Introduction of Examples of the Use of AIS Data

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1. INTRODUCTION

In recent years, it has become possible to grasp information on the movement of ships, which had been difficult with conventional techniques, by acquiring Automatic Identification System (AIS) information by satellites, etc. AIS is a system for exchanging navigation information between ships operating at sea. With the increased number of satellite launches in recent years, it has become possible to acquire AIS signals from ships worldwide, and the range of uses of this data is expanding year by year. As examples of past research on AIS, a review paper on AIS data by Wada et al. [1] summarized examples of research on estimation of the volume of maritime cargo transportation, analysis and prediction of the condition of the maritime shipping market, prediction of demand for ship construction, analysis of the environmental impacts of ship operation, application to the cruise sector, and analysis of shipping networks and their changes over time, highlighting the diverse range of objects of research utilizing AIS data. As shown in Fig. 1, there is an increasing trend in the number of papers on ship AIS, and research on big data on marine logistics, which has become available in recent years, is being carried out from various angles.

Many initiatives to optimize ship operation by utilizing AIS data are also underway in industry. One example is the platform "Blue Visby Solution," which uses digital technology to optimize the arrival time of ships at their destinations [2]. Blue Visby Solution attempts to reduce CO_2 emissions by providing the optimum sailing speed considering the position and heading of ships heading toward the same port by using AIS data in addition to information on congestion in ports and the weather. It has been suggested that this technique has the potential to reduce CO_2 emissions by an average of 16%.

ClassNK (hereinafter, the Society) also has a record of actual results of utilizing AIS data in the development of ship rules. In the comprehensive revision of Rules and Guidance for the Construction and Survey of Steel Ships, Part C, which enables safer and more rational design of ship hull structures and strength evaluations, and the revision of Guidelines for Container Stowage and Securing Arrangements, AIS data and wave statistics were used to rationalize the design loads of ships [3), 4)]. In comparison with conventional rules based on empirical rules and limited information, the development of rules with high accuracy and transparency was achieved by using quantitative data showing the actual situation of operation of real ships.

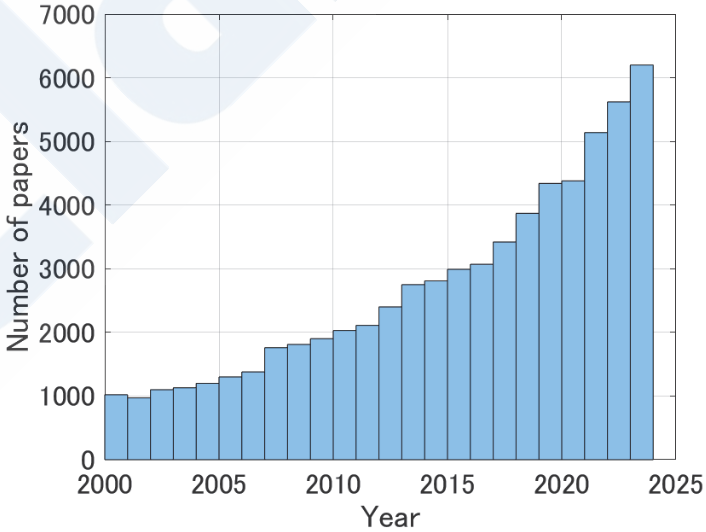

Fig. 1 Transition of the number of papers on ship AIS (source: Google Scholar)

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As described above, the regions of use of AIS data in academic research and industry are expanding, and the Society is also acquiring global AIS data and utilizing that data in the development of various services, beginning with rule development. The purpose of this paper is to introduce concrete examples of the use of AIS data and provide information widely to stakeholders involved in the maritime industry. As the overall composition, Chapter 2 presents an overview of AIS, Chapter 3 introduces examples of the results of analyses of the actual condition of ship operation by ship type and size, the characteristics of ships calling in Port of Tokyo, and the changes in navigation routes accompanying the deterioration of the situation in the Red Sea, and Chapter 4 presents the concluding remarks.

2. OVERVIEW OF AIS

The main purposes of AIS are to prevent collisions between ships, obtain information on ships in transit and their cargoes, and support ship operation control work. Based on Chapter V of the SOLAS Convention (International Convention for the Safety of Life at Sea), which took effect in 2002, the IMO (International Maritime Organization) required that all ships that meet certain standards carry and operate AIS equipment. This requirement is applicable to all ships with a gross tonnage of 300 tons or more which are engaged in international voyages, all ships with a gross tonnage of 500 tons or more which are not engaged in international voyages, and all passenger ships irrespective of size [5]. ITU-R M.1371 is adopted as the technical grounds, and IEC 61993-2 Ed. 1 is adopted as the equipment standard. As navigation equipment with upward compatibility, in recent years, the introduction of VDES (VHF Data Exchange System), which has a higher data transmission capacity, in addition to the AIS function, has been discussed in the IMO.

The radio waves of the AIS devices carried on ships have a horizontal range of 60 to 80 km. Initially, AIS signals were received by other ships and by ground stations, but since AIS signals reach a vertical altitude of 400 to 500 km, signals can also be acquired by satellites. With the increase in satellite launches from 2008 onward, it is now possible to capture AIS signals from ships operating in open seas [6].

