Prinses Elisabeth-zone (PEZ)
Offshore windpark

Aanvaringsstudie

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BETTER SHIPS, BLUE OCEANS

SHIPPING SAFETY EFFECTS FOR WIND ENERGY AREA PRINSES ELISABETH-ZONE

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SHIPPING SAFETY EFFECTS FOR WIND ENERGY AREA PRINSES ELISABETH-ZONE

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APPENDIX 2: RESULTS WINDPARK PEZ SCENARIO 2

LIST OF ABBREVIATIONS

VHF	Maritime radio communication in the VHF band. The transmitter/receiver has a range of approximately 30 nautical miles and must be available on all professional ships.
AIS	Automatic Identification System, which exchanges essential information (such as identity, course and navigation) between ships and between ship and shore for the safety of navigation.
VTM	Vessel Traffic Management, a public service aimed at ensuring the smooth and safe running of shipping traffic. and whose use may only be made mandatory in the territorial sea (VTS). The guidelines for VTM have been established by IMO and IALA A VTM can be established inside and outside of territorial waters (12 mile zone). VTM instructions in international waters are however not mandatory for ships.
IMO	The International Maritime Organization is the UN organization for shipping. It can establish agreements at international level between the participating Member States shipping safety and the environment.
SAR	Search And Rescue is the search for and provision of aid to people who are in distress or imminent danger.
SAMSON	Safety Assessment Model for Shipping and Offshore on the North Sea. This is the mathematical model MARIN uses to quantify collision risks at sea.
TSS	Traffic Separation Scheme. These “roads” at sea are established to guide, control and separate shipping routes to prevent collisions between ships.
ERTV	Emergency Response Towing Vessel, is emergency towing assistance provided by a tugboat often with additional firefighting capacity, SAR and to oil pollution prevention equipment.
EIA	Environmental Impact Assessment is a tool used to assess the significant effects of a project or development proposal on the environment.
EEZ	Exclusive Economic Zone. The sea area bordering a country where that state has the legal rights for economical activities such as mining, fishery and energy generation. These rights are founded in the United Nations Convention on the Law of the Sea (UNCLOS)

1 INTRODUCTION

By 2020, the last wind farm in the Eastern Zone of the Belgian part of the North Sea was completed, bringing a total installed capacity of 2261 MW since then. In the Marine Spatial Plan (MRP) 2020-2026, an additional area of 285 km² has been earmarked for the construction and operation of renewable energy sources. The Prinses Elisabeth-zone (PEZ), as defined in the spatial plan, consists of areas designated for the construction and operation of wind energy and transmission of electricity. The area is divided in three lots: PE I, II and III (see Figure 2-1) and together are the PEZ. The three lots will be built with little time interval so the effects for this study are considered with all three lots in place.

The presence of an offshore wind farm has implications for shipping traffic near and around it. A wind farm has a direct impact on traffic safety due to the risk of ships drifting to and colliding with the turbines. Some ships will also choose alternative routes or detour, resulting in changes in transport costs and emissions. Changes in traffic flows around the wind farm may also result in a change in the risk of ships colliding with each other (indirect effect).

This report describes the safety study for the three lots of the PEZ wind energy area conducted by MARIN on behalf of Arcadis Belgium nv/sa. The results of this study are part of the environmental impact report (EIR) by Arcadis nv/sa.

The structure of this report is as follows:

- Chapter 2 contains the objective of this study.
- Chapter 3 outlines how the safety study is designed, what information is needed and where this information comes from.
- Chapter 4 shows the shipping traffic flows and databases.
- The results of the safety study for the wind energy area are given in Chapter 5.
- Chapter 6 discusses possible measures to reduce the risk to shipping.
- Chapter 7 contains the conclusions and recommendations of the study.

