

THE MYTH AND LEGEND OF SADAI AND GASPAR STRAIT BANGKA BELITUNG (BANCA-BILLITON) AND OCEANOGRAPHIC CONDITIONS

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ABSTRACT: Sadai strait is located in between of Bangka and Lepar island (Pulo Lepar). Gaspar strait positioned between Bangka and Belitung island was named after the Spanish captain passed through it from Manilla in 1724. Southeast part of Bangka had been called Macclesfield after Captain Hurle in English ship Macclesfield. The myth of many pirates, the legend of many sunken of warship and merchant ships of Chinese, Dutch, Japanese at Gaspar Strait. The southernmost dangered Fairlie Rock was named and discovered by a merchant company ship Fairlie in 1813 and a more detail examination by Captain Ross at surveying ship Discovery in 1814. A Portuguese ship sail from Macao was wrecked in 1816 at Discovery Rock. The study aims to build and analyze the bathymetric, current spatial model and tide data to discover the oceanographic characters related to the sunken ships legends. Measurement based on a hydroacoustic method using single beam echosounder for primary data, GEBCO bathymetric and Landsat-8 satellite for secondary data. GPS coordinate and depth value of x-y-z was processed for a spatial layer using geo-statistical gridding method. A spatial numerical model of current based on data of bathymetry and tide data using the hydrodynamic module to build two and three-dimensional models based on a triangular mesh (system flexible mesh) spatial unit with consideration on the seawater baroclinic condition. Narrow strait and small islands widely distributed around Gaspar strait as a channel of no escape in the case of sailboat piracy. Oceanographic variable mainly caused by extremity and known as the most dangerous 'Fairli-and Discovery rock' with narrow and shallow rock bottom morphology especially at low tides and considerable extent of sand-dunes and the north (Natuna island) to south (Bangka-Belitung) seawater volume transport and current pattern interactions seems to be the most dominant and unpredictable situations for ship line safety.

Keywords: Gaspar, Strait, Bangka, Oceanographic

1. INTRODUCTION

The study area is Lepar strait at Sadai and Gaspar Strait, South Bangka Regency Province of Bangka Belitung coordinate of 106.585° – 106.85° E and 2.93° – 3.06° S (Figure 1), in between of Sadai coastal area and Lepar island. Sadai or Lepar strait is located in between of Sadai coast of Bangka and Lepar island (Pulo Lepar). While Gaspar strait positioned between Bangka and Belitung island was named after the Spanish captain passed through it from Manilla in 1724. South east part of Bangka had been called Macclesfield after Captain Hurle in English ship Macclesfield. The myth of many pirates, the legend of many sunken of warship and merchant ships of Chinese, Dutch, Japanese at Gaspar strait with many small islands, the extremity of shallow rock channels especially at low tides and considerable extent sand-dunes. The southernmost danger Fairlie Rock was named and discovered by a merchant company ship Fairlie in 1813 and a more detail examination by Captain Ross at surveying ship Discovery in 1814. A Portuguese ship sail from Macao was wrecked in 1816 at

Discovery Rock [1]. Estimated about 12.7 billion US dollar treasure worth of sunken ships in Indonesia [2].

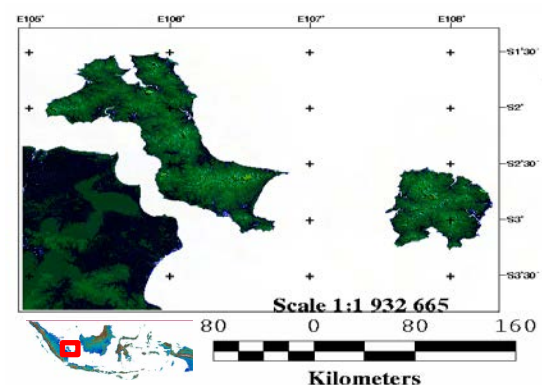


Figure 1. Study area at Gaspar strait between Bangka and Belitung island

Sadai strait located between Bangka and Pongok island, Lepar strait is between Pongok and

Belitung and Gaspar stait is located between Pongok-Bangka and Belitung island and there were about 27 small islands around such as Lepar, Panjang, Tinggi, Kelapan and Pongok islands [3]. The aim of the study is to collect the historic-maritime anthropological information and built spatial database of bathymetry, tide, current speed and direction numerical model as well as analysis the oceanographic character on the legend of Gaspar strait.