Fig. 2 shows the representative type of information that can be obtained by AIS. In addition to static information such as the identification numbers, etc. of navigating ships, this information includes dynamic information such as the ship position, speed, course, etc. Additionally, voyage-related information, such as the ship's draft and destination, can also be obtained. Fig. 3 shows an example of visualization of the information obtained by AIS in combination with data on the sea states. In this figure, the color represents the size of the significant wave height. The figures show information on the positions of ships under the two conditions of calm sea (top) and rough sea (bottom). In a calm sea state, ships basically sail the Great Circle route, which is the shortest route to their destination, but in rough sea states, ships are clearly avoiding the low pressure area near the center of the figure, where the significant wave height is 15 meter class. Thus, the sea states encountered by ships worldwide and the actual situation of navigation can be understood by using AIS and sea-state data. As described in the previous chapter, the Society used these data on encountered sea states in rule development [3), 4)].

Dynamic information	Static information	Voyage related information
• Latitude/Longitude	• MMSI/IMO number	• Draught
• Time	• Name	• Destination
• Headings	• Dimensions	• Estimated time of arrival (ETA)
• Speed over ground	• Type of ship	• Dangerous Cargo (Type)
• Course over ground	• Location of positioning system's antenna	• Route planning

Fig. 2 Information obtainable from AIS (Examples)

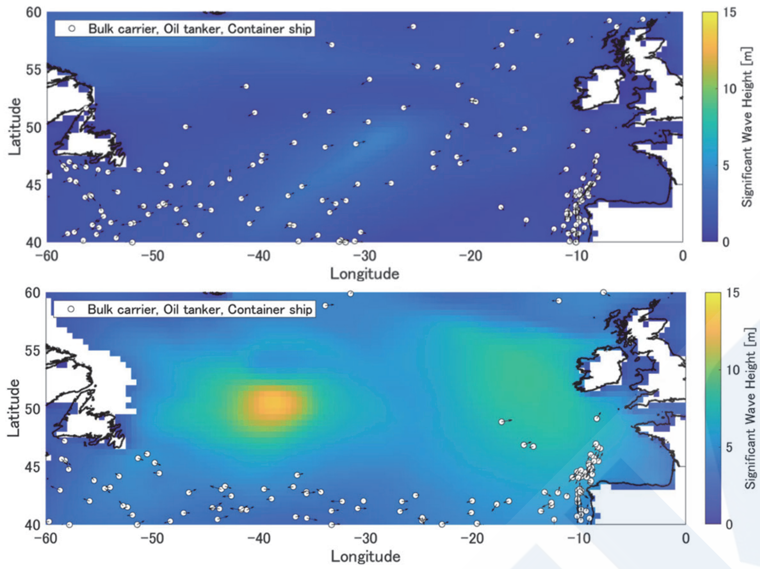


Fig. 3 Positions of ships in North Atlantic Ocean (top: calm sea state, bottom: rough sea state)

3. INTRODUCTION OF EXAMPLES OF USE OF AIS DATA

This paper introduces the results of three analyses using the worldwide AIS data provided by Kpler and the Clarkson ship database. The period of the AIS data used here is from January 1, 2022 to December 31, 2024. Data preprocessed in 3 hour time periods were used.

3.1 Actual Situation of Navigation by Ship Type and Size

It is possible to capture ship navigation routes by ship type and size by using AIS data. Fig. 4 and Fig. 5 show the tracks of containerships and bulk carriers each by ship size, respectively. The object period is 2022 to 2024, and ship speeds of 2 knots or less have been excluded. Darker colors indicate a high frequency of voyages. For example, in Fig. 4, containerships with sizes of less than 3 000 TEU sailed in a wide range of coastal areas, whereas a large proportion of voyages by large containerships of more than 17 000 TEU were on Asia-Europe routes. Comparing containerships of the 8 000 to 11 999 TEU class and those of the 12 000 to 16 999 TEU class, a relatively large number of voyages by the former were on the North Atlantic Ocean route. Among the bulk carriers in Fig. 5, voyages by ships of both sizes were distributed uniformly worldwide, but voyages by VLOC (Very Large Ore Carriers) and Cape-size vessels with DWT (deadweight tonnage: tonnage of the cargo) of 100 000 DWT or more were concentrated on Asia-Brazil routes, showing the tracks of vessels transporting South American iron ore to Asia.

