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Research on Optimization of Route Selection for Capesize Ships in 12.5 m Deep Water Channel of the Yangtze River

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Abstract: At present, the navigation environment of the Jiangsu section of the Yangtze River is complex, the tidal current direction near the wharf, anchorage and waterway is complex, and the flow velocity is large, and the maximum flood period can reach 6-7 knots. With the full play of the function of the golden waterway, the increasing density of ships' navigation and the increasingly complex navigation environment, the safety of ship pilotage is facing increasing pressure and challenges. The construction of the 12.5-meter deepwater channel in Jiangsu section of the Yangtze River has been improved, and the improvement of the navigation environment has become possible. The entry and exit of 150000 DWT ships in Jiangsu section of the Yangtze River will be normalized. In the process of entering the port, ships need to go through navigation, anchor dropping, berthing and unberthing and other operations. Large ships, especially restricted ships (mainly refers to super draught ships), are limited by water depth. During the process of navigation, anchor dropping, berthing and unberthing, tidal optimization is indispensable. The optimization of anchorage capacity model and berthing and unberthing time is particularly important. Tidal optimization model and algorithm are reflected in the accurate calculation of tides, In order to maximize the use of water depth. Based on the analysis of the existing route selection of Cape ships in the 12.5m deep water channel of the Yangtze River, this paper quantitatively analyzes the existing data from the wharf, anchorage, entry and departure time, etc. The efficiency of navigation and berthing and berthing in the Yangtze River promotes the integrated and high-quality development of the Yangtze River Economic Belt and the Yangtze River Delta region.

Keywords: Deep Water Channel, Capesize Ships, Route Selection, Optimization, Safe Navigation

1. Introduction

The Jiangsu section of the Yangtze River is close to the river and the sea, with unique water transportation resources, and the effect of cost reduction and efficiency improvement is outstanding. On May 8, 2018, the 12.5-meter deep water channel below Nanjing on the Yangtze River was fully connected, playing an important role in serving national strategies such as the "Belt and Road" initiative, the development of the Yangtze River Economic Belt and the regional integration of the Yangtze River Delta. The most direct effect is that the ship becomes larger, the actual load rate increases and the transportation cost decreases [1]. According to estimates, each additional 1 ton of cargo loaded on a 50,000-ton-class ocean-going vessel can save more than 20 yuan in transportation costs, which effectively promotes the high-quality development of the Yangtze River Economic Belt.

Due to the changes in the demand for cape type ships in Jiangsu section of the Yangtze River, the proportion of 130-170000 DWT ships arriving at the port and berthing has increased significantly, especially in Suzhou Port and Jiangyin port. The number of cape type ships berthing has reached an average of 500 per year, and the production pressure of wharves along the river has increased sharply. In the increasingly complex navigation environment, how to operate super large seagoing ships to reasonably use anchorage

resources is a subject worthy of careful study by the Yangtze River pilots.

2. Status of Capesize Ships

Capesize ships have a deadweight tonnage of 120,000 to 200,000 tons, and are generally used to transport large quantities of raw materials, such as coal, iron ore, etc [2] According to the standard described by BCI (BALTICCAPE2SIZEINDEX), the maximum deadweight ton is 180,000 tons, the summer full-load draft is 18.2M; the maximum age is 10 years; the bulk volume is 198,000 cubic meters; the total length is 290 meters, the width is 45 meters; Water-carrying) ballast/14 knots (cargo-carrying). The main dimensions of typical capesize ships are as follows in Table 1:

Table 1. *Representative ship types of capesize ships.*

Ship type	DW	LOA	B	D	T
Capesize ship	130,000-170,000 tons	274.32-330m	41-45m	22.3-24.6m	17.2-17.8m

Capesize ships are currently the largest operating ships entering the Yangtze River. Each Capesize ship not only directly brings economic benefits of millions of yuan to port enterprises, but also greatly reduces the logistics cost of cargo transit and effectively reduces the cost of goods in the process of river-sea transshipment. Pollution emissions [3]. According to the characteristics of the natural waterway of the Yangtze River that are curved and narrow, the difficulties in manoeuvring a Cape of Good Hope ship, the currents at the front of the wharf, and the characteristics of water depth, etc., a detailed piloting plan, berthing plan and specific safety measures are formulated in advance [4].

From 2018 to 2020, the data of Capesize ships led by the Yangtze River Pilotage Center are shown in Figure 1 below:

