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Development And Field Test Of Gps-Gsm Drifting Buoy For Measurement Of Sea Surface Current Data

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Abstract

Spatial data of coastal currents are generally obtained from altimetry satellites. However, the data obtained still has shortcomings, such as the low level of resolution and the need for field validation (ground truth). The electronic drifting buoy (GPS-GSM) is an oceanographic data acquisition instrument that uses a cyber-physical system (SSF) and follows the movement of water around the instrument. The application of the SSF system will facilitate data acquisition from the drifting buoy because the data will be directly entered into the database, transmitted through the GSM system, and monitored in real-time. The design of the ESP32 microcontroller-based instrument is supported by a GPS module for location data acquisition and a GSM module for data transmission to the database. The drifting buoy has dimensions of 52 cm high and 30 cm wide, while the current trap section has dimensions of 26 cm high and 15 cm wide for each wing made of iron. The field test was conducted in the Seribu Islands, DKI Jakarta province, with the current velocity ranged from 0.03 m/s to 0.35 m/s and the average current velocity was 0.19 m/s, while the surface temperature ranged from 26.37 to 27.83 °C with an average value of 26.75 °C.

Keywords: Drifting buoy, GPS-GSM, sea currents, sea surface temperature, seribu island

1. Introduction

Coastal waters are the most productive marine ecosystems that provide nutrition, health, and other ecosystem benefits for mankind, whose roles and functions increase with population growth. However, coastal areas are among the least monitored in the world. Instead, the desired 'blue economy' drive hinges on developing sustainable monitoring capacities to provide the knowledge needed for integrated coastal and marine area management, smart marine spatial planning, and effective implementation of Marine Protected Areas (MPAs) to protect biodiversity marine life. The lack of human and infrastructure capacities together with the urgency of developing coastal observation networks has recently been overcome by the development of newer technologies such as the internet.

With the development of our society and economy, the marine environment has attracted the attention of scientists and scholars for more comprehensive research. However, conventional monitoring activities will certainly take time and are very expensive due to the condition of the territory of Indonesia which is an archipelagic country where there are lots of small islands. Monitoring water conditions in real-time is an important mission to preserve aquatic ecosystems in developing maritime and archipelagic countries, including Indonesia, which relies on the wealth of aquatic resources. Several instruments for observing water conditions have been developed, such as a drifting buoy.

The drifting buoy is an oceanographic data acquisition instrument that moves following the movement of the water around the instrument so that the drifting buoy can be used to see the pattern of the surface current movement. Lutjeharms and Heydorn (1981) initiated the use of drift buoys for monitoring marine data by testing the possibility of using free drift buoys in determining the recruitment mechanism for reef lobster (Jasus tristani) larvae that were carried by currents and succeeded satisfactorily. Due to its ability to follow the movement of water, drift buoys can be used to study the circulation of the surface layer (Charria et al. (2013) and used to assess model accuracy (Amemou et al. 2020), even when combined with satellite monitoring technology and indirect air monitoring. manned, drift buoys can be used to monitor marine biota (Bao et al. 2015), observe the dynamics of the trajectory of microplastic debris on the sea surface (Maximenko et al. 2012), study small-scale current rotations (Alpers et al. 2013), and measure time. crude oil spill residency (Garcia-Pineda et al. 2019) In addition, data from drift buoys can be utilized to determine the location of ocean current-based power plants (Chang et al. 2015), determine the area of the Aquaculture Management Bay (Ratsimandresya et al. 2020), increasing the success rate of catching tuna fisheries (Imzilen et al. 2018) and in the period 1986-2016 has been used by Celentano et al. (2020) to observe the connectivity, circulation, and transit times of currents between the Ionian Sea and various parts of the waters of the Mediterranean Sea.

Due to a large number of uses of drift buoy data as a medium for monitoring marine data, the development of drift buoys continues to be carried out. Ribotti et al. (2002) began to develop and test a surface buoy in Oristano Bay, Sardinia (Italy) for measuring coastal currents, then Sebille (2014) developed a drifting buoy, Adrift.org.au, to study current patterns and their implications for plankton dispersal and Lee et al. (2016) who designed and tested a GPS drift buoy to measure rip current patterns in the surface layer. Subbaraya et. al (2016) developed a drifting buoy designed for monitoring marine waters near the coast, this drift buoy is also connected to an autonomous underwater vehicle (AUV), research vessels, and base stations on land. Furthermore, the development of drift buoys was carried out to be able to carry out near-real-time monitoring (Srinivasan et al. 2017) and in real-time using open source-based software and hardware for monitoring offshore waters (Cadena 2018).