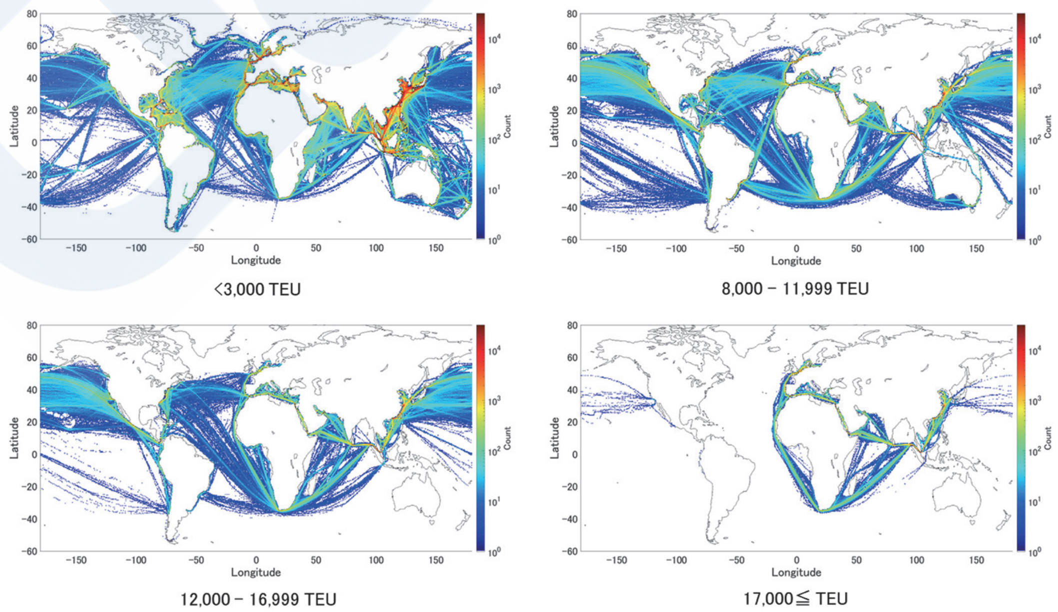


Fig. 4 Track charts of containerships by size (2022-2024)

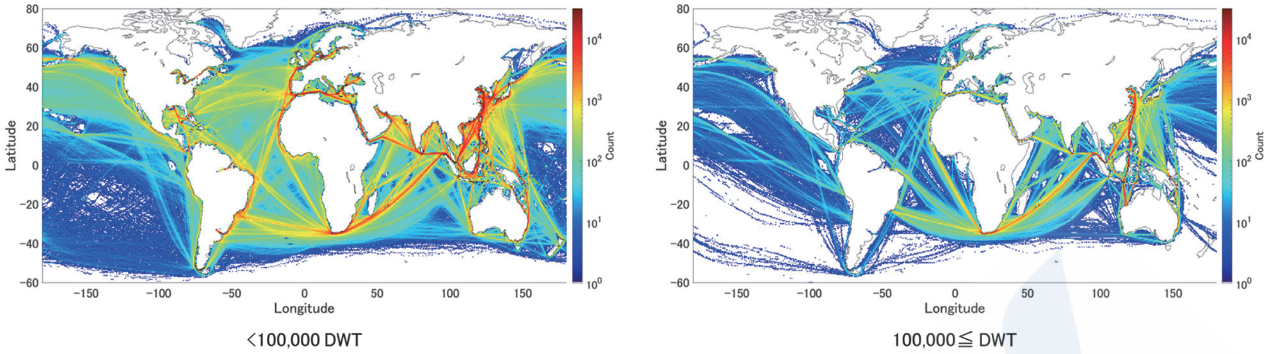
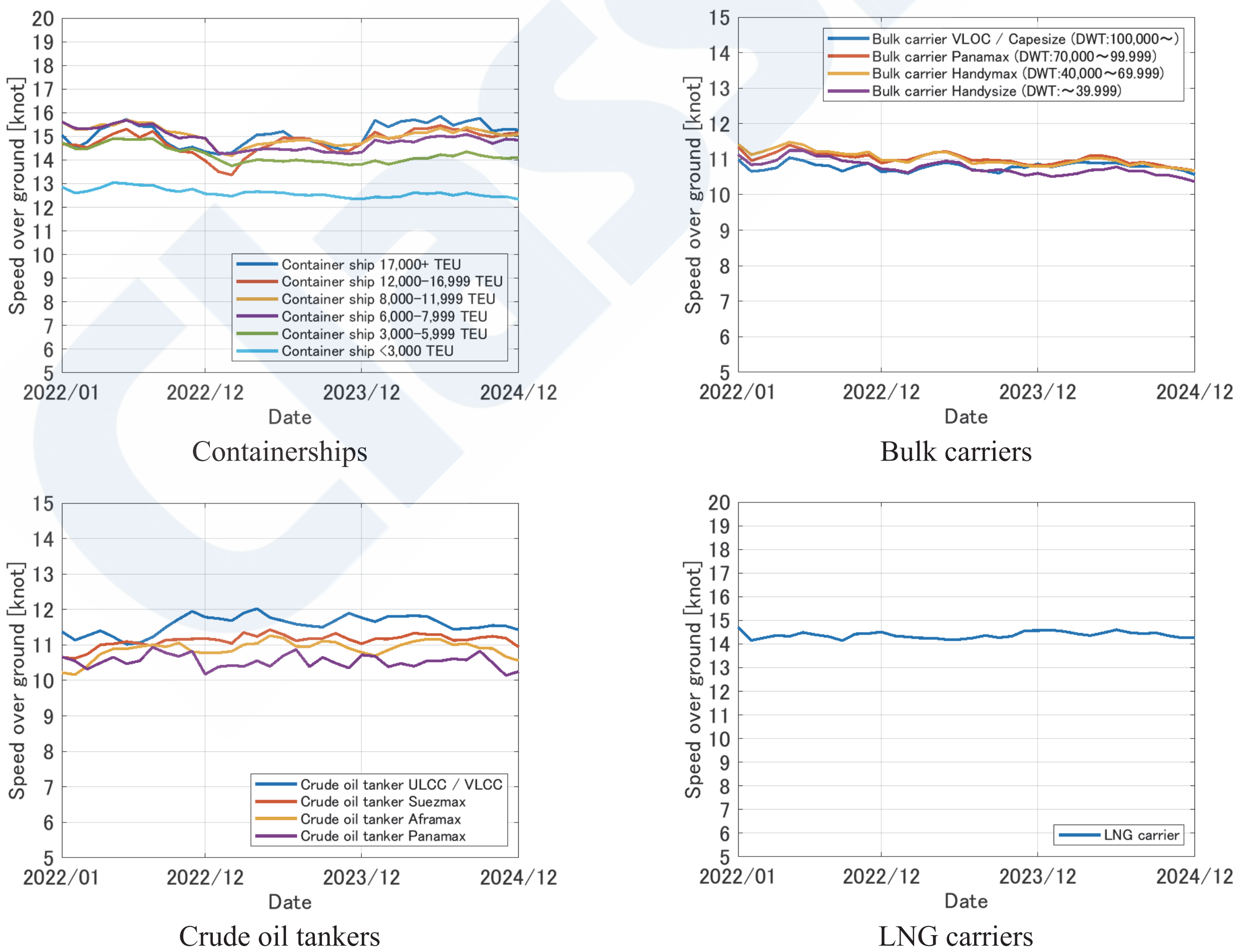
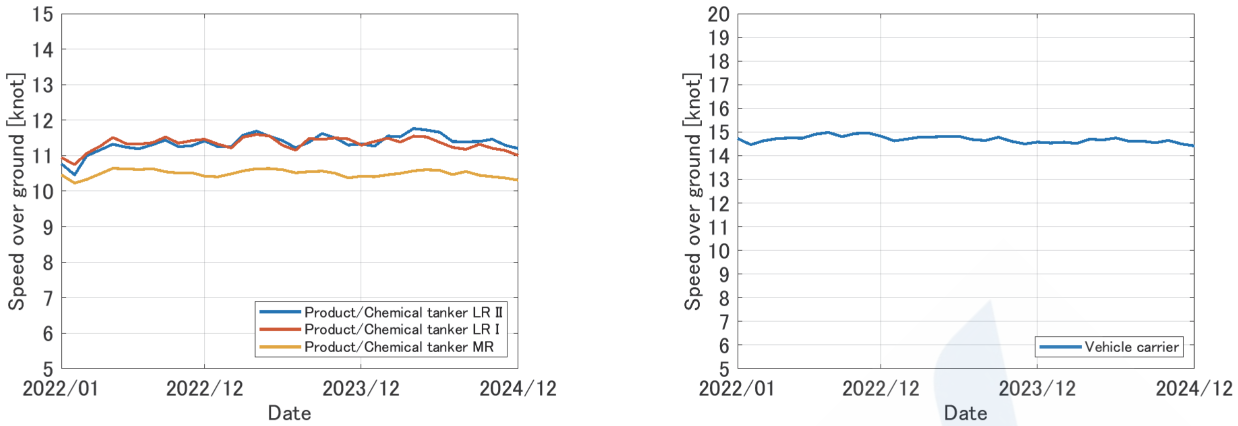