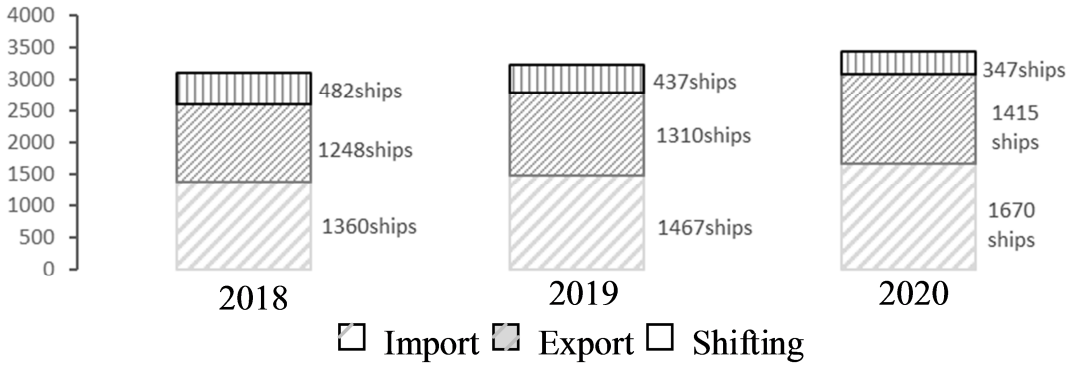

Figure 1. *Data of Capesize ships led by Yangtze River Pilotage Center from 2018 to 2020.*

Note: After some ships enter the Yangtze River, they enter and call at different ports for import, and export directly to Wusongkou for export, so import (vessel) > export (vessel).

The import and export of Capesize ships is increasing year by year, and the number of berthing ships is decreasing year by year. The trend of large-scale transportation ships in the Yangtze River is becoming more and more obvious, and the ports along the river are becoming seaports, and the import and export of Capesize ships will further increase [5].

3. Path Analysis of Capesize Ships

After the Cape of Good Hope ship Wusongkou enters the Yangtze River, different paths are selected, as shown in Figure 2 below.

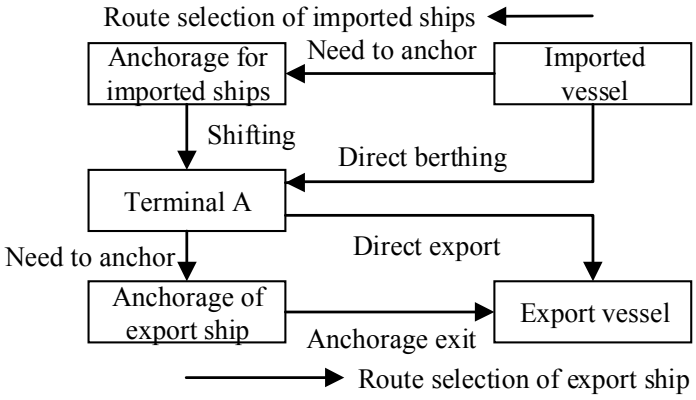

Figure 2. *The route selection diagram of capesize ships entering and leaving the Yangtze River.*

There are 4 main routes: direct berthing and direct exit; berthing and direct exit after passing through the anchorage; berthing after passing through the anchorage and then exit after passing through the anchorage; direct berthing and exit after passing through the anchorage.

3.1. Analysis by Terminal Classification

1) Taicang Wugang Wharf (including Wugang 1 and Wugang 2, there are 2 berths)

The Capesize ships berth at the Liwu Port wharf, and the number of berthing ships is as follows in Table 2:

Table 2. *The berthing capacity of ships at Taicang Wugang Wharf.*

Year	The berthing capacity of Wugang Wharf	Ships entering		Ships leaving	
		Berthing	Anchorage	Export	Anchorage
2018	284	123	161	194	90
2019	304	177	127	171	133
2020	306	206	100	220	86
Average	298	169	129	195	103

Taking into account the indicators issued by the superior group company, the progress of loading and unloading operations, and comprehensive factors, Wugang Wharf has a certain stability in receiving Capesize ships, and the berthing capacity is planned and continuous. The number of piers increased by about 20 [6]. The anchorage of Wugang Wharf is mainly selected as the Liuhe anchorage in Taicang, and a small number of ships choose the seagoing anchorage in Taicang Port. The import route selection of capesize ships is gradually changed from the original anchorage and then berthing at the pier to the berth directly at the import [7]. The exit route selection has been gradually changed from the original direct berthing to anchoring and then exiting. In 2020, the direct berthing rate has been greatly increased due to the reduction of anchorages due to the epidemic, and the conflict between anchorage and the peak flow of ships. The berthing capacity of Wugang Wharf is shown in Figure 3 below:

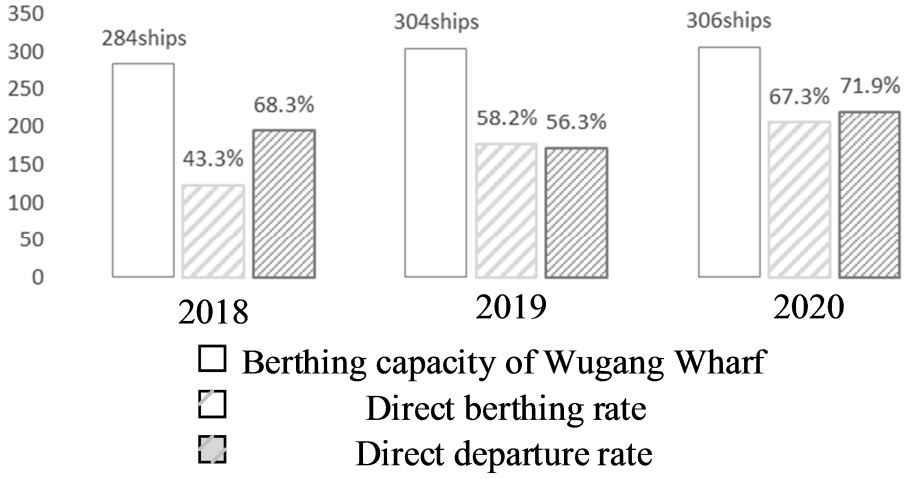

Figure 3. *Schematic diagram of the berthing capacity (vessels) of Wugang Wharf.*

