[S-100WG8]

Paper for Consideration by S-100WG8

Ecological Benefit and Navigational Safety Study based on S-10X Data

Submitted by:	Republic of Korea (KHOA, KRISO)
Executive Summary:	Ecological benefit and navigational safety study was conducted by using S-111 through optimization of route planning and ship operation process.
Related Documents:	S-100, S-111
Related Projects:	KHOA S-100 testbed project

Introduction / Background

KHOA reported a paper about "Evaluation of the economic feasibility of using S-100 based product services in a ship operating environment" at the IHO 2022 6th Council. Passenger ships operating on the west coast of Korea generally use normal routes and roundabout routes. KHOA team designed a alternative route for ship using S-102 and S-104 data. As a result of the simulation, the alternative route was 55% shorter than the roundabout route, and the fuel consumption also differed by 45.5%, so it was determined that 124,186 USD could be saved annually.

This paper is about the results of ecological benefit and navigational safety study based on S-111 data since the last council. Ship route and engine RPM usage were optimized in consideration of S-111 surface currents that change every hour.

Analysis/Discussion

Economic efficiency regarding S-111 surface currents

Long-distance ferry routes between Mokpo and Jeju were selected to evaluate the impact of tidal currents on ship operations. The route is about 92 miles, which takes 4 hours and 30 minutes in general conditions, and a 9,832-ton ship with 900 people on board is actually operating.

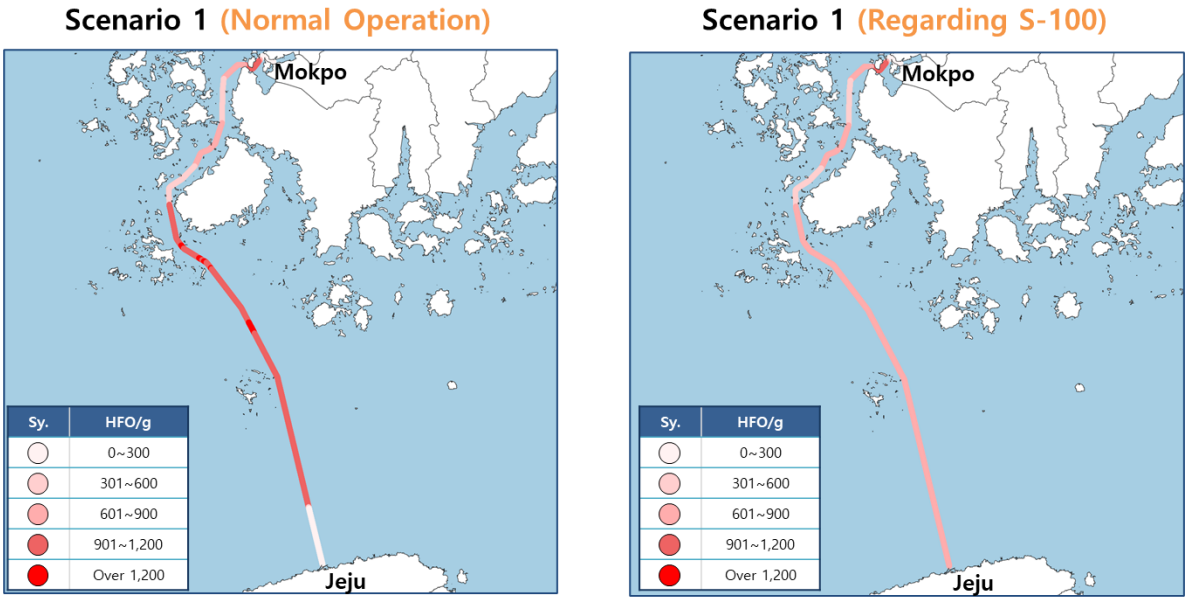

Figure 1. Route Plan Scenarios between Mokpo to Jeju

With government approval, we designed scenario 1 that considers general operating patterns for legal routes that actually operate, and scenario 2 that optimizes RPM usage by section by reflecting S-111 seawater flow.

The range of S-111 data generated by KHOA's physical prediction model is 72 hours. Surface currents grids are 300m 2km and 3km, and 2km grids were used in this test.

Scenario 1 shows that fuel consumption is somewhat high because it operates at a high speed of 23-24 knots after leaving the speed limit area near Mokpo, and then approaches in time for entry by lowering RPM consumption from near Jeju Port. Scenario 2 optimized the RPM use plan by considering the flow of seawater in advance for each point where the ship moves. In addition, ships were allowed to use seawater flow near Jindo Island, where the maximum flow rate occurs.

Table 1. Comparison of Ship Pollutant Emissions

Category	Scenario 1 (Normal Operation)	Scenario 2 (Regarding S-100)
HFO	13.02	11.12 (↓)
CO_2	40.54	34.64 (↓)
NOx	1.006	0.859 (↓)
SOx	0.621	0.531 (↓)
PM	0.094	0.081 (↓)
CH_4	0.00065	0.00056 (↓)

The amount of fuel consumed for 4 hours and 30 minutes was analyzed using the engine RPM log and fuel consumption rate used in the simulation. The fuel required 13.02 tons and 11.12 tons, respectively, which reduced fuel consumption by 14.6% when the ship was operated after establishing an optimized routing plan in consideration of S-111 seawater flow. Although the arrival time and average speed were almost the same, it can be seen that the route plan reflecting S-111 surface currents and considering Just-in-time is much more economical.

Table 1 compares the discharge results of ship pollutants by scenario. As fuel consumption was reduced by about 14.6%, the emission of pollutants such as carbon and nitrogen oxides was also reduced to a similar percentage.

Navigational safety regarding S-111 surface currents

The tugboat line(towboat vessels including tug boat and barge) between Pyeongtaek Port and Incheon Port uses two routes. It is a Joongsudo route that operates outward around Yeongheung Island and a Yeongheungsudo route that operates inward. The research team analysed S-111 data and tidal tables to find the time zones of the maximum flood and maximum ebb time.

Maximum flood time : 2023, January 23, 15:00, 6.2kts
Maximum ebb time : January 23, 2023, 09:00, 4.3kts

The tugboat row that connected the tugboat (33.1m in length, 12.0m in width, 4.4m in flow) and the barge (76.2m in length, 23.2m in width, and 8m in flow) was selected as the test target. The safety evaluation index was a six-degree exercise in which ships operated and recorded changes in yaw, pitch, roll, surge, swing, and heel in real time.

At the time of the maximum ebb time, the average hull motion during the total voyage time was similar in both routes, and there was no significant difference. Even on the time series graph, it was difficult to identify the section with a large difference in motion change.

Table 2. Comparison of Ship Navigational Safety

	Maximum flood		Maximum ebb	
	Yeongheung	Joong	Yeongheung	Joong
Surge	4.00m	3.47m	4.08m	4.04m
Sway	0.38m	0.44m	0.29m	0.26m
Heave	0.09m	0.08m	0.08m	0.08m
Yaw	2.07°	1.66°	1.07°	0.80°
Roll	0.51°	0.46°	0.31°	0.30°
Pitch	1.27°	1.25°	1.15°	1.15°

However, there was a difference in average hull motion during the maximum flood time. In particular, in the case of the yaw movement, which means up and down rotation, it was confirmed that the passage to Yeongheungsudo was about 24% larger than that of the passage to the Joongsudo. If the operating ship's control performance is poor, it is believed that passage safety will be secured if the S-100 dynamic hydrographic data is used to select the Joongsudo route in the maximum flood situation.

Action Required of S-100WG

The S-100WG is invited to:

a. note the activities of ecological benefit and navigational safety based on S-10X Data