

## Overview of physical oceanographic condition at Biawak Island: past achievement and future challenge

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**Abstract.** Biawak Islands is one of Marine Protected Areas (MPA) in Java Seas and categorized as remote area. The purpose of this research is to assess data's from 2011-2017 and to understand about these island from oceanographic point of view. Due to its location in the center of Java Sea (JS), variations of oceanographic condition at Biawak Island is supposed to be similarity with JS. Seasonal variations in this shallow-flat topography of JS are mostly influenced by the monsoon due to the sea level difference between Pacific and Indian Ocean. Water masses from the South China Sea (SCS) and Pacific Ocean (PO) take turns to enter JS at two distinct monsoon seasons. The results showed that temperature ranges 26.28 - 34.3 °C, salinity ranges 27.5 - 34.5 psu, transparency ranges 0.7 - 20 m, dissolved oxygen ranges 4.1 - 6.5 mg/L, and pH 6.30-8.5. Tides with mixed tide prevailing diurnal. The wind pattern with monsoonal variation and the surface current is about 0.2-0.8 m/sec. The dominant substrat in the Biawak is sand and coral. Further, there is a need long-term programs concentrate on delivering quantification data related to environmental issues.

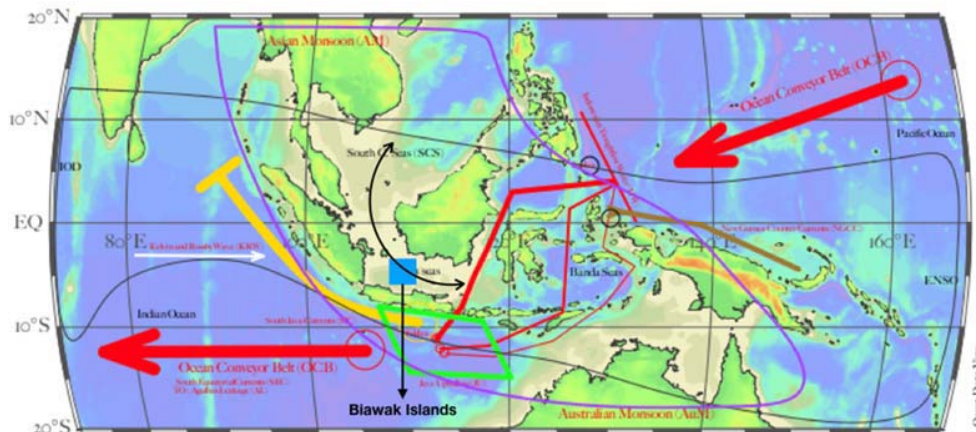
### 1. Introduction

Biawak Island (before namely as Bonpies or Rakit) located at Java Seas. Biawak Island consists of two islands (Biawak and Gosong) and 1 atoll (Candikian). The biggest island named Biawak (other name is Rakit Island) is a small island located in the north of West Java, precisely in the north of Indramayu with its center coordinate at 5.930752 °S and 108.379548 °E. These islands is one of 4 remote islands in Java Sea, which have been intensively observed by Marine Science Department of Universitas Padjadjaran in the last six years by several research and projects. However, little is known about data and information that summarized all those six years observations, since the observations itself were performed by separate individuals or groups as well as at different time. Thus, the results that have been obtained are limited by short observations and the discussion of one component of oceanography, either physical or biological is also limited. Therefore, the information about the annual variability and the relationship between the physical and biological components can't be obtained.