2) Nantong Rugao Wharf (mainly 1 berth of Rugao Port)

Capesize ships berthed normally when they berthed at Zhonglin Rugao Wharf, and the number of berthing ships is as follows in Table 3:

Table 3. *Ship berthing capacity at Rugao Wharf.*

Year	The berthing capacity of Rugao Wharf	Ships entering		Ships leaving	
		Berthing	Anchorage	Export	Anchorage
2018	55	28	27	40	15
2019	52	24	28	32	20
2020	86	32	54	52	34
Average	64	28	36	41	23

On August 28, 2019, Zhonglin Rugao Wharf first berthed ships with a draft of 12 meters, and the berthing capacity of the wharf was further increased. For Capesize ships berthing at Zhonglin Rugao, choose direct berthing for the import route or

berth at the wharf the next day after anchoring at Taicang Port Seagoing Anchorage or Nantong Joint Inspection Anchorage. Export the next day. The anchor position of Nantong Joint Inspection Anchorage is mainly when ships break down at Zhonglin Rugao Wharf, so the anchorage transfer rate of Zhonglin Rugao Wharf remains high. The berthing capacity of Rugao Wharf is shown in Figure 4 below:

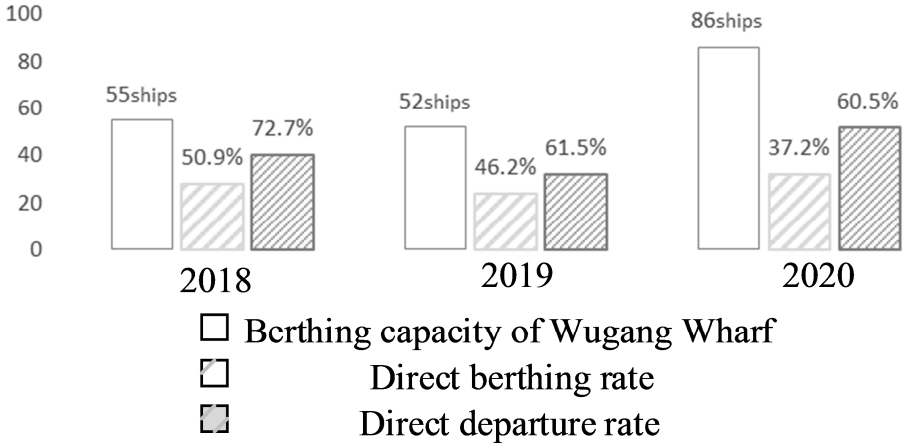

Figure 4. *Schematic diagram of berthing capacity (vessels) at Rugao Wharf.*

3) Jiangyin Huangtian Port Wharf (including Huangtian Port 5 and Huangtian Port 6, a total of 2 berths)
The Capesize ships berth at the Jiangyin Huangtian Port, and the number of berthings is as shown in Table 4:

Table 4. *Ship berthing capacity at Huangtian Port.*

Year	Huangtian Port berthing capacity	Ships entering		Ships leaving	
		Berthing	Anchorage	Export	Anchorage
2018	323	149	174	257	66
2019	381	186	195	320	61
2020	465	258	207	436	29
Average	390	198	192	338	52

The number of ships at Huangtian Port has grown at a rate of 20%, and the number of berthings at the terminal has continued to increase. The import route of capesize ships chooses to berth directly or berths the next day after anchoring at Liuhe anchorage in Taicang and Jiangyin anchorage, and the export route is mainly direct export. The number of ships, only under special circumstances, will be anchored and left the river. The berthing capacity of Huangtian Port is as shown in Figure 5:

