DOI: 10.1515/aon-2015-0011

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MODEL OF NAVIGATIONAL SAFETY OF FISHING VESSELS IN POLISH EEZ

ABSTRACT

The paper presents the assumptions of a simulation model for assessing the navigational safety of fishing vessels. The model consist of submodels of merchant and fishing vessels traffic, submodel of external condition and submodel of accident consequences. Paper present also a results of simulation experiment which was carried out for Polish EEZ. Model takes into account all Polish fishing vessels operating in the Polish EEZ with length more than 15 meters and the merchant vessels traffic in South Baltic Sea area. As a results positions of simulated collisions of fishing and merchant vessels, positions and sizes of simulated bunker spills and the positions of losses of fishing equipment were achieved.

Keywords:
navigational safety assessment, marine accidents, collision probability, fishing vessels, simulation model.

INTRODUCTION

The goal of the work is to assess navigational safety of fishing vessels with consideration of the possibility of oil spills arising as a result of collisions with other vessels or pollution resulting from loss of fishing equipment. To consider wide set of factors influencing the navigational safety stochastic simulation model was developed. The model is autonomous and run in fast time so it is possible to achieve statistically sufficient number of scenarios. The results of the experiment carried out are positions and sizes of the simulated oil spills and the positions of fishing equipment losses.

POLISH FISHING VESSELS FLEET

Model takes into account all Polish fishing vessels operating in the Polish EEZ with length more than 15 meters. Data necessary to model the traffic of fishing vessels are gathered from reports of Polish National Marine Fisheries Research Institute. The number and distributions of vessels are presented in tables 1–2. Data used in model are in bold.

Table 1. Distribution of length of Polish fishing vessels [National Marine, 2013]

Length [m]	Number of vessels		
	2010	2011	2012
< 12	591	591	603
12–14.9	52	53	52
15–17.9	62	57	**47**
18–19.9	16	20	**28**
20–22.9	18	20	**18**
23–24.9	14	13	**13**
25–25.9	14	11	**10**
> 26	22	22	**24**
Total	789	787	795

Table 2. Distribution of ports of registration of Polish fishing vessels (length > 15 m) [National Marine, 2013]

Port	Number of vessels		
	2010	2011	2012
Gdansk	4	4	**3**
Gorki Wschodnie	1	1	**1**
Gorki Zachodnie	4	4	**4**
Hel	10	8	**8**
Jastarnia	14	14	**14**
Wladyslawowo	39	39	**36**
Leba	10	10	**10**
Ustka	26	26	**27**
Darlowo	11	10	**10**
Kolobrzeg	18	18	**18**
Dziwnow	6	6	**6**
Swinoujscie	3	3	**3**
Total	146	143	**140**

PROBABILITY OF ACCIDENTS

Number of fishing fleet accidents in years 2001–2006 is relatively low and reaches a values from 0.55% to 1.51% of the total marine accidents (fig. 1) [Maritime Chamber, 2001–2006]. Marine accidents involving fishing vessels occur mostly in ports and roads or in open waters, accidents are caused mainly by inappropriate maneuvering of fishing vessel or other ships. The second type of accidents cause are the maneuvering restrictions resulting from use of fishing equipment. Moreover, the probability of accident is increased by the age of the fishing vessels which are usually outdated and require complete modernization. The most common type of accidents are collisions, particular data used in model are presented in figure 2.

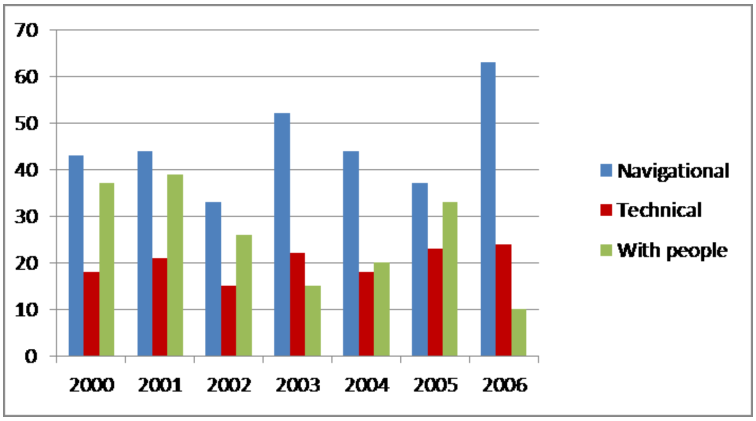

Fig. 1. Distribution of fishing vessels accidents causes [source: Maritime Chamber, 2001–2006]

