TRAINING MARITIME SPECIALISTS FOR TRANSPORT SERVICE OF FISHING VESSELS

Meyler, Leonid*; Moyseenko, Sergey

Baltic Fishing Fleet State Academy
of the Kaliningrad State Technical
University
Russia

Abstract. Training specialists in the Baltic Fishing Fleet State Academy (BFFSA) for organization of the maritime transportations includes studying the subject "Management of fleet operations". Cadets have to know and to use different approaches for managing, in particular, fishing fleet operations [4]. Fishery is a specific part of the maritime industry and one of organization forms is the fishing expedition when a fleet of fishing vessels is created. The expedition allows to exploit distant (ocean) fishing grounds. Receiving and transport vessels, floating bases (mother ships) are also included in the expedition in order to supply vessels with all the necessary, storage and processing of fish. An important task is optimization of the fishing vessels transport service. The transport service consists of the delivery on the fleet location such kind of objects as technical and technological supplies, food, products for the crew life support, fuel, fresh water, etc. Also it is necessary to provide unloading fish or finished fish products from fishing vessels and their transportation to the ports of destination. The efficiency of the fishing fleet is largely dependent on the level of the service logistics. Therefore, it is important to study so named "fishing logistics" as a part of the above mentioned subject. One of the goals of such kind of logistics is enhancing the efficiency of the fleet operations through the use of methods and models for optimization of the transport service [3]. There are the special conditions at fishing grounds: objects of fishery are inherently mobile; the weather is characterized with seasonality and "aggressiveness" (hydro-meteorological conditions); loading and unloading operations are carried out mainly at open sea; the regimes of maritime areas are governed by international laws and conventions. These conditions determine the character of the fishery and should be considered when designing logistics of the fishing fleet service by the transport fleet. A project-based approach and methods of the operations research are used as the methodological basis for training cadets to design the project of the fleet service. Basic principles of the project are the optimality and variability. Optimization of design solutions and plans of the fishing vessels service at ocean fishing grounds is based on mathematical and heuristic methods and practice-oriented models. Optimizing the vessels service is carried out according to the time criterion. The use of the project-based approach in the management of the transport service of the fishing fleet allows to improve significantly its quality as well as the fishery efficiency and the safety of fishing vessels. The paper describes an example (a case study) of the solution for one of specific/real problems.

Key words: training fishing fleet specialists, project-based approach, optimization of vessels transport service

*Corresponding author

Phone:+74012925089
Fax: +74012916690
e-mail: transport@bga.gazinter.net

1　THE STATEMENT OF THE PROBLEM

One of the important problems in industrial fishery is increasing the fishing time of vessels

and the volume of their catch respectively. Solving this problem, in particular, depends on the time, i.e. the speed of handling (servicing) the vessels at sea. In this regard, it is necessary to define the right order of the vessels handling by the servicing vessel (a floating fish factory or a transport vessel). The main condition is to minimize the total handling time of the group of fishing vessels as well as the downtime of the servicing vessel. A methodological basis for designing and planning the complex of the fish fleet servicing are the systematic approach and methods of the operations research.

1.1 A task of the transport service of fishing vessels

Let us suppose that fishing vessels operate at a fishing ground and have different distances to the servicing vessel: the refrigerated fish transport or the fish carrier (further – the transport vessel). The transport vessel has to handle these fishing vessels (unloading fish products/ fish raw materials and loading some supply). We suppose that several fishing vessels: 1, 2, 3, ... N work on catching at the fishing ground (the square). Each fishing vessel has to follow to the transport vessel with the full catch for handling and to return after handling at the fishing ground to continue fishing. The whole cycle performed by the vessel is shown schematically in Figure 1.
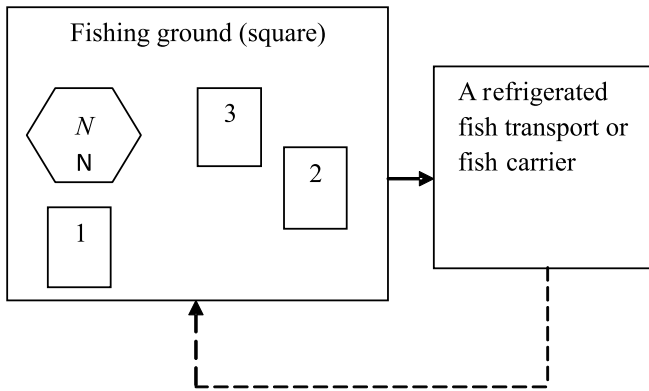

