ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001

Discussion on the Content and Methods of the Submarine Pipeline Anti-third Party Sabotage System

Kan Wang[1], Xiangkun Ji[2,3,*], Li Han[1], Lei Yang[1], Huanyong Jiang[1], Yongning An[2,3]

[1] Tianjin Beihai Oil Human Resources Consulting Service CO., LTD., Tianjin, 300452, China

[2] Tianjin Survey and Design Institute for Water Transport Engineering Co.,Ltd, Tianjin, 300456, China

[3] Tianjin Key Laboratory of Water Transport Engineering Survey Technology, Tianjin, 300456, China

[*]Email: 15610531171@sina.cn

Abstract

As an important channel for land-sea connection, the submarine pipeline is a link for offshore oil and gas development. Third-party activities are one of the important risk sources of submarine pipeline damage, and relevant scholars have researched this. With the diversification of marine development activities, the safety assessment of submarine pipelines by third-party activities must also keep pace with the times. Based on the analysis of the third-party risk factors of submarine pipelines by predecessors, this paper summarizes the current human activities at sea and divides these into three categories: water transportation and transportation, marine development and utilization, and fish farming and fishing. It discussed the mutual influence of various maritime activities on submarine pipelines and improved the investigation content system for preventing third-party sabotage of submarine pipelines. And taking a submarine pipeline as an example, the system is applied to the investigation of the third-party damage prevention of submarine pipelines. The third-party marine development activities affecting the operation and maintenance of submarine pipelines were classified and evaluated. The regional distribution of pipeline routing risks was proposed. The evaluation results have significant reference value for the planning, design, operation, and maintenance of submarine pipelines.

Keywords

Subsea Pipeline; Third-party Sabotage; System Construction; Investigation Content; Application Demonstration.

1. Introduction

The development and utilization of marine come to a wide range of fields in recent years. The problem of scarcity of marine resources has become increasingly prominent.The contradiction between the use of the sea by different industries continues to intensify, and the three-dimensional development of the marine has become the future development.Scholars propose that different types of marine development activities are carried out above the water surface, on the sea surface, on the water body, on the seabed, and on the subsoil [1,2], which will cause some areas of marine development activities to overlap with each other.Subsea pipelines are the lifeline of offshore oil and gas transportation. Ensuring the safe operation of submarine pipelines is the key to offshore oil and gas development.Submarine pipelines generally exist in a shallowly buried state on the seabed, occupying

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001

a small sea area and extending a long distance, which is bound to overlap with other marine development activity areas.Research shows that the keys causes of submarine pipeline accidents include corrosion failure, suspension fatigue failure, third-party damage, and other modes [3].Damage to submarine pipelines caused by third-party activities is called third-party damage. The mostly source of third-party damage come from human activities. According to incomplete statistics, submarine pipeline damage accidents caused by third-party damage account for more than 33% [4] .

If the submarine pipeline buried deep is not enough or scours out the seabed. While ships or offshore platforms operating in the waters above, there are behaviors such as anchoring, fishing boat trawling, ship cargo falling off, and heavy objects falling off the offshore platform. Towing to a subsea pipeline may damage the integrity of the subsea pipeline.Therefore, reasonable assessment and analysis of the impact of third-party offshore development activities on subsea pipelines and similar subsea projects are one of the main problem of marine three-dimensional development.

According to statistics, marine activities such as installation, anchoring, hoisting, submarine work, fishing activities, water transportation, and ship accidents affect the integrity of submarine pipelines [5]. These types summarize most marine development activities. However, The types and diversification of sea development activities, sea use methods, offshore operation modes, and development methods have increased. It's still many research hotspots related to the impact of ocean activities on submarine pipelines. In particular, the specific investigation content of submarine pipelines to prevent third-party sabotage. Based on the conclusions of previous studies, this paper elaborates, discusses, and summarizes the current specific third-party marine activities. The degree and scope of the possible impact of third-party activities on submarine pipelines are analyzed. And the assessment system for third-party activities on submarine pipelines is built. And take the investigation content of a submarine pipeline to prevent third-party sabotage as an example. This system is put into practical application. The conclusion provides an important reference value for the safe operation and maintenance of the subsea pipeline.