Fig. 5 Track charts of bulk carriers by size (2022-2024)

Fig. 6 shows the transition (average values) of the ship speed over ground for each month by ship type and size. Here, LNG carriers and vehicle carriers are not classified by size, and speeds of 2 knots or less are excluded from the calculations of the average values.

The speed of containerships with sizes of 6 000 TEU class and larger decreased from September 2022 to February 2023. This is presumed to be the result of a certain reduction in ship speed accompanying slack supply and demand for shipping due to a sharp decline in the movement of goods [7]. However, the average ship speed increased from around November 2023. Although this will be discussed in more detail in section 3.3 below, it is conjectured that some containerships avoided the Red Sea due to deterioration of the situation in those waters, and the average ship speed increased due to the longer cruising distance via the Cape of Good Hope. Among other types of ships, the average speed was generally flat or tended to decrease slightly.





Product and chemical tankers　　　　Vehicle carriers

Fig. 6　Transition of average ship speed by ship type

3.2　Information on Ocean-going Ships Calling at Ports of Tokyo

Information on the ships that call at a specified port can be grasped by combining the AIS data and Clarkson's ship database. As one example, this paper introduces information on ships calling at the Port of Tokyo. In this paper, ships with a speed of 2 knots or less for 6 continuous hours in the area shown in dark blue in Fig. 7 are regarded to calling at the port. The object of this analysis is ocean-going ships, and the totals indicate the number cases where the port of call before/after calling at the Port of Tokyo was outside of Japan.