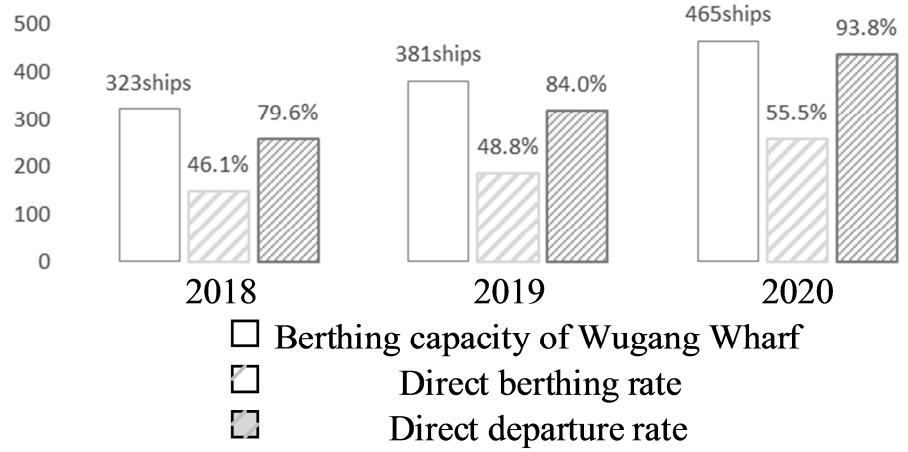

Figure 5. *Schematic diagram of berthing capacity (vessels) at Huangtian Port.*

4) Other piers (such as Da 12, Haili 6, Lu Anzhou, Shengtai 3, Zhang 4, etc.)
Cape-size ships sailing on the Yangtze River berth at other wharves, and the number of berthing ships is as follows in Table 5:

Table 5. *Ship berthing capacity at other terminals.*

Year	Berthing capacity of other terminals	Ships entering		Ships leaving	
		Berthing	Anchorage	Export	Anchorage
2018	439	251	188	272	167
2019	451	262	189	366	85
2020	484	286	198	442	42
Average	458	266	192	360	98

Imported ships are mainly berthed directly. If they really need to anchor at the Liuhe anchorage in Taicang, the seagoing ship anchorage in Taicang Port and the Taizhou seagoing ship anchorage, the export ships are basically exported directly. If they really need to anchor at the Taizhou seagoing ship anchorage. It is difficult to break anchor, especially for export ships. The berthing capacity of other terminals is shown in Figure 6 below:

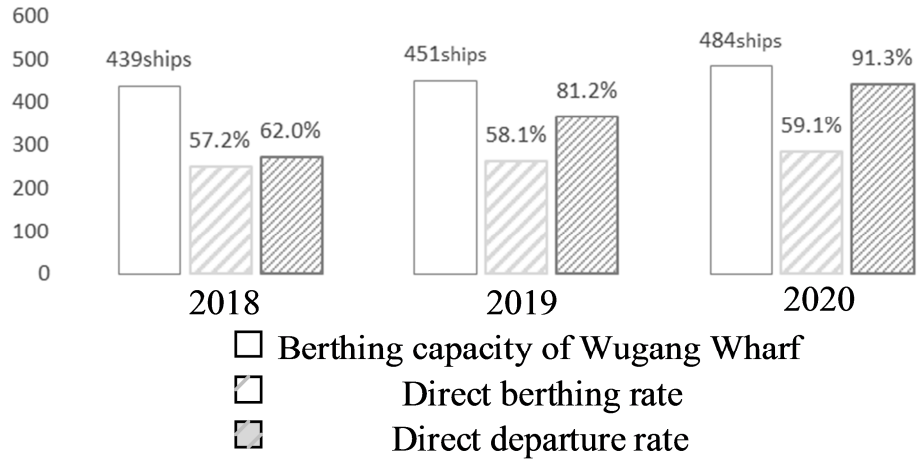

Figure 6. *Schematic diagram of the berthing capacity (vessels) of other terminals.*

5) The average annual berthing rate of each terminal is as follows:

At present, an average of 1,211 capes-sized ships enter the Yangtze River every year, 52.3% of which are directly berthed by imported ships, and 47.7% by anchorage; The average annual berthing capacity of each terminal is shown in Figure 7:

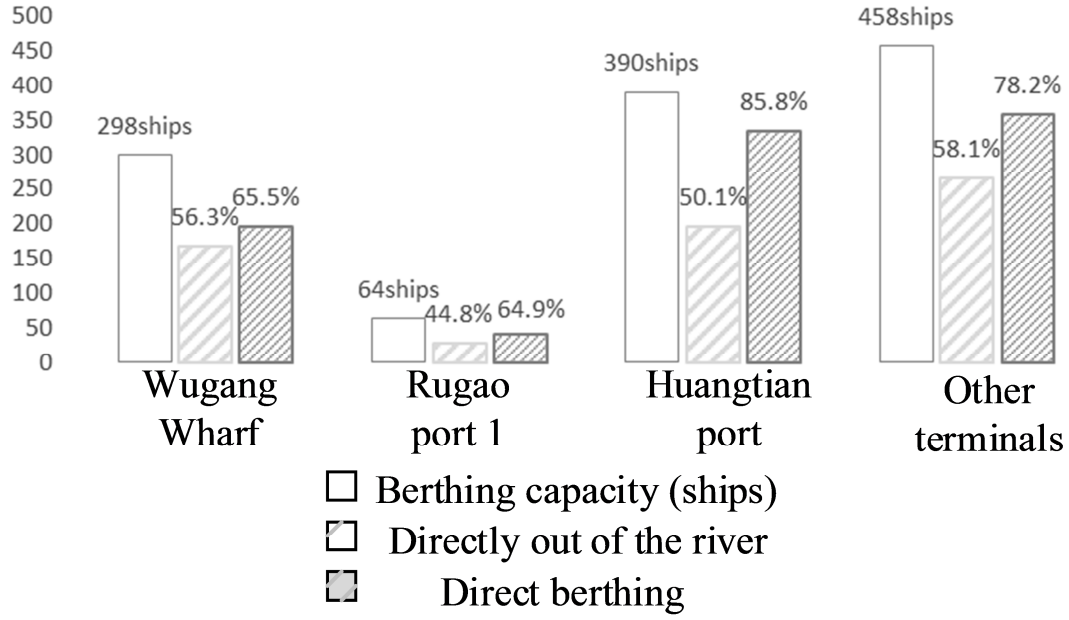

Figure 7. *Schematic diagram of the average annual number of berthings (vessels) at each terminal.*

