# Current resource assessment in Brunei's coastal waters

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**Abstract.** Current Resource Assessment plays a major part in Tidal Energy Resource Assessment. The paper looks at analysing the total current data collected from BSP at Fairley Oilfield from 1st January 2019 up to 31 December 2019. The total current data and its direction was measured using ADCP, and is placed at an area with a depth of about 60m. The data is categorized into 3 depths; current speed and direction for overall depth, current speed and direction for top half of the sea, current speed and direction for bottom half of the sea. According to the current speed for the overall depth, the current speed was recorded to have an average speed of 0.27m/s and a maximum speed of 1.4m/s. For the current speed and direction at the top half of the sea, the current speed was recorded to have an average speed of 0.33m/s and a maximum speed of 2.24m/s. Finally, for current speeds at the bottom part of the sea, the current speed has an average of 0.22m/s and a maximum speed of 1.66m/s. The direction for all three categorizes were consistent in which the flow is recorded to be coming in from the East-North East to East, majority of the time.

## Introduction

Coastal water management places an important part in the economic development of a country. Unfortunately, due to climate change, damages and breakdown of a country's coastline has been witnessed around the world [1]. Not only that, the affects towards marine life could also be seen, with marine animals losing their sense of direction and the extinction and reduction of marine life in general due to climate change [2]. Tidal currents are generated due to the rise and fall of the sea tide [3]. According to Newton's Theory, tides can be defined by its harmonic periods. However, even though tides can be predictable, due to the presences of bathymetry, coastlines, island and other forces that will affect the movement and flow of total currents, it is very difficult to exactly workout the behaviour of the total currents [4].

The total current is referred to the flow of water in rivers, sea or ocean, that is caused by factors including, Tidal Current, Ocean Current, Wind, Salinity, Temperature and etc. For areas with low Tidal Range, such as Brunei Darussalam, the Tidal Currents are not dominants and does not play a major role in Total Currents. However, in some areas, with high tidal range, the tidal current is dominant and follows a clear pattern with the tides. This would mean that the Tidal Currents are predictable and reliable. Even though some researcher would refer to the flow of the water as Tidal currents, it is impossible to collect data for tidal currents only, as other factors such as wind, temperature and etc. will affect the tidal current. Therefore, total current is more suitable to be mentioned.

There are many potentials in harnessing energy from tidal currents. 70% of the world is covered in water and it is estimated that, the potential energy generated by the movement of the water globally can go up to 3000GW [5]. With that being said, tidal energy is still considered a new form of renewable energy. Even though there has been implementation of tidal energy in the past. Not many studies have been done on tidal energy resource and further development of the tidal energy converters still needs to be made [6].

To work out the feasibility of tidal energy in a specific location, an in-depth resource assessment needs to be done. This resources assessment includes, the tide and tidal current resource

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assessment, bathymetry assessment and etc. [7,8]. The feasibility of tidal energy will determine includes the practicality and economic impact in harnessing energy through tides.

As mentioned earlier, Tidal turbines are still considered in the testing stages and much more development is required. With the existing tidal extraction devices available, the minimum cut in speed for the tidal extraction device is reported to be 0.5m/s [9]. Therefore, it is advisable that the average speed of the currents within the area to be at least 0.5m/s. However, there are a lot of concept designs that have been simulated which suggest that the cut in speeds to be lower to support low velocity currents. There are also many types of tidal turbine deployment suggested, such as Gravity Structure, Piled Structure or Floating Structure [10]. These deployment methods would be dependent on the site specification available at the area.

Most studies that have been done on tidal energy resource assessment have been seen at locations with high tidal currents with high tidal range at the oceans or seas, whereas less energetic currents have also been studied, however in shallower areas such as rivers for easy excess and installation. However not many studies on tidal energy have been done on many parts of the world yet [11]. Tidal current energy is proportional to the Fluid Density, Area and the cube of its velocity. The velocity plays a major role in the power output and therefore, a slight change in velocity will see a significant impact on the power output. The power output would also be determined by the size of the turbine, as channels and river that would usually have higher current flow may be limited to the size of the turbine generator compared to the sea or lake that will allow a bigger size turbine generator [12].