Fig. 8 shows the number of calls in Port of Tokyo in 2023 by ship type. In order, the largest number of calls was by containerships (4 343), general cargo ships (1 681) and Ro-Ro ships (1 256). According to the Tokyo Metropolitan Government's Bureau of Port and Harbor, there were 4 753 calls by ocean-going containerships in 2023. From this, it can be understood that the results of this analysis identified approximately 91% of the total number [8].

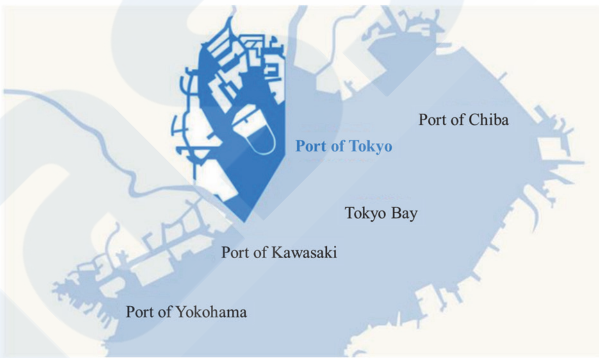


Fig. 7　Location of Port of Tokyo (source: Bureau of Port and Harbor, Tokyo Metropolitan Government)

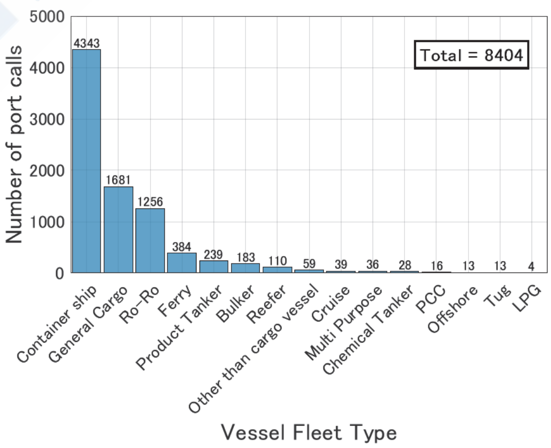


Fig. 8　Number of calls at Port of Tokyo by ship type (2023)

Fig. 9 shows the statistical values for the departure country/region, destination country/region, type of fuel (main engine), length overall, owner's nationality and the flag state of ships calling at the Port of Tokyo. By combining the AIS data and Clarkson database, it is also possible to understand the main engine fuel, the principal particulars of the ships, the owner's nationality and the flag state of ships calling at the Port of Tokyo. In order, the departure and destination country/regions are China, Korea and Taiwan, and China has particularly large share. In almost all cases, the fuel type of the main engine is intermediate fuel oil (IFO). By expanding these analyses to ports throughout the world, it would be possible, for example, to understand how frequently dual fuel vessels call at ports. However, since it is difficult to judge what fuels dual fuel vessels are actually using from the AIS data, it is necessary to examine the AIS data in combination with another database.