Figure 1 Cycle of fishing vessels transport servicing

There are the following recurrence relations:

$$\left.\begin{aligned}
_1 &= t_1 \\
_2 &= \max\left(t_1 + t_2 - \tau_1 - X_1, 0\right) \\
_1 + X_2 &= \max\left(t_1 + t_2 - \tau_1, t_1\right) \\
_3 &= \max\left(\sum_{i=1}^{3} t_i - \sum_{i=1}^{2} \tau_i - \sum_{i=1}^{2} X_i, 0\right) \\
_1 + X_2 + X_3 &= \max\left(\sum_{i=1}^{3} t_i - \sum_{i=1}^{2} \tau_i, \sum_{i=1}^{2} t_i - \tau_1, t_1\right)
\end{aligned}\right\} \quad (1)$$

Then the following expressions are received using an induction:

$$\left.\begin{aligned}
\sum_{i=1}^{N} X_i &= \max, K_n \\
K_n &= \sum_{i=1}^{n} i - \sum_{i=1}^{n-1} \tau_i
\end{aligned}\right\} \quad (2)$$

$$1 \le n \le N$$

Minimization expressions (2) is required to solve the given task of optimization of fishing vessels relocation. An algorithm for solution of this problem was developed by the dynamic programming method [1, 2].

1.2 Solution of the task by the dynamic programming method

Let us denote that the expression $\varphi(t_1, \tau_1, t_2, \tau_2, ..., t_n, \tau_n, T)$ is the time required to make a full cycle for N number of fishing vessels. The handling process starts at the time T when the i-th fishing vessel begins the trip from the fishing ground to the transport vessel, t_i – the trip time, τ_i – handling time of the i-th vessel at the optimum relocation. Pairs of vessels are denoted by symbols ij in order to identify their relocations. The functional equation:

$$\begin{aligned}
\varphi(&t_1, \tau_1, t_2, \tau_2, ..., t_n, \tau_n, T) = \\
&= \min\left[t_1 + \varphi(t_1, \tau_1, t_2, \tau_2, ..., 0, 0, ..., t_N, \tau_N, \tau_i + \right. \\
&\left. + \max(T - t_i, 0)\right]
\end{aligned} \quad (3)$$

is obtained when the i-th vessel begins the trip and the handling process.

The pair (0, 0) replaces the pair (t_i, τ_i) in the expression (3). The optimal relocation is obtained by replacing two vessels using the expression (3), i.e. the i-th vessel follows to the transport vessel first and then it makes the j-th vessel.

$$\begin{aligned}
\varphi(&t_1, \tau_1, t_2, \tau_2, ..., t_T, \tau_T, T) = t_i + t_j + \\
&+ \varphi(t_1, \tau_1, 0, 0, ..., t_N, \tau_N, T_{ij})
\end{aligned} \quad (4)$$

where:

$$\begin{aligned}
T_{ij} &= \tau_j + \max\left[\tau_i + \max(T - t_i, 0) - t_j, 0\right] = \\
&= \tau_j + \tau_i - t_j + \max\left[\max(T - t_i, 0), t_j - \tau_i\right] = \\
&= \tau_j + \tau_i - t_i - t_j + \max\left[T, t_i + t_j - \tau_i, t_i)\right] = \\
&= \tau_j + \tau_i - t_j - t_i + \max\left[T, \max(t_i + t_j - \tau_i, t_i)\right]
\end{aligned} \quad (5)$$