2. Analysis of Third-party Survey Content

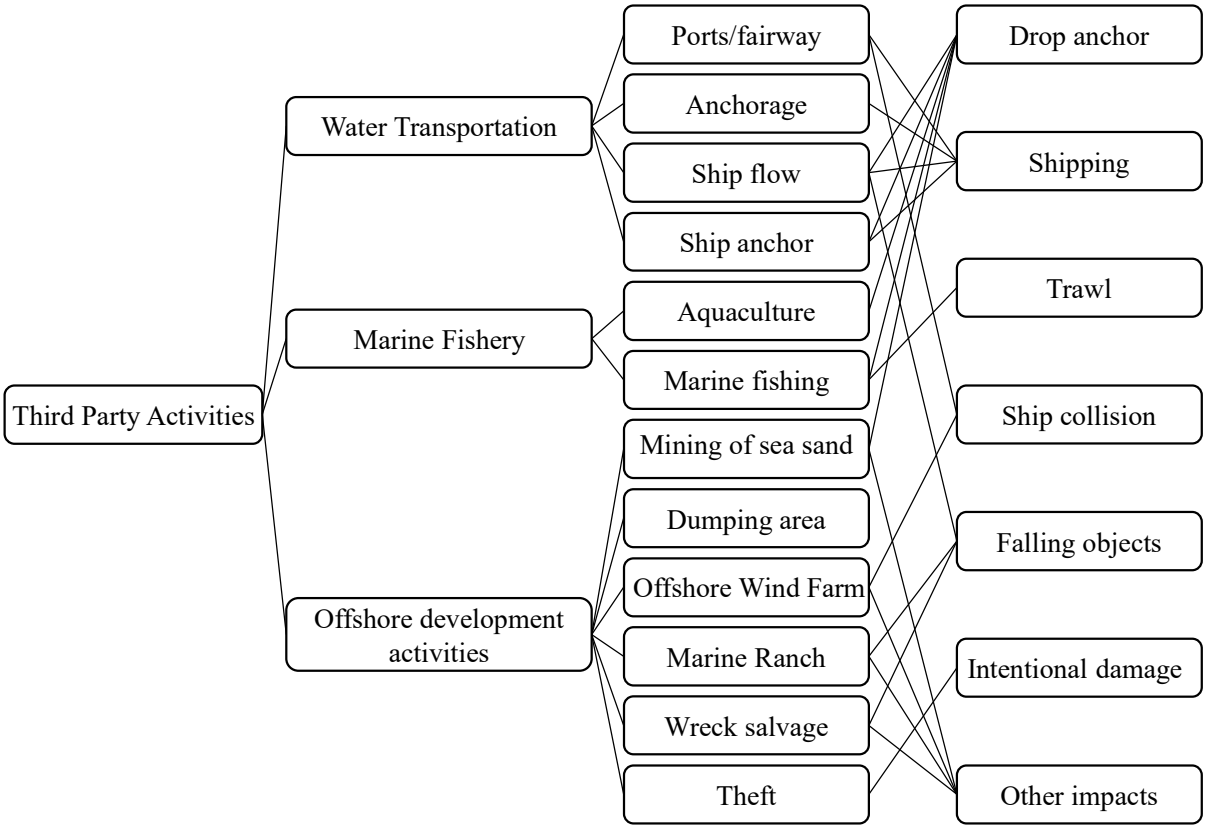


Fig. 1 Relationship between third-party risks and marine activities

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001

The current offshore development activities are summarized and summarized. The third-party offshore activities, which affect submarine pipelines, can be roughly divided into three categories according to many conditions such as correlation or distribution location, including water transportation, marine resource development, and marine fishery. In addition, other submarine pipelines may also affect each other.