2 OBJECTIVE

The aim of the study is to determine the risks to shipping for the wind energy area PEZ (see Figure 2-1) for each lot based on two layout alternatives, differentiating between the maximum number of turbines and a scenario with the largest turbines. This is done by determining the potential collision frequencies with wind turbines and their consequences. The alterations in safety due to a change in the routes taken by ships, the effects on CO2 emissions due to different routes, and the effects of wind turbines on visual sight lines are also included within this analysis.

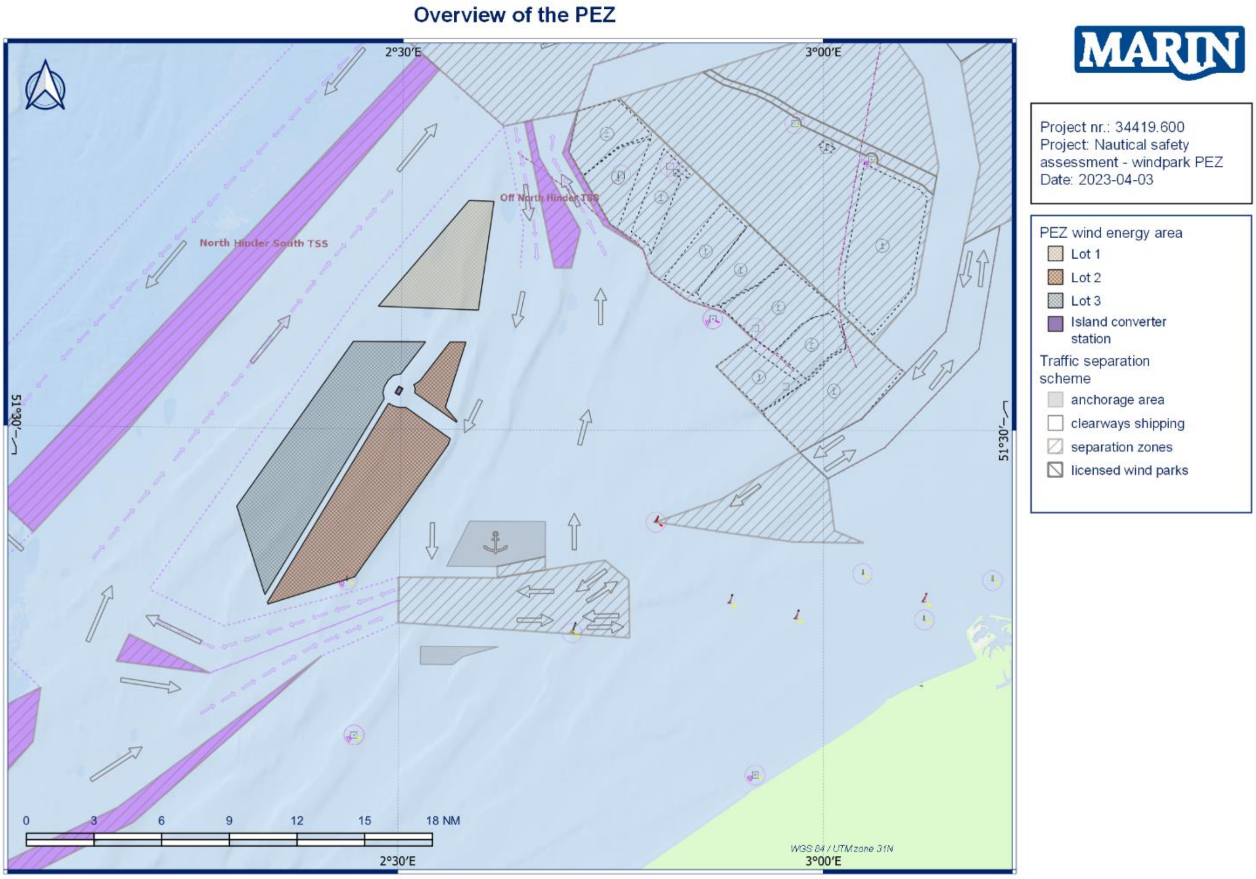

Figure 2-1 Plot of the PEZ windfarm lots I, II and III

3 METHOD

This section describes the generic methodology for wind farm safety studies. The model inputs and assumptions used in this study are also outlined in Section 3.3.