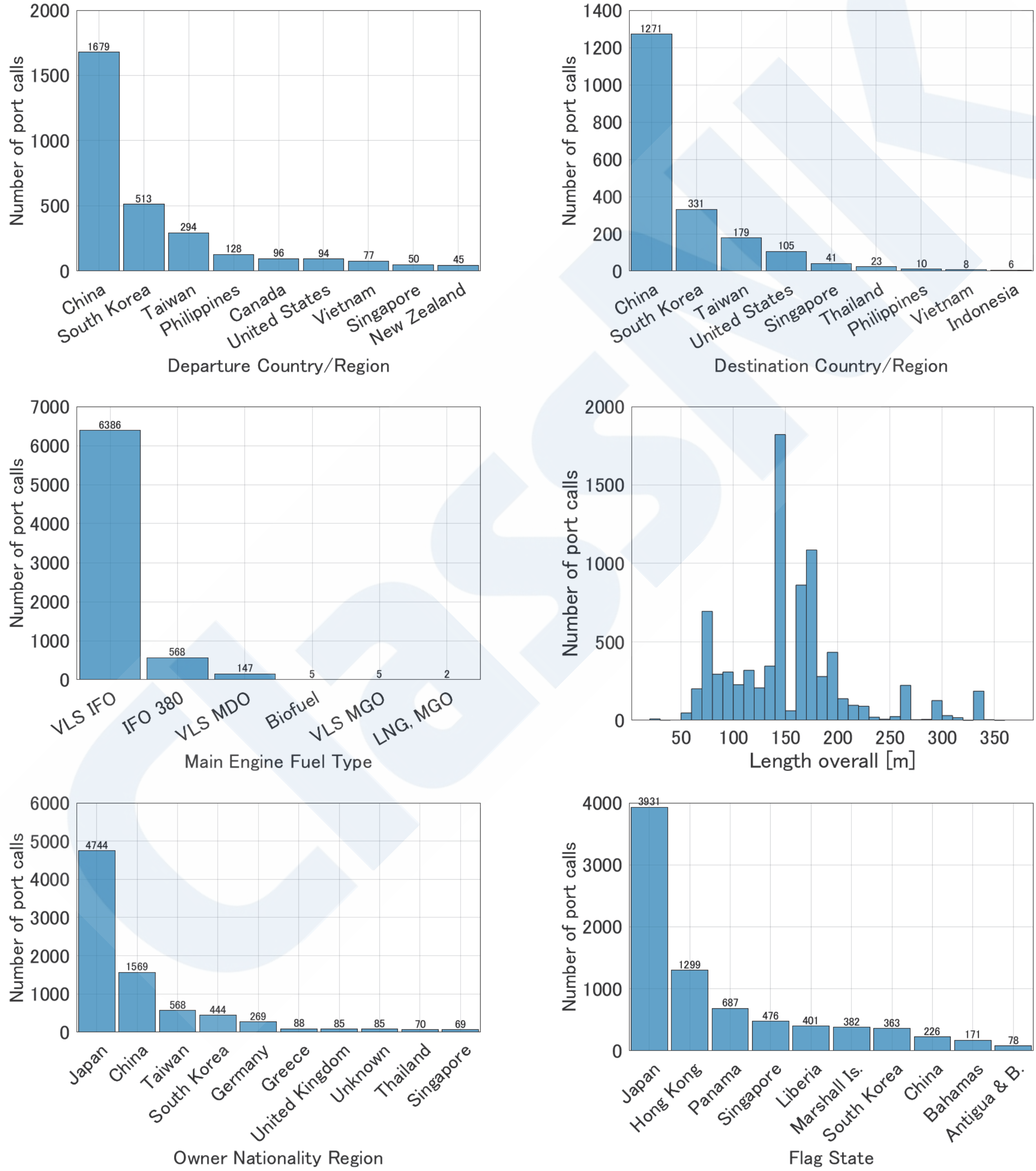


Fig. 9 Information on ships called at Port of Tokyo (2023)

3.3 Changes in Route of Voyages with Deterioration of Situation in the Red Sea

Deterioration of the geopolitical situation in the Red Sea region is one critical issue for international shipping. To make a quantitative analysis of the impact of avoidance of the Red Sea route, in this section, we analyzed not only the macroscopic changes in the number of vessels using the Red Sea route, but also the moves by ship type and nationality of the owner and management company. Using the AIS data, the number of ships sailing even one time in the region of the Red Sea and the Cape of Good Hope (shown by the blue circles in Fig. 10) was counted. Here, the Red Sea area is defined as a radius of 2° (approximately 220 km) from the center coordinates, and the Cape of Good Hope area is defined as a radius of 4° (approximately 440 km) from the center coordinates.

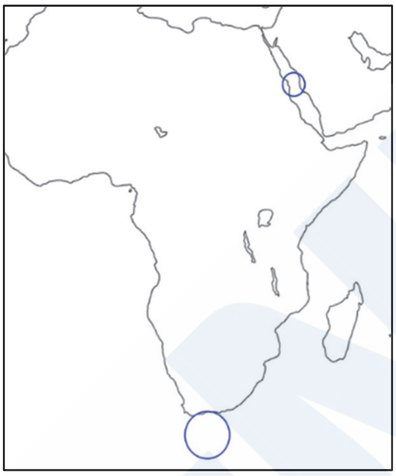


Fig. 10 Areas where ship is judged to sail through Red Sea or Cape of Good Hope

From Fig. 11, a large decrease in ships selecting the Red Sea route and a large increase in ships selecting the Cape of Good Hope route can be seen accompanying the deterioration of the situation in the Red Sea from November 2023. The number of ships sailing the Red Sea route decreased to less than half accompanying the worsening of the Red Sea situation, while the number sailing by way of the Cape of Good Hope increased rapidly from around January 2024, and ships using this route more than doubled from the number in 2023. Fig. 12 shows that the speed of containerships using the Red Sea route decreased after November 2023, and the speed of ships using the Cape of Good Hope route increased. As the reason for this increase in the average speed of ships sailing the Cape of Good Hope route, it is inferred that the ship speed was increased to keep the ships' schedules because the change from the Red Sea route to the Cape of Good Hope route required an additional voyage time of 2 weeks.

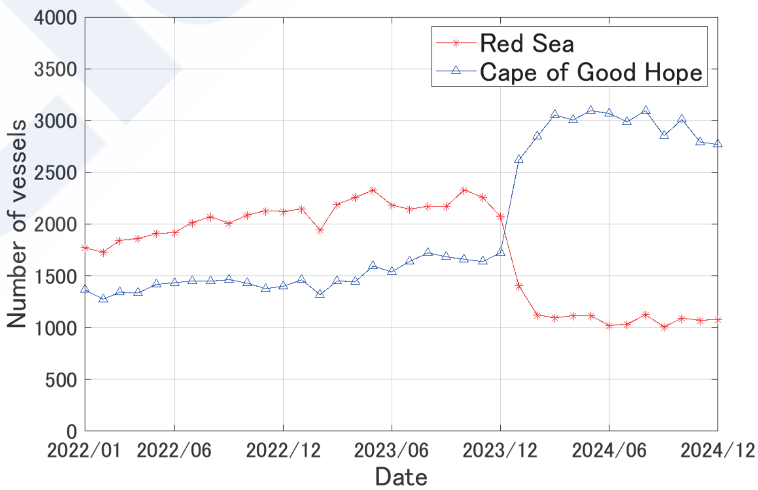


Fig. 11 Number of vessels sailing Red Sea and Cape of Good Hope routes (by month)