2. METHOD.

Bathymetry data and processing.

Bathymetric measurement based on a hydro acoustic method using single beam echo sounder for primary data, combined with GEBCO bathymetric and Landsat-8 satellite for secondary data [4,5,6]. Water depth acoustic measurement using a zig-zag V-track with consideration of local coastal condition such as sand dunes, underwater seagrass beds or coral reef for good spatial data coverage. GPS coordinate of latitude, longitude and depth value of x-y-z data column *Microsoft excel* format was processed for a spatial layer using geo-statistical gridding method. Bathymetric measurement based on a hydro-electric or acoustic method using single beam echo sounder by means of a transducer and receiver of acoustic signals (Indonesian National Standard SNI.7646-2010) and using a survey vessel. Transceiver releases the acoustic beam and swept over the bottom of the sea.

Extrapolations from the point or coordinate into a spatial layer transformation using ER Mapper software with the geodetic datum of WGS-84 and S-UTM48 map projection. The spatial bathymetric data then corrected based on the real numeric bathymetric data from echo sounding. The spatial bathymetric data can be presented also as two and three-dimensional forms with spatial scale and depth contour lines [7]. Also supported with satellite data processing for *Satellite-Derived Bathymetry* (SDB) method for bathymetric analysis [7,8,9,10,11,12,13,14] where the basic concept is :

$$\text{Satellite-Derived Bathymetry} = \text{Ln Blue} / \text{Ln Green}$$

The further algorithm had been developed base on band-5 and band-2 of Landsat-8 satellite data and validated using field measurement bathymetric data. The concept based on a consideration of medium land-sea contrast band and seawater penetrating short wave length or seawater attenuation band. Three approaches of band-ratoning, band-thresholding and band-mean value method had been explored and compared. In order

to smooth the value bathymetric data scale then a logarithmic transformation was used in the algorithm. That is a logarithmic transformation of 500 - 600 nm to 400–500 nm wavelength band [15].

Spatial Numeric Current Model:

A spatial numerical model of current using bathymetry and tide data for a hydrodynamic module to build two-dimensional spatial models based on a triangular mesh (flexible mesh) spatial unit with consideration on the seawater baroclinic condition [16].

The dynamic numeric spatial current model was build using MIKE-21 (Evaluation Licence-Waindo Specterra). Design for the spatial model using '*triangular flexible mesh method*' with total 1966 grid element as in Figure 2.

Tide variable was as set as the main generating force in the hydrodynamic model. Harmonic component of tide variables M2, S2, K1, and O1 was used as input for tide-generating force. Horizontal eddy's viscosity using Smagorinsky constant of 0.28 and for bottom resistance using *Manning Number* of 32 m^{1/3}/s. All constant used in the model in the sensitivity range of hydrodinamical model as suggested by DHI as developed in MIKE-21. Main bathymetric data used in the model was the real field data and also data of *General Bathymetric Chart of Ocean* (GEBCO) with 30'' (second) resolution (Figure 2). Other than tide data used also using 10 m resolution wind speed data above the sea from the *European Center for Medium-Range Weather Forecast* (ECMWF) with 0.125° resolution [17].