While in Indonesia itself, research on drift buoys was first carried out by Soeboer (2007) who succeeded in designing drift buoys for measuring the sea surface current pattern of Pelabuhan Ratu and later developed by Iqbal (2011) with the results of a drift buoy design that is more economical, durable, easy to operate and has a GSM-based transmission system. In addition to being used for current measurements, drift buoys are also added with GPS, usually, other water physical parameter sensors are installed to carry out monitoring of wider marine data as described above.

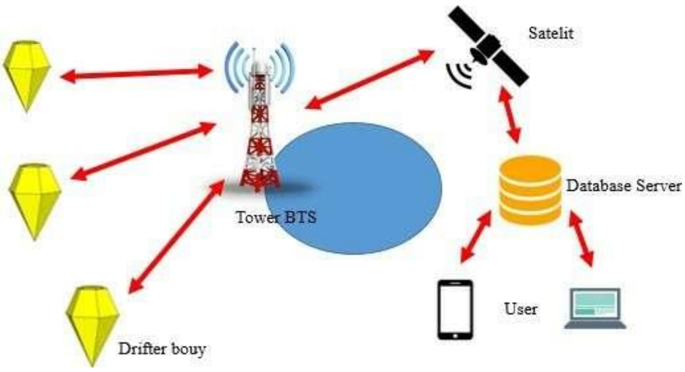

Figure 1. System to be implemented

2. Materials and Methods

The research was carried out in May – July 2019. The design and manufacture and trial of the drifting buoydesig n laboratory were carried out at the Instrumentation Workshop, Marine Acoustic and Instrumentation Laboratory, Department of Marine Science and Technology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University. Field trials were carried out in the Seribu Islands area, DKI Jakarta province.

In this research, the design and construction of drift buoys uses GPRS network media as a data transmission medium. The microcontroller controls the sending of data connected to the GPRS modem to the database on the destination server. The collected data can then be accessed by users through websites built using computers or smart phones. Figure 1 is a description of the work system applied to the design.

The research procedure was carried out by following the steps in Figure 2. Overall the research procedure was divided into five step. First, research planning. Second, instrument manufacture that contain software development, electronic circuit manufacturing and buoy construction. Third, Laboratory test that contain buoyancy and transmission data test. Fourth, Field test on seawater and fifth is data analysis.

