The Methodology for Assessing the Impact of Offshore Wind Farms on Navigation, Based on the Automatic Identification System Historical Data

Krzysztof Naus 1,*, Katarzyna Banaszak 1 and Piotr Szymak 2

1 Department of Navigation and Naval Weapons, Gdynia, Polish Naval Academy, Smidowicza 69, 81-127 Gdynia, Poland; k.banaszak@amw.gdynia.pl
2 Institute of Electrical Engineering and Automatics, Gdynia, Polish Naval Academy, Smidowicza 69, 81-127 Gdynia, Poland; p.szymak@amw.gdynia.pl
* Correspondence: k.naus@amw.gdynia.pl

Abstract: Mounting offshore renewable energy installations often involves extra risk regarding the safety of navigation, especially for areas with high traffic intensity. The decision-makers planning such projects need to anticipate and plan appropriate solutions in order to manage navigation risks. This process is referred to as “environmental impact assessment”. In what way can these threats be reduced using the available Automatic Identification System (AIS) tool? This paper presents a study of the concept for the methodology of an a posteriori vessel traffic description in the form of quantitative and qualitative characteristics created based on a large set of historical AIS data (big data). The research was oriented primarily towards the practical application and verification of the methodology used when assessing the impact of the planned Offshore Wind Farm (OWF) Baltic II on the safety of ships in Polish Marine Areas, and on the effectiveness of navigation, taking into account the existing shipping routes and customary and traffic separation systems. The research results (e.g., a significant distance of the Baltic II from the nearest customary shipping route equal to 3 Nm, a small number of vessels in its area in 2017 amounting to only 930) obtained on the basis of the annual AIS data set allowed for an unambiguous and reliable assessment of the impact of OWFs on shipping, thus confirming the suitability of the methodology for MREI spatial planning.

Keywords: marine renewable energy installation (MREI); Offshore Wind Farm (OWF); Automatic Identification System (AIS)

1. Introduction

Poland, as a member of the European Union, is obliged to reduce greenhouse gas emissions. One of the flagship projects aimed at achieving the planned reduction of GHG emissions is using wind farms to replace the energy deficit resulting from the gradually closing coal-fired power plants. By 2030, Renewable Energy Sources are to replace 66.6% of coal. Therefore, they constitute the main measures for achieving the target imposed by the European Union.

Over the last 10 years, the share of wind farms in the generating of electric power in Poland has increased more than 6-fold [1]. In addition, the installed capacity has increased more than 5-fold during the period 2010–2020.

According to data from the Energy Regulatory Office, at the end of 2020, there were 1239 wind farms operating in the country, including 1111 with a capacity of less than 10 MW (89.7%) and 128 with a capacity greater than or equal to 10 MW. The amount of energy produced from wind sources is also systematically growing, and is being introduced into the Polish power system. In 2020, they produced 14,174 GW h of energy (compared to 13,903 GW h in 2019). Wind energy accounted for approx. 8.2% of the energy consumed in the country in 2019. According to the assumptions of the National Energy and Climate
Plan for 2021–2030 (NECP) [2], the share of energy from renewable sources is set to increase steadily, starting with 15% in 2020, then 17.6% in 2025, rising to 21% in the year 2030. Offshore wind farms are expected to contribute to achieving this goal in four years.

However, in addition to their benefits, wind farms also pose various threats to fauna and flora, the marine environment, and to the safety of navigation. Studies conducted in recent years have paid particular attention to the impact of wind farms on wildlife [3,4], and described a holistic approach to the problem of the impact of OWFs on the environment [5,6].

Until now, during research into the impact of OWFs on navigation safety, mainly quantitative methodologies have been used, including vessel traffic analysis as well as modeling and simulations [7]. Data on the movement of commercial vessels were taken from AIS, and data on fishing and recreational units were taken from radar or visual observations. Statistical analysis of the impact of OWFs on sea traffic in terms of minimum passing distances and lateral distribution of ship trajectories in the vicinity of an OWF has also been applied [8]. Unfortunately, this is a simplified analysis, based on the characteristics of the impact of OWF on a specific route, which is probabilistically modeled. However, the focus was not on the qualitative aspect of these data, or on the development of specialized software for precise data analysis and the generation of end products such as traffic maps of individual units, taking into account their type, length, and draft.

An accurate definition of OWF interference with the safety of navigation necessitates looking at Navigational Risk Assessment (NRA), defined as “a combination of the probability and consequences of undesirable events that arise as a result of the permutation of passive hazards and active failures in a system or process” [9]. The terms “probability” and “consequences” refer to the likelihood of an accident and the nature and severity of the accident, respectively. Accordingly, the NRA process enables stakeholders to assess the likelihood, consequences, and overall risk of an undesirable event that an OWF creates for ship safety, using a variety of methods, models, tools, and even stakeholder feedback. The likelihood of an accident is usually assessed by analyzing vessel traffic in the area and forecasting the impact on vessel traffic when obstructions such as OWFs are installed or when the safe space available to ships is reduced due to an OWF.

When focusing on the issues of the spatial planning of the optimal location for OWFs, it is necessary to take into account three basic factors in the safe passage of a ship. First, the space around the ship and the nearby OWF should provide a safe buffer to allow an appropriate maneuver to be performed in an emergency, so as to avoid the hazard. The OWF and the navigation routes around the OWF should be designed so that the structure does not obstruct smaller vessels, e.g., fishing, recreational, or inspection vessels, which could create a risk of collision.

Second, the location of the OWF should not significantly interfere with the existing, customary route, mainly of a merchant ship. When planning the transition of such a unit, emphasis is placed on time and fuel costs. Too large a deviation from the current route may make them uneconomical [10].

Third, account must be taken of the presence of other, persistent navigational hazards in the vicinity of the OWF, or other shipping routes that could affect the maneuverability of ships.

The general availability of AIS has contributed to the development of a large number of maritime traffic risk-modeling tools. Their composition includes statistical analysis of ship activity, geometric analysis of ship routes [11–13], and time domain models, which have been used across the entire industry for several dozens of years [14–17]. A large number of the above-mentioned tools are frequently used by national regulators to support the development of wind farms, but many are of a prognostic nature and require an assessment of future traffic routes.

Another issue to consider is the determination of the interval at which ships should pass the OWF. The approach here differs from country to country. The Maritime and Coastguard Agency UK has defined the following scopes:
- 0–0.45 nautical miles—unacceptable;
- 0.45–2 nautical miles—acceptable, medium, and high risk;
- 2–3.5 nautical miles—acceptable, low risk;
- >3.5 nautical miles—very low risk.