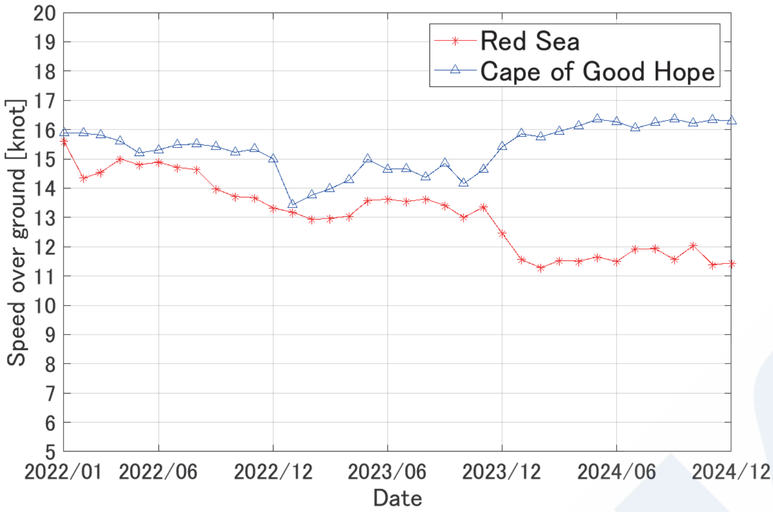


Fig. 12 Average speed of containerships sailing Red Sea and Cape of Good Hope routes (by month)

Next, the attributes of vessels sailing the Red Sea and Cape of Good Hope routes in months before and after (Sept. 2023 and Sept. 2024) the deterioration of the situation in the Red Sea were analyzed.

Fig. 13 shows the number of vessels by ship type of the ships sailing the Red Sea route and the Cape of Good Hope route. For all types of ships, the number of ships sailing the Red Sea decreased, while the number sailing the Cape of Good Hope increased, and these tendencies were particularly remarkable for containerships, LNG carriers and LPG carriers. It may also be noted that no remarkable difference was seen in the total number of ships using the two routes before and after the deterioration of the Red Sea situation.

Fig. 14 and Fig. 15 show a summary of the ships sailing the Red Sea and Cape of Good Hope routes by the nationality/region of the owner and the ship management company, respectively. In the Red Sea, Japanese, Norwegian and Korean ship owners and ship management companies in Singapore, Japan and Korea showed a tendency to avoid the Red Sea route. On the other hand, on the Cape of Good Hope route, the number of vessels of all ship owners and management companies increased, but this increase was particularly large in the case of the Japanese, Norwegian and Korean ship owners and ship management companies in Singapore, Japan, Korea, etc., which showed a remarkable tendency to avoid the Red Sea. It is suggested that this tendency occurred because many of the ships that avoided voyages through the Red Sea sailed by way of the Cape of Good Hope.

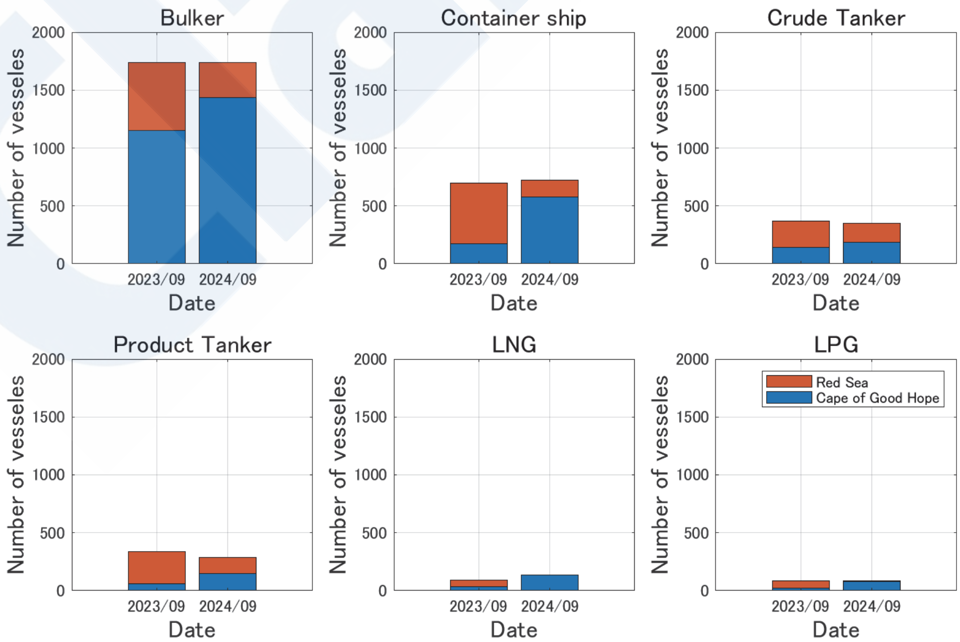


Fig. 13 Statistics by ship type for ships sailing Red Sea and Cape of Good Hope routes
(orange: Red Sea, blue: Cape of Good Hope)