It is seen from the expression (5) that:

$$\max(t_i + t_j - \tau_i, t_i) < \max(t_i + t_j - \tau_j, t_j) \quad (6)$$

It makes sense to relocate the i-th and j-th vessels. Their relocation is reasonable when:

$$\min(\tau_i, t_j) > \min(\tau_j, t_i) \quad (7)$$

2 AN ALGORITHM FOR DETERMINATION OF THE OPTIMAL RELOCATION OF VESSELS

Results described by expressions (6, 7) allow to determine the optimum relocation of the fishing vessels using the following algorithm:

1) to obtain information about the state of fishing vessels and to fill Table 1;

2) to determine the list of fishing vessels to be handled by the transport vessel;

3) to define values of parameters t_i and τ_i according to data in Table 1 and to fill Table 2;

4) to find the least among the values of t_i and τ_i;

5) if the least value would be one of the value t_i, this vessel begins first to make the trip to the transport vessel;

6) if the least value would be one of the value τ_i, this vessel is the last handled by the transport vessel;

7) to delete values of t_i and τ_i in Table 2;

8) to repeat this process with the $(2n - 2)$ remaining values;

9) to select the vessel with a lower number of priority if there are the several minimum valuesand to order vessels on the value of t_i if t_i is equal to τ_i;

10) to calculate the schedule of handling (Table 3).

2.1 A practical example (case study) for planning the transport service of fishing vessels

Let us assume that the transport vessel works at sea with six fishing vessels. The conditions of fishing are relatively stable. At the beginning of the period the state of the vessels group is determined by the parameters given in Table 4.

Table 1 Data on the location and catches of fishing vessels

Parameters		Data			
Hull number of the vessel	N	N_1	N_2	...	N_n
Type of the vessel		A	B	...	...
Coordinates of the vessel	Latitude φ_i	φ_1	φ_2	...	φ_n
	Longitude λ_i	λ_1	λ_2	...	λ_n
Distance to the transport vessel	S_i, miles	S_1	S_2	...	S_n
Speed of the vessel	V_i, knots	V_1	V_2	...	V_n
Catch	Q_i, tons	Q_1	Q_2	...	Q_n

Table 2 Values of fishing vessels parameters

Parameters	Data			
Hull number of the vessel	N_1	N_2	...	N_n
i	1	2	...	N
t_i	T_1	T_2	...	T_n
τ_i	τ_1	τ_2	...	τ_n

Table 3 Form of a schedule of fishing vessels handling by the transport vessel

Parameters		Data			
№ of the order		1	2	...	n
Hull number of the vessel	N_i	N_1	N_2	...	N_n
Catch	Q_i, tons	Q_1	Q_2	...	Q_n
Period of working time	Start T_{si}	T_{s1}	T_{s2}	...	T_{sn}
	Finish T_{fi}	T_{f1}	T_{f2}	...	T_{fn}
Working time	τ_i, hours	τ_1	τ_2	...	τ_n

Table 4 Dislocation of fishing vessels at the fishing ground

Parameters		Data					
Hull number of the vessel	N	1	2	3	4	5	6
Type of the vessel		A	B	C	D	E	F
Coordinates of the vessel	Latitude φ_i	φ_1	φ_2	φ_3	φ_4	φ_5	φ_6
	Longitude λ_i	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
Distance to the transport vessel	S_i, miles	7	10	5	12	5	6
Speed of the vessel	V_i, knots	7	9	10	10	7	10
Catch	Q, tons	5	10	7	15	8	12

Table 5 Stepwise solution of the problem of determining the order of fishing vessels handling by the transport vessel

i	t_i, hours	τ_i, hours	On the first step			On the second step		
			i	t_i, hours	τ_i, hours	i	t_i, hours	τ_i, hours
1	1.0	0.7	3	0.5	0.9	3	0.5	0.9
2	1.1	1.0	1	1.0	0.7	6	0.6	1.0
3	0.5	0.9	2	1.1	1.0	1	1.0	0.7
4	1.2	1.1	4	1.2	1.1	2	1.1	1.0
5	0.7	1.2	5	0.7	1.2	4	1.2	1.1
6	0.6	1.0	6	0.6	1.0	5	0.7	1.2