In turn, in 2014, the Pacific Northwest National Laboratory issued a report indicating that ships generally chose to leave a distance of 5 nautical miles from the OWF, and this was safe [18]. On the other hand, the UK NOREL working group assumes that a distance of 2 nautical miles should be kept between the OWF border and the shipping route [19,20]. However, decisions regarding this parameter are generally made on a case-by-case basis, taking into account the existing obstacles and dangers to navigate as well as the location and layout of routes.

The research presented in this article focuses on the previously missing aspect of the effective use of AIS in spatial planning, supporting the optimal location of marine renewable energy installations through analysis, and the description of ship traffic in the form of quantitative and qualitative characteristics specified for various types of ships, as well as their draft and length. The results were obtained as part of an expert assessment of the impact of the planned OWF Baltic II on the safety of ships in Polish Maritime Areas and the effectiveness of their navigation, taking into account the existing shipping routes, and customary and traffic separation schemes commissioned by Baltic Trade and Invest (BTI) [21]. Currently the OWF Baltic II is managed by RWE Renewables as the project owner. RWE is going to utilize the conclusions drawn from the expert opinion on the safety of ships in Polish Maritime Areas and the effectiveness of their navigation while implementing the project.

The novelty of the proposed methodology is that it allows for the simultaneous implementation of quantitative and qualitative analyses, both in a small area of the OWF, and on the nearby customary shipping routes or the established maritime traffic regulation system. To use this methodology, three following data sets are needed:
- describing maritime traffic (data come from coastal AIS stations);
- describing the boundaries of the OWF area along with buffers;
- about the marine environment (data obtained from electronic navigational charts, authorized by national hydrographic offices, guaranteeing their quality, reliability and timeliness).

The appropriate joint processing of these data sets makes it possible to obtain information to decide on the location of the OWF. The comparison of the gathered information, obtained before and after the building of the OWF, allows us to assess its impact on shipping.

The first part of the article presents the location of the planned OWF Baltic II in relation to the AIS coastal station system, the research tools used, as well as the AIS data coding and processing methodology.

The main part contains the developed quantitative and qualitative characteristics of ship traffic generalized to the area of the central coast of the Polish Maritime Areas (PMA) [22], detailed for the area of the OWF Baltic II and covering the nearest shipping routes [23].

The final part, however, is an analysis of quantitative characteristics, taking into account, inter alia, the main traffic flows and the analysis of qualitative characteristics broken down into the type, length, and draft of the vessel. Based on this, generalized final conclusions have been drawn.

2. Materials and Methods

Polish law requires an examination of the impact of MREI on the safety of the environment and shipping [24]. The research used AIS data collected in the database of the polish coastal system AIS-PL in 2017 and made available by the Maritime Office in Gdynia [25–27]. The identification of the characteristics of the vessels was carried out on the basis of information on vessel traffic obtained as a result of the appropriate processing of data from the AIS system (proprietary software). It concerned the part of the Baltic Sea basin where the OWF Baltic II is planned (Figure 1).
2. Materials and Methods

Polish law requires an examination of the impact of MREI on the safety of the environment and shipping [24]. The research used AIS data collected in the database of the Polish coastal system AIS-PL in 2017 and made available by the Maritime Office in Gdynia [25–27]. The identification of the characteristics of the vessels was carried out on the basis of information on vessel traffic obtained as a result of appropriate processing of data from the AIS system (proprietary software). It concerned the part of the Baltic Sea basin where the OWF Baltic II is planned (Figure 1).

Figure 1. South Baltic with the coast of Poland [26].

Figure 1 shows the location of the OWF Baltic II in relation to the monitoring area covered by the AIS coastal station system on the Polish coast. The shipping area around the installation is within the operating range of the available shore stations, which provides access to archival and current data on vessel traffic in the OWF Baltic II zone.

2.1. Analysis Tools

Information on the characteristics of the vessels maneuvering in the OWF area was obtained as a result of processing “raw” AIS data. A specially prepared software application, “Analyzer”, was used for this purpose. The application was made in the C++ Builder 10.2.3 integrated application development environment [28], designed for the Windows 10 operating system (Figure 2).

Its basic functionalities allow for the processing of raw VDM/NEMA 0183 messages used for transmitting the entire content of the AIS message packet received via the VHF/RS 232C/RS 422 link into information useful for the quantitative and qualitative analysis of vessel traffic [29,30]. The information created in this way is made available in the form of a GRID file (for quantitative analysis) and a tabular file (for qualitative analysis). GRID files are in the form of a regular square grid. Each square was assigned a value corresponding to the number of ships “staying” in it during a given period of time, determined as a result of the analysis of the mutual positions of successive sections along which vessels move and sections delimiting individual GRID meshes (Figure 3).

Figure 3 shows a fragment of the GRID (its four meshes) and two trajectories of vessel movement, which were determined on the basis of the coordinates of the positions of the vessels tracked in the AIS system. Inside each mesh (square) there is a knot that is assigned a value determined as a result of the analysis of the mutual position of the successive sections along which the vessel moves and the sections delimiting the individual meshes of the GRID mesh. The value of the knot increases by one if the section on which the vessel is moving crosses any of the sections that make up the sides of the square bounding the knot mesh. A vessel that has increased its value in a node may increase it by one only when the next section of its trajectory is crossed by one of the sections forming the sides of the square bounding the other mesh. This avoids multiple impacts of the same vessel on the same node. This is particularly important in the case of messages with position coordinates (no. 1–3, 18), which can be transmitted with high frequency (as much as every 2 s) depending on the navigational status, speed, and maneuvering method [31]. The following
are the relationships for determining the coordinates \((X, Y)\) of the point of intersection of straight lines passing through points \(A(x_1, y_1)\) and \(B(x_2, y_2)\) forming the next segment of the ship’s trajectory, and lines passing through the sides of the square of the mesh for each node of the GRID:

\[
X = \frac{x_2 - x_1}{y_2 - y_1}(G_j - y_1) + x_1 \tag{1}
\]

\[
Y = \frac{y_2 - y_1}{x_2 - x_1}(G_i - x_1) + y_1 \tag{2}
\]

The calculated coordinates of the point should fall on the analyzed square side-line, which means that the unit enters the mesh area, and the value of the knot should be increased by one. The format of the resulting GRID network saved into the output file is shown below [32,33].

![Figure 2. The main window of the “Analyzer” software application.](image)

![Figure 3. Geometric interpretation of the method for determining the value of a mesh in a GRID mesh.](image)
This file can be imported by applications such as Geographic Information Systems (GIS), including MapInfo and ArcGIS, and used subsequently in these applications to create maps with the distribution of the intensity of vessel traffic on a cartographic basis (e.g., in the Mercator mapping projection). The resulting table files can, in turn, be imported by applications with a spreadsheet functionality, e.g., Microsoft Excel, and then used to create qualitative statistics on vessel traffic.

