# Deep-seawater Oceanographic Survey: An Experience in Facing Challenges and Opportunities

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Abstract: Onshore and offshore structure planning requires wave and current data which are the result of direct measurements on site. One area that affects the measurements is the deep-sea, where the area has large wave energy and currents that greatly affect the condition of the waters adjacent to the location of planned coastal and offshore structures. One of the most widely used survey equipment is ADP or ADCP. This paper explains the experiences of collecting oceanography data in deep-sea. The survey method entails placing an equipment on the seabed, which will emit signals indicating the flow and wave data according to the desired time and depth. The survey process, especially for the deep-sea, requires good preparation so as not to fail. The result of this paper is the identification of the technical, natural and social challenges of such project. The technical challenges are tool stability, buoyancy effects, and visualization tools with underwater camera system, underwater visibility, and sedimentation. Natural challenges are big waves, strong currents, and weather. The social challenges are destruction of property, fishing grounds on land, and the behaviour of local people. Therefore, before the survey, safety procedures and documents must be made in the form of HIRA (Hazard Identification and Risk Analysis). The authors hope that the challenges identified in this survey can be considered for other surveyors conducting similar projects in mitigating potential failures during the survey.

## 1 INTRODUCTION

The vast oceans of Indonesia have a huge potential to meet the wide range of human needs. Indonesia's maritime potential takes shape in various forms such as ocean currents, tidal waves, and others. Sea current is the water mass movement towards equilibrium which causes horizontal and vertical displacement of water masses. The movement is the result of several acting forces and factors that influence it.

An ocean current is the mass movement of sea water from one place to another, either vertically (upward motion) or horizontally (sideways movement).

According to Gross and Gross (1996), a current may be caused by wind movement, movement of thermohaline, tide flow, turbulence, tsunami, and another wave. Another potential for wave source is the tidal wave. These environmental conditions may be used to classify a potential site, for example to mark a potential location for a tidal wave-basd power plant (Junianto et al., 2020).

According to Xie et al. (2019), tidal wave is a phenomenon in which sea water rises and falls periodically caused by a combination of Earth's gravity and the gravitational pull of astronomical objects, primarily the Sun, Earth and moon. The influence of other celestial bodies is negligible due to greater or lesser distances. Under such circumstances, ocean waves play a very big role in the potential TSB.

Research on waves and ocean currents has been widely implemented in Indonesia to determine its potential. Oceanographic surveys mostly use Acoustic Doppler Current Profiler (ADCP) (Sindlinger et al., 2005; Guerrero et al., 2014; Bouferrouk et al., 2016; Latosinski et al., 2017; Huang, 2018; Santos et al., 2020; Scherelis et al., 2020; Yin et al., 2020). The equipment is mostly placed under a vessel to measure ocean current conditions, for example at a depth of 35.94 to 50.94



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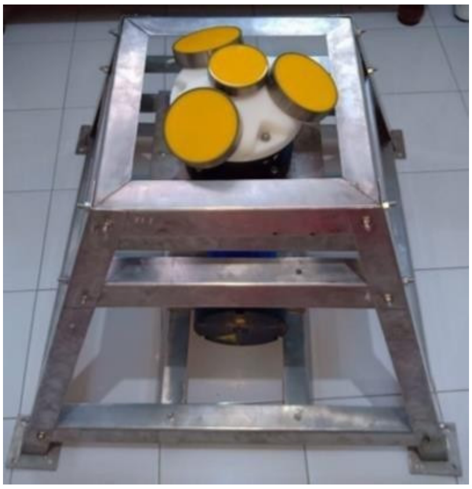

Figure 1: Nortek AWAC 400 KHz.

m, obtaining an average speed of 40.51 cm/ sec with a south westerly direction.

ADCP is one of the main tools used to determine the value of the speed and direction of ocean currents of a body of water. Its use is already very helpful for human needs in various depths. Oceanographic surveys are rarely carried out in the deep-sea, so information on constraints and opportunities is rarely found in references. Considering the remarkable potentials of deep-sea waters, this paper will thus be discussing:

1. The identification of challenges of deep-sea oceanographic marine survey in Indonesia.
2. The opportunity to develop deep-sea surveys.

## 2 POTENTIALS OF DEEP- SEA SURVEY

Deep-sea has biological and physical characters of not letting sunlight penetrate through after a certain depth. This condition forces the ecosystem in there to adapt to it as well as to different physical condition in general environment. By having several characteristics, such as low temperature, stable, clear, not pathogenic, containing nutrients, minerals such as magnesium (Mg), calcium (Ca), potassium (K) as well as other minerals in large quantities, deep-sea holds a great potential for exploration.

