2021 MCM-SJTU

Problem B: Pilotage Safety and Efficiency in Bad Sea Conditions

With the development of the trade around the world, the shipping industry is booming. As a result, the number of ships arriving at and leaving harbors is also increasing. In order to defend national sovereignty and ensure the safety of ships, harbors and facilities, **pilotage** is introduced to guide ships arriving at and leaving harbors. Pilotage is to pilot ships in a specific area to navigate safely, arrive at or leave the piers, or go through restricted waters. Some regulations are given in the attached data for you to refer to.

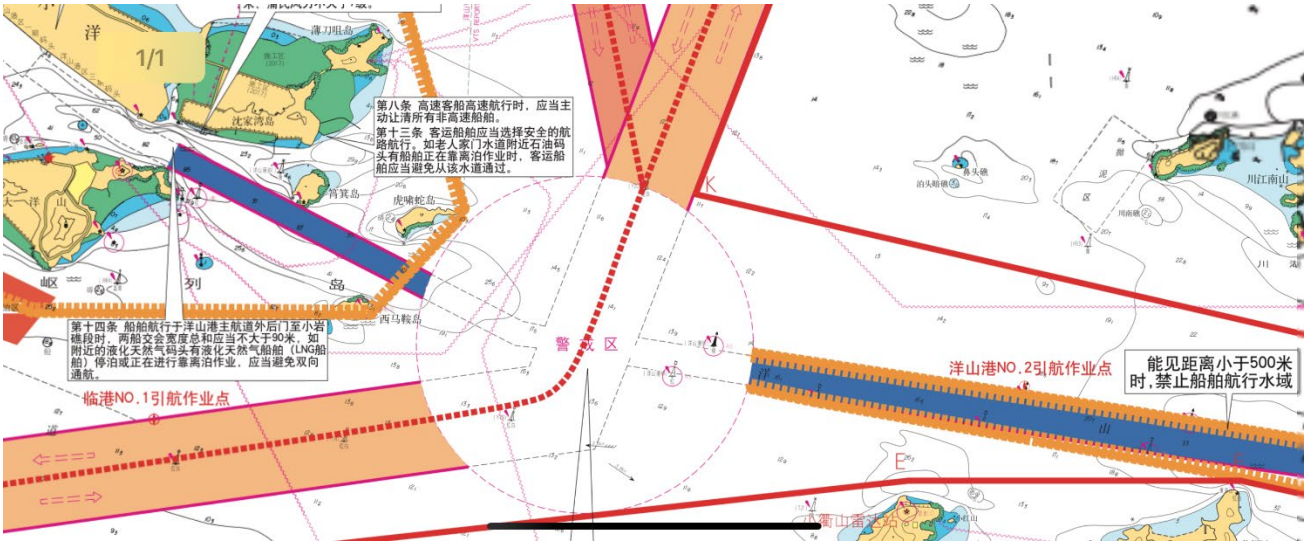

Fig. 1 The Traffic Control Scheme of Yangshan Port

Yangshan Deep-water Port is located in Zhejiang Province, China, connected to Shanghai by the Donghai Bridge. It is the largest smart container terminal in the world. Fig. 1 is the map of the coastal waters of Yangshan Port. The blue region is the Main Course of Yangshan Port. Most large ships arriving at and leaving Yangshan Port including foreign ships, most of which are container ships, stick to this course. The red region is the Jinshan Course. Most of the ships in this course are crude tankers and hazardous chemical ships. A precautionary area is set up at the crossing of the two courses, which is a circle whose radius is 2 sea miles. In this area, ships in the two courses have to slow down and avoid collisions. The attached data gives the records of the ships going across 6 observation lines, part of which are shown in Fig. 2.