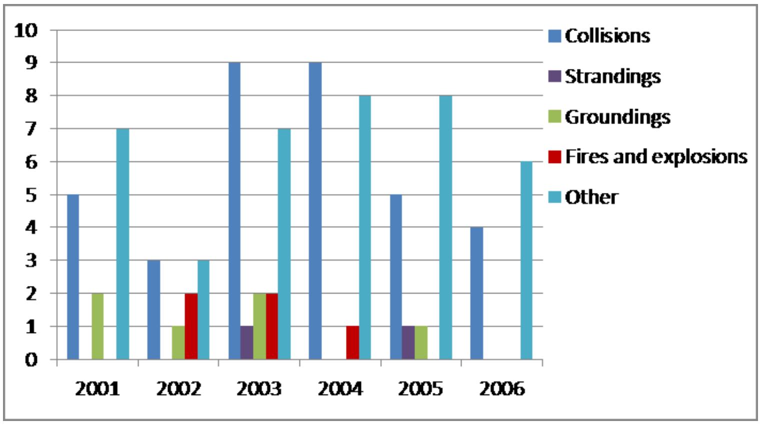

Fig. 2. Distribution of fishing vessels accident types [source: Matsuoka T., 2005]

Broken and abandoned fishing equipment causes long-term pollution and large losses in fish stocks. This is a very serious environmental problem. No official statistics concerning losses of fishing equipment are recorded in Poland so to simulate this type of accidents Japanese database was used [Matsuoka T., 2005]. The assumed loss factors are as follows: for drift nets 0.08–0.23 per year and the number of nets varies from 14 to 19 per vessel, for trawl nets 1–2 losses per year.

MODEL OF NAVIGATIONAL SAFETY ASSESSMENT

Assumptions

Simulation experiment was carried out with use of stochastic model of navigational safety assessment in coastal waters developed in Institute of Marine Traffic Engineering in Maritime University in Szczecin. A functional diagram of the model is shown in figure 3. It is a simulation model based on Monte Carlo method. Simulation time is intentionally accelerated, which allows to obtain a statistically stable results.

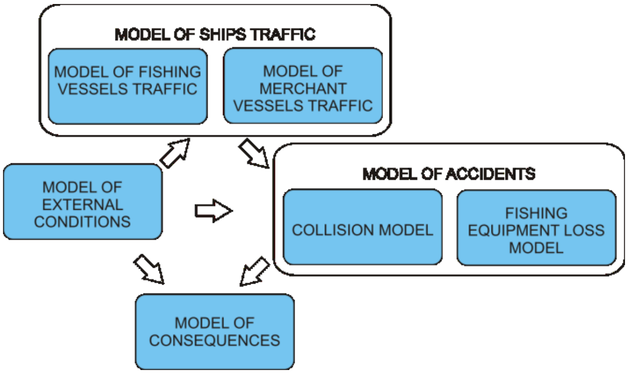

Fig. 3. Functional diagram of the model of navigational safety assessment of fishing vessels

Model of ships traffic

Ship traffic is described on the basis of data obtained from AIS, MARIS systems and statistical data concerning traffic in the main ports in research area (fig. 4). On basis of the analysis of gathered data main routes and the distributions of traffic (inter alia: size, type and speed of ships) on these routes were evaluated. Simulated traffic routes are presented in figure 5.