Brunei Darussalam is located in South East Asia, in Borneo Island. The country, faces the South China Sea and has a coastline of 161km, which means the country would have an opportunity to extract energy through the currents. Not only that, about 85% of the residence, resides in the coastal area in which majority of activities such as social, cultural and economic activities are concentrated. However, as it stands, there have been no proper study on the currents in Brunei Darussalam to suggest the possibility of Tidal Energy in Brunei Darussalam [13].

## Methodology

The total currents at the coastal waters of Brunei Darussalam were measured using an ADCP, which was set up by Brunei's Shell Petroleum (BSP). The ADCP was placed near one of BSP's oilfield, Fairley Oilfield. Fairley Oilfield, is located west of Brunei Darussalam, and is located 45km away from the shoreline. The ADCP was placed on the seabed which has a depth of about 63m. The data collected was from 1st January 2019 up to 31 December 2019. The data was measured with 10mins interval at depths 3.5m, 7.5m, 11.5m, 15.5m, 19.5m, 23.5m, 27.5m, 31.5m, 35.5m and 39.5m. On top of that the direction of the currents were also recorded by the ADCP for each depth. The direction of the current, which was measured by the ADCP, was measured using bearing system.

The investigation is done by looking at the effects of the depth towards the velocity of the currents and its directions in the Coastal Waters of Brunei Darussalam. This study will present how the current behaves in the Coastal waters of Brunei Darussalam, which includes looking at the maximum and average velocities of the current, the average direction of the currents and how it all behaves as the depth changes. Consistency in the water velocity and direction will also be touched upon to see the stability of the water at different depths and time. These assessments play a major role in assessing the current resource for energy extraction and device determination.

The data are categorized into three depths; the data for overall depth of the sea, the data at the top half of the sea & the data at the bottom half of the sea. The water velocities are compared for the three categorize depths to see how different depths affect the water velocity. The direction in which the water flow is also investigated to see whether the incoming flow changes direction or remains constant.

**Results & Discussion**

Fig. 1 shows the direction of the current compared to the 3 categorized depths of the sea. As can be seen in Fig. 1, for all the categorize, the highest percentage of the direction in which the current flows are flowing towards the North East to East direction, with about 18% of the flow flowing towards the East and 14% flowing towards the East-North East for the total average current for the entire depth of the sea. For the top half of the sea, about 14% of the flow is recorded to be flowing towards the East-North East and about 13% of the flow is recorded to be flowing towards the South East. For the Bottom half of the sea, 23% of the flow is recorded to be flowing towards the East-North East Direction, whereas the other incoming flow is recorded to be heading towards the North East and East direction with a total of about 22% combined.

For all categories, it can be seen that majority of the water flow would be flowing towards the East-North East to East direction, with only a small percentage of the water flow changing its direction. However, comparing to all three categorizes the currents flowing at the Bottom half of the sea, shows the most consistent in which the current flows towards the East-North East majority of the time. This would make it favorable for energy extraction using currents, as the device does not need to consider the changing direction of currents.

Fig. 2 shows the average current speed for all depths at the coastal waters of Brunei Darussalam for the whole of 2019. As can be seen in Fig. 3, there are times in which the device stopped recording, due to device malfunctioning or maintenance where being done on it. From the data collected, the average velocity is recorded at 0.27m/s only, with the highest recorded value at 1.43m/s. However, it can be seen that there are fluctuations in the water velocity which suggest that the water velocity is not stable and also, in general, the middle of the year provides a higher water velocity.