2.1 Water Transportation

China is one of the most developed regions in the world for shipping. There are a large number of ports and shipping routes along the coast. All kinds of ships arrive and depart the port with heavy traffic. And there are many shipping vessels above certain routing areas of submarine pipelines. According to the information come from the Nautical Charts. Many submarine pipelines are close to water transport areas like ports and waterways in the China Sea. The source of harm to the submarine pipeline comes from the anchor and the number of the ship. The sea areas around marine transportation facilities such as ports, waterways, routes, and anchorages usually have concentrated ship activities. In addition, the anchoring depth of different types of ships has to be considered. We can determine the type of tonnage of ships around the port base on the type of waterway and anchorage,which are related to the scope of the type of anchor and the type of the ship.

2.2 Offshore Development Activities

Marine development and utilization activities include marine organisms, seabed minerals, seawater chemistry, marine renewable energy development, marine space utilization, and marine environmental protection. The degree of marine development has increased in the last two decades, and the types of offshore development activities have diversified. China has formulated a national marine functional zoning for the rational development and utilization of the ocean. The activity of the ocean can be divided into several categories first-level about 8 and second-level about 22. It's concluded agricultural and fishery, port shipping, mineral and energy, etc. Then, All marine development activities need to refer to marine functional zoning in China. As a subsea project, the submarine pipeline extends linearly on the seabed, which may have a different construction sequence from other offshore development activities, which is bound to overlap with the sea used for other offshore development activities. Specific marine development activities include sand excavation, channel dredging, shipwreck salvage, submarine cable maintenance, offshore wind power, and marine ranch construction.

2.3 Marine Fishery

Farming and fishing are two categories of fishery activities in China. Marine aquaculture methods tend to be diversified now, including pond engineering aquaculture, shallow sea aquaculture, cage aquaculture, and deep-sea aquaculture. Fishery aquaculture areas are usually distributed in coastal waters, and aquaculture areas are distributed like blocks and spots in the sea. According to 2019 statistics, commonly used fishing gears along the coast include dragnet, fences, gillnets, fyke nets, fishing gear, etc in China. Among them, fishing gears such as purse seine nets, gill nets, and Zhang nets only have a small impact on the seabed as long as they catch pelagic fish. Trawling is suitable for marine fishing grounds and inland waters with flat bottoms. It mainly fishes bottom fish, and the fishing output accounts for about 47.6% of the total fishing volume. There are 335,000 fishing boats and 27,000 trawlers in the country, with an average tonnage of about 124 T [6].

3. Discussion on Third-party Influence Factors

3.1 Risk Analysis of Damage Caused by Third-party Activities

The previous research results of submarine pipeline accident statistics [3] and system integrity management were reviewed [4]. The third-party damage mechanism of submarine pipelines comes from the impact of certain marine activities, objects, ships, etc. on the pipeline. The impact of marine transportation-related factors on submarine pipelines mainly comes from ship anchoring, accidental

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001

falling objects, or ship accidents.Among them, the failures caused by the anchor to the submarine pipeline are the most frequent, and the degree of damage to the submarine pipeline by the anchor is related to the anchor weight. There are many active ships in areas such as waterways, anchorages, ports, and routes, and the probability of ship accidents is relatively high.

Shipwreck salvage, offshore wind power construction, and sand mining are usually under construction by multiple construction ships during the development and utilization of marine resources. Therefore, these engineering activities will occupy a large sea area. Thus the offshore development activities are close to or overlap with submarine pipelines.It is easy to affect the submarine pipeline if the influence scope of specific engineering is under construction. The impact on submarine pipelines is already considered before the design and operation of offshore development activities. There are still potential threats because of extreme weather, unclear seabed conditions, and human operation errors.

Marine fish farming is mostly distributed in coastal waters, and submarine pipelines will more or less overlap with marine fishery areas. The government usually avoids the subsea pipeline routing area when applying for approval for fishery sea use. Trawling is one of the greatest threats to submarine pipelines in various marine fisheries activities, and the main source of danger comes from the impact damage of trawl plates to pipelines [7]. Subsea pipelines tend to pass through fishing grounds. The trawls of fishing boats are irregular, and the trawls may impact, drag, and tug on the submarine pipeline, which will increase the risk of damage to the submarine pipeline. For the purpose of protecting fishery resources. China has promulgated a no-fishing area for coastal trawling fisheries. In the protected area, fences, gillnets, fyke netsare used for fishing, and trawling is prohibited, which has less impact on submarine pipelines.