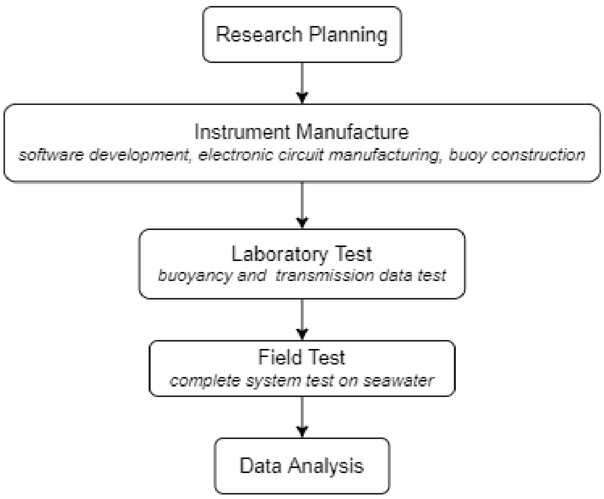

Figure 2. Research procedure to development and field testing the drifting buoy

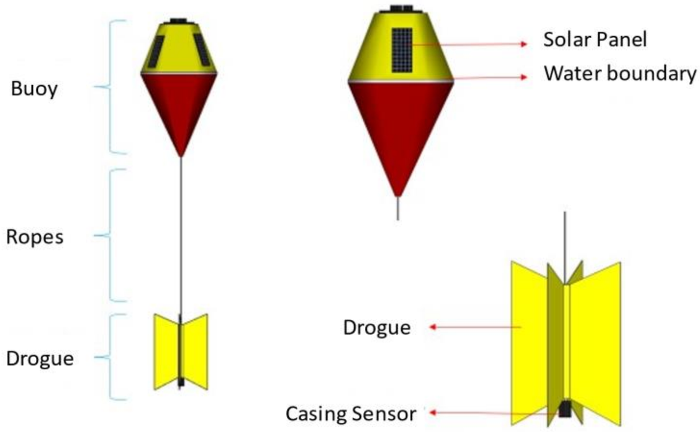

Figure 3. Design of the drifting buoy

The mechanical part consists of three main parts, consist the floating buoy, current catcher, and casing sensor. The design of the three parts from drifting buoy can be seen in Figure 3. The part of the floating buoy is made with a hexagon pyramid shape, this shape is expected to minimize the effects of waves so that they can capture currents more optimally. The main electronic compartment will be placed on the inside of the floating buoy, while the temperature and RGB sensors will be placed on the sensor vehicle. The drifting buoy to be made has a maximum length and width of 30 cm and a height of 43.4 cm. The current catcher has X-Shape form so that it can capture surface currents optimally.

Electronic circuits that are built using several electronic components including temperature and color sensor modules, Wemos D1 mini pro, Lolin ESP32, GPS modules, GPRS modules. The RGB color and temperature sensor module use an I2C communication line for data acquisition. Data acquisition from these sensors is controlled by the Wemos D1 Mini Pro. Lolin ESP32 as the motherboard, this device is connected with GPS, GPRS module as data transmission, and MicroSD module as data storage media. The acquisition of RGB color and temperature data is regulated by the Wemos D1 Mini Pro, then the data will be collected in the Lolin ESP32 which serves as the motherboard. Data transmission interval is set to five minutes.

The direction and speed of the current obtained is the result of calculating the distance from the two points of the buoy position then divided by the displacement time. To calculate the distance from two different coordinate points, the Pythagorean formula can be used as in equation (1) below

$$d = R \cdot \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \ldots\ldots(1)$$

$$v = \frac{d}{\Delta t} \ldots\ldots..(2)$$

where:

d = distance (m) x = longitude
v = velocity (m/s) y = latitude
R = earth radius (6371000m)
Δt = delta time (s)

3. Result and Discussion

3.1 Development Drifting Buoy

Gerin et al. (2018) stated that the drifting buoy is a moving instrument that ideally moves with the surrounding water so that almost the entire buoy structure is submerged in water but only part of the structure is out of the water to facilitate localization and data transmission which is practically affected by wind. Based on this statement, it can be said that this drift buoy has positive buoyancy and must be designed to minimize the effects of wind and maximize the drag area so that it can work optimally in carrying out its functions.

The drifting buoy that was built consists of three parts, namely the buoy section, the current trap section, and the sensor vehicle section (Figure 3). The float section is used for laying the main compartment of the electronic system, while the sensor vehicle section is used as a sensor placement containing the temperature sensor and RGB sensor. The parts of the buoy design can be seen in Figure 3. The buoy consists of two parts, namely the lower structure which is submerged in water, and the upper structure which is outside the water. At the bottom, the buoy is built in the shape of a hexagon pyramid with a height of 30 cm and a width of 30 cm. The cover has the same shape, namely a hexagon pyramid with a flat top for the float cover with dimensions of 13 cm high and 30 cm wide. The material used for buoy buoys is made of a mixture of resin and matt (fiber) with a buoy cover using a 3 inch PVC pipe cover. The current trap section has dimensions of 25 cm high and 12.5 cm wide each of the wings made of iron. The current trap and buoy are connected by a 150 cm long rope. The part of the sensor vehicle is in the form of a tube with a height of 9 cm with a diameter of 5 cm which is made of PVC material and is tied to a current trap using a rope. In this section, the RGB sensor and temperature sensor are placed at the bottom of the vehicle. The description of the dimensions of each part of the instrument can be seen in Figure 4.

The electronic system consists of an electronic sensor system located on the sensor vehicle and the main electronic system on the buoy. The electronic system on the sensor vehicle serves to collect temperature and RGB data, which then results are sent to the main electronic system to be stored and forwarded to the database. The microcontroller used in this sensor electronic system is the Wemos D1 mini esp8266 which can allow data from the temperature sensor and RGB sensor to be sent via a serial cable to the main electronic system. The temperature sensor used is a waterproof LM35 and the RGB sensor used is the TCS34725 RGB sensor which is the latest version of the TCS3200 and TC230 color sensors. The RGB sensor is equipped with an infrared/IR filter so that the color obtained is close to the color captured by the human eye. Another advantage of this sensor is that it is not affected by infrared light so it is resistant to light interference. However, this sensor can detect the color of objects in low light conditions with an optimum reading distance of 1 cm.