This file is created as a result of the appropriate processing of messages with static information about the ship, i.e., no. 5 and 24, into text form [31]. It contains a numerical list of ships divided into types consistent with ITU-R M.1371-5 (Table 1), based on the draft, length, and class of the AIS transponder used.

Table 1. Division of ships into types used in AIS [31], p. 114.

| Identifier No. | Special Craft                                      |
|---------------|---------------------------------------------------|
| 50            | Pilot vessel                                      |
| 51            | Search and rescue vessels                         |
| 52            | Tugs                                              |
| 53            | Port tenders                                      |
| 54            | Vessels with anti-pollution facilities or equipment |
Table 1. Cont.

Identifiers to Be Used by Ships to Report Their Type

| Identifier No. | Special Craft |
|----------------|--------------|
| 55             | Law enforcement vessels |
| 56             | Spare—for assignments to local vessels |
| 57             | Spare—for assignments to local vessels |
| 58             | Medical transports (as defined in the 1949 Geneva Conventions and Additional Protocols) |
| 59             | Ships and aircraft of States not party to an armed conflict |

Other ships

| First digit (1) | Second digit (1) | First digit (1) | Second digit (1) |
|-----------------|------------------|-----------------|------------------|
| 1—Reserved for future use | 0—All ships of this type | – | 0—Fishing |
| 2—WIG | 1—Carrying DG, HS, or MP, IMO hazard or pollutant category X (2) | – | 1—Towing |
| 3—See right column | 2—Carrying DG, HS, or MP, IMO hazard or pollutant category Y (2) | 3—Vessel | 2—Towing and length of the tow exceeds 200 m or breadth exceeds 25 m |
| 4—HSC | 3—Carrying DG, HS, or MP, IMO hazard or pollutant category Z (2) | – | 3—Engaged in dredging or underwater operations |
| 5—See above | 4—Carrying DG, HS, or MP, IMO hazard or pollutant category OS (2) | – | 4—Engaged in diving operations |
| 5—Reserved for future use | – | 5—Engaged in military operations |
| 6—Passenger ships | 6—Reserved for future use | – | 6—Sailing |
| 7—Cargo ships | 7—Reserved for future use | – | 7—Pleasure craft |
| 8—Tanker(s) | 8—Reserved for future use | – | 8—Reserved for future use |
| 9—Other types of ship | 9—No additional information | – | 9—Reserved for future use |

DG: dangerous goods; HS: harmful substances; MP: marine pollutants. (1) The identifier should be constructed by selecting the appropriate first and second digits. (2) NOTE 1—The digits 1, 2, 3 and 4 reflecting categories X, Y, Z and OS were formerly categories A, B, C and D.

Software validation was carried out using the AIS transponder simulator and the real data about ships standing, entering and leaving ports (obtained from the Harbor Master’s Offices). The simulation generated a list of messages sent by many ships traveling on the same route (with a given Cross Track Distance (XTD)), standing at anchorages and moored to a harbor wharf. The compliance of the quantitative and qualitative values obtained with the developed software was checked with the true and simulated values corresponding to them. The results of the fifty validation tests carried out confirm the correctness of the software’s operation.

2.2. The Analysis Process

The analysis of vessel characteristics was based on the AIS-PL archive data collected in the NMSS (National Maritime Safety System) database in 2017. These data, in the form
of an annual set of one-day files with a capacity of 39.6 GB (after unpacking), were made available by the Maritime Office in Gdynia.

On the basis of this set of files, using the original “Analyzer” software, 839322999 “raw” AIS messages were processed, and 64856, being incorrect, were rejected (including on the basis of the checksum), and then converted into GRID files and tabular files. Secondly, this allowed for the description of the movement of ships in the form of:

- quantitative characteristics—based on distributions of traffic intensity, made with the use of a GRID file with a mesh resolution of 2”;
- qualitative characteristics—based on spreadsheets used in Microsoft Excel to build statistics broken down by ship type, draft, and length.

These characteristics constitute the source of information used to identify the vessels sailing in the studied water, which helped to determine the customary routes and enabled the prediction of vessel movement in the spatial planning supporting the optimal location of offshore renewable energy installations.

3. Results

3.1. The Results of the Identification of the Characteristic Features of Ships in a Large Sea Area around the OWF (Central Coast of the Polish Maritime Areas—PMA)

After the AIS data had been processed with the use of proprietary software, a quantitative and qualitative analysis was performed for various types of vessels, among which passenger, cargo, special, and fishing vessels were selected, due to their increased traffic within the wind farm. In total, 3861 unique vessel types were registered, including 3281 (85%) with an AIS Class A transponder and 581 (15%) with a Class B transponder. The results are presented in graphical form below.

3.1.1. Quantitative and Qualitative Characteristics of All Types of Ships

Figure 4 and Table 2 shows the distribution of traffic intensity and the qualitative characteristics for all types of ships covering a large sea area surrounding OWF.

![Figure 4](image-url)  
Figure 4. Distribution of traffic intensity for all types of ships covering a large sea area surrounding OWF AIS-PL 2017.
3.1.2. Quantitative and Qualitative Characteristics of Fishing Vessels

Figure 5 and Table 3 shows the distribution of traffic intensity and the qualitative characteristics for fishing vessels covering a large sea area surrounding OWF.

3.1.3. Quantitative and Qualitative Characteristics of Passenger Ships

Figure 6 and Table 4 shows the distribution of traffic intensity and the qualitative characteristics for passenger ships covering a large sea area surrounding OWF.
Table 3. Qualitative characteristics of fishing vessels.

| Percentage share of unique vessels by draft | Quantitative distribution of unique ships by their length |
|-------------------------------------------|----------------------------------------------------------|
| undefined 35%                              | undefined |
| < 2m 4%                                    | > 300m |
| 2m - 4m 35%                               | 200m - 300m |
| 6m - 8m 18%                               | 100m - 200m |
| > 10m 0%                                  | 50m - 100m |
| 8m - 10m 0%                               | < 50m |
| 6m - 8m 8%                                | undefined |

Figure 6. Distribution of passenger ship traffic intensity covering a large sea area around the OWF (ship type numbers: 60–69, AIS-PL 2017).

Table 5 shows that a total of 113 unique passenger ships were registered, of which 84 (74.3%) had AIS Class A transponders and 29 (25.7%) had Class B transponders.