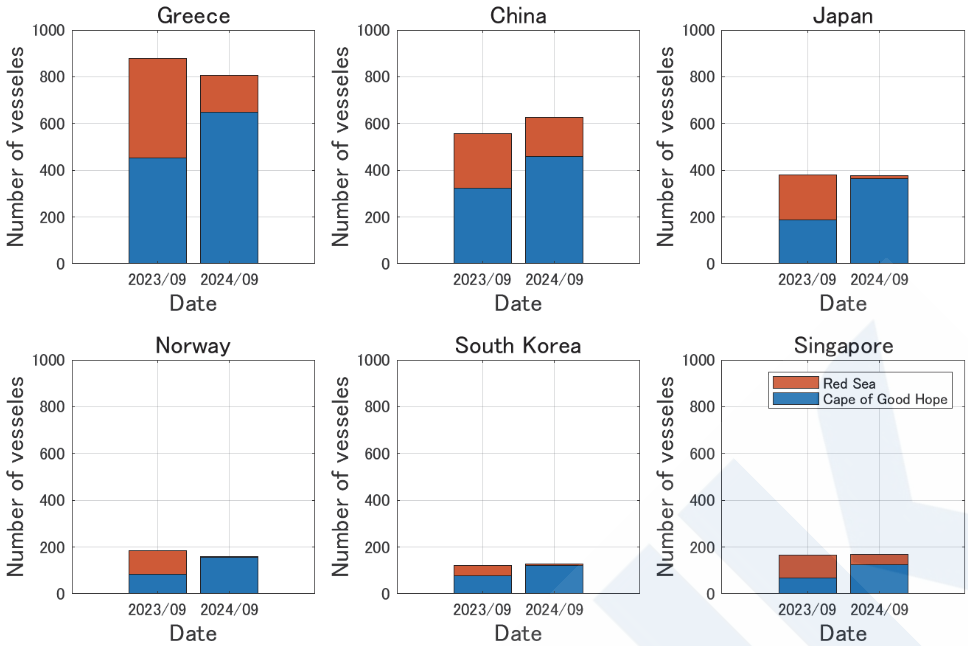


Fig. 14 Statistics by ship owner's nationality/region for ships sailing Red Sea and Cape of Good Hope routes (orange: Red Sea, blue: Cape of Good Hope)

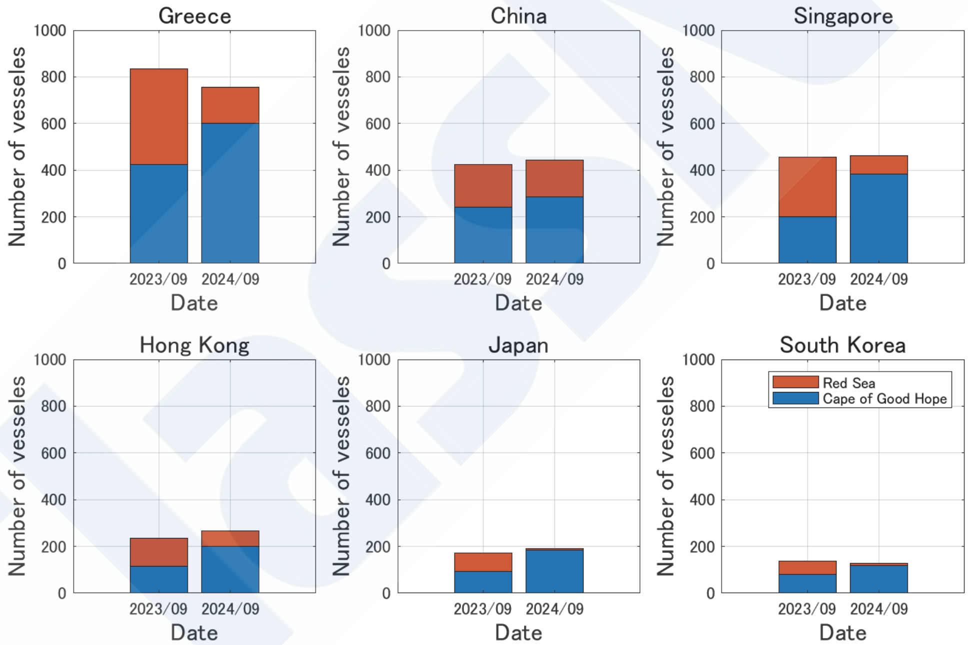


Fig. 15 Statistics by ship management company's nationality/region for ships sailing Red Sea and Cape of Good Hope routes (orange: Red Sea, blue: Cape of Good Hope)

4. CONCLUSION

As examples of the uses of AIS data, this paper introduced the results of analyses of the condition of voyages by ship type and size, information on ocean-going ships calling in Port of Tokyo, and changes in the root of voyages accompanied by the deterioration of the situation in the Red Sea. The Society acquired AIS data for ships registered with the Society after 2015 and all ships after 2022, and used the data mainly in rule development and ship classification services. Because AIS data are also expected to be used in diverse applications other than the development of services of the Society, in the future, we plan to summarize and publish the information obtained from AIS data periodically, based on the needs of those involved in the maritime industry.

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