Due to its location in the center of Java Sea (JS), variations of oceanographic condition at Biawak Island is supposed to be similarity with JS [1]. Seasonal variations in this shallow-flat topography of JS are mostly influenced by the monsoon due to the sea level difference between Pacific and Indian Ocean [2, 3]. Water masses from the South China Sea (SCS) and Pacific Ocean (PO) take turns to enter JS at two distinct monsoon seasons. The Northwest (NW) monsoon transports the SCS water through Karimata Strait from November to March and increasing the Sea Surface Temperature (SST) of JS, whereas the Southeast (SE) monsoon transports PO water through Makassar Strait and Banda Sea from May to September and decreasing the Sea Surface Salinity (SSS) of JS [3, 4]. The circulation that regulated between SCS-JS-PO suggested containing strong signal of El-Nino and Southern Oscillation



(ENSO) and Indian Ocean Dipole (IOD) that somehow altered the weather and climate regionally or globally [4, 5, 6]. Therefore, all those alterations to the JS may as well influencing the local condition of Biawak Island and vice versa.



**Figure 1.** The location of Biawak Island between local and regional phenomenon [7, 8, 9].

The islands are remote areas and limited access to go, therefore oceanographic, geomorphological, and ecosystem data are still rare [10]. From the literature, not more than 3 studies were conducted before 2011 in this island. Since 2011, KOMITMEN (Study Group of Instruments and Marine Surveys) Unpad and FPIK-Unpad conduct research in this region intensively as well as by some researcher [11, 12]. Ecosystem that can be found in Biawak Island are mangroves, seagrasses and coral reefs. The density of mangrove ecosystem in this island ranging from low to high density. The percentage of seagrass beds coverages are very low (5-10%) with sand as bottom substrate and *Enhalus acoroides* as the main species. The coral reef was categorized as poor (6.25%) to good (63.75%) condition, but in the average, coral reefs are in the medium (34.69%) condition [10].

The objective of this paper is to provide an introduction of the local physical oceanographic data and information of Biawak Island based on previous observations. First, we briefly introduce and describe the physical condition in Biawak Islands. Second, analyzing the conditions with the characteristic of Java Seas and regional phenomenon. Finally, we discuss about future activities in Biawak Island that would lead to assess a comprehensive feature of oceanographic condition.

## 2. Materials and methods

### 2.1. Study sites

This study area chosen for this work, Biawak Islands, consists of three islands, the Candikian, Gosong and Biawak Islands itself (figure 1 and 2). These island is Marine Protected Areas because of its high diversity. The distance from mainland of Java Islands is about 36 km. All of data in the Biawak Island are primary data that collected from 2011 to 2017 from several research projects.



**Figure 2.** Position of Biawak Islands, Biawak as a main island (5.9310 S, 108.3795 W), Gosong (5.882 S, 108.4026 W), and Candiklan (5.8076 S, 108.4394 W).

In this research, we use several portable instrument to measure insitu data. Hand optical refractometer to measure salinity, the temperature measure by two instrument, one in GARMIN and in pH meter combine, with the standard deviation is less than 1 degree Celsius. For sediment, the Ekman grab [13, 14,15] operated from the water surface by a line and messenger. Salinity measured by optical hand-refractometer, the tides with model combine and manual insitu measurement only in Biawak Island. The transparency measured by white secchi disc with 40 cm diameter.

**Table 1.** List of research/project in Biawak from 2011 to 2016.

No.	Date	Parameter measured
1	March and May 2011 [16, 17, 18]	Temperature, salinity, dissolved oxygen
2	June and November 2012 [19]	Temperature, salinity, pH, dissolved oxygen, water transparency, bathymetry, tides, current wind, substrate
3	June 2013	Temperature, salinity, dissolved oxygen, pH
4	October 2014	Temperature, salinity, pH, dissolved oxygen, water transparency, bathymetry, tides, current wind
5	April 2015	Temperature, salinity, dissolved oxygen, pH
6	May 2015	Temperature, salinity, pH, dissolved oxygen, water transparency, bathymetry, tides, current wind, substrate
7	May 2016	Temperature, salinity, pH, dissolved oxygen, water transparency, bathymetry, tides, current wind, substrate, and tides
8	April 2017 [20]	Temperature and salinity