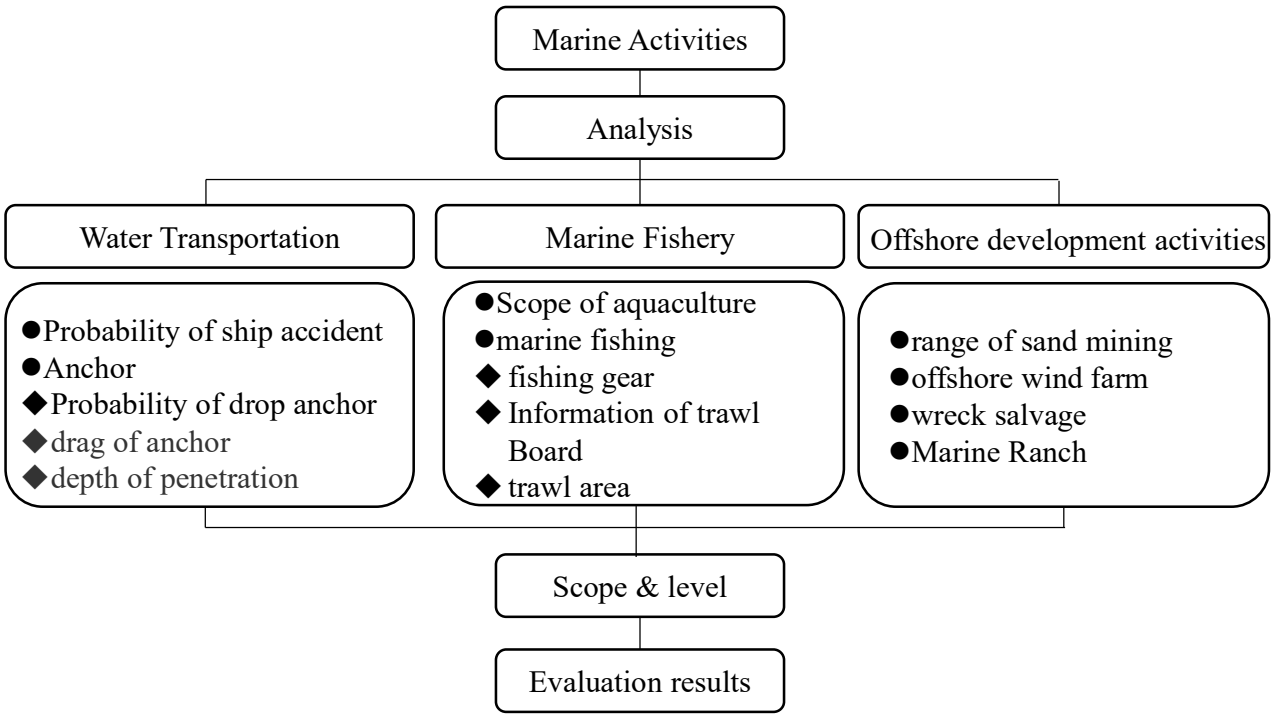


Fig. 2 Third-Party Activity Evaluation Process

3.2 Risk Assessment of Third-Party Activities

The risk of third-party damage to the subsea pipeline mainly comes from the impact or tow of other objects.How assess the impact of third-party activities on submarine pipelines is an important part of preventing third-party damage to the contents of the investigation.