With the obvious trend of ships becoming larger, the number of ships will gradually increase due to factors such as terminal upgrades and accelerated loading and unloading operations. There is a big difference in the berthing rate

between the wharves, and the ships at Wugang Wharf are in normal operation; Rugao Port 1 basically does not need to worry about the problem of anchorage, and can be implemented regardless of entry or exit; Huangtian Port Wharf has a large number of Cape-type ships, and the anchorage problem is particularly prominent; other The anchorage resources of the wharf are inferior to those of Wugang Wharf and Rugao Port 1.

3.2. Analysis According to Anchorage Classification

According to the "Regulations on the Vessel Routing System of the Jiangsu Section of the Yangtze River (2021)", the anchorage information is displayed as shown in Table 6 below:

Table 6. *List of some anchorages in the Jiangsu section of the Yangtze River.*

Numbering	Name	Location	Scale (m)
No. 1B	Taicang Liuhe Anchorage	Liuhe waterway, Yangtze River #2 Heifu to Baibei #1 North of Heifu	Length 4430, width 1000-1580
No. 1	Taicang Port Sea Vessel Anchorage	Baimaosha Waterway, Yangtze River #6 Heifu to the north side of Yangtze River #7 Heifu	Length 4000, width 1100
No. 5	Nantong Joint Inspection Anchorage	Tongzhou Shadong Waterway, the north side of the Yangtze River #25 Heifu to #26 Heifu	Length 3310, width 600-860
No. 15	Jiangyin anchorage	Jiangyin Waterway, Yangtze River #63 Heifu to the north of Yangtze River #64 Heifu	Length 3257, width 500

1) Taicang Anchorage (here refers to Taicang Liuhe Anchorage and Taicang Port Sea Vessel Anchorage)

The Taicang anchorage has an average of 621 anchored ships per year, of which 66% are imported and 34% are exported. The details are shown in Table 7:

Table 7. *Statistics of the number of anchored ships in Taicang anchorage.*

Year	Anchored	Anchor in port		Departure to anchor	
		Import	to Wugang	Export	from Wugang
2018	685	435	161	250	90
2019	651	404	127	247	133
2020	528	392	100	136	86
Average	621	410	129	211	103

Ships at Wugang Wharf accounted for 37.4% of ships at Taicang anchorage. The Taicang Anchorage is mainly used for anchorage of Capesize ships along the Jiangsu section of the Yangtze River for the night, and the majority of imported ships are. Ships entering and leaving Wugang Wharf are the main ships that break down at Taicang Anchorage.

2) The situation of Nantong anchorage (here is the guide for the joint inspection anchorage)

Nantong anchorage has an average of 62 anchored ships per year, of which import ships account for 59.7% and export ships account for 40.3%. The details are shown in Table 8:

Table 8. *Statistics of the number of ships at Nantong anchorage.*

Year	Anchored	Anchor in port		Departure to anchor	
		Import	To Rugao	Export	From Rugao
2018	78	39	15	39	10
2019	46	27	15	19	13
2020	61	44	27	17	17
Average	62	37	19	25	13

Ships at Rugao Wharf accounted for 51.6% of ships at Nantong anchorage. Compared with Taicang anchorage, Nantong anchorage has fewer anchored ships. Ships at Rugao Wharf have sufficient anchorages, so you only need to choose the required path.

3) Jiangyin anchorage situation

Jiangyin anchorage has an average of 42 anchored ships per year, of which 69% are imported and 31% are exported. The details are as follows in Table 9:

Table 9. *Statistical table of the number of anchored ships in Jiangyin anchorage.*

Year	Anchored	Anchor in port		Departure to anchor	
		import	To Huangtian	Export ship	From Huangtian
2018	11	7	7	4	4
2019	50	31	30	19	17
2020	65	48	44	17	17
Average	42	29	27	13	13

Ships at Huangtian Port accounted for 95.2% of ships anchored in Jiangyin. Since the new operation is about 3 years old, it is expected that the number of anchored ships will increase in the follow-up. Jiangyin anchorage is mainly due to the tight anchorage of ships in Huangtian Port. If they really need to drop anchor, they will drop anchor at Jiangyin anchorage. Cape-size ships in other ports are basically not dropped at Jiangyin anchorage.

