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THE EFFECT OF TRAWL BOARD PULL-OVER LOAD ON SUBSEA PIPELINE OF OFFSHORE SABAH

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Abstract: Trawling is a method of catching fish in a large volume where fish net is pulled through water using one or two boats. Bottom trawling is where the nets are pulled over or close to seabed and can affect the subsea pipeline if found along the route. Therefore, the objective of this study was to determine the impact of pull-over to selected subsea pipelines in Sabah and Labuan waters. This study involved four oil and gas pipelines in Sabah and Labuan waters from the oil fields to shore terminals. The research started with obtaining data of the pipelines and specification of trawl gear in Sabah. Fishing trawler traffic data along the pipelines route was determined by AIS system and site observation to determine the density of the trawlers. Trawl gear pull-over load was calculated using DNV algorithm and the inputs were trawl gear specification ^and fishing trawl speed. The severity was based on pull-over load calculated and pipeline yield stress. Then frequency was based on AIS data and density of fishing trawl per area. Based on the comparison between trawl pull-over load and yield strength/stress, the effect of trawl board pull-over is considered as minor, which is the lowest in the severity index.

Keywords: Trawling, subsea pipeline and pull-over impact

Introduction

Sabah (East Malaysia) situated on the north of Borneo, is known for its fresh sea catches, as three seas (Seas of Sulu, Sulawesi and South China) which surround Sabah on three sides contribute 48.2% in marine fish catches in Malaysia. Sabah fisheries and aquaculture industries produce nearly 200,000 metric tons of fish annually and contribute to Sabah's annual Gross Domestic Product by 2.8%. Marine capture fisheries contributed about 80% of fish catches and were the major contributor (Department of Fisheries Sabah, 2017) and trawling method is the main mode used in the marine fish catches in Sabah, contributing 41% of the total landings. Trawling is a method of fishing where the fish net is pulled through water using one or two boats. The type of trawling method depends on the length of warp line released. Trawling can be classified into bottom trawling and mid-water trawling (Anon, 1981).

The existing subsea pipelines connecting oil field to shore may be affected by trawling operations especially bottom trawling. Likewise, in Norway, trawl gear interaction with subsea pipeline is a major issue. Hitherto, no study has been done on trawl gear interaction with subsea pipelines in Sabah. Therefore, the objective of this study was to determine trawl gear pull-over load on subsea pipelines of Sabah's offshore.

Methodology

Research Activities

In this research, several methods were used to achieve the set objectives. The flow chart of research activities is shown in Figure 1.

The explanation of each method is given in the following paragraphs.

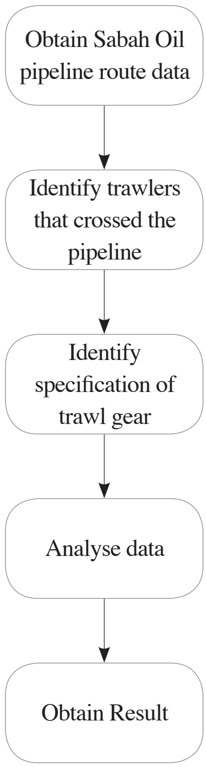

Figure 1: Overall research activities

The first step of this research is to obtain information on oil and gas pipelines all over Sabah waters. The information was obtained from the relevant MAL navigation charts, which are produced by the National Hydrographic Centre. The electronic navigation chart series are available from producers such as C-Map. The pipelines data were also obtained from the oil and gas companies that own the pipelines. An observation was made to determine the type of vessels operating along the eight pipelines with a focus on fishing vessels so as to determine the size of vessels, type of fishing gear used, position and heading. The observation was done via online Automatic Identification System (AIS) programme, namely Vessel Tracker and Marine Traffic. The shipping traffic data along the pipeline route were collected for 6 months using an online AIS program from March 2017 to August 2017. The AIS online programme was connected to terrestrial based AIS tracking system. The spreadsheet data retrieved form the AIS online programme was processed by sorting the data according to the type of vessel and focused on fishing vessels. Next, the acquirements of secondary data were done. Literature review of trawl fisherman in Kota Kinabalu Sabah and the method of catching fish were made in order to identify the trawl equipment used by the trawl fisherman. Literature review was conducted by focusing on relevant publications on fishing industries in Sabah notably in West Sabah. Information regarding trawling in Sabah was further searched online and straight from the Fisheries Department Malaysia for further detailed information. Site visits were conducted to fishing jetties and a shipyard to obtain information on the specification on the fishing vessels and the trawl gear used. In the second phase of this research, secondary data were acquired through literature review focusing on related subject such as, annual report by subsea pipeline operating company in Sabah's offshore in order to identify the parameter (specification) of subsea pipeline in Sabah In Phase 3 of this research, after collecting all required data from Phase 1 and Phase 2, "pull-over impact" analysis was done using the guideline from DNV-RP-F111 (DNV GL, 2017).