Table 4. List of unique passenger ships staying in the waters in 2017, broken down by type.

| Type of Vessel (Identifier No.) | Number of Vessels | Percentage Share |
|---------------------------------|-------------------|------------------|
| Passenger ship (60)             | 46                | 40.7%            |
| Passenger ships—carrying DG, HS, or MP, IMO hazard or pollutant category A (61) | 9 | 8.0% |
| Passenger ships—carrying DG, HS, or MP, IMO hazard or pollutant category B (62) | 2 | 1.8% |
| Passenger ships—carrying DG, HS, or MP, IMO hazard or pollutant category C (63) | 1 | 0.9% |
| Passenger ships—carrying DG, HS, or MP, IMO hazard or pollutant category D (64) | 12 | 10.6% |
| Passenger ships (65)            | 5                 | 4.4%             |
| Passenger ships (69)            | 38                | 33.6%            |
3.1.4. Quantitative and Qualitative Characteristics of Cargo Ships

Figure 7 shows the flow of traffic running through the center of the OWF. It was created by the Russian OMSKIY-133 vessel (MMSI no.: 273310900, length = 108.4 m, width = 15 m), which ran several times a month between the ports of the eastern and western Baltic coasts, i.e., Saint Petersburg, Riga, Kaliningrad, Klaipeda, Kunda, Ventspils, Svetliy and Szczecin, Police, Frederiksvaerk and Rostock.

Table 5. Quality characteristics of passenger ships.

| Percentage share of unique ships by draft | Quantitative distribution of unique ships by their length |
|-----------------------------------------|--------------------------------------------------------|
| undefined                               | undefined                                              |
| < 2 m                                   | > 300 m                                                |
| 2 m                                     | 200 m - 300 m                                          |
| 4 m                                     | 100 m - 200 m                                          |
| 6 m                                     | 50 m - 100 m                                           |
| 8 m                                     | < 50 m                                                 |
| 10 m                                    |                                                        |
| 4%                                      |                                                        |
| 38%                                     |                                                        |
| 28%                                     |                                                        |
| undefined                               |                                                        |

Figure 7. Distribution of cargo vessel traffic intensity No. 70-79 (AIS – PL 2017).

In total, 2164 unique cargo ships were registered, of which 2108 (97.4%) had an AIS Class A transponder and 56 (2.6%) had a Class B transponder (Tables 6 and 7).
Table 6. List of unique passenger ships staying in the waters in 2017, broken down by type.

| Type of Vessel (Identifier No.) | Number of Vessels | Percentage Share |
|---------------------------------|-------------------|------------------|
| Cargo ship (70)                 | 1638              | 75.7%            |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category A (71) | 117 | 5.4% |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category B (72) | 16 | 0.7% |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category C (73) | 9 | 0.4% |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category D (74) | 14 | 0.6% |
| Cargo ship (75)                 | 7                 | 0.3%             |
| Cargo ship (76)                 | 17                | 0.8%             |
| Cargo ship (77)                 | 15                | 0.7%             |
| Cargo ship (78)                 | 14                | 0.6%             |
| Cargo ship (79)                 | 317               | 14.6%            |

Table 7. Qualitative characteristics of cargo vessels.

| Percentage breakdown of unique ships by draft | Quantitative breakdown of unique ships by their length |
|---------------------------------------------|-----------------------------------------------------|
| undefined                                    | undefined                                           |
| > 10m                                       | > 300m                                              |
| 8m - 10m                                    | 200m - 300m                                         |
| 6m - 8m                                     | 100m - 200m                                         |
| < 2m                                        | 50m - 100m                                          |
| < 5m                                        | < 50m                                               |

3.2. The Results of the Identification of the Characteristics of the Ships in the OWF BALTIC II Area and the Nearest Shipping Routes

Figure 8 presents an area involving the OWF and the measurement profiles of the nearest shipping routes adopted for the analysis.
3.2.1. Quantitative and Qualitative Characteristics of the OWF Baltic II Area

Figures 9 and 10 and Table 8 shows the distribution of traffic intensity and the qualitative characteristics for all types ships in the OWF area plus a 2 Nm buffer.

Figure 8. Location of the analyzed area and measurement profiles.

Figure 9. Traffic intensity of all types of ships on the main axes of the OWF area increased by a 2 Nm buffer (the profiles formed a 2′′ GRID mesh).
Figure 10. Vessel traffic intensity of all types in the OWF area plus a 2 Nm buffer (1′′ mesh GRID).

Table 8. Qualitative characteristics of all types of ships.

| Percentage share of unique ships by draft | Quantitative distribution of unique ships by their length |
|------------------------------------------|--------------------------------------------------------|
| undefined                                | Number of unique vessels of all types                  |
|                                          | Length                                                 |
| < 2m                                     | 0%                                                     |
| 2-4m                                     | 25%                                                    |
| 4-6m                                     | 31%                                                    |
| 6-8m                                     | 22%                                                    |
| 8-10m                                    | 7%                                                     |
| > 10m                                    | 8%                                                     |

The results presented below were obtained from the Maritime Office in Gdynia (Figures 11 and 12).

3.2.2. Qualitative Characteristics of the Measurement Cross NW (E) Route

In total, 433 unique ships of all types were registered on the measurement profile 1-1, including 426 (98.4%) with AIS class A transponders and 7 (1.6%) with class B transponders (Tables 9 and 10).

3.2.3. Qualitative Characteristics of the Measurement Cross NE (D) Route

In total, on the measurement profile 2-2, 232 unique ships of all types were registered, including 232 (100.0%) with AIS Class A transponders and 0 (0.0%) with Class B transponders (Tables 11 and 12).
3.2.4. Qualitative Characteristics of the Measuring Cross EW (I) Route

In total, on the profile 3-3, 1996 unique ships of all types were registered on the measurement profile, including 1952 (97.8%) with AIS class A transponders and 44 (2.2%) with class B transponders (Tables 13 and 14).

![Ship traffic in the OWF Baltic II region in 2016](image)

*Figure 11. Percentage breakdown of ships by type in 2016.*
Figure 12. Percentage breakdown of ships by type in 2017.