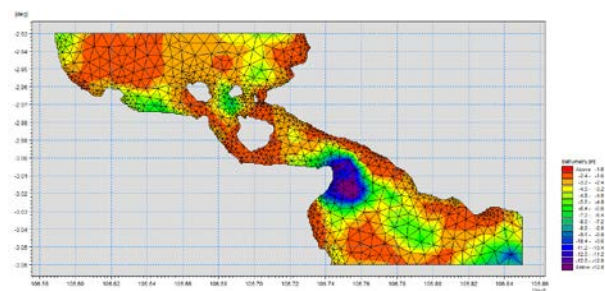


Figure 2. Flexible *triangular mesh* for the current domain model with depth (m) color scale bar

Hydrodynamic equations used in the three dimation model is *Incompressible Reynolds Averaged Navier Stokes* using assumption of Boussinesq and hydrostatic pressure. The continuity equations are as developed by [17]:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \quad (1)$$

While moment equations on the x and y absis [17]

$$\frac{\partial u}{\partial t} + \frac{\partial u^2}{\partial x} + \frac{\partial uv}{\partial y} + \frac{\partial wu}{\partial z} = f v - g \frac{\partial \eta}{\partial x} - \frac{1}{\rho_0} - \frac{\partial p_a}{\partial x} - \frac{g}{\rho_0} \int_z^\eta \frac{\partial \rho}{\partial x} dz + F_u + \frac{\partial}{\partial z} \left(V_t \frac{\partial u}{\partial t} \right) + u_s S \quad (2)$$

$$\frac{\partial v}{\partial t} + \frac{\partial v^2}{\partial x} + \frac{\partial uv}{\partial y} + \frac{\partial wv}{\partial z} = -f u - g \frac{\partial \eta}{\partial y} - \frac{1}{\rho_0} - \frac{\partial p_a}{\partial y} - \frac{g}{\rho_0} \int_z^\eta \frac{\partial \rho}{\partial y} dz + F_v + \frac{\partial}{\partial z} \left(V_t \frac{\partial v}{\partial t} \right) + v_s S \quad (3)$$

where t as time; x , y and z kartesian coordinate; η sea surface water elevation; d as water depth; h as $\eta + d$ total depth; u , v and w is velocity component (x , y and z); f as $2\Omega \sin \phi$ is coriolis variable and ϕ geographical latitude; g as gravitation; ρ as density; V_t is vertical turbulence (or eddy viscosity); p_a is atmospheric pressure and ρ_0 as reference density. Tide phenomena known as interactionthe of sun, moon and earth and each generates different of tide components. T-Tide is one tide analysis based on *Least Square* on MATLAB software. Program based on harmonic constant analysis consist of some subrutin steps in MIKE-21 tide simulation. Tide components used in the model for Sadai and Gaspar strait as presented in Tabel 1. Several tide analysis are *Mean Sea Level* (MSL) is average seath water level, *Mean High Level Water* (MHWL) is average of the high water level in 18.6 years period. *Highest High Level Water* (HHWL) is the highest water level at full moon or dark moon period. *Mean Low Level Water* (MHLW) is average of the the highest watthe er level for 18.6 years period. *Lowest Low Level Water* (HHWL) is the lowest seawater level in the full and dark moon.

Tabel 1. Value of main tide components at Sadai and Gaspar strait

Component	Frequency	Amplitude	Phase
M2	0.0805114	0.0767	344.5
S2	0.0833333	0.0283	160.93
N2	0.0789992	0.0143	262.67
K2	0.0835615	0.0261	225.18
K1	0.0417807	0.6793	32.44
O1	0.0387307	0.441	336.67
P1	0.0415526	0.2248	39.51
M4	0.1610228	0	127.73
MS4	0.1638447	0	193.06
S ₀		-0.00692	

3. RESULT AND DISCUSSION

Gaspar strait had been officially determined as *ALKI (Alur Laut Kepulauan Indonesia)* that is the Indonesian 'nusantara' sea-lines as one main transport system lines. In broad sense meaning as well as maritime anthropological interactions for economical, ethnic – cultural civilization, imperial envoys since the 7th century, such as I-Tsing bhudist envoys to Sriwijaya kingdom at central Sumatera. The international community is known Gaspar strait as part of 'the silk line' for trades mainly spices products which were dominant at the era. Spice traders and imperial envoys from European, Arabian, Chinese to Indonesian waters had been plays an important role at the time. The cultural and civilization is Cheng Ho or Zheng He Chinese imperial envoys to the north coast of Java. Also, the Chinese imperial envoys of Ong Tien Nio who become the queen of the King Sunan Gunungjati at Cirebon Kingdom west Java in 14 century. Sailing map of the spice trade from the Ryukyu kingdom at Okinawa Japan to Srivijaya at Palembang central Sumatera, Bangka and Java island was officially documented in the Ryukyu imperial palace.

