrounding community, which would be even worse with the planned development of Legon Bajak port. Therefore, it is necessary to have a comprehensive environmental impact analysis and regulation among stakeholders who have an interest in government, society, investors and the private sector to prevent a broader coastline from causing disruption to the marine ecosystem. Fig. 15 shows that there has been a change in the coastline, as revealed by the comparison of the monitor lines in 2013 and 2016.

Based on Fig. 14, it can be said that in the northern part of the port of Legon Bajak from 2003 to 2016 the coastline accretion was 13 m (or 1 m/year). To the south of the port of Legon Bajak from 2003 to 2016, there was an 8 m (0.6 m/year) coastline abrasion.

It is estimated that the next 5 years accretion that occurs in the northern part of the port is 5 m, while to the south the port of Legon Bajak will experience an abrasion of 3 m. The creation and abrasion that occur do not cause interference to the buildings on the beach (Parker 2007).

Based on the description above, the environmental conditions without this project are categorized as poor. The construction of the pier with erection will affect the changes in the bathymetry of current and wave patterns in the waters around the port area. The changes in current and wave patterns will result in changes in sedimentation patterns that can lead to abrasion and creation (changes in shoreline), given the structure of the jetty which is protruding towards the sea, but the changes that occur are not due to the extension of the existing dock. Based on the description above, the environmental conditions with the next 5 years project remain the same as the coastline conditions for the next 5 years without projects, so that these environmental conditions are categorized as poor.

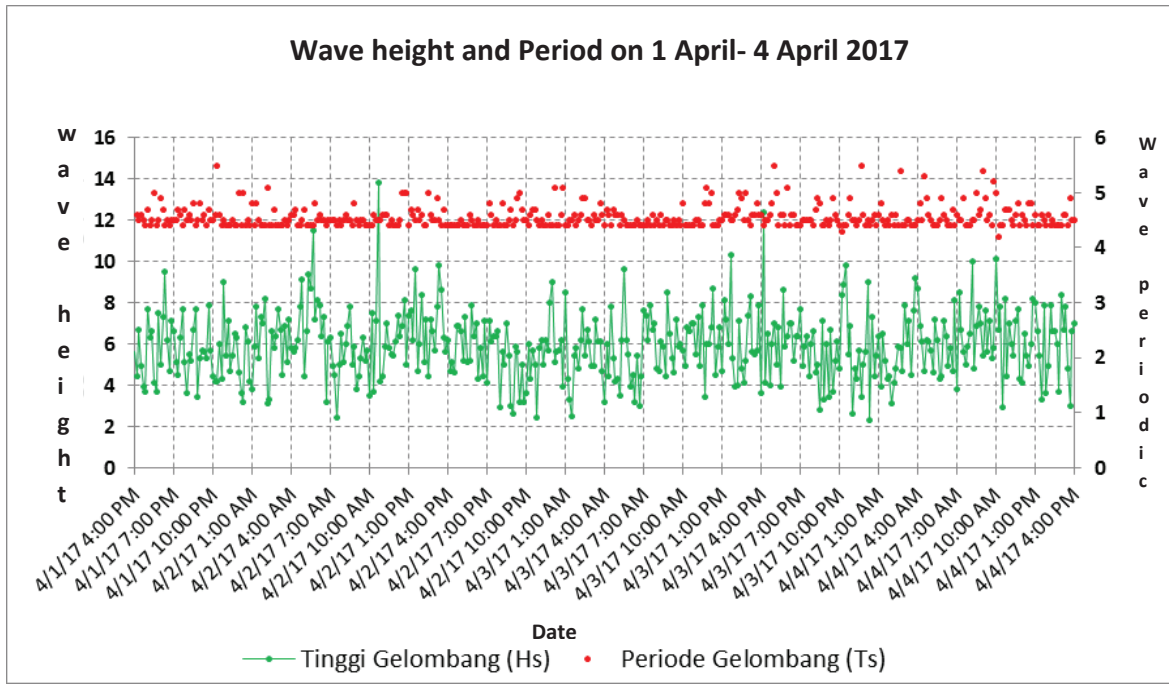


Fig. 13: Height and wave period, April 1, 2017-April 4, 2017.