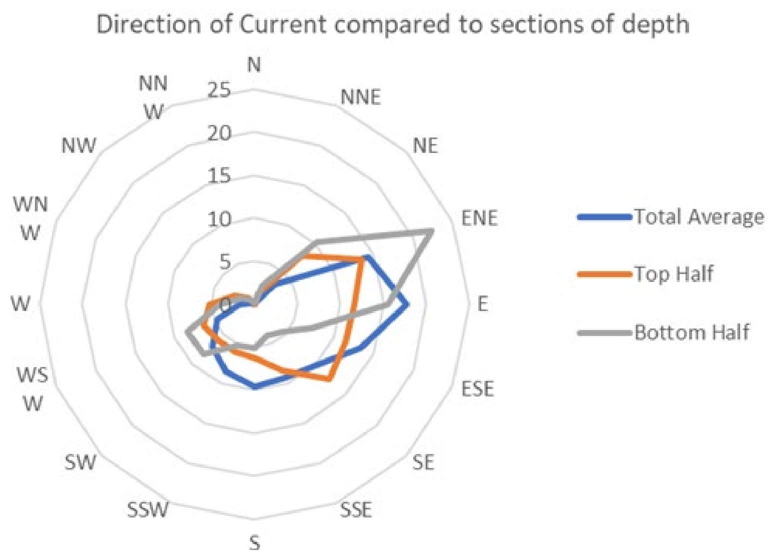


*Fig. 1. Direction of the currents at different depths*

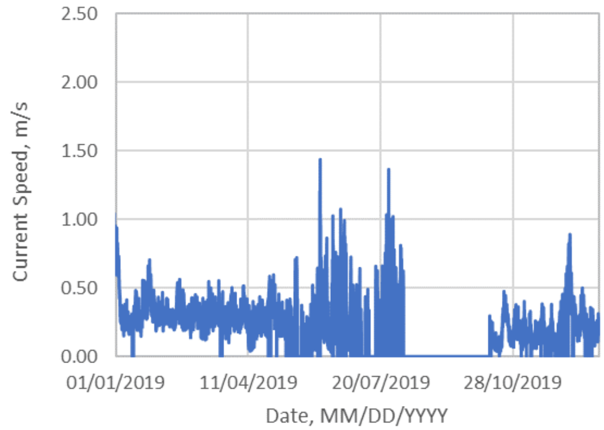


*Fig. 2. Total Average Current at the Coastal Waters of Brunei Darussalam*

According to Fig. 2, there are no evidence in which the total currents follow a pattern, which means that predicting the water velocity in Brunei would be very difficult. The current speed also rarely exceeds, 1m/s for the whole year of 2019, with sudden spikes appearing that do exceed 1.0m/s. These sudden spikes are not consistent and may be due to a lot of factures, such as bad weather in the South China Sea. Fig. 3 shows the average current speed for 2019, for the top half of the sea at the coastal waters of Brunei Darussalam. The average current flow was found to be 0.3m/s for the whole year of 2019 with the highest recorded value of 2.24m/s.

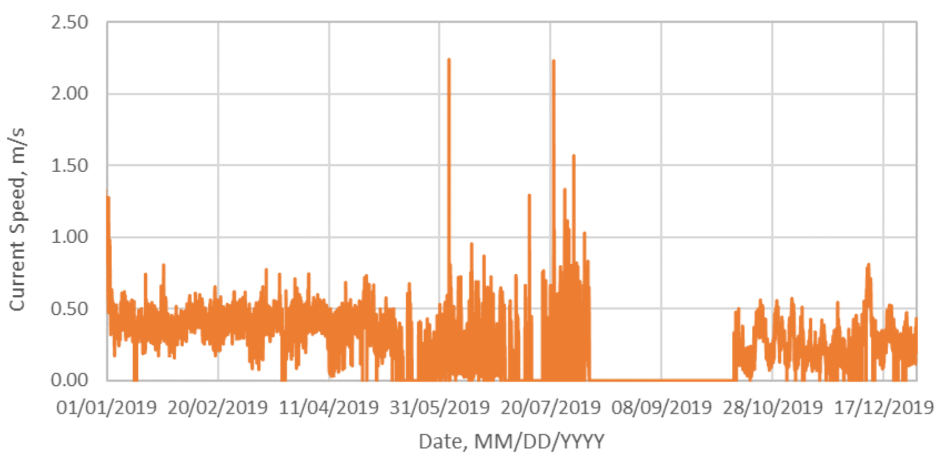


*Fig. 3. Average Current at the top half at the Coastal Waters of Brunei Darussalam*