While in the main electronic system, the microcontroller used is Lolin ESP32. Lolin ESP32 is an expressive platform electronic module that is commonly used in electronic circuits for mobile device applications and Internet of Thing applications because the module contains a WiFi chip and provides wireless communication features. The Lolin ESP32 controls the electronic systems located in the main compartment as well as the electronic systems of the sensor vehicle. The data taken by the temperature sensor and RGB is then sent via a serial cable and received by Lolin ESP33 which is then stored in the SD card and then sent to the database by the GPRS SIM800L module. The micro SD Card Adapter module is a micro SD card reader module through the file system and SPI interface driver. The MCU functions to complete the file system for reading and writing micro SD cards. In addition, in the main electronic system, there is also a GPS module Ublox

Neo 6 which is used to record data on the position of the drifting buy instrument. The tp4056s charger module is a module to charge a 1 Ampere Lithium (Li-ion rechargeable battery) rechargeable battery. This module uses the tp4056s IC which is a linear charger IC for a single cell lithium-ion battery with constant current and voltage equipped with a thermal regulation system. This module is used to charge the Lippo 5500 mAh battery which is used for the power supply of electronic systems. The source of power that flows from this charger module comes from a solar panel that has been placed on the float.

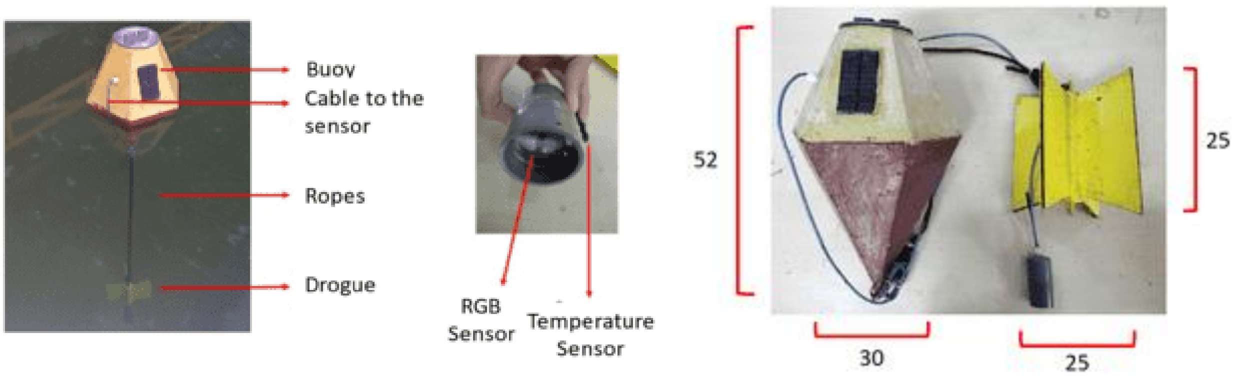

Figure 4. Drifting buoy instrument development result with its dimension

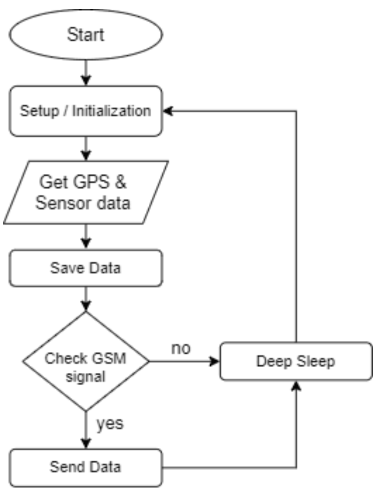

Figure 5. The programming flow of drifting buoy instrument

The programming flow built for the drift buoy electronic system can be seen in Figure 5. The acquisition of RGB color and temperature data is regulated by the Wemos D1 Mini Pro which is located on the sensor vehicle, then the acquisition data will be sent and collected at Lolin ESP32 which serves as the motherboard in the electronic system. main. In addition to sensor acquisition data, GPS data is also collected by LolinESP32 which will then be sent by the GPRS module to databases at intervals of every 2 minutes.

The measurement data format stored in the SD card and sent to the database consists of tool id, latitude, longitude, date, time, direction, speed, color temperature from sensor data RGB, lux, red, green, blue, c, and temperature data. Based on this format, the data that is then used for data analysis is speed data taken from the calculation of changes in latitude and longitude positions, RGB data used is data on the red, green, blue sections and temperature data used is temperature data from the temperature sensor.