The maritime anthropological interaction than in turn was widely distributed at many Indonesian underwater archaeological sites as sunken ships and wreck. According to historian J.J. Rizal in [18,19] along with the development of astronomical knowledge in 15-16 century, the Italian - European explorer Christopher Columbus and Vasco da Gama from Portugal had looking for the origin of spices site. While the southeast Asian spice traders hide the maps so that the European explorers could not find. The aggressive European explorer was aimed to dominate the spice commodities at southeast Asia. The case was so important in the feudalistic European community whom ones to be eligible or to enter the elite class level.

Even many explorers had to sacrifice their life in order to dominate in the southeast Asia spice trading struggle. Hundreds of Vasco da Gama boat crews had died in their 1498 expedition to Asia. Then European spice trader had reached Indonesian 'nusantara' archipelago in 16th century. With the most expensive spice trinity pepper-clove-nutmeg as the main trade commodity in Europe. That commodity was mainly found at Bangka Belitung, Ternate-Banda Molucas and Java. The era followed by the three and half century Dutch colonization to Indonesia since then with the addition of sugar cane and tea-leaf commodity. Further trade penetration and colonization happened in the era of Srivijaya, Demak, Banten, Gowa and Mataram kingdom [19]. The legend of Gaspar strait has been widely known along with the history as the very dangerous shipping line since the 14th century, known as a

channel of no escape for sail boat piracy and underwater treasure of many sunken ships. According to the Indonesian National Rescue, the latest incident was three ships sank at Gaspar strait in January 2017 with two crew ship dead. Legend of the European sunken ships 'Flor de la Mar' (Flower of the Sea) with 60 ton of gold in the bunker of the ship. Another most phenomenal sunken ship history was Tek Sing or 'Bintang Sejati' (The True Star) a big sailing boat of Chinese had sunken on February 6th 1822. The boat was called as 'The Titanic from the East' length of 50 and wide 10 meters, weight 1,000 ton and a sailing mast height of 90 feet. The boat was sailing from Amoy (Xiamen) at Hokkian heading to Batavia (Jakarta) carrying of ceramics, crashing coral rock and sunken at depth of 100 feet. At May 12th 1999 Englishman treasure hunter Michael Hatcher had found the wreck and excavated 350 thousand pieces of the Chinese ceramics[19,20].

Analysis of tide variables based on tide components at Sadai and Gaspar strait (Table.1) with a series of formula and value as follows :

$$Z_0 = M_2 + S_2 + N_2 + K_2 + K_1 + O_1 + P_1 + M_4 + MS_4 = 1.4905$$

$$MSL = S_0 = -0.00692$$

$$HHWL = S_0 + Z_0 = 1.48358$$

$$MHWL = S_0 + (K_1 + O_1) = 1.11338$$

$$LLWL = S_0 - Z_0 = -1.49742$$

$$MLWL = S_0 - (K_1 + O_1) = -1.12722$$

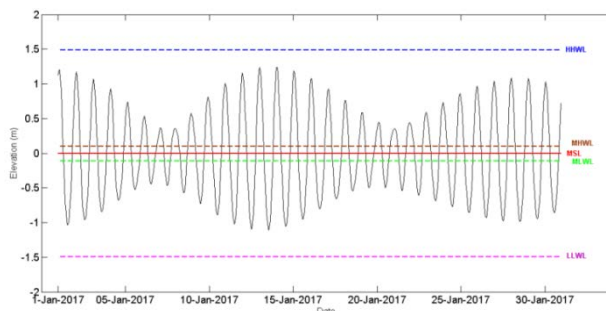


Figure 3: Graphic and Value of MSL, MHWL, HHWL, MLWL and LLWL of Sadai and Gaspar Strait