Usage of Deep-sea Water (DSW) is not limited only to matters relating to fisheries, but also for other things such as industrial purposes, and even health and environmental rehabilitation (Shane, 2015). The potentials of the deep-sea comes from very rich chemical contents and excellent physical conditions.

In a hydro-oceanographic survey work, there are various activities performed as bathymetry survey (mapping the shape of the seabed), measurements of ocean currents, ocean tidal measurement, measurement control nets (benchmarking), sampling of seawater and seabed sediments, and others. Hydro-Oceanographic surveys usually done in vary of jobs in coastal areas or offshore. Due to the varying parameters of deep-sea measurements, various tools have to be employed to collect these data. Required tools include:

1. Bathymetry: Single Beam Echo Sounder (SBES) or Multi Beam Echo Sounder (MBES),
2. Ocean currents: Current Meter (CM) or Acoustic Doppler Current Profiler (ADCP),
3. Tides: palm of tidal / Tide Staff or Tide Gauge, and
4. Ocean waves: Automatic Water Level Recorder (AWLR) or Wave Recorder, etc.

In deep-sea surveys, one of the main types used are ADP NORTEK AWAC 400 kHz (Figure 1). AWAC withstands water pressure up to a depth of 100 m, has an accuracy capability of up to 1.5 Hz pulse wave, and is able to measure current speed and direction. The specifications are explained in Table 1.

Table 1. Technical specifications of NORTEK AWAC - 400 kHz.

| | | |
|---|---|---|
| **Water velocity measurements** | | |
| Maximum profiling 100 m | | range |
| Cell size | | 1.0-8.0 m |
| Number of cells | | Typical 20-40, max. 128 |
| Velocity range | | ±10 m/s horizontal, ±5 m/s along beam |
| Accuracy | | ±1% of measured value ±0.5 cm/s |
| Maximum output rate | | 1 Hz |
| Internal sampling rate | | 2 Hz |
| **Wave measurement option (AST)** | | |
| Maximum depth | | 100 m |
| Data types | | Pressure, one velocity along each beam, AST |
| Sampling (output) rate | Velocity | 0.75 Hz |
| | AST | 1.5 Hz |
| No. of samples per burst | | 512, 1024 or 2048 |

A survey in East Java began from a depth of 35 m below the sea surface. With the depth of at least 35m, we classify the challenges of deep-sea survey using a case study in eastern Java's survey into several parts.

### 2.1 Technical Obstacles

Deep-sea marine survey is strongly influenced by the uncertain natural conditions. Therefore, preparation and monitoring are important to obtain a good measurement output. Some technical barriers are caused by stability of the ship, which may allow for less measuring equipment to be installed onboard to maintain its stability.

Figure 2: 30 GT Vessel is suitable for deep-sea survey.

## 3 CHALLENGES OF DEEP- SEA SURVEY

Deep-sea water surveys introduce more challenges than shallow water surveys. Waves are the main factor taken into account because it will introduce forces against coastal structures. The calculation of the planned structure takes into account wave classification according to the relative depth, which is the ratio between the water depth $d$ and the wavelength $L$ so that it becomes $\left({}^{d}/_{L}\right)$. The ocean wave is formulated in Equation (1) as follows:

$$L > {}^{1}/_{d} \qquad (1)$$

Where:

$d$ : depth
$L$ : wave period

Figure 3: web frame of ADP construction.

In the case of East Java study, the survey vessel used was a vessel of about 30 GT (Figure 2). The ship was originally a fishing vessel equipped with a pulley, which was used to roll the rope to lift up the instruments. The instruments on the ship were not stable because the wave height exceeded 2 meters. Therefore, the ADP instrument had to be framed to stabilize it when it was lowered to a water depth of 150 m. ADP web frame (Figure 3) was useful to provide additional weight effect and increased stability to maintain the position of ADP on sea floor against external forces.

Another technical obstacle of using ADCP for deep-sea water survey was the poor underwater visibility beginning at 150 m depth. Ideally, the use of ROV would be preferred to monitor the equipment. However, the cost of deploying an ROV is very expensive. Instead of using ROV, monitoring was carried out using a MK-I deep-sea Underwater Camera System (Figure 4) to monitor ADP at a depth of 150m. MK-I had a much lower operational cost compared to the ROV.


Figure 4: Visualization of MK I Deep-Sea Underwater Camera System.

### 3.1 Nature Challenge

The seabed had a calmer condition than the surface. However, predictions of current speed and direction (Figure 5) in the bottom area were a challenge that must be handled at the time of the survey.