Table 9. List of ships on the measurement profile, broken down by type.

| Type of Vessel (Identifier No.) | Number of Vessels | Percentage Share |
|--------------------------------|------------------|-----------------|
| Vessel—Fishing (30)            | 30               | 6.9%            |
| Vessel—Towing (31)             | 1                | 0.2%            |
| Vessel—Engaged in dredging or underwater operations (33) | 1 | 0.2% |
| Vessel—Engaged in military operations (35) | 1 | 0.2% |
| Vessel—Sailing (36)            | 2                | 0.5%            |
| Vessel (39)                    | 1                | 0.2%            |
| High Speed Craft (HSC)—carrying DG, HS, or MP, IMO hazard or pollutant category D (44) | 1 | 0.2% |
| High Speed Craft (HSC) (48)    | 1                | 0.2%            |
| Search and rescue vessel (51)  | 2                | 0.5%            |
| Tug (52)                       | 5                | 1.2%            |
Table 9. Cont.

| Type of Vessel (Identifier No.) | Number of Vessels | Percentage Share |
|---------------------------------|------------------|------------------|
| Law enforcement vessel (55)     | 2                | 0.5%             |
| Passenger ship (60)             | 4                | 0.9%             |
| Passenger ship—carrying DG, HS, or MP, IMO hazard or pollutant category A (61) | 2 | 0.5% |
| Passenger ship—carrying DG, HS, or MP, IMO hazard or pollutant category B (62) | 1 | 0.2% |
| Passenger ship (69)             | 1                | 0.2%             |
| Cargo ship (70)                 | 235              | 54.3%            |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category A (71) | 15 | 3.5% |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category B (72) | 3 | 0.7% |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category D (74) | 2 | 0.5% |
| Cargo ship (76)                 | 2                | 0.5%             |
| Cargo ship (77)                 | 2                | 0.5%             |
| Cargo ship (79)                 | 48               | 11.1%            |
| Chemical tanker, oil tanker, gas carrier (80) | 29 | 6.7% |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category A (81) | 4 | 0.9% |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category B (82) | 3 | 0.7% |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category C (83) | 1 | 0.2% |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category D (84) | 3 | 0.7% |
| Chemical tanker, oil tanker, gas carrier (89) | 15 | 3.5% |
| Other type of ship (90)         | 8                | 1.8%             |
| Other type of ship (99)         | 3                | 0.7%             |
| Other type of ship (0)          | 5                | 1.2%             |

Table 10. Qualitative characteristics of all types of ships.

| Percentage share of unique ships by draft | Quantitative distribution of unique ships by their length |
|------------------------------------------|----------------------------------------------------------|
| Length                                   | Number of unique vessels of all types                    |
| < 5m                                      | 0                                                         |
| 5m - 10m                                 | 50                                                       |
| 10m - 15m                                | 150                                                      |
| 15m - 20m                                | 200                                                      |
| 20m - 25m                                | 250                                                      |
| 25m - 30m                                | 300                                                      |
| 30m - 35m                                | 350                                                      |
| > 35m                                    | 400                                                      |

- undefined
- < 2m
- 2m - 4m
- 4m - 6m
- 6m - 8m
- 8m - 10m
- 10m - 12m
- 12m - 15m
- 15m - 18m
- 18m - 20m
- 20m - 22m
- 22m - 25m
- 25m - 27m
- 27m - 30m
- 30m - 32m
- 32m - 34m
- 34m - 36m
- 36m - 38m
- 38m - 40m
- 40m - 42m
- 42m - 44m
- 44m - 46m
- 46m - 48m
- 48m - 50m
- 50m - 52m
- 52m - 54m
- 54m - 56m
- 56m - 58m
- 58m - 60m
- > 60m
Table 11. List of ships on the 2-2 measurement profile, broken down by type.

| Type of Vessel (Identifier No.) | Number of Vessels | Percentage Share |
|----------------------------------|-------------------|------------------|
| Vessel—Fishing (30)              | 31                | 13.4%            |
| Vessel—Towing and length of the tow exceeds 200 m or breadth exceeds 25 m (32) | 1 | 0.4% |
| Vessel—Sailing (36)              | 2                 | 0.9%             |
| Tug (52)                         | 1                 | 0.4%             |
| Law enforcement vessel (55)      | 1                 | 0.4%             |
| Passenger ship (60)              | 6                 | 2.6%             |
| Passenger ship (69)              | 2                 | 0.9%             |
| Cargo ship (70)                  | 108               | 46.6%            |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category A (71) | 4 | 1.7% |
| Cargo ship—carrying DG, HS, or MP, IMO hazard or pollutant category D (74) | 1 | 0.4% |
| Cargo ship (79)                  | 23                | 9.9%             |
| Chemical tanker, oil tanker, gas carrier (80) | 22 | 9.5% |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category A (81) | 6 | 2.6% |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category B (82) | 3 | 1.3% |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category C (83) | 1 | 0.4% |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category D (84) | 2 | 0.9% |
| Chemical tanker, oil tanker, gas carrier (89) | 7 | 3.0% |

Table 12. Qualitative characteristics of all types of ships.

| Percentage share of unique ships by draft | Quantitative distribution of unique ships by their length |
|------------------------------------------|---------------------------------------------------------|
| undefined                                | undefined                                               |
| > 10m                                    | > 300m                                                  |
| 8m                                       | 200m - 300m                                             |
| 6m                                       | 100m - 200m                                             |
| 6m - 8m                                  | 50m - 100m                                              |
| 8m                                       | < 50m                                                   |
| 2m - 2.5m                                | 0 - 50                                                  |
| 4m - 4.5m                                | 50 - 100                                                |
| undefined                                | 100 - 150                                               |
| undefined                                | 150 - 200                                               |

Number of unique vessels of all types
Table 13. List of vessels on the 3-3 measurement profile, broken down by type.