The algorithm used for the calculation of Pull-Over load is as below**:**

$$F_p = C_F\ V(m_t k_w)\tfrac{1}{2} \qquad \text{(Equation 1)}$$

Where:
F_p, is Pull-Over Load of a Trawl Board
k_w, is warp line stiffness,
V, is trawling velocity
m_t, is steel mass of board/beam with shoes
C_F, is empirical coefficient that will be further determined by:

$C_F = 8.0 \cdot (1-e^{-0.8H})$ (Equation 2)

Where:

H is a dimensionless height:

$$H = \frac{H_{sp} + OD/2 + 0.2}{B} \quad \text{(Equation 3)}$$

Where:

H_{sp} : the span height (negatively for partly buried trenched pipeline)

OD : the pipeline outer diameter including coating

B : half of the trawl board height

The warp stiffness, k_w is assumed as:

$$k_w = \frac{3.5 \ . \ 10^7}{L_w} \quad \text{(Equation 4)}$$

Where:

L_w is the length of warp line in meters.

Hence, trawl board maximum vertical force acting on the area of impact can be estimated as:

Polyvalent and rectangular boards:

$$F_z = F_P(0.2+0.8e^{-2.5H}) \quad \text{(Equation 5)}$$

Pull-over duration

The pull-over time duration T_p is the total time where the trawl board is in contact with the pipe and it is given by Equation 6.

$$T_p = C_T . \ C_F \ (m_t / k_w)^{½} + \delta_p / V \quad \text{(Equation 6)}$$

Where:

δ_p is the displacement of pipe which is unknown and has to be assumed. Therefore, the value of δ_p / V must be assumed as in Equation 7.

$$T_p = C_T . \ C_F \ (m_t / k_w)^{½} + 10 \quad \text{(Equation 7)}$$

C_T, the coefficient for pullover duration is given as:

$C_T = 2.0$, *for trawl boards*

$C_T = 1.5$, for beam trawls

Severity of Consequences (Pull-Over)

In this research, in determining the severity of trawl board pull over, severity ranking system approach was used. The systems are simple and flexible. The consequences of a trawl-board pull-over load are identified once the maximum forces are obtained by comparing with the standard requirement of a pipeline. A comparative local analysis method was used after obtaining the maximum trawl board pull-over forces. The result was compared to the pipeline design properties. The consequence is normally evaluated for human safety, environmental impact and economic loss Det Norske Veritas (2001). The consequence ranking is used to describe the severity of a consequence. The consequence is ranked from 1 (minor, insignificant) to 5 (major, catastrophic) as shown in Table 1. The severity index in this research is directly applied from the IMO severity index (IMO, 2002). The severity index is shown in the table.

Table 1: Severity index

SEVERITY INDEX (SI)				
SI	**Severity**	**Effects on Human Safety**	**Effects on Ship**	**S**
1	Minor	Single or minor injuries	Local equipment damage	0.01
2	Significant	Multiple or severe injuries	Non-severe ship damage	0.1
3	Severe	Single fatality or multiple severe injuries	Severe damage	1
4	Catastrophic	Multiple fatalities	Total loss	10

(Source: (IMO, 2002)

Results and Discussion

Trawl gear specification

To achieve the objective of this section, fishing vessels data of Sabah such as the fishing area in Sabah waters and fishing vessels crossing at Sabah offshore were obtained first.

The result of observations based on the fishing vessel data of Sabah shows that the number of vessels that crossed on pipelines according to type of vessel within the periods given was sorted out as shown in Table 2.

Table 2: Vessels crossing record at pipeline ERB west to SBGAST.

Erb West to SBGAST	
Date First	06/03/2017
Date Last	06/08/2017
Duration (days)	153
Type of Vessel:	
Anti-pollution facility/ equipment	42
Cargo ship	319
Dredging or underwater operation	0
Fishing (trawlers)	**22 (AIS)**
Crew boat	189
Local ship	60
Military operation	33
Other	0
Multi-purpose offshore vessel	48
Landing craft	71
Passenger ship	1400
Pilot	1
Pleasure craft	92
Sailing	14
Search/rescue	2
Tanker	109
Towing	4
Tug	159
Unspecified	42
Total	**2607**

Based on the instrumentation of data collection, the trawlers in Sabah are using the typical otter trawl (rectangular board) gear as shown in Figure 1. This type of trawl gear consists of a pair of otter boards, warp line and net. There are two types of otter board used by trawlers in Sabah, namely the steel otter board and the steel reinforced wooden otter board. Details of the trawl boards are shown in Table 3.

Figure 1: Otter Trawl (rectangular board) onboard fish trawlers in Sabah.