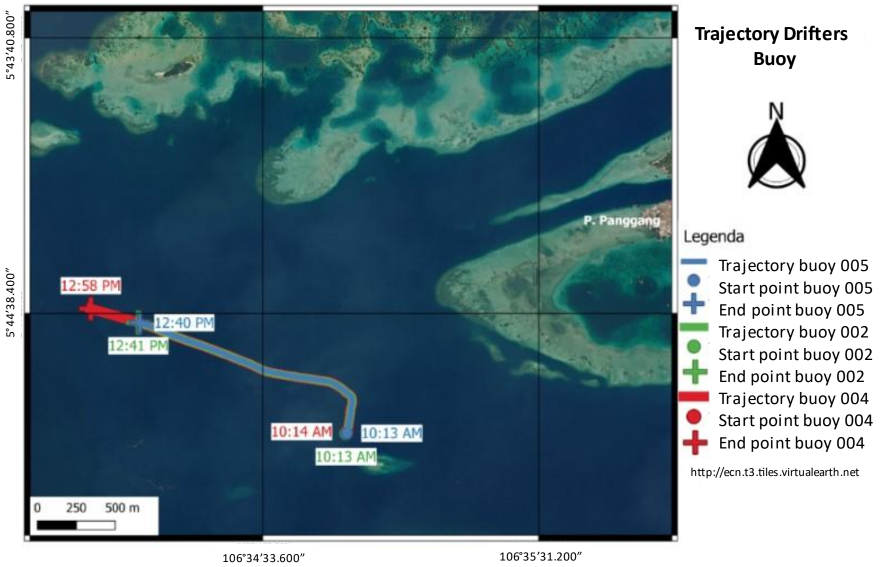

Figure 6. Release location and trajectories of the three drifting buoys

3.2 Field Test

Field trials were carried out in the west of Panggang island, precisely at coordinates -5.75102 South Latitude and 106.580795, three drifting buoys were released with buoy code 002, buoy 004, and buoy 005. The location of the instrument release was chosen to see the condition of the direction and speed of the current passing through the strait between the islands. roast and burn the bushes. The location of the buoy release can be seen in Figure 6. While Figures 7 shows that the three buoys move towards the north and then turn to the west. This is as explained by Rosyid and Luthfi (2019) that the currents in the Thousand Islands follow the pattern of wind gusts. In May – September the direction of the current is towards the west and the peak of the current occurs in August. The buoys are released simultaneously at 10.13 am until they stop at 12.40 pm respectively for 005 buoys, 12.41 noon for 002 buoy, and 12.58 noon for 005 buoy.

The condition of the waters of the Seribu Islands is influenced by the season where the west season occurs in December-March and the east season occurs in June-September. The transitional season I occur between April-May and the transitional season II occurs in October-November (Sachoemar 2008). Based on the results of plotting the overall current, the maximum speed value is 0.35 m/s and the minimum is 0.03 m/s with an average current speed of 0.19 m/s. This is in line with the results of research by Mustikasari and Rustam (2016) in the waters of the Thousand Islands during the East monsoon which showed that the maximum current velocity was 0.164 m/s and the minimum current velocity was around 0.002 m/s. (Assuyuti et al. 2018) explained that the current velocity in the waters of the Thousand Islands in the East monsoon was lower than during the western monsoon. In addition, the speed of surface currents is usually caused by winds that generate surface currents.