| Type of Vessel (Identifier No.)                                                                 | Number of Vessels | Percentage Share |
|-------------------------------------------------------------------------------------------------|-------------------|------------------|
| Vessel—Fishing (30)                                                                            | 34                | 1.7%             |
| Vessel—Towing (31)                                                                             | 6                 | 0.3%             |
| Vessel—Towing and length of the tow exceeds 200 m or breadth exceeds 25 m (32)                   | 4                 | 0.2%             |
| Vessel—Engaged in dredging or underwater operations (33)                                        | 19                | 1.0%             |
| Vessel—Engaged in diving operations (34)                                                        | 5                 | 0.3%             |
| Vessel—Engaged in military operations (35)                                                      | 15                | 0.8%             |
| Vessel—Sailing (36)                                                                            | 19                | 1.0%             |
| Vessel—Pleasure craft (37)                                                                      | 1                 | 0.1%             |
| Vessel (38)                                                                                     | 2                 | 0.1%             |
| Vessel (39)                                                                                     | 2                 | 0.1%             |
| High Speed Craft (HSC) carrying DG, HS, or MP, IMO hazard or pollutant category D (44)          | 4                 | 0.2%             |
| Search and rescue vessel (51)                                                                   | 1                 | 0.1%             |
| Tug (52)                                                                                        | 42                | 2.1%             |
| Vessel with anti-pollution facilities or equipment (54)                                          | 1                 | 0.1%             |
| Law enforcement vessel (55)                                                                     | 2                 | 0.1%             |
| Spare—for assignments to local vessel (57)                                                      | 1                 | 0.1%             |
| Passenger ship (60)                                                                             | 22                | 1.1%             |
| Passenger ship—carrying DG, HS, or MP, IMO hazard or pollutant category A (61)                   | 2                 | 0.1%             |
| Passenger ship—carrying DG, HS, or MP, IMO hazard or pollutant category B (62)                   | 1                 | 0.1%             |
| Passenger ship—carrying DG, HS, or MP, IMO hazard or pollutant category C (63)                   | 1                 | 0.1%             |
| Passenger ship—carrying DG, HS, or MP, IMO hazard or pollutant category D (64)                   | 1                 | 0.1%             |
| Passenger ship (69)                                                                             | 23                | 1.2%             |
| Cargo ships (70)                                                                                | 1080              | 54.1%            |
| Cargo ships—carrying DG, HS, or MP, IMO hazard or pollutant category A (71)                     | 93                | 4.7%             |
| Cargo ships—carrying DG, HS, or MP, IMO hazard or pollutant category B (72)                     | 6                 | 0.3%             |
| Cargo ships—carrying DG, HS, or MP, IMO hazard or pollutant category C (73)                     | 3                 | 0.2%             |
| Cargo ships—carrying DG, HS, or MP, IMO hazard or pollutant category D (74)                     | 8                 | 0.4%             |
| Cargo ships (75)                                                                                | 2                 | 0.1%             |
| Cargo ships (76)                                                                                | 1                 | 0.1%             |
| Cargo ships (77)                                                                                | 1                 | 0.1%             |
| Cargo ships (78)                                                                                | 1                 | 0.1%             |
| Cargo ships (79)                                                                                | 228               | 11.4%            |
| Chemical tanker, oil tanker, gas carrier (80)                                                   | 128               | 6.4%             |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category A (81) | 18                | 0.9%             |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category B (82) | 27                | 1.4%             |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category C (83) | 11                | 0.6%             |
| Chemical tanker, oil tanker, gas carrier—carrying DG, HS, or MP, IMO hazard or pollutant category D (84) | 5                 | 0.3%             |
| Chemical tanker, oil tanker, gas carrier (85)                                                   | 1                 | 0.1%             |
| Chemical tanker, oil tanker, gas carrier (89)                                                   | 72                | 3.6%             |
| Other types of ship (90)                                                                         | 30                | 1.5%             |
| Other types of ship (97)                                                                         | 2                 | 0.1%             |
| Other types of ship (99)                                                                         | 11                | 0.6%             |
4. Discussion

4.1. Quantitative Characteristics of Traffic

The analysis of AIS data with the use of the proprietary software shows that OWF Baltic II will be located at a considerable distance from the lines of the main ship traffic flows, which minimizes its impact on the navigation course in the PMA and the South Baltic Sea. However, when considering a large sea area around an OWF, three main streams of ship traffic can be distinguished, as follows (Figure 8):

- Customary Route D (NE), running approximately 3 nautical miles from the north–west border of the Baltic II OWF. In 2017, only 232 unique ships used it (cargo—60.3%, tankers—17.7%, fishing vessels—13.4%, passenger vessels—3.4%, other—5.2%).
- Customary route E (NW), running south of the South Central Bank, connecting Klaipeda with the southern Baltic ports—mainly the ports of Świnoujście, Sassnitz, and Mukram. In 2017, 433 unique ships used it (cargo—77.6%, tankers—12.7%, fishing vessels—6.9%, passenger vessels—1.8%, others—1.0%).
- Route I (EW), passing through the “Lawica Słupska” Ship Traffic Distinction System, is the second most frequently used route of the Baltic Sea. Ships going along it head from west to east, avoiding Bornholm from the south in the direction of the Polish and Russian ports of the southern Baltic Sea. In 2017, 1996 unique ships used it (cargo—71.5%, tankers—13.3%, fishing vessels—2.7%, passenger vessels—1.8%, other—11.0%).

For the safety of navigation, most important are the customary routes E and D, which are approximately 2–3 nautical miles away. Ship traffic on both these routes can be considered low compared to route I. Only 433 and 232 unique vessels exceeded the measurement profiles 1-1 and 2-2 in 2017. The maximum traffic intensity measured on both profiles in the 2” mesh areas of GRID was only 90 (profile 1-1) and 20 (profile 2-2) vessels in 2017.

In the OWF area alone (in a small area of analysis; Figure 8), there were 794 vessels in 2016 and 930 in 2017. The maximum traffic intensity in the main OWF axes (AA and BB measurement profiles Figure 9) amounted to approximately 18 vessels in 2017 (measured on both profiles in the areas of 2” GRID meshes). These results give the basis for the conclusion that the numbers and intensity of vessel traffic in the OWF Baltic II region are low, even compared to the adjacent waters, including those located on the eastern side and selected for offshore wind farms.

4.2. Qualitative Characteristics of Traffic

When analyzing the movement of ships in the large body of water presented in Figure 4, it is clearly visible that cargo ships are dominant. Out of the total number of 3861 registered vessels of all types, there were as many as 2164 (56%) unique types. Ships with a draft of

Table 14. Qualitative characteristics of all types of ships.

| Percentage share of unique ships by draft | Quantitative distribution of unique ships by their length |
|------------------------------------------|--------------------------------------------------------|
| undefined                                | undefined                                              |
| > 10m                                    | > 300m                                                 |
| 8m                                       | 200m - 300m                                            |
| 10m                                      | 100m - 200m                                            |
| 8m - 10m                                 | 50m - 100m                                             |
| 6m - 8m                                  | < 50m                                                  |
| 26%                                      | Number of unique ships of all types                    |

[Diagram showing qualitative characteristics of all types of ships with percentages for undefined, > 10m, 8m, 10m, 6m-8m, and 26% categories.]

[Diagram showing quantitative distribution of unique ships by length with bars for undefined, > 300m, 200m-300m, 100m-200m, 50m-100m, and < 50m categories.]
4–6 m (31%) and a length of 100–200 m (49%) prevailed. The vast majority of ships of this type use the “Ławica Słupska” Ship Traffic Separation System, so the planned OWF does not have a significant impact on their navigation (mainly due to their distance of about 11 Nm from the OWF).

Fishing vessels constitute the next group in terms of numbers (237). Their movement is concentrated in the area of Rynna Słupska and their approach tracks to the ports of Ustka and Łeba (Figure 5). Vessels with a draft of 2–6 m (53%) and with a length of less than 50 m (84%) prevail. The movement of these ships in the area of the planned OWF can be considered low.