Table 3: Trawl board parameters
(used in calculation)

Specification	Value
Trawl board steel mass	500kg
Trawl size (length x height)	190 x 106 cm
Trawl velocity	3knot
Warp line length	150m (*3x times the depth of water)
Warp line diameter	2.5cm

Subsea Pipeline Specification

The specification of subsea pipelines in Sabah and Labuan area is shown in Table 4. The older pipelines such as ID80 and ID107 have relatively lower yield strength compared to the newer pipelines, namely ID85 and ID302.

Table 4: Subsea pipeline sabah data

Pipeline ID	Route	Service designation	Pipe length (km)	Pipe Diameter (inch)	Design Code	Wall Thickness (mm)
80	ERB WEST to LABUAN	Export line	140.4	14	API 5L X42	9.53
85	ERB WEST to SBGAST	Export line	60.4	16	API 5L X60	15.9
107	SMG-A to LGAST	Export line	46	14	API 5L X52 / X42	9.53
302	KBB to SOGT (Kimanis)	Export line	143	14	API 5L X65	12.7 (KP 0 to KP 0.5) 17.5 (KP 0.5 to KP 123)

Trawl Board Pull-Over Load Calculation

ERB West to Labuan

Dimensionless height:

$$H = \frac{H_{sp} + OD/2 + 0.2}{B}$$

$$= 0.7128$$

The empirical coefficient:

$$C_F = 8.0 \cdot (1\text{-}e^{-0.8H})$$
$$C_F = 3.47$$

The warp line stiffness:

$$k_w = \frac{3.5 \,.\, 10^7}{L_w}$$

$$= 233.33 kN/m$$

The maximum pull-over force becomes:

$$F_P = C_F \,.\, V(m_t / k_w)^{½}$$
$$F_P = 112.4 kN$$

ERB West to SBGAST

Dimensionless height:

$$H = \frac{H_{sp} + OD/2 + 0.2}{B}$$

$$= 0.759$$

The empirical coefficient:

$$C_F = 8.0 \cdot (1\text{-}e^{-0.8H})$$
$$C_F = 3.64$$

The warp line stiffness:

$$k_w = \frac{3.5 \,.\, 10^7}{L_w}$$

$$= 233.33\ kN/m$$

The maximum pull-over force becomes:

$$F_P = C_F \,.\, V(m_t / k_w)^{½}$$
$$F_P = 117.95 kN$$

SMG-A to LGAST

Dimensionless height:

$$H = \frac{H_{sp} + OD/2 + 0.2}{B}$$

$$= 0.7128$$

The empirical coefficient:

$$C_F = 8.0 \cdot (1\text{-}e^{-0.8H})$$
$$C_F = 3.47$$

The warp line stiffness:

$$k_w = \frac{3.5 \,.\, 10^7}{L_w}$$

$$= 233.33 kN/m$$

The maximum pull-over force becomes:

$$F_P = C_F \,.\, V(m_t / k_w)^{½}$$
$$F_P = 112.4\ kN$$

KBB to SOGT (KIMANIS)

Dimensionless height:

$$H = \frac{H_{sp} + OD/2 + 0.2}{B}$$

$$= 0.7128$$

The empirical coefficient:

$$C_F = 8.0 \cdot (1\text{-}e^{-0.8H})$$
$$C_F = 3.47$$

The warp line stiffness:

$$k_w = \frac{3.5 \,.\, 10^7}{L_w}$$

$$= 233.33 kN/m$$

The maximum pull-over force becomes:

$$F_P = C_F \,.\, V(m_t / k_w)^{½}$$
$$F_P = 112.4 kN$$

Severity of Consequences

Based on the calculation, to determine whether the trawl board pull-over load was able to significantly damage the pipeline, the maximum pull-over forces is compared to maximum yield strength/stress according to the pipeline material design specification as shown in Table 5. Based on the comparison, the effect of trawl board pull-over is considered as minor, which is the lowest in the severity index, although the severity stipulated local damage to the pipeline, the load would not damage the pipelines.

Table 5: Comparison between material design limit and trawl board pull-over forces

PIPELINE	MATERIAL DESIGN	MAX. YIELD STRENGTH (APL) ()	MAX. PULL-OVER FORCES ()
ERB West to Labuan	API 5L X42	290.27	112.4
ERB West to Karambunai	API 5L X60	415.06	117.95
SMG-A to LGAST	API 5L X52 / X42	359.91	112.4
KBB to SOGT (Kimanis)	API 5L X65	450.23	112.4

Conclusion

This paper analysed the impact of trawling activities on oil and gas pipelines in Sabah and Labuan waters. Fishing trawlers in Sabah and Labuan were using bottom trawling single otter trawl method which interact with the subsea pipelines. Based on the comparison between trawl pull-over load and pipeline yield strength/stress, the trawl board pull-over are lower than the pipelines yield strength/stress. Therefore, the effect of trawl board pull-over is considered as minor, which is the lowest in the severity index.

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