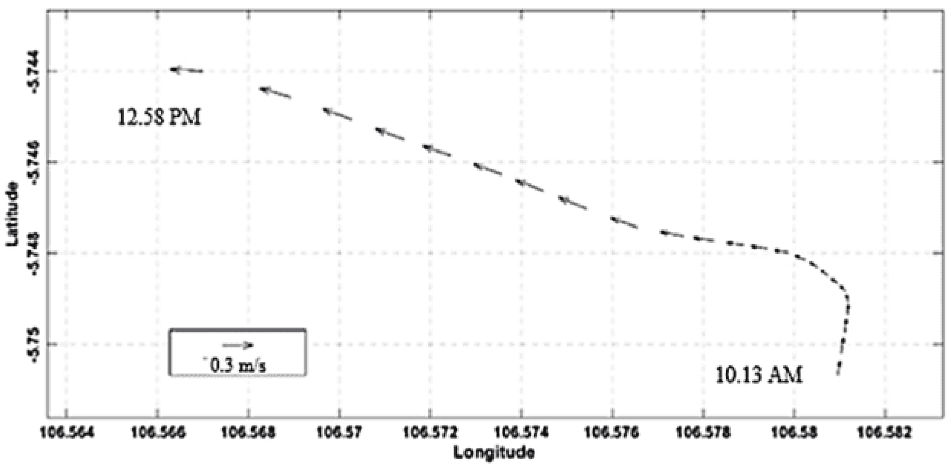

Figure 7. The plotting data from drifting buoy and current velocity during the field test

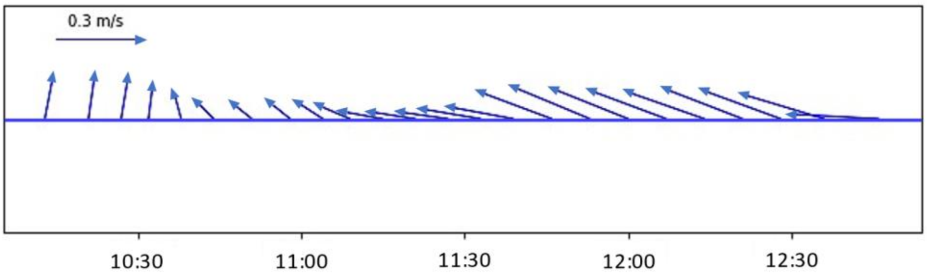

Figure 8. Vector surface current velocity at the research site

Figure 8 above is the result of the vector surface current velocity at the research site. Based on the figure 8, it can be seen that the dominant current direction is westward even though at the time of the initial release of the drift vector buoy, it points to the north. Besides being influenced by wind, the current speed is also influenced by tides. Nontji (2007) explains that tides can affect the entire mass of water in each layer and have very large energy. In coastal waters, especially in bays or narrow straits, the movement of up and down water levels can cause tides and usually, the direction is back and forth.

Figure 9 is a plot of the temperature distribution obtained from the drifting buoy. The temperature distribution obtained ranged from 26.37 to 27.83 °C with an average of 26.75 °C. This range value is by research conducted by Rositasari et.al (2017) that sea surface temperature in Jakarta Bay has a range of tropical waters in general, which is 25.6 °C to 32.3 °C. At the peak of the west and east monsoons, wind speeds and high evaporation rates reduce sea surface temperatures where the minimum temperature occurs in July and January Rositasari et.al (2017).

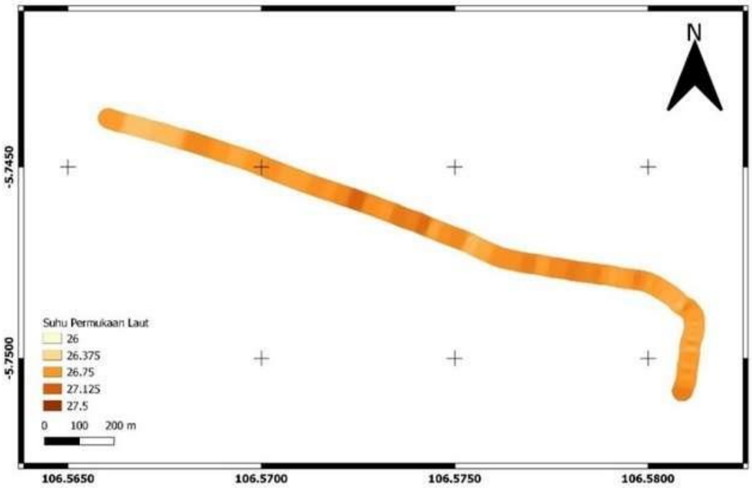

Figure 9. Sea surface temperature record during the field test

4. Conclusion

The results of trials in the field of floating float instruments have very good performance. The drifting buoy instrument that has been tested is very stable and can move with the surface currents so that it can determine the condition of the surface currents at the research site. The results showed that the current direction of the current at the research site was pointing to the West with current speeds ranging from 0.35 m/s to 0.03 m/s and an average current velocity of 0.19 m/s, while the temperature sensor installed in the drift float could measure the surface temperature. sea well which produces a temperature value of 26.37 to 27.83 °C with an average of 26.75 °C

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