Tide range in the area between 1.5 m at high tide (HHWL) and minus 1.5 m at low tide (LLWL). Spatial bathymetry data base resulted from field echo-sounding with cm-scale resolution accuracy. Bathymetry or depth data measured by

echosounder from the sea surface or satellite data derived depth then processed as a spatial layer should describe the bottom morphology of the Sadai and Gaspar strait as in Figure 4 and 5 [7,21]. An important finding of Gaspar strait was that the narrowest cross-section with 10.2 km (6.34 miles) wide V-type bottom morphology to 70 m depth. Very shallow at both sides of V-cross section with depth range 1 – 5 m. The depth information, especially in shallow seas and it's dynamic, would be important physically for its oceanographic phenomenon such as tides, current, waves, as well as ecology, coastal risk-hazards and economic investment potentials [22].

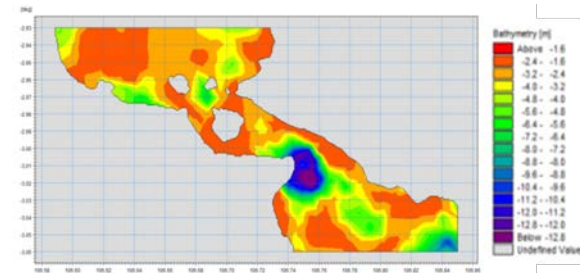


Figure 4: Field Measured Bathymetric Data of Sadai – Lepar straits

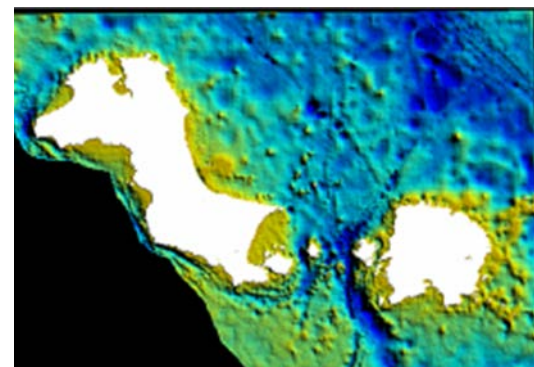
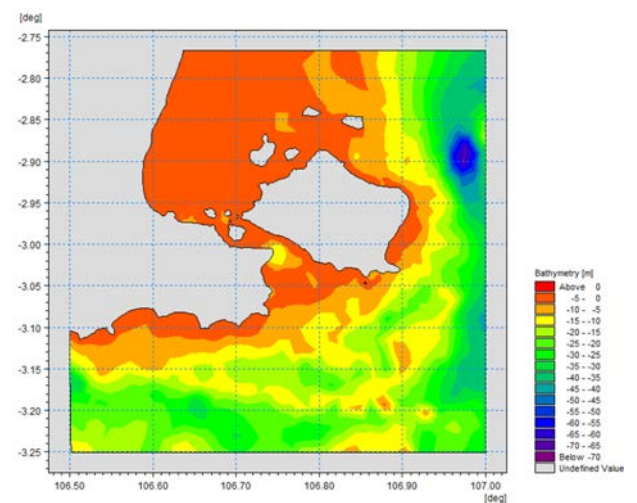


Figure 5: Field measured bathymetry data of Sadai, Lepar (above) and GEBCO bathymetry of Gaspar strait (below)

Three algorithms for *Satellite-Derived Bathymetry* (SDB) had compared three approach *band-ratoning*, *band-thresholding* and *band-mean value* using band-5 and band-2 of Landsat-8 satellite data. The best fit spatial model of SDB found was band thresholding based on a polynomial regression $y = -235.3(\log B5 - \log B2)^2 - 126.2(\log B5 - \log B2) - 13.35$ with highest coefficient of determination $R^2 = 0.849$ as in Figure 6 [15]. Where for the more smooth gradient of bathymetric data a logarithmic transformation was applied. The more detail three-dimensional bathymetric layouts of Sadai and Gaspar straits as in Figure 6 and 7 indicates of some gentle and steep narrow slope bottom morphology at relatively shallow straits. In the case a vessel sails in a narrow and high current velocity, the vessel should take to the nearest to the coast side, but another risk of shallow bottom collision possibilities.