From the data analysis from Fig. 3, it is clear that the average speed is higher compared to the average current speed for the whole depth of the sea. This could be due to less friction from the sea bed which would affect the water flow, and also, the bathymetry of the sea would have less impact on the current speed. One of the main reasons why, the currents at the top half of the sea are travelling faster is also due to the influence on the wind at the South China Sea, which would accelerate the water flow. Similar to the data for the overall depth, it can be seen that the data is not stable and that fluctuations form. In fact, it can be seen that there are more fluctuations at the top half of the sea.

Fig. 4 shows the average current at the bottom half of the sea at the coastal waters of Brunei Darussalam. The average current speed for the bottom half of the sea is recorded at 0.22m/s, whereas the highest recorded value is at 1.7m/s. Again, similar to Fig. 2 & 3, spikes are form at the same time as when the other recordings recorded the spikes. The average current speed is lower than the average current speed at the top half of the sea and overall depth of the sea. However, if we compare the highest recorded value for the current at the Bottom half of the sea, and the overall depth of the sea, the bottom half of the sea has a higher value with 1.66m/s, whilst the overall depth of the sea has a value of 1.4m/s. Fig. 5 shows the average current speed throughout the year of 2019, against the depth of the sea. As can be seen in the figure, as the water gets deeper, the velocity of the water reduces drastically. The figure shows that at the surface of the water, the water is flowing more than 0.6m/s. However, after 10m depth into the sea, the water reduces drastically to about 0.23m/s and fluctuates slightly up to about 40m in depth. However, pass 40m deep, the velocity decreases even more as by 60m, which is few meters from the seabed, the velocity falls to zero.

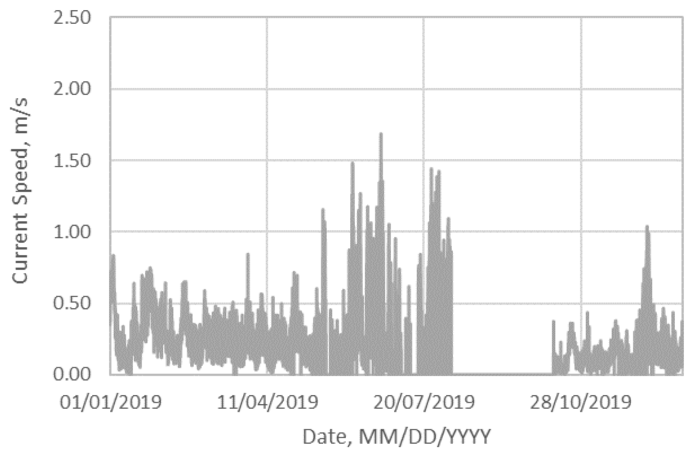


*Fig. 4. Average Current at the bottom half at the Coastal Waters of Brunei Darussalam*

According to the research, the water flows much faster at the top of the surface as, wind accelerated the flow of the water. However, as it goes deeper, bathymetry and friction affect the flow causing the flow to slow down. Fig. 6 represents that satellite projection of the water flow at the South China Sea for 15th June 2019 at 08:00 Local time. Brunei Darussalam is located in the Borneo Island and to the north of Brunei is the South China Sea. It shows that there are circulation form in the South China Sea, which would result in the overall velocities to be slow. On top of that, there are other countries surrounding Brunei Darussalam, which would result in the water flow to reduce its energy, hence why the water flow in Brunei Darussalam is considerably low.