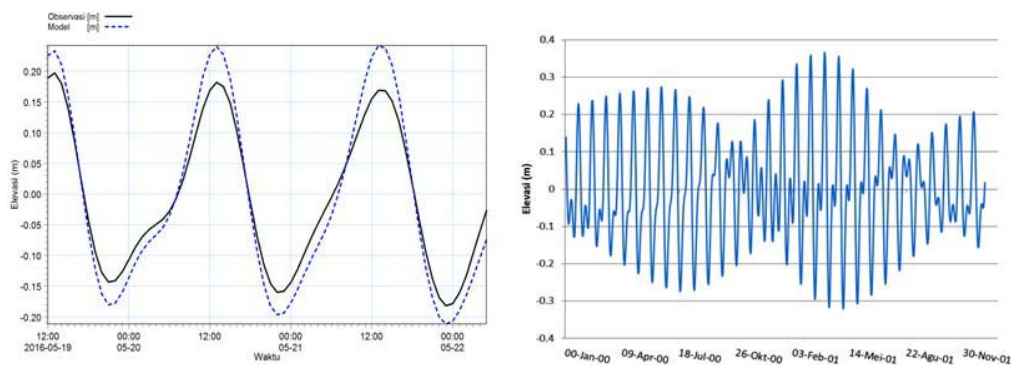
Here, we measured the temperature with 4668 data, salinity from 187 stations, wind, current, tidal, and brightness from 124 stations, dissolved oxygen and pH from 209 stations. The tides are measured by using tidal pole that installed at the Biawak Island, while other parameters above are measured from the ship and also from the transect that conducted in the shallow waters. Depth profiles data are obtained

by primary measurements from 4668 stations and an analog maps from DISHIDROS (2013). In addition, wind data is analyzed from the European Center for Medium-Range Weather Forecasts (ECMWF) ([www.ecmwf.int](http://www.ecmwf.int)) per 6 hours with spatial resolution  $0.125^\circ \times 0.125^\circ$ . Obtained data are then calibrated statistically, processed, visualized and interpreted using ODV (Ocean Data View) software [21], while tidal data are analyzed using Formzahl numbers to determine the type of tidal. We analyze the data with temporal and spatial distribution with focus on surface water column

### 3. Results and discussions

#### 3.1. Tides

Tidal conditions in the area shows a mixed tide prevailing diurnal type with 1.7446 Formzahl number. This is similar to the type of tides in some areas such as Kalimantan and Java Sea in general [22, 23]. It means that there will be 2 peaks during high waters and 2 valleys during low waters in one day with differ high water level.

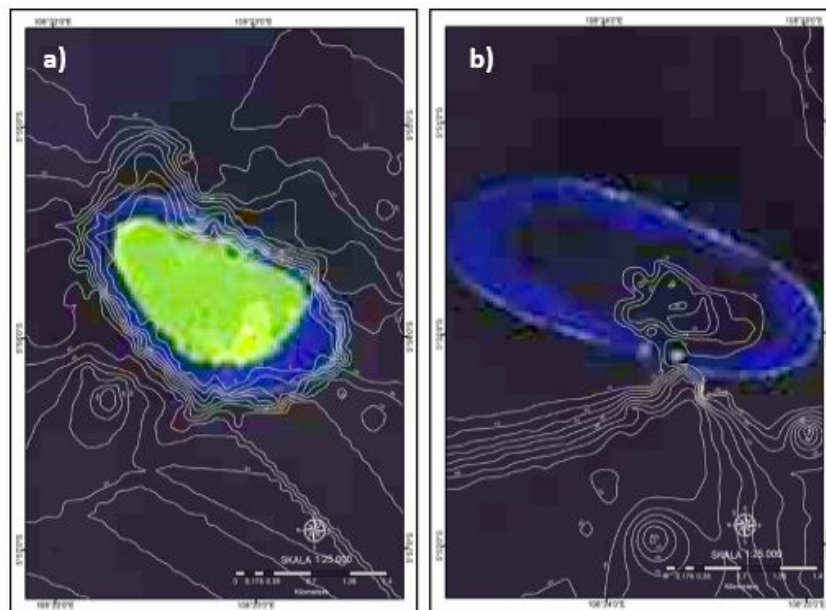


**Figure 3.** Three days tides pattern (left); combination between three days tide pattern and one month model (right).

Figure 3 shows that the primary data and the model have a similar pattern, which means the tidal corection is right, but there is a little different at maximum and minimum in height. Measurement data affected by many factors, such as condition of weather during measurement result a big deal in accuracy. These condition made a measurement more complex than model.