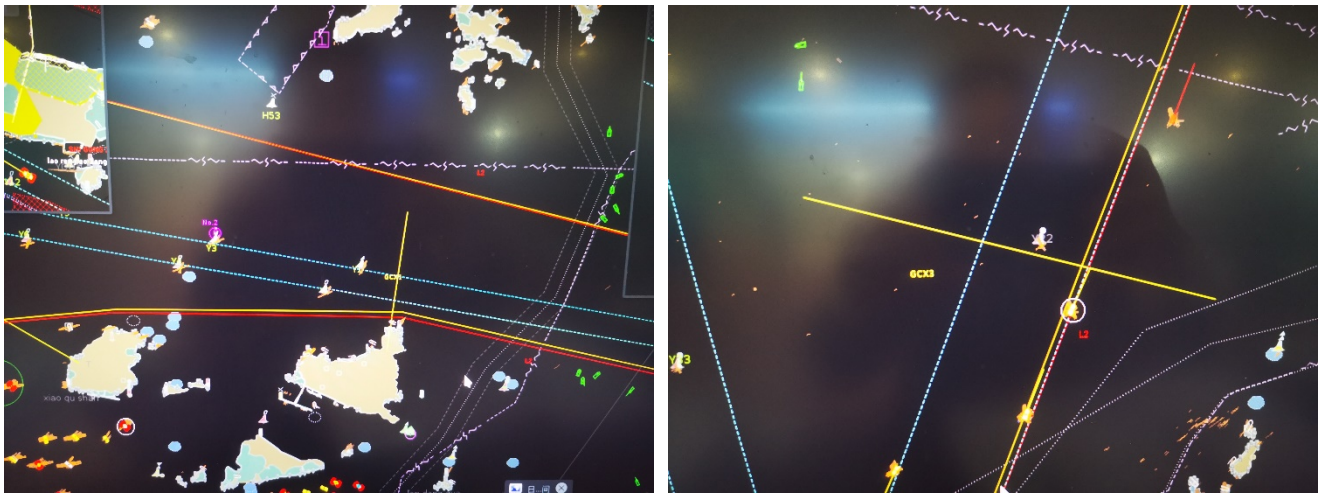

Fig. 2 Observation Lines 1 and 3

At present, the process of pilotage at Yangshan Port is, the pilot takes a tugboat to the Yangshan Port Pilotage Point No. 2 in Fig. 1 to board the target ship, and then guides the ship along the main course to the corresponding pier. However, when the port region encounters bad weather, the awful sea conditions make it impossible for the pilots to board the ships at the Point No. 2 that is far away from the port and ships have to wait at the anchorage or open waters until the weather gets better, which is called **pilotage suspension**. Pilotage suspension may contribute to a low efficiency of port operation and extra cost of ships affected by it. The attached data gives the records of pilotage suspension at Yangshan Port. ONLY pilotage suspension caused by strong wind is under consideration in this case. According to the experience of specialists, it happens less than 10 times on average per year.

To improve the efficiency of Yangshan Port and reduce the cost of the ships, the management team of Yangshan Port is considering altering the pilotage point to an alternative one in the northwest of the precautionary area in Fig. 1 so that the pilots can board the ships even in bad weather. However, the alternative scheme means that foreign ships have to go through the unfamiliar precautionary area on their own, which may induce collision accident there. Therefore, the management team invites you, the MCM team, to find out the pros and cons of their preliminary scheme, provide an overall analysis and raise a feasible plan.

Your tasks are the following:

Task 1: Explore the rules of pilotage suspension. Pilotage suspension is mostly related to surge (wave height) and wind (speed, direction). Surge is a direct factor while wind is an indirect one. Try to quantify the two factors and tell in what situations the pilotage has to be suspended? You may refer to the pilotage suspension and weather data in the attached data. Are there any other factors which may influence the pilotage?

Task 2: Find out an alternative pilotage point. According to the experience, the management team of Yangshan Port thinks that the alternative pilotage point should be in the main course between Shaoji Island and Huxiaoshe Island, but they are not sure whether it is feasible and where the precise location is. The depth of water and the terrain are given in the attached data. Try to validate the scheme and give the precise location. How much is the efficiency improved after using the new point? After all, do you have any other good ideas?

Task 3: Analyze the traffic flow in the precautionary area. What are the differences of the traffic flow in the precautionary area when there is a pilotage suspension or not? If the new scheme is adopted, how should the foreign ships going to Yangshan Port navigate through the precautionary area? What kinds of rules should they obey? Do you have any other advice on the traffic organization in the area to keep safe and improve the traffic efficiency? Try to prove your conclusions.

Task 4: Propose an overall pilotage plan. Combine your conclusions before and try to analyze the pros and cons of the new scheme. Give an outline of pilotage for pilots to follow. Write a one-page pilotage plan including process description, benefit analysis and risk warning.

Your submission should consist of:

- One-page Summary Sheet,
- One-page Pilotage Plan,
- Your solution of no more than 25 pages, for a maximum of 26 pages with your pilotage plan.

- Note: Summary Page, Outline, Reference List, and any appendices DO count toward the page limit. You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Ensure you cite the sources for your ideas and the materials used in your report.

Some Introduction of pilotage can be seen from:

- https://mp.weixin.qq.com/s/78qOLGyBn5PSWagyvXeaYA
- https://mp.weixin.qq.com/s/VyUKBGkw4d3bkRWt5nzV_g

About data: The attached data in this problem is confidential. Any team who would like to use the data has to sign a non-disclosure agreement (will all team-member signatures). Please name the signed agreement with Team No. and send it back in PDF format to tutor Mr. Dejun Kong via QQ (1240814267) or find him in QQ group to get the data. Only the team leader is asked to contact with the tutor. Please remark your Team No. and name in the standard form (e.g., 000-张三) when adding QQ friends. The tutor will not send the data packets until the team leader sends back the signed agreement. Please be noticed that do not share the data packets to anywhere.

Acknowledgement: This problem was proposed by Prof. Xiangen Bai from Merchant Marine College at Shanghai Maritime University, modified and formalized by Prof. Xiaofeng Gao (gao-xf@cs.sjtu.edu.cn) from Department of Computer Science and Engineering at Shanghai Jiao Tong University, and was integrated, reorganized, and finalized by Ph. D. Student Dejun Kong (kdjkdjkdj99@sjtu.edu.cn) from DCE Lab. He also collected the related data.