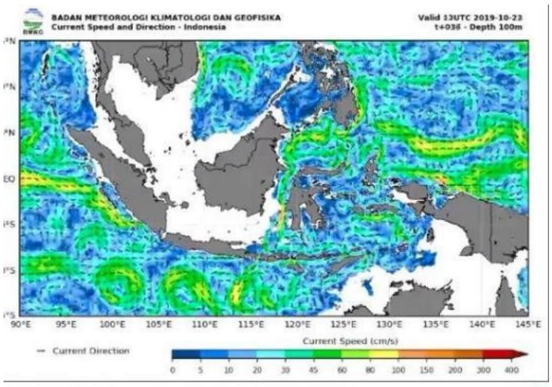


Figure 5: Current velocity and direction prediction at 100m at the time of ADP monitoring (Junianto et al., 2020).

The challenges did not include only current speed and direction, but also the water temperature. Therefore, it was necessary to ensure various safety requirements were met for this survey.

### 3.2 Social Challenges

The deep-survey was done in the offshore area far from the coastal area. Despite the remoteness of the location, vandalism still occurred. The deployed survey equipment was not attended and therefore was lost because of sabotage. (Figure 6). This highlights the need for surveys to have good security. The marker buoy should not be put on the water surface.

The society around the oceanographic survey site always determines the purpose of the survey activity. They ensure no losses on equipment occur to the surrounding site. Therefore, it is important to approach local societies before the survey.

Figure 6: Sabotaged Buoy of ADCP.

Figure 7: Fishing Net Disturbing The Buoy of ADCP.

In addition, the survey marker buoy was caught in fishing nets in the sea (Figure 7). This can interfere with the data retrieval process by ADCP. The placement of equipment at the survey location should also consider the fishermen's activities around that location.

## 4 DISCUSSIONS

The safety of personnel and equipment is paramount to the sustainability of the survey. In order to prevent risk to personnel and instruments, hazard and risk identification is necessary. This process is necessary to anticipate the risks that may hinder the activities of the survey. Table 2 shows a list identifying hazards that could potentially occur in the survey.

The explanation of activity during the survey in the deep-sea area in previous section shows that the risk of this survey is relatively large. Therefore, these risks cannot be ignored during the planning stage for deep-sea surveys. The reports during this survey, especially in the technical and social aspects, can then be used for future surveys.

Health and safety (K3) as a whole means that all workers involved in a field project are entitled to health and safety services regardless of the status of sector (formal/informal), company size, and type of work. Both the development and growth of the industrial sector are always accompanied by a huge problem of workplace accidents and occupational diseases (Scherelis et al., 2020).

## 5 CONCLUSION

A successful deep-sea survey can be performed after considering several aspects. These aspects include

Table 2. Hazard Identification and Risk Analysis.

| No | Hazard | Risk | Mitigation |
|---|---|---|---|
| **Mobilization/Demobilization** | | | |
| 1 | Instruments stolen | Instruments lost | • Attaching keys and security cover<br>• Guarding during travel |
| 2 | Instruments shaken | Broken instruments | Packing with safety tool box and selecting a suitable vehicle |
| **Instruments Deployment** | | | |
| 1 | Over-capacity boat | The boat sinks | Using qualified boat |
| 2 | Broken rope while installing instrument | Instruments lost | • Using certified rope<br>• Hiring qualified winch operator |
| 3 | Flipped | Bad measured data | Using ballast and anchor, develop stable frame, deploy in weak current period, visual check with underwater camera |
| **Data Recording** | | | |
| 1 | Insufficient power | Bad/lost measured data | Use new battery |
| 2 | Vandalism | Buoy/ marker lost | Monitoring periodically, using sling wire attached on buoy, and 24-hour guarding |
| 3 | Hit by other object | Instruments flipped | • 24-hour guarding<br>• Two 24 hour stand by guarding boat |
| **Data Acquisition** | | | |
| 1 | Broken rope when lifting the instrument | Instrument lost | Using certified rope, and hiring qualified winch operator |
| 2 | Download failure | Incomplete data | Using required battery set, using high grade data cable, and avoid hard impact |
| **Social Issues** | | | |
| 1 | Vandalism and deliberate damaging | Equipment removed from survey site | Approaching local leader and local people around the survey site, and submitting notification and permit to the Marines, Headman and DKP |

environmental, technical and social factors. This paper has presented activity in every aspect during a deep-sea survey. The paper may serve as a reference in the future to mitigate potential risks in carrying out deep-sea surveys.

Deep-sea surveys may have more complex environmental conditions, especially in sea level conditions where breaking waves do not occur. The survey equipment must be more advanced and tested for its strength so that data security, safety and quality are guaranteed. Another concern in this activity is the social interactions which may cause deployed equipment to be stolen or damaged.

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