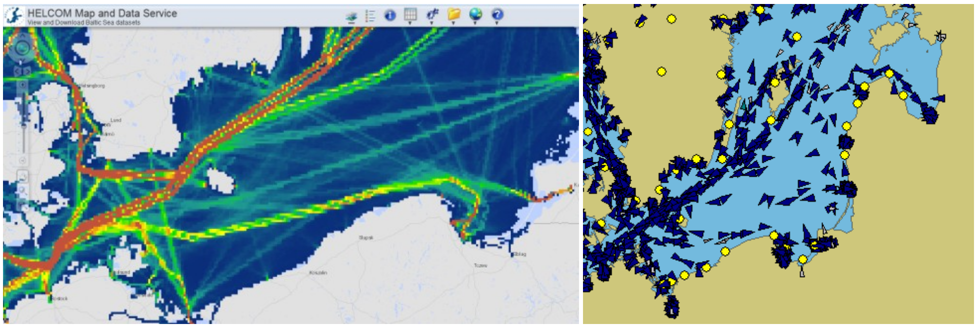

Fig. 4. Main routes and data from MARIS system

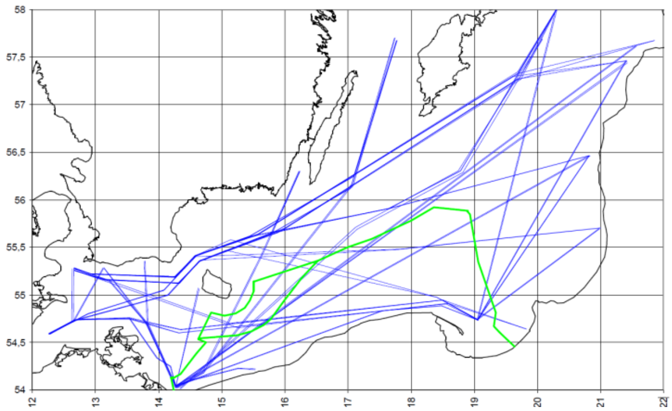

Fig. 5. Simulated routes and Polish EEZ

Fishing areas and the routes followed by fishing vessels were determined on the basis of data from the Polish Fisheries Monitoring Centre (FMC) (fig. 6). The study area was limited to the Polish Exclusive Economic Zone (fig. 5). It was found that most common areas of fishing are in the western part of EEZ (the area of the island of Bornholm) and the eastern part (about 18°E). The movement of fishing vessels is divided into two stages: 1-proceeding to the fishery and return from the fishery, and 2-movement associated with fishing. Routes and the speed of vessels during fishing operations were modeled on the basis of interviews with experts.

The study takes into account all fishing vessels with length > 15 m. Number of vessels included in the study in different ports and the distribution of length are shown in figures 7 and 8. The total number of units was 140. Analysis of the data concerning the length of fishing vessels shows that the units of length less than 20 m and over 26 m dominate in the study area.