3.1 SAMSON

Collision frequencies are determined with the SAMSON model (Safety Assessment Model for Shipping and Offshore on the North Sea). The model was developed for the Dutch Directorate-General for Goods Transport (now Directorate-General for Aviation and Maritime Affairs) and is used to estimate the probabilities and consequences of all types of accidents at sea. A general description of the model can be found in [Ref 1.] The POLSSS executive summary, Policy for Sea Shipping Safety [Ref 2.], describes how SAMSON has been used to predict the costs and consequences of a wide range of policies. A global description of SAMSON is also shown at:
https://www.iala-aism.org/wiki/iwrap/index.php/SAMSON

Most of the blocks of the maritime traffic system diagram shown in Figure 3-1 are modelled in the SAMSON model. The large block "Maritime Traffic System" contains four sub-blocks. These blocks describe the traffic situation; the number of movements, vessel characteristics and the layout of the sea area. The accident models for collisions, groundings and fire/explosions etc. are used to calculate the frequency of accidents based on the traffic situation. The large block "Impact" contains the sub-blocks used to determine the impact of the accidents. The model parameters were determined by analysing the global accident database 1990-2012 from Lloyds' Register Fairplay (now IHS Fairplay).

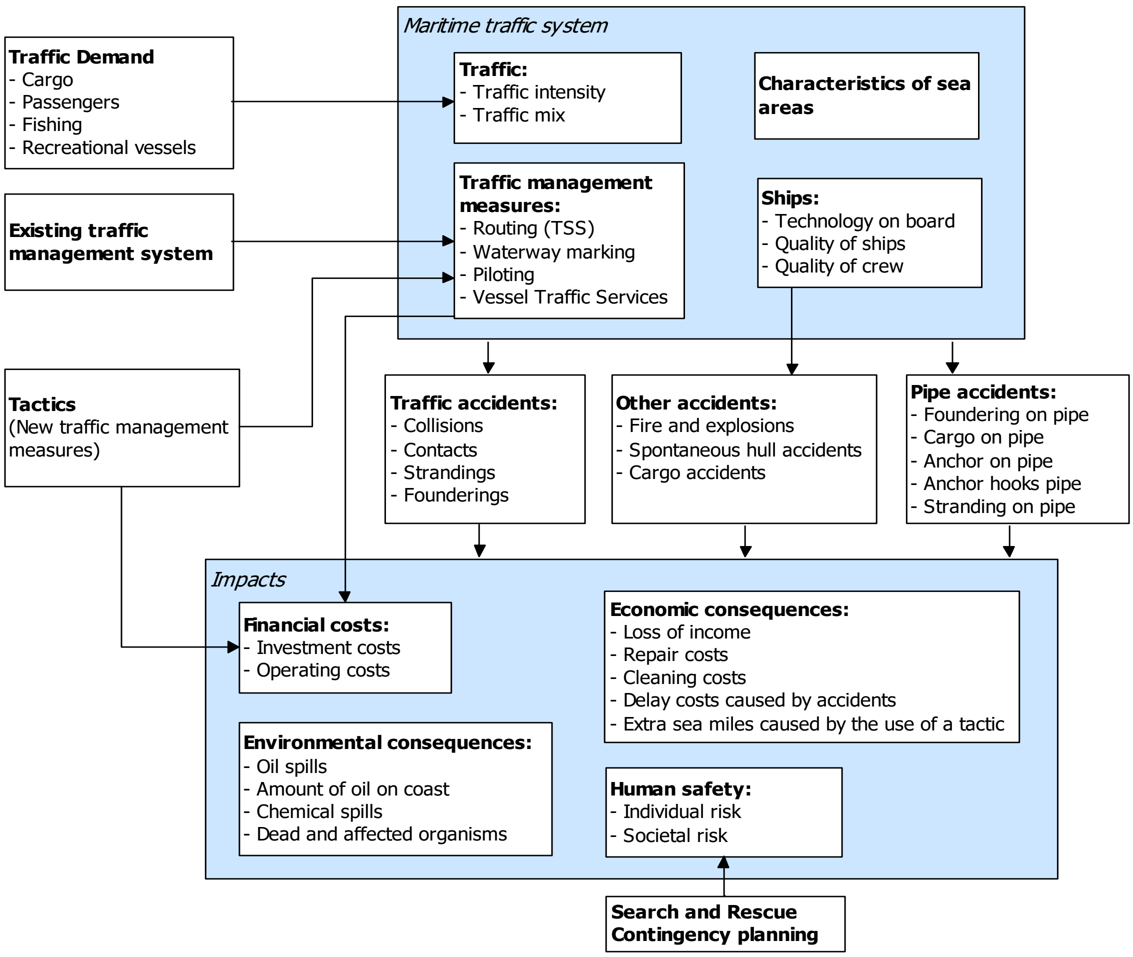

Figure 3-1 System diagram SAMSON

3.2 Effect of a wind park

The construction of a wind farm affects shipping traffic. In the future, a ship currently following a route through a future wind farm will have to divert its route and pass the wind farm at least 500 meters distance. This means that this ship will be hindered by the wind farm. In addition, there are more consequences. As the ship takes a different route, the shipping routes outside the wind farm will have a higher (perhaps fractional) intensity. As a result of the higher intensities on these routes, the number of encounters and hence the number of accidents is expected to increase. The above effects are referred to as the "indirect" impacts.

Due to the direct impacts of a wind farm to the shipping, new types of accidents occur, namely collisions with a wind turbine of the wind farm. In SAMSON, these types of accidents are referred to as ramming and drifting contacts, respectively:

- A powered collision results from a navigational error, when the navigator of a vessel, which is on a collision course with a wind turbine of the wind farm, fails to react or reacts too late. A navigational error can have several causes, such as; ignorance, not seeing the wind farm, not being present on the bridge, becoming unwell and unable to respond etc. The collision speed is high.