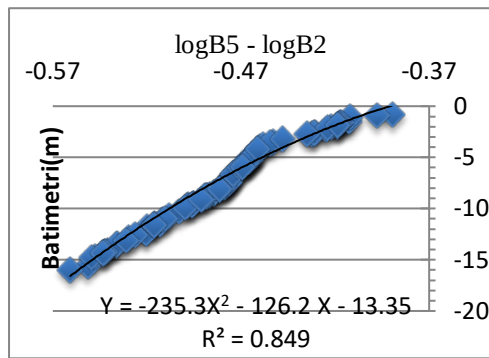


Figure 6: Polynomial regression of $\log B5 - \log B2$ thresholding *Satellite-Derived Bathymetry* Landsat-8 with field bathymetry data.

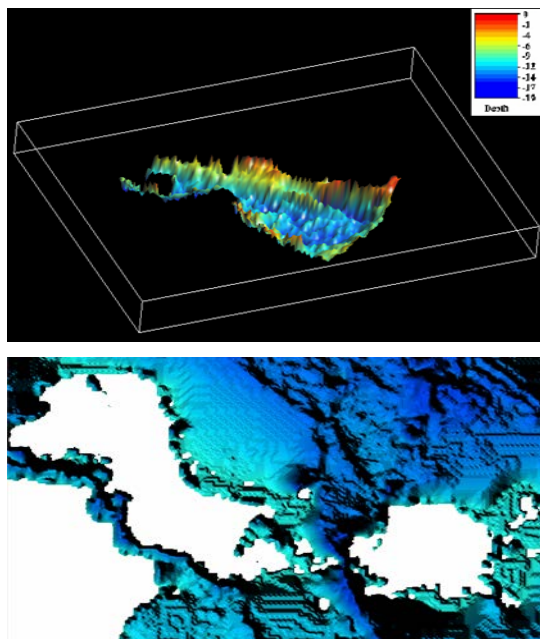


Figure 7: Result of bathymetric spatial model based on SDB of field and LogB5-LogB2 Band-thresholding of Landsat-8 at Sadai and Gaspar strait

Result of current speed based on numerical model at Sadai straits between 0.015 – 0.225 m/s, Lepar strait between 0.025 – 0.350 m/s and at Gaspar strait during high tide revealed that maximum southward current speed of 0.24 - 0.65 m/sec (Figure 8), and result of numerical model according to [23] the highest current speed was in December about 2.12 m/s that is during transition from low to high tide period with dominant influence of tide and surface winds.