#### 3.2. Bathymetry and substrate

Bathymetry of the Biawak Islands according to DISHIDROS Data (2013) which from analog map in 1970, ranged from 5 to 20 m. Bathymetry in Biawak Islands have similarity with Java Sea that have isodepth 20 m in open water [24]. Gosong Island has 25 m maximum depth located in the middle of island and 5 m depth in attol's reef flat during observation in 2006. This Island become a target for sand mining location in 1990's. The area changes from 2765 km<sup>2</sup> (1990) to 2257 km<sup>2</sup> (2016). Thus, the island has decreased about 0.508 km<sup>2</sup> in 26 years.



**Figure 4.** Bathymetry of Biawak Islands; (a) Biawak Island; (b) Gosong Island.

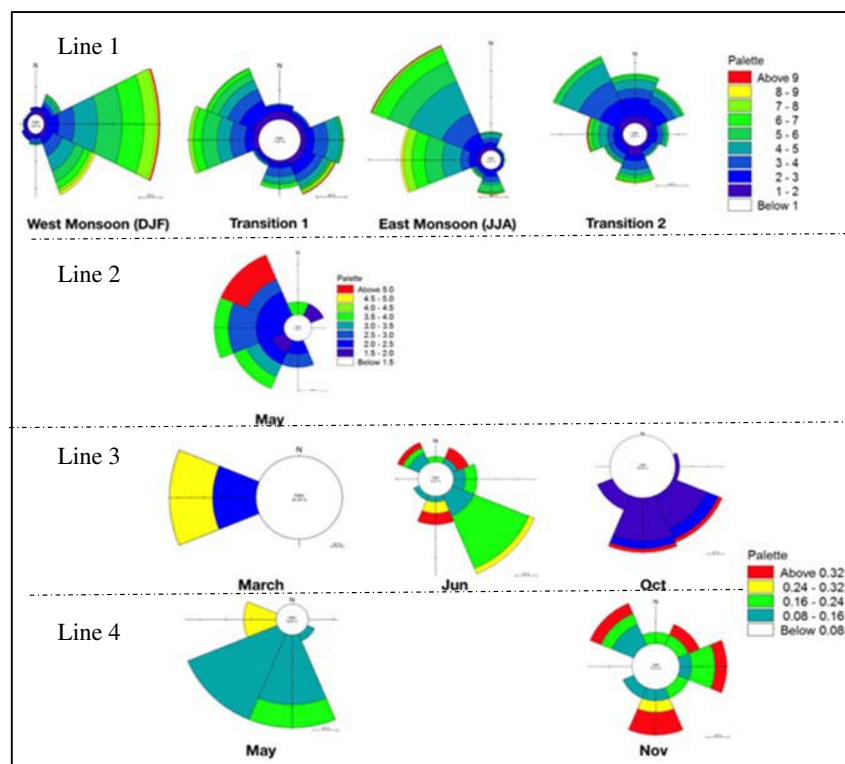
From survey data, depth of the Biawak Islands ranges from 0.9 to 75 m (figure 4a). The largest shallow areas of Biawak Island is located in the southeast of the island (0.9-1.2 m), which composed of corals, sand, and mud as dominant substrates, while the deepest waters are in the southern of the island. Around 500 m to the outside dominated by coral and sand substrate. In some parts (West) is dominated by mud. Depth at Gosong Island is about 4 - 28 m on the inside while on the outside it is around 50 m (figure 4b). The inside of the island of Gosong is a closed water. Gosong Island mostly dominated by sand and coral with percentage 70:30 on the inside or outside atoll. Depth in Candikian Island is about 1-2 m with the coral substrate. Outside island, the depth can reach 47 m. This is also similar to the data released by DISHIDROS in 2013. This depth contour also shows the shallow profile of Java Seas. Candikian Island dominated by sand and corals with a percentage of 30:70.