- A drifting collision occurs when a vessel is no longer manoeuvrable due to machinery failure. Initially, the anchor could be used to stop the vessel, but if this is not possible or fails, the movement of the vessel (speed and direction) will depend entirely on the environmental condition (wind, waves and current). Subsequently, a floating vessel may inevitably collide with a wind turbine. The collision is transverse and the speed is low.

These accidents are caused by shipping traffic around the wind farm and are not necessarily limited to the group of ships that passed through the wind farm area when it was not there.

To calculate the effects of the wind farm on shipping, an adjusted shipping traffic for the situation with the wind farm can be modelled in SAMSON. Shipping has to pass the wind farm at least 500 m distance. The extent to which traffic is affected depends on the size and location of the wind farm. For the location of the wind farm, a new traffic database can be created to include the changed shipping pattern.

3.3 Model input and assumptions

The following assumptions, model inputs and parameters are used for the calculations.

3.3.1 Traffic

Maritime traffic is divided into two groups, namely "route-bound" and "non-route-bound" traffic. Route-bound traffic includes the ship movements of merchant ships, which are on their way from port A to port B. Non-route-bound traffic includes the ship movements of ships that have a mission somewhere at sea, such as fishing, supply shipping, work shipping and recreational shipping. In SAMSON, these ship groups are modelled differently.

3.3.1.1 Route bound traffic

Route-bound traffic is modelled on shipping lanes across the North Sea. Because of the location of ports and traffic separation schemes, most of these ships move along as a network of links (with a certain width), similar to the road network on land. In practice, ships can travel outside these links as one is allowed to travel anywhere as long as one follows the rules. However, the proportion of route-bound traffic sailing outside the routes is very small, as the links include the shortest and safest connections between ports taking into account shallows and other obstacles.

For this study, the 2021 AIS data has been used. Based on the analysis on traffic developments in previous years it is not expected that more recent data will differ significantly from the 2021 data.