(1) Impact risk analysis

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001

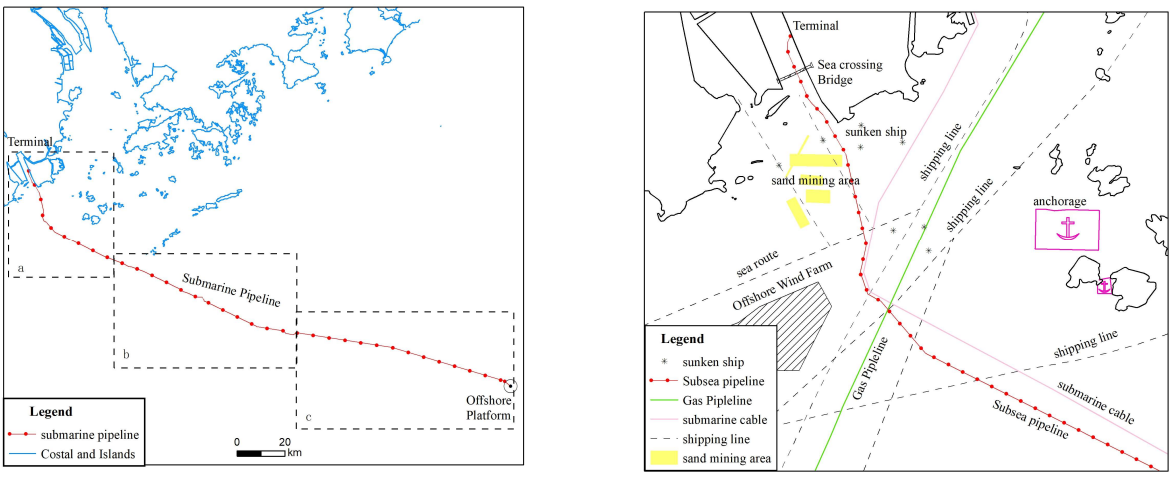
The risk of submarine pipeline collision mainly comes from the anchoring or towing of ships in third-party activities.The amount of deformation of the submarine pipeline is related to the energy absorbed by the pipeline when the anchor hits the submarine pipeline and ultimately depends on the final speed of the anchor falling into the water.According to the research on the impact risk and penetration depth of the drop anchor. The descending speed of the anchor is close to the free-fall speed when the anchor is in free fall about 10m[8].However, when the ship's anchorage falls, it is also restricted by the brake of the anchor windlass, and it is not a free fall.According to the tonnage statistics of my country's marine ships, most of the ships are below the 10,000-ton level, most of the anchors are Hall anchors, and the anchor weight is about 1~3t.According to calculations, when the submarine pipeline is hit by a 3t Hall anchor, the ratio of the minimum deformation of the steel pipe to the outer diameter exceeds the DNV standard, while the ratio of the steel deformation to the outer diameter caused by the trawl plate is lower than the DNV standard.The probability of anchoring submarine pipelines is mainly related to shipping flow [9], and the risk in areas with large ship flow is relatively high.The harm caused by the final anchor impact on the submarine pipeline is also related to the buried depth of the submarine pipeline, the material, whether there is a protective layer, and other factors.

(2) Scope of activity analysis

Most offshore development activities are carried out by ships. The scope of ship activities is an important basis for evaluating the risk level of offshore development activities.Song Yang conducted a statistical analysis of the anchoring radius of 257 ships through AIS data and indicated that the anchoring radius of the ship was about 579.7m under the anchoring water depth of 18m [10].The "Provisions for the Protection of Submarine Cables and Pipelines" proposes that submarine cables and pipelines protected an area of about 500m on each side of the wide sea, 100m on each side of the narrow sea such as bays, and 50m on each side of the harbor area.CNOOC has studied the third-party risks of pipelines. When the offshore development activity is 1km away from the submarine pipeline, the risk level is higher.Above those, it can be concluded that 2000m, 1000m, and 500m are the extent of influence of third-party activities on submarine pipelines.It's necessary that Consider the increased risk of special marine environments such as weather extreme, or the need for multiple ships to operate certain marine activities. The risk of specific activity assessment results should be discussed after the distance scale basis on special circumstances.