4) Other anchorage conditions

At other anchorages, 100 ships are anchored every year, of which 73% are imported and 27% are exported. The details are shown in Table 10.

Compared with export ships, there are more anchored ships in imports, and the shortage of anchorage is prominent.

Table 10. *Statistical table of the number of anchored ships at other anchorages.*

Year	Ships at other anchorages	Import	Export
2018	114	69	45
2019	91	77	14
2020	96	75	21
Average	100	73	27

5) The average annual proportion of ships importing and exporting at anchorage is as follows

The use of anchorage resources can be seen from the schematic diagram of the average annual import and export of ships at each anchorage. Specifically as shown in Figure 8:

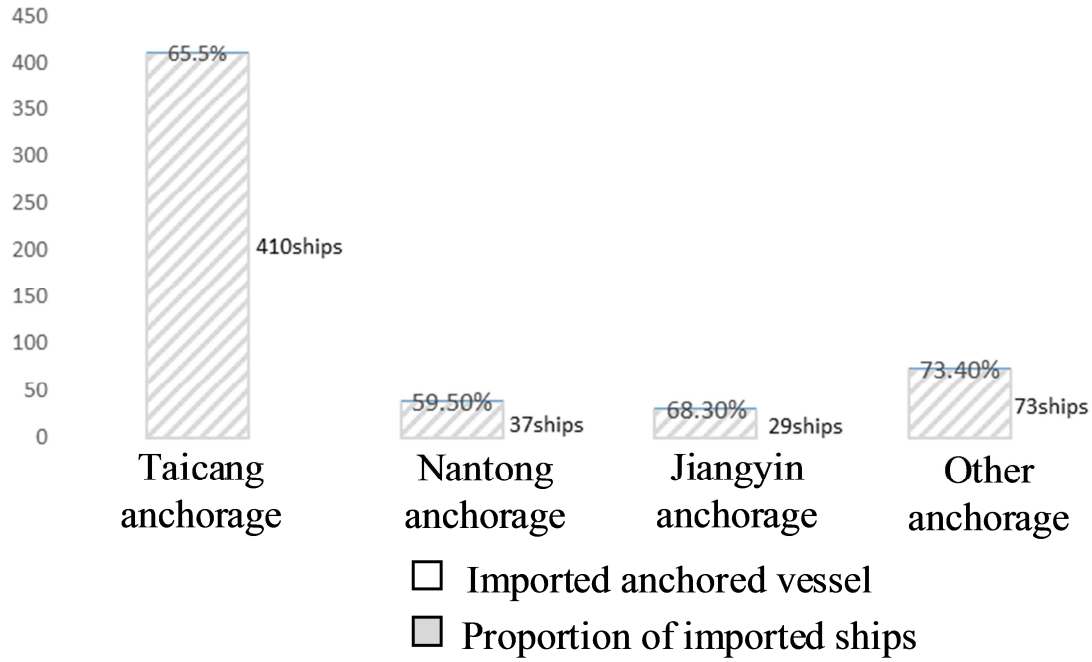

Figure 8. *Schematic diagram of the average annual import and export ships (ships) at each anchorage.*

The Yangtze River anchorage resources are limited and have little change. Under the premise of not expanding the anchorage, the Yangtze River anchorage is basically unchanged [8]. On average, 1,211 Capesize ships are imported each year, and 549 imported ships are anchored, accounting for 45.3%; export ships 276 vessels broke down, accounting for 22.8%. On average, all anchorages can accommodate 825 ships at anchor each year, of which 66.5% are imported and 33.5% are exported. The Taicang anchorage accounts for 75.3% of the Yangtze River anchorage resources. The Taicang anchorage is the first choice for Cape-type ships to enter and exit the Yangtze River anchorage. The Nantong anchorage is mainly used by ships at Rugao Wharf, and the Jiangyin anchorage is gradually being opened for the use of Huangtian Port Wharf.

3.3. Analysis According to the Date of Entry and Exit of Ships

1) Analysis by month

The Capesize data showed no significant change in the number of characteristics of the ships leading each month. Monthly capesize numbers were erratic in 2018 and stabilized in 2020. Specifically as shown in Figure 9:

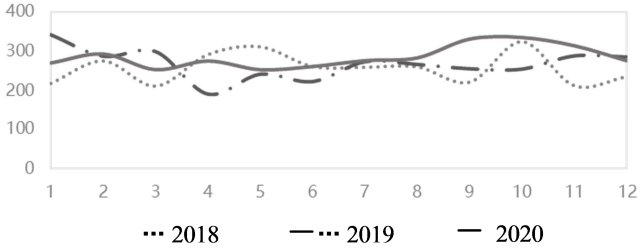

Figure 9. *Schematic diagram of the monthly number of Capesize ships from 2018 to 2020.*

2) Take the data of Capesize ships in 2020 as an example

In the days near the spring tide, the import and export of Capesize ships may peak, as shown in Table 11 below:

Table 11. *Peak monthly import and export ships in 2020.*

Gregorian month	Peak export and import ships	Lunar date
Jan.	17	Twenty
Feb.	15	Fourth grade
Mar.	16	Fourteen, Sixteen
Apr.	16	Eleven twelve
May.	11	The ninth, eleventh, fourteenth, twenty-two, twenty-four
Jun.	16	The first and third grades
Jul.	21	Nineteen
Aug.	19	Third grade
Sep.	17	Twenty seven
Oct.	19	The third and fifteenth grade
Nov.	16	Twenty-one
Dec.	17	Eleven

System preparations for anchoring and berthing should be made to prevent too many imported ships, resulting in tight anchorages, ship pressure in ports, and poor dock turnover.