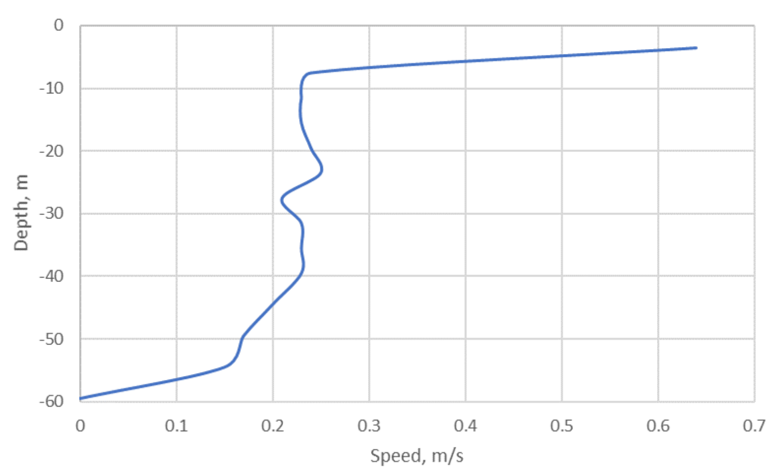


*Fig. 5. The Average Current Speed vs the Depth of the Sea*

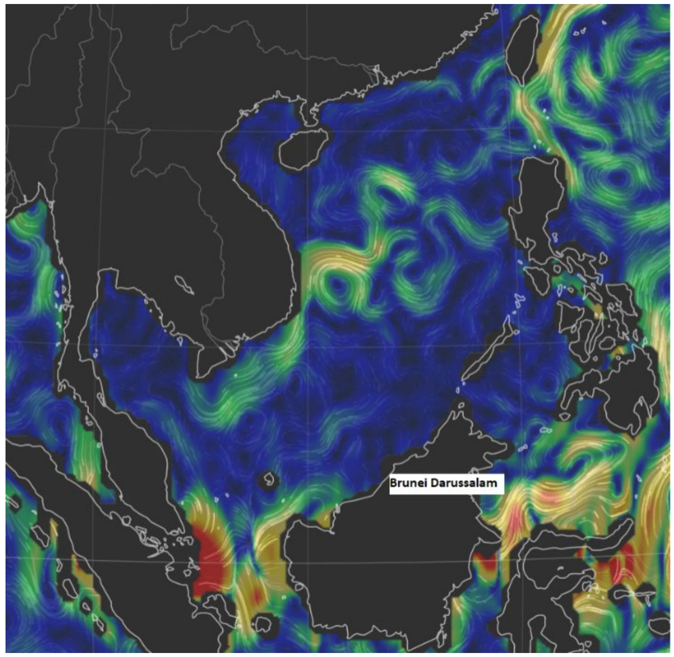


*Fig. 6. Satellite Projection of water flow at the South China Sea*

## Conclusion

According to existing Tidal turbines, current tidal turbine designs would have a minimum cut in speed of about 0.5m/s [14]. However, in order to produce energy economically, the average velocity should be around 1.5-3.5m/s [15]. With that being said, even though Brunei has a good location and that the currents in Brunei Darussalam shows promising results. It is not sufficient to generate electricity through tidal currents in Brunei Darussalam economically. Furthermore, more research needs to be done at different parts of the Coastal waters of Brunei Darussalam, to fully determine the feasibility of Tidal Energy and examine the Total Currents Resource in Brunei Darussalam.

From the data collected, the overall depth, the current speed was recorded to have an average speed of 0.27m/s and a maximum speed of 1.4m/s. For the current speed and direction at the top half of the sea, the current speed was recorded to have an average speed of 0.33m/s and a maximum speed of 2.24m/s. Finally, for current speeds at the bottom part of the sea, the current speed has an average of 0.22m/s and a maximum speed of 1.66m/s. The direction for all three categorizes were consistent in which the flow is recorded to be flowing towards the East-North East to East, majority of the time. Therefore, when comparing which area provides the highest average and maximum velocity, the top half of the sea would provide the highest velocity, however with the least consistent direction. With that being said, even though the bottom half of the sea provides the lowest average velocity, it is also the most consistent in the direction of the current flow.

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