Java Seas is generally dominated by mud and sand. The most part of bottom substratum of the Java Sea is constituted by silt and formed by highly dense mud layer, with large muddy bed in the North-East and central area which are mixed with coral and shell debris [22].

### 3.3. Wind and currents

Wind patterns in the Biawak Island, following periodically monsoon pattern of the Java Sea that blows horizontally from east to west during the eastern monsoon and blows in the opposite direction during the west monsoon [22]. Western monsoon occurs in December to February, the Transitional Monsoon 1 and 2 occurs in March to May and in September to November, while the eastern monsoon occurs in June to August as shown in the line 1 and 2 of Figure 5. Wind data measurement in 4 m height above mainland ( $U^4$ ).



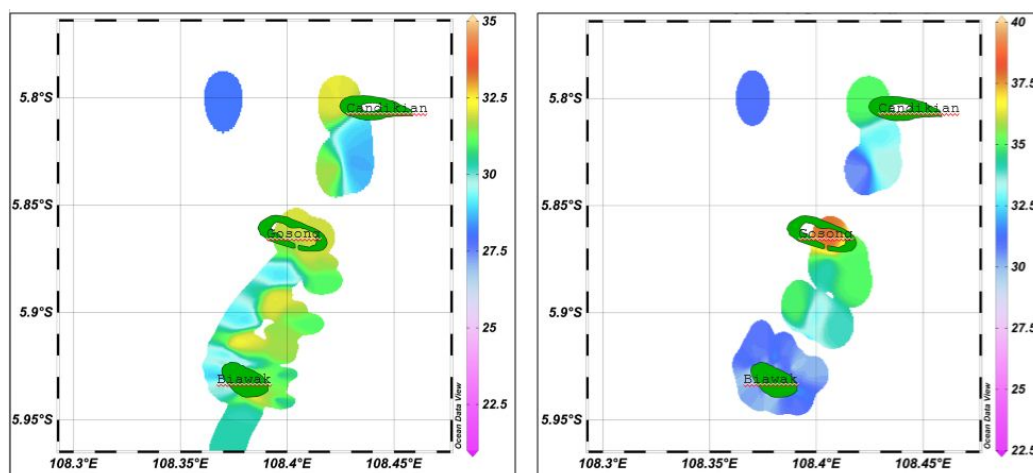


**Figure 5.** Wind ( $U^4$ : ~4 m from sea level) rose patterns in Biawak Island (line 1: wind from ecmwf; line: 2 from field survey), and current rose pattern (line 3 and 4) from field survey).

Monthly wind speed ranges from 1-7 m/sec throughout the year, while from the speed of the instantaneous measurement in May is 1-5 m/sec. Wind direction corresponds to the seasonal direction that controls the atmosphere in the Java Sea. For surface currents, the current velocity is below 1 m/sec and the direction is not always the same as the wind direction. Current Speed pattern in Biawak Island more complex than the other 2 islands, Gosong and Candikia Island. Besides, wind forces of monsoon will give effect to current speed pattern. Characteristically this region represents Java Sea waters with current speed of 0.15-1 m/sec, which mostly influenced by tidal [25] and monsoon [26].

### 3.4. Sea surface temperature and salinity

Sea Surface Temperature in Biawak Islands range 26.3 - 34.4 °C with an average of 30.7 °C (figure 6). The highest sea temperature in Biawak Islands occurs during NW Monsoon (34.4 °C) while the lowest sea surface temperature value 26.2 °C founded in May. The NW monsoon transports the South China Seas (SCS) water through Karimata Strait from November to March and increasing the Sea Surface Temperature (SST) of Java Sea (JS). Before NW Monsoon enter (Transition II), temperature in Biawak Island considerate in 29-30 °C. These Variation determined by bathymetry and water transparency of waters. In general, temperature in Biawak Island still consider as normal condition [27].