4. Anchorage Capacity Model

4.1. Selection of Anchorage Capacity Model

Using the basic theory of Monte Carlo method and establishing a model based on the Monte Carlo simulation algorithm to study the anchorage capacity, the anchorage capacity is essentially a problem of the number of random anchored ships within the anchorage range, and the fundamental reason for the change is the random distribution of the anchored ship positions [9]. Based on the research on the anchorage capacity model of "Ningbo Zhoushan Port Xiashimen Anchorage Capacity and Planning Research". Anchorage capacity is a functional expression of the design length and anchorage area. This formula is applicable to the single-anchor mooring mode of ships. The value range of the anchorage area S is 0~10km², and the value range of the ship length L is 0.1~0.35km.

$$N = 0.02S \times L^{-1.905} \tag{1}$$

This expression directly calculates the anchorage capacity N (ship) according to the anchorage area S (km²) and the ship length L (km) within the value range, which is used for the calculation of the anchorage capacity.

4.2. Calculation of Anchorage Capacity

According to the data in the announcement of "Regulations on Vessel Routing System in Jiangsu Section of the Yangtze River (2021)", the N value is calculated, and the following table 12 [10] is obtained:

Table 12. *Calculation of N value representing anchorage.*

Name	Scale (m)	S	L	N
Taicang Liuhe Anchorage	Length 4430, width 1000-1580	6.6	0.29	1.4
Taicang Port Sea Vessel Anchorage	Length 4000, width 1100	4.4	0.29	0.9
Nantong Joint Inspection Anchorage	Length 3310, width 600-860	2.64	0.29	0.5
Jiangyin anchorage	Length 3257, width 500	1.6	0.29	0.3

4.3. Anchorage Capacity Verification

According to the data of the average annual anchorage ships, the actual number of anchored ships per day from 2018 to 2020 is calculated, and compared with the theoretical value N, the anchorage utilization rate is obtained, as shown in Table 13 below:

Table 13. *Utilization rate of some anchorages in the Jiangsu section of the Yangtze River.*

Anchorage name	Actual value from 2018 to 2020	Theoretical value N	Anchorage utilization
Taicang anchorage	1.7	2.3	74%
Nantong anchorage	0.2	0.5	40%
Jiangyin anchorage	0.1	0.3	33%

5. Optimization of Route Selection for Cape-Type Ships

Due to historical objective reasons, in the early stage of the construction of the channel, it was considered that the number of Cape-type ships was small and the supporting anchorage was insufficient. With the increase of ship flow, the port anchorage was less. In the process of high-quality development of the Yangtze River, it is recommended to optimize.

5.1. Pre-planning Optimization

Under the condition that the anchorage remains unchanged, when the wharf has plans to add new berthing capesize ships,

it is necessary to simultaneously plan, implement and construct the supporting anchorage in the early stage of the design and construction of the wharf, so as to alleviate the difficulty of anchorage of capesize ships in the Yangtze River.

5.2. Anchorage Selection

The import and export anchorage should be anchored in Hong Kong for berthing or export as far as possible, so as to avoid the crowding of anchorage resources to the Taicang anchorage [11]. Ships exported from Huangtian Port will drop anchor at Jiangyin anchorage or Changshu anchorage, so as to avoid the VTS control period during the peak flow of ships in Shanghai when leaving the anchorage.

5.3. Optimization of the Timing of Entering and Leaving the Anchorage

1) Import of heavy-duty ships

Since the handover time of Baoshan import is 1 hour after the high tide of Wusong, the peak flow of ships on Taicang water is generally one hour after the lowest tide of Wusong, and it is necessary to avoid this time period when entering and leaving the anchorage. Imported ships entering the Taicang anchorage and anchoring will generally not encounter the peak flow of ships in Sheung Shui. When entering the anchorage the next day, the anchor must be lifted out of Taicang anchorage after the lowest tide in Wusong or the peak flow of ships in Sheung Shui.

2) Export of empty ships

When entering the anchorage, it is necessary to avoid the peak flow of ships in the Sheung Shui, and the next day the anchorage will be handed over to Baoshan [12].

Situation 1: The export has to go through the Shanghai North Channel, and it needs to sail according to the Shanghai VTS traffic control regulations.

Situation 2: The export empty-loaded ship needs to go through the Shanghai Nancao Channel. The water depth of the channel is not enough, and it needs to pass by tide. The export empty-loaded ship needs to go to the lowest tide in Wusong to lift anchor and leave the Taicang anchorage. The sailing time is controlled for about 3 hours until it arrives at the Wusong handover area.