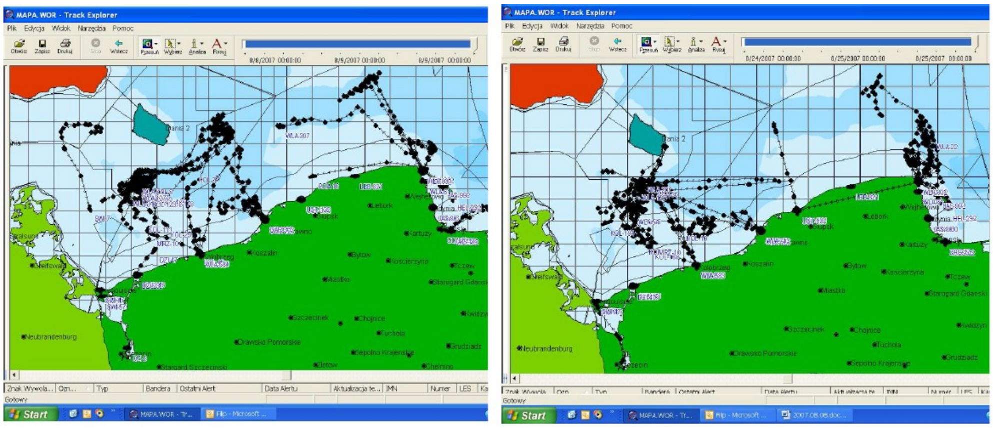

Fig. 6. Examples of fishing areas gathered on the basis of data from FMC

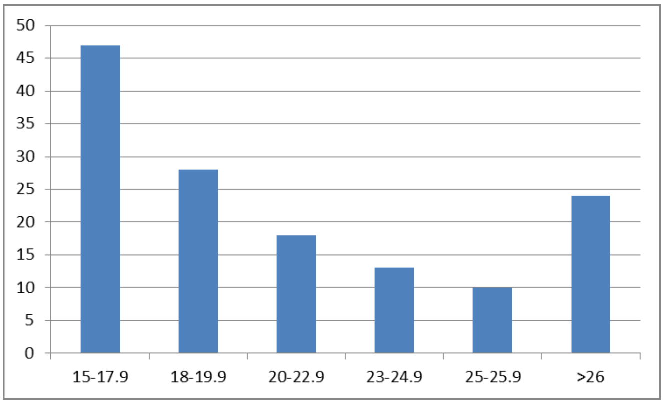

Fig. 7. Distribution of length of fishing vessels simulated in the model

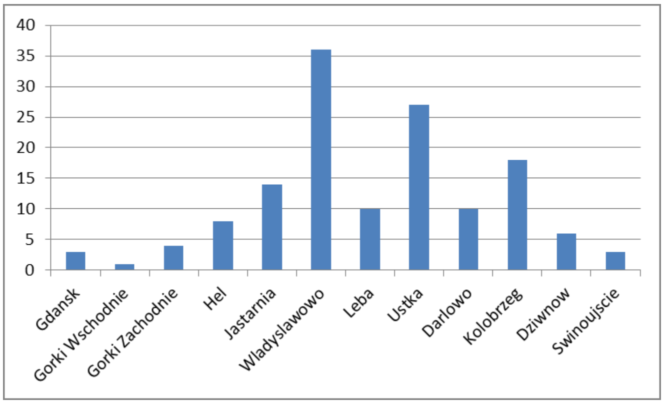

Fig. 8. Number of fishing vessel in given ports simulated in the model

The model takes into account hydro meteorological conditions and their impact on traffic streams. Monthly distributions describing the inter alia direction and speed of wind and height of waves have been developed on the basis of long term observation in Polish meteorological stations.

Model of oil spills

Analysis of the statistical data on the number of accidents (fig. 2) and the probability of bunker spill, estimated on the basis of a set of accident databases [MEHRA, 1999; ITOPF, 1998; LMIS, 2004; MAIB, 2005; HECSALV, 1996; IMO, 2001], showed that the only type of accident causing a real threat of oil spill is collision. For this reason in was decided to analyse only this type of accidents. The size spill is estimated on the basis of the volume of tanks of boats involved in a collision and the size of the tanks depends on the size of the fishing boat. It was assumed that tanks are 40–70% full.

SIMULATION EXPERIMENT

The goal of the first stage of the study was to calculate the number of the encounter situations. It means the situation when the distance between merchant ship and fishing boat is less than 0.1 Nm. In the next step, with knowledge about a number of encounter situations and the number of collisions of vessels, which occurred in the years 2001–2006 [Maritime Chamber, 2002–2007], the collision probability in encounter situation was calculated. The calculated probability is about $3.2 \cdot 10^{-3}$. In the next stage final simulation experiment was carried out, which resulted in positions of simulated collisions, positions and sizes of spills of bunker and positions of simulated losses of fishing gear. The simulations were performed in trials each of one year of simulation. The total number of trials carried out is 30. This allowed to obtain statistically stable results.

Results

Simulated collision positions are shown in figure 9. The average annual number of simulated collisions is 5.17 per year. Intensity collision can be described by a Poisson distribution with $\lambda = 5.17$. Distribution of positions and the sizes of the simulated spills are shown in figure 10. The average annual number of simulated spills is 0.63. The average size of spill is 10.6 tons. Positions losses of fishing equipment is shown in figure 11. On average, one vessel was losing about 2.1 nets per year.