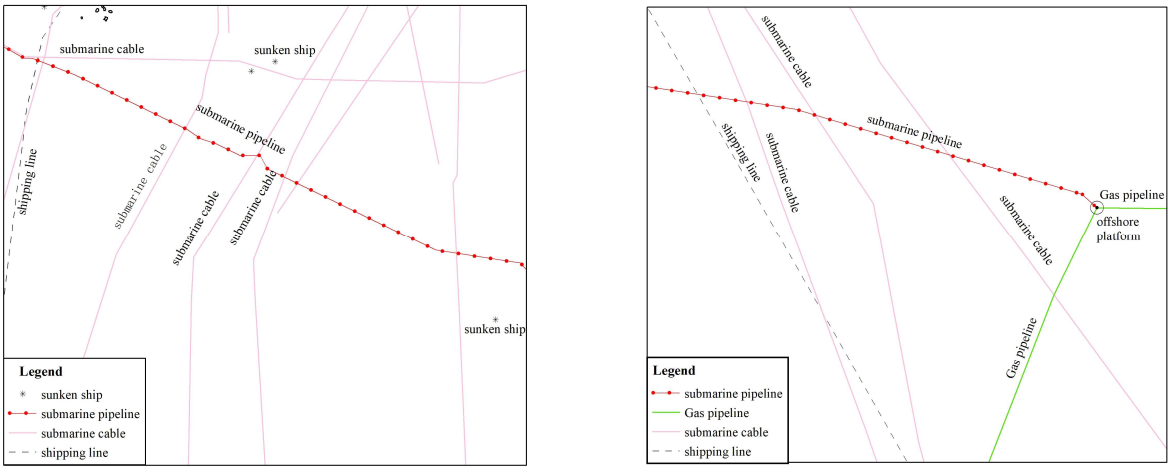
4. Application Demonstration

Taking a submarine pipeline in the northern part of the South China Sea (Fig 3-a) as an example, the application of the submarine pipeline anti-third-party investigation content system in the submarine pipeline is analyzed.



a b

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001



c d

Fig. 3 Location map of submarine pipeline and the results of third-party activities survey

a.location map of submarine pipeline; b,c,d: the results of third-party activities survey around submarine pipeline

4.1 Third-party Activity Survey Results

(1) Water Transportation

According to the survey, the submarine pipeline landed along the river near the shore, and the upstream was the local central fishing port. Subsea pipelines are far away from ports, waterways, and anchorages (>5km). The entire submarine pipeline intersects with multiple sea routes, and the landing section overlaps with the habitual sea routes. According to statistics, most of the ships on the habitual sea routes are fishing vessels and small cargo vessels[11]. The water depth of this route is shallow. Therefore, the tonnage of ships that can pass is usually small. According to the statistics of ship flow in 2019, according to the classification of fishing vessels, commercial vessels (including passenger/cargo vessels), and offshore engineering vessels (including various construction vessels). The flow rate of ships passing above the submarine pipeline is 89600, 109400, and 4600. Most ship activities are distributed in the nearshore range (Fig. 3-b).

(2) Offshore development activities

Offshore development activities similar to submarine pipelines include submarine cable laying and maintenance, sea sand mining, shipwreck salvage, offshore wind farm, and soon on. Due to the different construction times of the submarine cable, the research submarine pipeline intersects with a gas pipeline and 9 submarine cables and is relatively close to a submarine cable, and the closest point is about 200m.There are 4 marine sand mining areas near the submarine pipeline (Fig. 3-b), and one sand mining area is about 0.27km away from the submarine pipeline. It can be known that there are many sunken ships, the nature of the sunken ships is unknown, on both sides of the submarine pipeline according to the information contained in the chart. The closest sunken ship to the submarine pipeline is about 1 km away. The boundary of the established offshore wind farm is about 3.1km away from the pipeline.The submarine pipeline terminal crosses the sea-crossing bridge under construction.

(3) Marine Fishery

According to local fishery statistics, the scope of fishing activities is roughly bounded by the prohibited fishing line for wheel trawling. In the waters within the prohibited fishing line of the wheel trawler, the coastal areas are mainly fishery. The types of fishing gear used in the fishery are mainly fixed nets, shrimp trawls, and drift gill nets. Trawl nets, gill nets, and cover nets are the main fishing gears in the waters beyond the prohibited fishing line of wheel trawling. According to the analysis of remote sensing images, there are some fish farms around the nearshore section of the submarine pipeline, and the closest distance to the submarine pipeline is about 0.22km. The upstream of the

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001

landing end of the submarine pipeline is the local central fishing port. When fishing boats enter and leave the fishing port through the habitual route, the flow of ships will greatly increase [12].