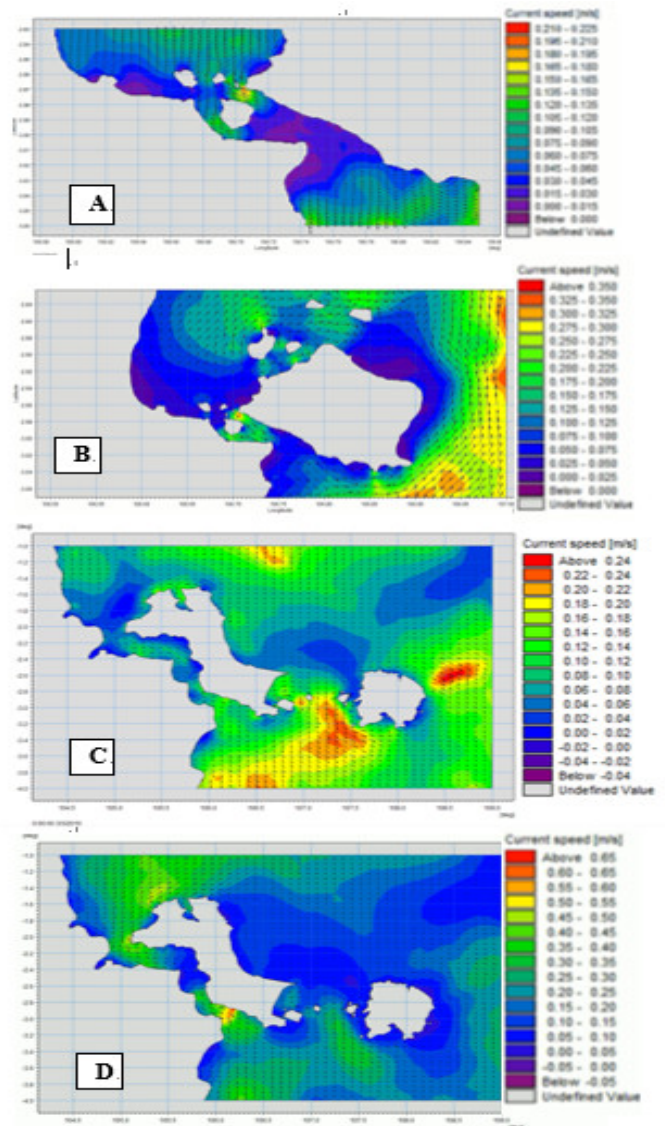


Figure 8: Result of spatial current speed and direction at Sadai (A), Lepar (B), Gaspar strait low tide (C) and Gaspar strait high tide (D)

As stated by [24] that significant wave height (SWH or H_s) for 100 years return period for Natuna sea based on SWAN (Simulating Wave Near-shore) model is 2.97-3.37 m, ERA-Interim

model is 4.01-4.13 m and SEAFINE (SEAMOS-South Fine Grid Hindcast) model is 5.24-5.67 m. During the North East Monsoon Season, the average significant wave height is up to 1.5 m and the corresponding average wave peak period is 7–8s. The western region experiences waves with a smaller height of 0.5–1.0 m with an average wave period of 4–5s. Average significant wave height is less than or equal to 1.0 m and the average peak period is shorter (2–4 s) during the South West Monsoon Season and both transitional seasons in this region [24,25].

The north-south Natuna to Bangka Belitung islands seawater volume transport average in the period of 2010-2014 flows through Karimata and Gaspar straits were -2.75 Sv and -1.98 Sv, respectively (where 1 Sv = 106 m³/s). The negative value shows the southward volume transport, while positive to the north [26].

The southward total seawater transport from the South China Sea to Karimata Strait and Gaspar Strait to the Java Sea indicates that these may be due to the system of the West - Indonesia Through Flow (W-ITF). In the case, Gaspar straits with three-dimensional bathymetric layouts with a steep slope in a narrow bottom morphology at relatively shallow straits will increase to double the current speed. In the case a vessel sails in a narrow and high current velocity, the vessel should take to the nearest distance to the coast side [27], but with another risk of shallow bottom collision possibilities. The north-south current speed in the area seems to be strengthened by other oceanographic variables such as wave, wind and seawater transport volume.

4.CONCLUSION

The myth and legend of Gaspar strait many sunken ships accidents, known as the channel of no escape in the case of sail boat piracy and much excavated underwater treasure represented mainly Chinese ceramics. Gaspar strait as maritime anthropological interactions for the economy as 'the silk line' for spices products trades from European countries to Indonesia. An ethnic and cultural civilization, imperial envoys since the 7th century, such as I-Tsing bhudist envoys to Sriwijaya kingdom at central Sumatera. The sunken ships analysis based on oceanographic variables is mainly caused by narrow and shallow strait bathymetric morphology known as to collision of the ships onto underwater rocks, coral-reefs and sand dunes. Also caused by the interaction of north-south Natuna to Bangka Belitung seawater volume transport, current speed and pattern during low-high tide transition.

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