**Figure 6.** Distribution of temperature (left) and salinity (right) in Biawak Island.

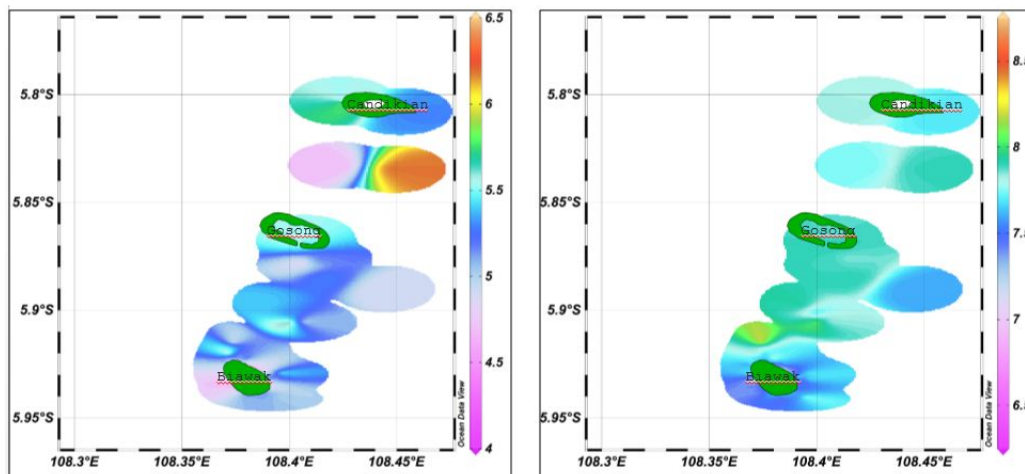
The maximum temperature in Biawak Island is 32 °C. North area of Biawak Island has the highest temperature than south area. Variability of temperature in Biawak Island is diverse by location. The minimum temperature is in west of Candikian Island, because this island faced to the open sea area. The waters nearest island has a highest temperature than in the open water area. This is because the type waters with a semi-closed water. SST at Gosong Island ranges from 29.6 - 30.2 °C.

Salinity distribution in the sea is influenced by various factors such as the pattern of water circulation, evaporation, rainfall and river flow [28, 29]. Salinity in Biawak Islands ranges 27.50-34.50 psu with an average of 30.88 psu (figure 6). Salinity in Biawak Island has range between 27.50-31.08 psu and in Gosong Island 32.00 – 34.00 psu. In Java Sea (JS), salinity in range 29.00 – 34.00 psu still categorized normal [30]. The fluctuations of these two parameters (SST and Salinity) are influenced by the water mass that coming from the South China Sea (TSS) [1] and also from Makassar Strait via ITF [24].

### 3.5. Dissolved Oxygen (DO) and pH

The content of dissolved oxygen (DO) in a waters is influenced by the diffusion speed of oxygen from the air as well as the rate of photosynthesis and respiration of aquatic organisms. DO needs in organisms varies greatly depending on type, phase and activity [31]. Phytoplankton as primer organism in sea-life, can live well at oxygen concentrations greater than 3.00 mg/L. DO in Biawak Island between 4.10 - 6.50 mg/L (figure 6) which support phytoplankton boundary life. DO in Gosong Island tends to be homogeneous and do not have much variability.

A certain range of pH values may indicate a change in water quality [32]. The value of pH in Biawak Islands has range 6.30 – 8.52 with averages 7.54 (figure 7). According to Quality Standart from Ministry of Environment and Forestry, pH values in Biawak Islands categorized as suitable for marine life.