4.2 Risk Assessment of Third-party Activities

It is divided into five grades: large, large, medium, small, and small base on previous studies on pipeline safety and third-party damage and combined with the type of offshore development activities and the relative position of the submarine pipeline. And then the risk level assessment is carried out for offshore development activities on both sides of the subsea pipeline.

(1) Water Transportation

The danger of ship shipping to submarine pipelines comes from accidental anchoring or impact damage to submarine pipelines by falling objects. The submarine pipeline intersects with many routes, all of which are merchant shipping routes, and the ships are in a sailing state. Therefore, the frequency of ship accidents, accidental anchoring, or falling objects is small, the probability of anchoring the pipeline is low, and damage is not common. Submarine pipelines intersect with habitual routes, and the sailing ships are mainly small cargo ships and fishing boats, among which fishing boats may break down relatively frequently.The fishing boat anchor with a length of 50m weighs about 0.5t, a length of 30~40m weighs about 0.25t, and a length of about 20m weighs about 0.1t come to the field investigation. Therefore, the penetration depth of fishing boat anchors is limited, which is mostly less than the buried depth of submarine pipelines. The area where the pipeline intersects with habitual shipping routes is assessed as moderate, and the area where it intersects with other merchant shipping routes is assessed as having less impact. Ports, waterways, and anchorages are far away from submarine pipelines, and port facilities have less impact on submarine pipelines. The submarine pipeline is closer to the anchorage or intersects with the waterway in another sea. And the risk assessment should be increased in these areas. The evaluation results are shown in Table 1.

(2) Offshore development activities

The main risk arising from the proximity or intersection of submarine cables comes from the operation and maintenance of submarine cables.Generally, protective pads or other protective solutions are installed in the cross-section of the umbilical cable. However, there are many restrictions on underwater maintenance operations. It is easy to cause damage accidents and while the operation is improper. The period of umbilical maintenance work is evaluated as moderate. Offshore wind farms are far away from submarine pipelines and have little impact. Although the construction of the cross-sea bridge and the salvage activities of sunken ships are close to the submarine pipeline. And the impact on the subsea pipeline will be taken into account during construction. The risk of accidental occurrence is still not ruled out, and both types of activities are assessed as moderate. There are many sand mining areas within the scope of the investigation that are close to the submarine pipeline. And there have been submarine pipeline damage accidents caused by sand mining in the past, and the sand mining activity is evaluated as the greatest risk.

(3) Marine Fishery

Although the nearshore aquaculture fishing rafts are closer to the submarine pipeline, they are mostly in a semi-fixed state and have relatively little impact on the submarine pipeline. Because fishing boats enter and leave the fishing boat wharf, there are many fishing boats in the landing section of the submarine pipeline, and fishing boats generally do not anchor and fish in this area. In the area within the prohibited fishing line of wheel trawling, the scope of fishing operations is mostly in the middle and upper water bodies, which has little impact on the seabed. Fishing trawling is widespread in areas outside the wheel trawling prohibition line. There will be a certain disturbance to the seabed during the operation and the disturbance depth is relatively small. Subsea pipelines are laid shallowly or take into account the effects of fishing trawls. Fishing trawls have a greater impact on suspended or exposed submarine pipelines. It's not feasible to rate it all as moderate that subsea pipelines extend beyond the wheel trawl line. The risk level analysis should refer to the sub-regional assessment of the buried depth monitoring results of the submarine pipeline.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001

The overall assessment of the subsea pipeline is carried out using the data from the above analysis. The near-shore section (Fig.3-b) is affected by a variety of third-party activities with high-risk levels, and the overall assessment of this section can be moderate to large. The other two routing areas (Fig. 3-c and Fig. 3-d) are relatively less affected by third-party activities or the location of risk sources is relatively fixed. The assessment of these two areas as medium to small areas refers to many factors such as fisheries trawls.