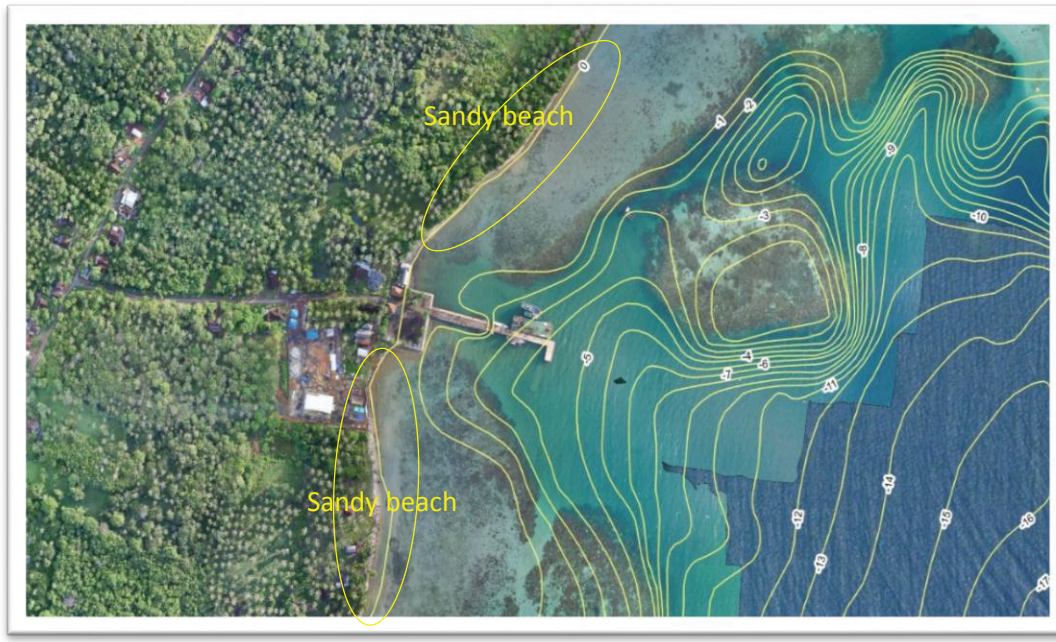


Fig. 14: Visual aerial photograph of Legon Bajak Port.

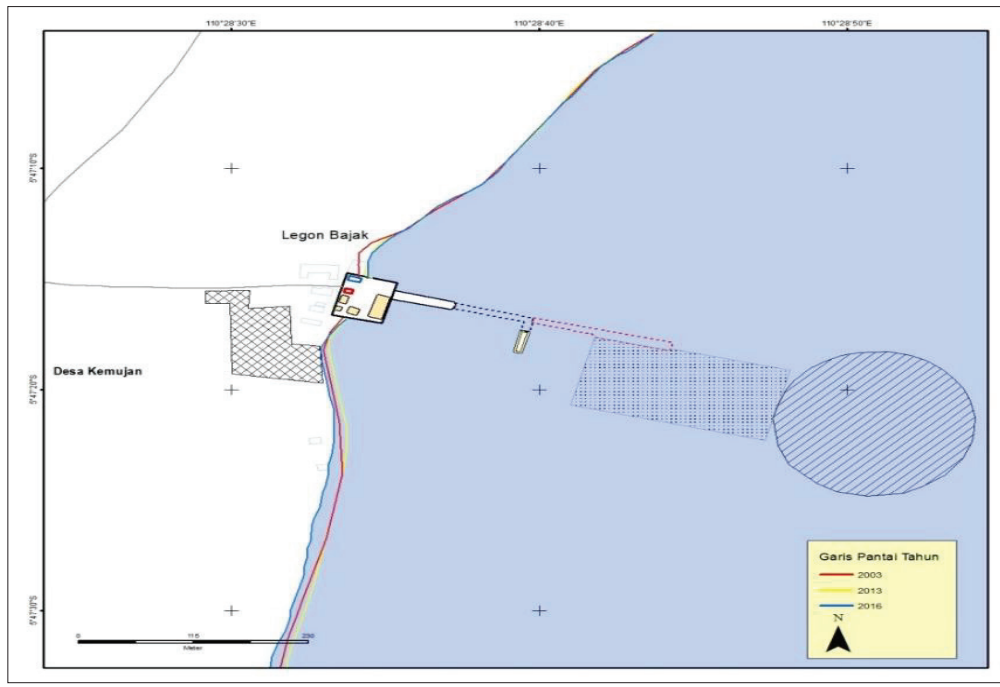


Fig. 15: Coastline conditions in 2003 and 2016.

## SIGNIFICANT STATEMENTS

This study is a study of seawater quality in terms of diversity of seaweed and krang reefs. The study also examined the conditions of environmental parameters, including current, wave, climate, and bathymetry data at the study site. The purpose of this study was to find out the initial description as the basis for the ecological status of the Legon Bajak waters. The results of this study indicate that the quality of seawater is in good condition but the condition of the diversity of seaweed and coral reefs is in damaged condition, as well as environmental parameters such as currents, coastlines, bathymetry and ocean waves make it possible to increase environmental damage. Legon Bajak Port is included in the Karimunjawa water park conservation area, therefore the development and expansion of the Legon Bajak port that will be carried out by Rembang Regency must be carried out comprehensively and refer to the results of this study so that the development and expansion of port Legon Bajak will not damage sea conditions and remain sustainable.

## CONCLUSION

The quality of the Legon Bajak seawater port is based on an analysis of seawater quality data that is still in good category, but if analysed based on the seaweed and coral diversity, diversity index that has been included in the damaged ecosystem category, the secondary data parameters include atus, wave and raus the sea, the coastline needs special attention from the authority of Karimunjawa National Marine Park, the local government of Rembang district, central Java Province and the Environment Ministry of the Republic of Indonesia because the Legon Bajak port includes the Karimunjawa National Marine Park Conservation Area.

## ACKNOWLEDGEMENTS

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