**Figure 7.** Distribution of dissolve oxygen (left) and pH values (right) in Biawak Island.

### 3.6. Water transparency

The water transparency of Biawak Island has wide ranges variability from 0.7 – 20 m with an average of 8.06 m. The transparency of ocean water affected by chemical and physical factors [33]. Water transparency also affected by bathymetry and the type of sediment in sea bed. The intensity of sunlight is often a very rapid limiting factor because it is affected by depth and turbidity [34]. Water transparency becomes an important factor in controlling the primary productivity of waters as it relates to the rate of penetration of sunlight that will determine the rate of photosynthesis and primary productivity of the waters [20].

### 3.7. Substrate

Substrate in the area of Biawak Island and its surroundings have morphological similarities. The basic material that built is sand and the coral fragments. Observations in November 2014 stated that, found four types of substrate in the shallow waters of Biawak are sand, rocky sand, muddy sand and mud. According to [35] the substrate of waters of Biawak Island consists of sand, Dead Coral (DC), live corals, sandy mud, and rubble. The DC area is located on the island of Biawak with of  $\pm 216,000 \text{ m}^2$ , while the coral reef area is  $\pm 111,000 \text{ m}^2$ . The sand substrate has an area of  $525,000 \text{ m}^2$ , then the fracture ranges from  $348,000 \text{ m}^2$ , sandy mud around  $91,000 \text{ m}^2$  and mud with an area of  $90,000 \text{ m}^2$  range. In the northern part of the island has a rubble substrate, while in the southeast part of the island is dominated by dead coral (DC). [36] states that in the intertidal zone Biawak Island consists of three basic substrate types, namely substrate of fine sand in the southeast to the east, rocky rock substrate (coral rubble) in the north and muddy sand substrate in the northwest to south. In the southern part of the island has sand and rocky sand substrate. The southern part of the shallow waters of Biawak Island is a habitat of coral massive coral reefs. Such coral reefs can only live in waters with sandy sediments. In the western part it has mud substrate and muddy sand. In the area is found many mangrove *Avicenia* sp. This type of mangrove generally grows shallow water with sediments of muddy sand. The substrate on Gosong Island consists of sand, live corals, dead coral, and grassy seagrass. The southern part of the island is dominated by sand grass substrate (sand with seagrass), which indicates that the island also has potential as a macrozoobenthos habitat. According [36] the most optimal substrate for sand cucumber habitat is sand or sand with seagrass-covered rocks. For the surroundings of the island there are many living coral substrates, but in the eastern part of the island is dominated by DC.

## 4. Future challenge

The study of hydro-oceanography in the islands of Biawak is need to develop. The Physical conditions are important parameters which can determined productivity of marine life. Continuous data and routine measurements can determine how the characteristics of the water masses in these islands primarily to



see how regional phenomena such as the Indian Ocean Dipole (IOD) [8] and El Nino Southern Oscillation (ENSO) affect it [9]. Biawak Island that located in JS is affected by local, regional, and global phenomenon. Biawak Islands also as path of national and international ship.

Furthermore, that shallow sea waters located in Biawak are very rich in important micro-organisms that build food chains. On Gosong Island, morphological changes because sand dredging conduce sea bed profiles changes. Ecosystems degradation in this area which can reduce marine biota who associate with ecosystems. Research on the Gosong Island and Candikian Island also needs to be multiplied in the future to get complete and comprehensive data about the condition of Biawak Island waters. The Biawak Islands of the future will be determined by the physical oceanographic condition. Integrated research is required condition especially from biological and chemical aspects.

## 5. Conclusions

This paper deals with physical oceanographic condition on the Biawak Island. During the period of research, shows that Biawak has unique water characteristics based on physical conditions of the area. This is because the areas located in the Java Seas that have many variabilities from local to global scale impact (IOD, ENSO, Monsoon, ITF path, and climate change). The monsoonal system seems has a significant effect on physical parameters (SST, salinities, oxygen dissolved) and the substrate similar to Java Island than Borneo island. Based on the physical aspect, there are lack of data especially in temporal data collection. The next research in temporal scale and in inner of Gosong and Candikian is the priorities because of its geomorphology and local condition.

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