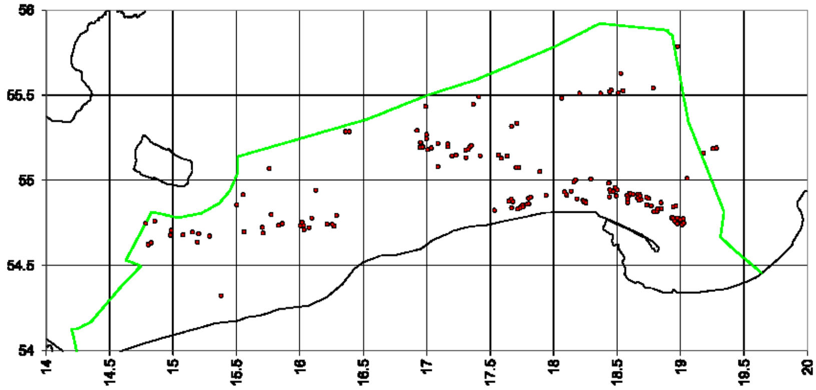

Fig. 9. Positions of simulated collisions of fishing and merchant vessels

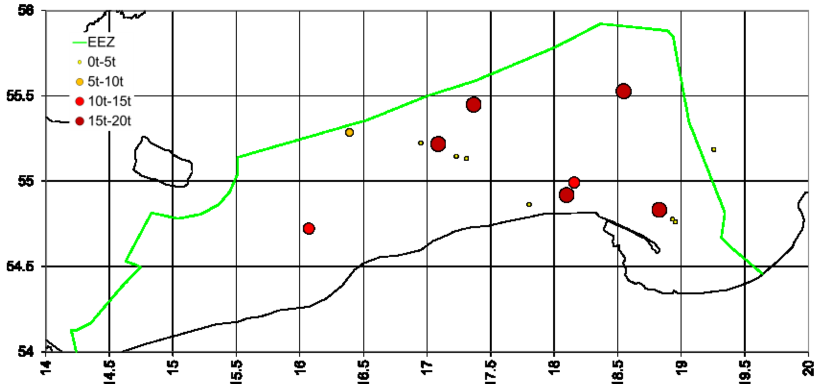

Fig. 10. Positions and sizes of simulated bunker spills

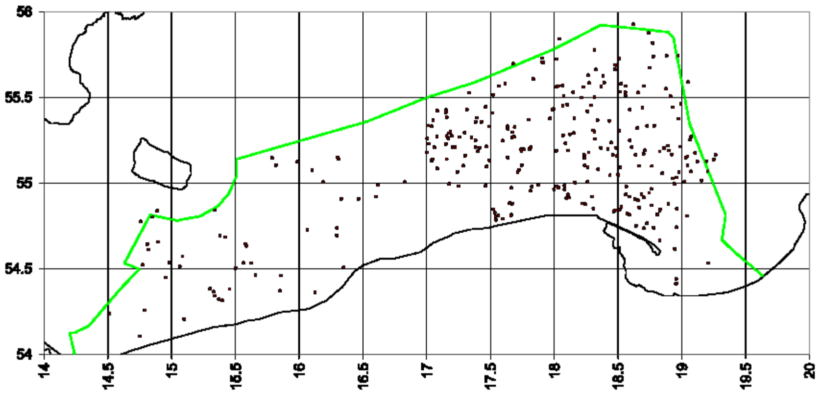

Fig. 11. Positions of simulated losses of fishing equipment in one year

CONCLUSIONS

In this study, the risk of environmental pollution caused by bunker spill from fishing boats was evaluated. It was assumed that collisions of fishing boats and merchant vessels are the only statistically significant cause of bunker spill. In addition, the possibility of environmental pollution caused by losses of fishing equipment was determined.

The study used an original model for the assessment of safety of navigation. Model gives the possibility to speed up simulation time what gives the possibility of observation of a large number of accident scenarios and obtain statistically stable results.

As a result of the carried out simulation experiment following values were obtained. Average intensity collisions of vessels is 5.17 collisions per year, about 8% of the collisions resulted in the spillage of bunker. Average intensity of bunker spill is 0.63 per year, over 40% of spills are less than 5 tons. Maximum spills, not exceeding 20 tons. Collisions occur in places where the routes of merchant vessels intersect fishing areas. The average intensity of loss of fishing equipment equals approximately 2 per year per fishing boat. Positions of equipment loss coincide with the fishing areas.

Further work on this subject should focus on verification presented model and obtaining accurate input data to increase the adequacy of the model.

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Received September 2014
Reviewed December 2014

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STRESZCZENIE

W artykule przedstawiono założenia złożonego modelu symulacyjnego dla szacowania bezpieczeństwa nawigacyjnego statków rybackich. Model składa się z modeli ruchu statków handlowych i statków rybackich, modelu warunków środowiskowych oraz modelu skutków zdarzenia. Ponadto w artykule przedstawiono rezultaty eksperymentu symulacyjnego przeprowadzonego dla polskiej wyłącznej strefy ekonomicznej. Model uwzględnia wszystkie polskie statki rybackie operujące w polskiej wyłącznej strefie ekonomicznej o długości większej niż piętnaście metrów oraz ruch statków handlowych na południowej części Morza Bałtyckiego. W rezultacie otrzymano pozycje prawdopodobnych kolizji statków transportowych oraz rybackich, pozycje i rozmiary prawdopodobnych rozlewów olejowych oraz pozycje utraty narzędzi połowowych.