In total, 113 passenger vessels form another group. The greatest intensity of this type of vessel occurs on the Gdynia-Karlskrona route. Passenger and cargo ferries run regularly throughout the year. Most of them are vessels with a draft in the range of 4–8 m (66%) and a length of 100–200 m (52%). Vessels of this type pass the OWF on the south side, but at a distance greater than 2 Nm.

In the small scope of analysis covered by the OWF (Figure 8), there were 764 vessels in 2016 and 930 in 2017 (according to data authorized by the Maritime Office in Gdynia). In 2016, cargo vessels accounted for the largest share of 324 (40.9%), followed by vessels engaged in fishing, at 245 (30.9%), and finally there were 55 (7.3%) vessels with a navigational status as sailing.

In 2017, as in 2016, the largest share was occupied by cargo vessels, numbering 363 (39.0%), followed by 279 (30.0%) vessels engaged in fishing, and finally 75 passenger vessels (8%) (Figures 5–7).

It should be noted that the slightly higher number of cargo ships results from the fact that fragments of the E and D routes were included in the analyzed area. In 2017, 433 unique ships used route E (cargo 77.6%, tankers 12.7%, fishing 6.9%, passenger 1.8%, other 1.0%), and D route was used by 232 unique ships (cargo 60.3%, tankers 17.7%, fishing 13.4%, passenger 3.4%, other 5.2%). The vast majority of ships with a draft of 2–6 m (56%) and lengths between 200 and 300 m (39%) navigated along the E route. On the other hand, the ships traveling along the D route had a draft above 4 m (65%) and a length of more than 100 m (89%). The results from a small area covering the OWF region and the 1-1 and 2-2 measurement profiles are consistent with those from a previous analysis covering the central PMA coast. Both, however, prove that the planned Baltic II wind farm together with the accompanying infrastructure will not have a significant impact on the safety of ships in Polish Maritime Areas, or on the efficiency of their navigation, taking into account the existing shipping routes and traffic separation schemes.

5. Conclusions

The obtained research results confirm the hypothesis that it is possible to use historical AIS data during the implementation of the spatial planning process aimed at optimizing the location of marine renewable energy installations. After their appropriate processing, it is possible to obtain a description of vessel traffic in the form of quantitative characteristics, based on traffic intensity distributions, and qualitative characteristics, based on statistics broken down by ship type, draft, and length. These characteristics may, in turn, constitute a secondary source of information used to identify vessels sailing in the studied area. Thus, they can be used to determine the course of customary routes, the intensity of traffic, or the number of ships staying in a given water area in a given period of time.

The advantages of the proposed solution are as follows:

- the possibility of using the most reliable and qualitatively superior static and dynamic data regarding ships in the AIS for ship traffic analysis;
- the automation of the process of developing quantitative and qualitative characteristics for any sea area and time period (including those obtained from satellite AIS);
- the possibility of creating the course lines of customary shipping routes without the need to use marine navigation charts and nautical publications (e.g., with the division of ships into types, or with a specific draft or length).
The proposed methodology is used to obtain new information on shipping and the marine environment, supporting decision-making related to the planning of OWF locations. This is included in maps made up of three layers, i.e., ship streams generated on the basis of adequately processed AIS data, the boundary of the planned OWF area with buffers, and electronic navigational charts and statistical data specified for the various vessel types, draft and lengths. However, it should be emphasized that the final decision on the location of the OWF is made in an arbitrary manner. On the other hand, a comparison of the juxtaposed information obtained before and after building the OWF allows for only a final assessment of its impact on shipping.

The proposed solution is the effect of preliminary research, but based on the results, it can be concluded that this research is worth continuing, although it should be taken into account that the application of the proposed solution requires the collection and processing of very large AIS data sets. Therefore, future research could be focused on increasing the computational efficiency of the data processing process.