Table 6 The optimum order of the fishing vessels approach to the transport vessel

i	t_i	τ_i
3	0.5	0.9
6	0.6	1.0
5	0.7	1.2
4	1.2	1.1
2	1.1	1.0
1	1.0	0.7

Table 7 The schedule of handling vessels

Parameters		Data					
№ of the order		1	2	3	4	5	6
Hull number of the vessel	N_i	3	6	5	4	2	1
Catch	Q_i, tons	7	12	8	15	10	5
Period of working time	Start T_{si}, hour^{min}	0^{00}	0^{54}	1^{54}	3^{06}	4^{12}	5^{12}
	Finish T_{fi}, hour^{min}	0^{54}	1^{54}	3^{06}	4^{12}	5^{12}	5^{54}
Working time	τ_i, hours	0.9	1.0	1.0	1.1	1.0	0.7

Parameters t_i and τ_i for each fishing vessel are defined and Table 5 is formed.

The optimal order of the fishing vessels approach for handling by the transport vessel is obtained using further to the above algorithm (Table 6).

Then the schedule of handling vessels (Table 7) is calculated. An analysis of the sensitivity of the solution allows to determine the limits of the parameters variation where the found strategy of fishing vessels handling by the transport vessel remains optimal [6]. Thus, in this example, an increase of the catch of 20% does not change the order but the handling schedule requires adjustment on time.

3 CONCLUSION

The proposed mathematical model can be used as a simulation of the process of transport service of fishing vessels. It allows to study and to analyze the behavior of the system "fleet service" under its different initial data and parameters. Also the model gives a possibility to find the options for the system improving (for example, to improve the efficiency of loading and unloading operations).

The given above algorithm for determining the optimal handling of fishing vessels was tested in practice. The efficiency of the proposed method was verified by comparing the results of the implementation of the decisions taken by the traditional method with solutions based on the use of the algorithm for solving the problem by dynamic programming.

Thus, the result of 20-th realizations (under approximately the same conditions of the fleet operation) shows that the use of the optimization algorithm of the fishing vessels priority service minimized by 15-20% downtime of the transport vessel and the loss of fishing time by fishing vessels [5].

The fishing process has a probabilistic character; however the proposed method allows to find approximate strategies even in more complex models.

REFERENCES

[1] Ackoff R., Sasieni M., 1971, *Fundamentals of Operation Research*, Moscow: Mir (in Russian).

[2] Bellman P., Kalaba P., 1969, *Dynamic programming and modern control theory*, Moscow: Nauka (in Russian).

[3] Moyseenko S., 2009, *Management of the fleet operation*, Kaliningrad: BFFSA Publ. House (in Russian).

[4] Moyseenko S., Meyler L., 2010, Theoretical and practical problems of specialists' professional competence development in the field of maritime transport organization. *Diversity Unifies - Diversity in Engineering Education*; Proc. the Joint Intern. IGIP-SEFI Annual Conf., Trnava, Slovakia, September 2010, No. 2383.

[5] Moyseenko S., Meyler L., 2011, Optimal management of fleet relocation at deep-sea fishing grounds. *Green ships, Eco shipping, Clean seas;* Proc. 12th Annual General Assembly of the International Association of Maritime Universities (IAMU) AGA12. Gdynia, Poland, June 2011, pp. 197-208.

[6] Moyseenko S., Meyler L., Semenkov V., 2011, Organization of Fishing Fleet Transport Service at Ocean Fishing Grounds. *Maritime logistics in the global economy. Current trend and approaches*; Proc. Hamburg Intern. Conf. on Logistics (HICL 2011). Hamburg, Germany, September 2011, pp. 193-203.