Table 1. Offshore Activities and Subsea Pipeline Location and Risk Assessment

Offshore Development Activities	Mileage of Submarine pipeline	Position	Destruction Risk Source	Grade
Offshore platforms	kP0			
submarine cable	kP26/kP49/kP60/kP108/kP130/kP133/kP138/kP148/kP168/KP210	cross	maintenance	middle
	kP172/kP215	0.2km/0.25km	maintenance	middle
shipping line	kP69/kP169/kP200/kP207/kP210/kP217	cross	sailing	lesser
offshore wind farm	kP211	3.1km	construction	small
sand mining area	kP220/kP221/kP223	2.1km/2.3km/0.3km	sand mining	larger
sunken ship	KP223/kP225	1.3km/1.03km	wreck salvage	middle
aquaculture area	KP227	0.22	aquaculture	lesser
Sea crossing bridge	kP231	0.17km	construction	middle
terminal	kP234			

5. Summary

The risk sources of third-party damage to submarine pipelines are becoming complex while the trend of diversified development of marine development and the combination of various ways of using the sea. The contents of the third-party investigations affecting the subsea pipeline are analyzed concerning the subsea pipeline integrity management data. It can be divided into maritime transportation, marine development and utilization, and fish farming and fishing.A discussion of the sources of risk arising from third-party activities leads to the conclusion that the impact and the extent of marine activities are two important factors for assessing third-party activities.An overview of the risk of collision and the extent of the vessel's movement is provided.The content of the investigation on the prevention of third-party damage to the submarine pipeline is briefly described that taking a submarine pipeline as an example. The damage risk level of various third-party activities was evaluated regarding the impact risk, the scope of the ship's activities, and other factors.The evaluation results obtained have important reference significance for the operation and maintenance of submarine pipelines.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0001

Acknowledgments

The work was supported by theFundamental Research Funds of Management of Central Scientific Research Institutions(TKS20200301).

References

[1] LI Yan-ping. LIU Da-hai. Research on methods of marine resources allocation based on three-dimensional development. Marine Environmental Science, (2019). 38(03):435-440.

[2] YANGHongsheng. RU Xiaoshang. ZHANG Libin et al. Industrial Convergence of Marine Ranching and Offshore Wind Power: Concept and Prospect. Bulletin of Chinese Academy of Sciences, (2019).34(06): 700-707.

[3] WANGHonghong.LiuGuoheng.Statistics and analysis of subsea pipeline accidents of CNOOC.China Offshore Oil and Gas, (2017). 29(5)157-160.

[4] FANG Na.CHEN Guoming. ZHU Hongwei et al. Statistical analysis of leakage accidents of submarine pipeline. Oil & Gas Storage and Transportation,(2014). 33(01):99-103.

[5] National Energy Administration. Integrity management of submarine pipeline systems SY/T 7342-2016, (2016). Beijing.

[6] Fisheries and Fisheries Administration. MARA.China Fishery Statistics Yearbook.(2020).Beijing:China Agriculture Press.

[7] Wei Zhang. Research on Impact Damage and Energy of Subsea protection Structures by Trawlboard. (2021). Harbin Engineering University.

[8] JIANG Feng-Yuan.DONG Sheng.Risk analysis of submarine pipeline subjected to impact loads by anchor. Periodical of Ocean University of China, (2019).49(6):126-132.

[9] ZhaoDongyan. Wang Cong. Luo Chao et al.Social environmental factors impact on the buried depth of subsea pipeline. China Offshore Oil and Gas, (2010) .22(04):275-278.

[10] Songyang. Research on mooring radius and ship spacing of large ships based on AIS data. (2010). Dalian Maritime University.

[11] Zheng Tong. Tang Yi. Analysis of current status of Chinese marine fishing fleet of South China Sea area. Journal of Shanghai Ocean University, (2016). 25(4): 620-627.

[12] Liu Run.Wang Jiayu.BieShe'an. Study of the Penetration Depth of an Anchor in the Dropping Anchor Process. Journal of Tianjin University(Science and Technology), (2020). 53(5): 508-516.