Author Contributions: Conceptualization, K.N., P.S. and K.B.; methodology, K.N., P.S.; software, K.N.; validation, K.N., P.S. and K.B.; formal analysis, K.N.; investigation, P.S.; resources, K.B.; data curation, K.B.; writing—original draft preparation, K.N., K.B. and P.S.; writing—review and editing, K.N., P.S. and K.B.; visualization, K.B.; supervision, K.N.; project administration, K.N.; funding acquisition, K.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Baltic Trade and Invest Sp. z o. o. as part of the expertise number O-4-2-0-003/2018.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References
1. Energy Regulatory Office. Available online: https://www.ure.gov.pl/pl/oze/potencjal-krajowy-oze/5755,Ilosc-energii-elektrycznej-wywtorzonej-z-OZE-w-latach-2005-2020-potwierdzonej-wy.html (accessed on 22 July 2021).
2. Service of the Republic of Poland. Available online: https://www.gov.pl/web/aktywa-panstwowe/krajowy-plan-na-rzecz-energii-i-klimatu-na-lata-2021-2030-przekazany-do-ke (accessed on 22 July 2021).
3. Bergström, L.; Kautsky, L.; Malm, T.; Rosenberg, R.; Wahlberg, M.; Astrand, C.; Wilhelmsson, D. Effects of offshore wind farms on marine wildlife—A generalized impact assessment. *Environ. Res. Lett.* 2014, 9, 034012. [CrossRef]
4. Gusatu, L.F.; Menegon, S.; Depellegrin, D.; Zuidema, C.; Faaij, A.; Yamu, C. Spatial and Temporal Analysis of Cumulative Environmental Effects of Offshore Wind Farms in the North Sea Basin. *Sci. Rep.* 2021, 11, 10125. [CrossRef]
5. Degraer, S.; Brabant, R.; Rumes, B.; Vigin, L. Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Marking a Decade of Monitoring, Research and Innovation; Royal Belgian Institute of Natural Sciences (RBINS): Brussels, Belgium, 2019.
6. Bailey, H.; Brookes, K.L.; Thompson, P.M. Assessing Environmental Impacts of Offshore Wind Farms: Lessons Learned and Recommendations for the Future. *Aquat. Biosyst.* 2014, 10, 8. [CrossRef]
7. Rawson, A.; Rogers, E. Assessing the impacts to vessel traffic from offshore wind farms in the Thames Estuary. *Sci. J. Marit. Univ. Szczec.* 2015, 43, 99–107.
8. Yu, Q.; Liu, K.; Teixeira, A.P.; Soares, C.G. Assessment of the Influence of Offshore Wind Farms on Ship Traffic Flow Based on AIS Data. *J. Navig.* 2020, 73, 131–148. [CrossRef]
9. Mehdi, R.A.; Schröder-Hinrichs, J.U.; van Overloop, J.; Nilsson, H.; Pålsson, J. Improving the Coexistence of Offshore Wind Farms and Shipping: An International Comparison of Navigational Risk Assessment Processes. *WMU J. Marit. Aff.* 2018, 17, 397–434. [CrossRef]
10. Toke, D. The UK Offshore Wind Power Programme: A Sea-Change in UK Energy Policy? *Energy Policy* 2011, 39, 526–534. [CrossRef]
11. Christiansen, C.F.; Andersen, L.W.; Pedersen, P.H. Ship collision risk for an offshore wind farm. In Proceedings of the Eighth International Conference on Structural Safety and Reliability ICOSSAR, Newport Beach, CA, USA, 17–22 June 2001.
12. Mazaheri, A.; Ylitalo, J. Comments on Geometrical Modeling of Ship Grounding. In 5th International Conference on Collision and Grounding of Ships; Aalto University: Espoo, Finland, 2010.
13. Wawruch, R.; Stupak, T. Modelling of Safety Distance Between Ships Route and Wind Farm. *Arch. Transp.* 2011, 23, 413–420. [CrossRef]
14. Fujii, Y.; Tanaka, K. Traffic Capacity. *J. Navig.* 1971, 24, 543–552. [CrossRef]
15. Goodwin, E.M. A Statistical Study of Ship Domains. *J. Navig.* 1975, 28, 328–344. [CrossRef]
16. Pietrzykowski, Z.; Uriasz, J. The Ship Domain—A Criterion of Navigational Safety Assessment in an Open Sea Area. *J. Navig.* 2009, 62, 93–108. [CrossRef]
17. Rawson, A.; Rogers, E.; Foster, D.; Phillips, D. Practical Application of Domain Analysis: Port of London Case Study. *J. Navig.* 2014, 67, 203–209. [CrossRef]
18. US Department of the Interior, Bureau of Ocean Energy Management. Available online: [https://www.boem.gov/search?keys=%2C+Parametrix++++++Offshore+Wind+and+Wave+Energy+Feasibility+Mapping+for+the+Outer+Continental+Shelf+off+the+State+of+Oregon](https://www.boem.gov/search?keys=%2C+Parametrix++++++Offshore+Wind+and+Wave+Energy+Feasibility+Mapping+for+the+Outer+Continental+Shelf+off+the+State+of+Oregon) (accessed on 22 July 2021).
19. Nautical Institute and World Ocean Council. Available online: [http://www.nautinst.org/en/forums/msp](http://www.nautinst.org/en/forums/msp) (accessed on 22 July 2021).
20. Summary Report: Bureau of Ocean Energy Management’s Offshore Wind and Maritime Industry Knowledge Exchange. Available online: [https://www.boem.gov/renewable-energy/marine-energy/maritime-industry-communication-and-engagement](https://www.boem.gov/renewable-energy/marine-energy/maritime-industry-communication-and-engagement) (accessed on 22 July 2021).
21. Rejestr.IO. Available online: [https://rejestr.io/krs/293888/baltic-trade-and-invest](https://rejestr.io/krs/293888/baltic-trade-and-invest) (accessed on 29 July 2021).
22. Maritime Office in Gdynia. Polish Maritime Areas. Available online: [https://www.umgdy.gov.pl/?page_id=17781](https://www.umgdy.gov.pl/?page_id=17781) (accessed on 29 July 2021).
23. Maritime Office in Gdynia. Detailed for the Area of OWF Baltic II and Covering the Nearest Shipping Routes. Available online: [https://www.umgdy.gov.pl/?page_id=1550](https://www.umgdy.gov.pl/?page_id=1550) (accessed on 25 July 2021).
24. Internet Legal Acts System. Available online: [http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu19910320131](http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu19910320131) (accessed on 29 July 2021).
25. Maritime & Coastguard Agency. Offshore Renewable Energy Installations (OREIs): Guidance to Mariners Operating in the Vicinity of UK OREIs. MGN 372 (M+F). 2008. Available online: [https://www.gov.uk/government/publications/mgn-372-guidance-to-mariners-operating-in-vicinity-of-uk-oreis](https://www.gov.uk/government/publications/mgn-372-guidance-to-mariners-operating-in-vicinity-of-uk-oreis) (accessed on 7 June 2021).
26. NIMA. Department of Defense World Geodetic System 1984: Its Definition and Relationships with Local Geodetic Systems. National Imagery and Mapping Agency. 2000. Available online: [https://www.bibsonomy.org/bibtex/b735f17234bb9a431255dee5b5a68a8](https://www.bibsonomy.org/bibtex/b735f17234bb9a431255dee5b5a68a8) (accessed on 10 June 2021).
27. HELCOM. Available online: [https://portal.helcom.fi/meetings/AIS%20EWD%202014-106/Documents/Current%20status%20of%20AIS-PL%20Network.pdf](https://portal.helcom.fi/meetings/AIS%20EWD%202014-106/Documents/Current%20status%20of%20AIS-PL%20Network.pdf) (accessed on 22 July 2021).
28. Docplayer. Available online: [https://docplayer.pl/62309478-Morskie-systemy-czasu-rzeczywistego-implmenetacja-ais-w-polscie.html](https://docplayer.pl/62309478-Morskie-systemy-czasu-rzeczywistego-implementacja-ais-w-polscie.html) (accessed on 22 July 2021).
29. BSC Poland. Available online: [http://www embarcadero.com.pl/produkty/cbuilder/](http://www embarcadero.com.pl/produkty/cbuilder/) (accessed on 7 May 2018).
30. IEC. 61162-3: Maritime Navigation and Radiocommunication Equipment and Systems—Digital Interfaces—Part 3: Multiple Talker and Multiple Listeners. High Speed Network Bus; Future Publication; IEC: Geneva, Switzerland, 2014.
31. ITU. M.1371-5, Technical Characteristics for an Automatic Identification System Using Time Division Multiple Access in the VHF Maritime Mobile Frequency Band; ITU: Geneva, Switzerland, 2014.
32. Maritime & Coastguard Agency. Offshore Renewable Energy Installations (OREIs): Guidance to Mariners Operating in the Vicinity of UK OREIs. MGN 372 (M+F). 2008. Available online: [https://www.gov.uk/government/publications/mgn-372-guidance-to-mariners-operating-in-vicinity-of-uk-oreis](https://www.gov.uk/government/publications/mgn-372-guidance-to-mariners-operating-in-vicinity-of-uk-oreis) (accessed on 7 June 2021).
33. Naus, K.; Makar, A.; Apanowicz, J. Usage AIS data for analyzing ship’s motion intensity. *Annu. Navig.* 2007, 1, 237–242.