5.4. Anchor Optimization

Taicang Liuhe anchorage has a total of 10 anchors, of which 5 anchors L1, L2, L4, L6, L7 can throw 4-5 Cape ships, and the other 5 anchors L3, L5, L8, L9, L10 are not suitable for The capesize ship broke down [13]. At the anchorage of the seagoing ship anchorage in Taicang Port, 1 capesize ship can drop anchor, and 1-2 capesize ships can drop anchor on the north side of the #5 Heifu of the Yangtze River. The Liuhe anchorage in Taicang has 2 fixed anchors for Cape-type ships, one of which is used for Taicang local port, and the other is used for other ports.

5.5. Linkage and Integration of Anchorage Resources

Through the integration of anchorage resources, especially during the spring tide and flood season, the Taicang anchorage and Nantong anchorage have added anchors for imported Capesize ships, and exported Capesize ships as far as possible to export directly [14].

5.6. Optimization of Ship Berthing and Departure Timing

Capesize ships do not berth at the unberthing pier when the water is rising rapidly, and can be reliably unberthed when falling into the water, level water, and slow rising water. When docking at the South Bank Pier, be careful to avoid the peak flow of launching ships. Try to avoid the situation that all ships on the wharf need to drop anchor at temporary anchorage due to the subsequent berthing of other ships. During maritime management and control, the peak flow of launching ships when leaving the berth, and the peak flow of launching ships entering and leaving the anchorage will bring about ship operations. inconvenient.

6. Conclusion

Due to the limitations of the anchorage operation, such as the crowded anchorage, the limited water area available for anchorage, and the poor maneuverability of super large ships at low speed, the anchorage resources are limited, so it is necessary to choose the appropriate route to enter and exit the Jiangsu section of the Yangtze River.

Path selection, follow the following principles:

1) Direct berthing and direct export;
2) If it is really necessary to break down, the import will berth and directly export after the anchor breaks down;
3) If it is really necessary to break down, exit directly after berthing and unberthing;
4) If it is really necessary to break down, the inlet will break down and then berth and leave the berth and then the outlet will be broken down;
5) It is really necessary to drop anchor, regardless of import and export, first to Hong Kong and then to outer port;
6) If it is really necessary to break down, choose the right time to enter and leave the anchorage;
7) Avoid choosing to break down at the exit during the spring tide;
8) Each anchorage shall reserve a special anchorage for Cape of Good Hope ships.

Through the optimization of path selection [15], the anchorage resources are further released, which effectively alleviates the problem of difficulty in anchoring, and the ships of the Cape of Good Hope can enter and exit the Yangtze River smoothly.

References

[1] Shan kwok-tung. Research on Dominant Logic of Chinese Equipment Manufacturing Enterprises and its Influencing Factors in Transition Economy [D]. Dalian University of Technology, 2017.

[2] Hou weitao. Zhoushan iron ore distribution center development countermeasure research [D]. Zhejiang Ocean University, 2017.

[3] Zhang Weifeng. Study on Technological Innovation Models of Chinese Shipbuilding Enterprises [D]. Harbin Engineering University, 2013.

[4] Mengjiao Wei. The Shipping Line Configuration Research of Dry Bulk Terminal Loading System base on Ship Form [D]. Wuhan University of Technology, 2013.

[5] Guan Feng. Tramp Fleet Routing and Scheduling Problem under Uncertain Operating Condition [D]. Dalian Maritime University, 2018.

[6] Ying Wang. Research on the Construction of Zhoushan River-and-sea Coordinated Transport Service Center [D]. Zhejiang Ocean University, 2017.

[7] Xu Hongjuan. Study on Navigation Capacity of Xiazhimenkouwai Artificial Channel [D]. Zhejiang Ocean University, 2018.

[8] Xiaohong Liu. Valin Steel Iron Ore Waterway Transportation Management Optimizationl [D]. Hunan University, 2014.

[9] Chaoyue Zhang. Research on Capacity and Planning for Xiashimen Anchorage in Ningbo Zhoushan Port [D]. Dalian Maritime University, 2020.

[10] Wu Yuan. Study on Channel Capacity of Port System Based on Navigation Safety [D]. Shanghai Jiao Tong University, 2015.

[11] Hui cheung-pin. Study on Ship Delay Recovery Model and Algorithm under the Influence of Weather [D]. Dalian Maritime University, 2018.

[12] Yi Yi Li. The Study of Rick Identification and Control of Navigation Safety in Construction Water Area [D]. Dalian Maritime University, 2019.

[13] Chow cheung-sang. An example of safe operation of VLOC into the anchorage of TRMT port [J]. Navigation technology, 2018 (05): 11-13.

[14] Jiang Zhenfeng. Study on Verical Intergration and Operations Management of Dry Bulk Shipping Company [D]. Dalian Maritime University, 2020.

[15] Zhang Xu. Research on Optimization of Collection and Distribution Network of Imported Iron Ore in Wuhan Port [D]. Zhejiang Ocean University, 2020.