Therefore traffic growth was not taken into account in this study, so the traffic database has not been corrected with growth rates for the future.

A traffic database is used for the calculations. A traffic database contains links, link intensities and link characteristics. A link is a straight connection between two points. The link intensity describes the number of vessels passing over that link per year, broken down by vessel type and vessel size. The link characteristic describes how wide the link is and the lateral distribution how traffic is distributed over that link.

3.3.1.2 Non-route bound traffic

Non-route traffic (fishing, supply shipping, working and recreational shipping) cannot be modelled in the previous way. The behaviour of this traffic at sea is clearly different. One does not sail from port A to port B along clear routes, but from port A to one or more destinations at sea and then usually back to departure port A. The behaviour at sea is usually unpredictable. Moreover, fishermen often sail back and forth in a fishing area. This is why this traffic is modelled by densities in SAMSON.

The average density in the 4 x 4 km grid cells is based on an analysis of the 2021 AIS data. It has been assumed for the current study that there will be no integral traffic (shared use of the wind farm area) passage or dedicated traffic passages for smaller vessels. Traffic that was initially within the boundaries of the wind energy area is shifted to the edges around the area. As a result, some grid cells located inside and near the wind farms will have no or very low density.

The SAMSON model was not designed to determine/calculate the incident frequencies for working vessels inside an offshore wind farm. The operational behaviour of vessels bound for the wind farm itself is different from other non-route bound traffic which has an effect on the probability and intensity of a collision with wind turbines. Wind farm bound traffic is usually well prepared for their operations inside the field as ship and crew are equipped and trained to operate the area. The conventional contact-model for non-route bound traffic in SAMSON is therefore not adequate. In addition, there is no significant and verified database of incidents inside offshore wind farms available yet which is essential for collision frequency calculations.

3.3.2 Models used

The overall SAMSON model consists of several sub-models for the different accidents. To quantify the effect of the wind farm on shipping around the area, the number of powered and drifting collisions per year is determined. The following model is used for this purpose:

- Contact with a fixed object (wind turbine):
  - as a result of a navigational error (powered collision);
  - as a result of an engine failure (drifting collision).

For the current study, no new calculations were carried out to determine the indirect effects.

3.4 Consequential damage

A so-called consequential damage can occur as a result of a drifting contact or collision between vessel and wind turbine. This damage consists of damage to the wind turbine, damage to the ship, environmental damage due to oil spill when a ship is damaged and personal injury due to the collision/contact.

The information of vessels (such as the distribution of sailing speeds, sailing direction, vessel type and vessel size) that collide or in contact with the wind farm is known in the model. These data are sufficient to determine the maximum energy present in the collision. This energy measure is used partly on the basis of experience and partly on the basis of complex calculations to determine the damage to the vessel that collides with another vessel or object. The basic assumption is that all the energy is dissipated in the collision. The energy present in sailing or drifting vessels has also been determined for this study and is presented per vessel type with the corresponding probabilities of occurrence.

3.4.1 Damage to wind turbine and ship

For most ship types, there is no complete dissipation of energy after a collision due to the limited energy absorption of the object being collided with. The failure behaviour of wind turbines has been investigated [Ref 5.]. This showed that for almost all ship types, the wind turbine fails statically, dissipating only a fraction of the energy. For further analysis of consequential damage, the following two failure modes are distinguished:

- Buckling; the wind turbine fails by buckling at the point of impact, followed by plastic deformation, with the mast remaining fixed. Finally, the turbine falls towards the ship or away from the ship. In the case where the turbine falls towards the ship, the rotor may end up with the nacelle on the deck.

- Hinging; the wind turbine collapses due to the formation of a plastic hinge at its "attachment" to the bottom of the sea. As a result of the creation of this hinge, the wind turbine may break off or be knocked over as a whole (including the bottom). The actual hinge point is then distributed along its length in the bottom and is no longer a point but a part of the mast foundation in the bottom that bends plastically and yields partially.

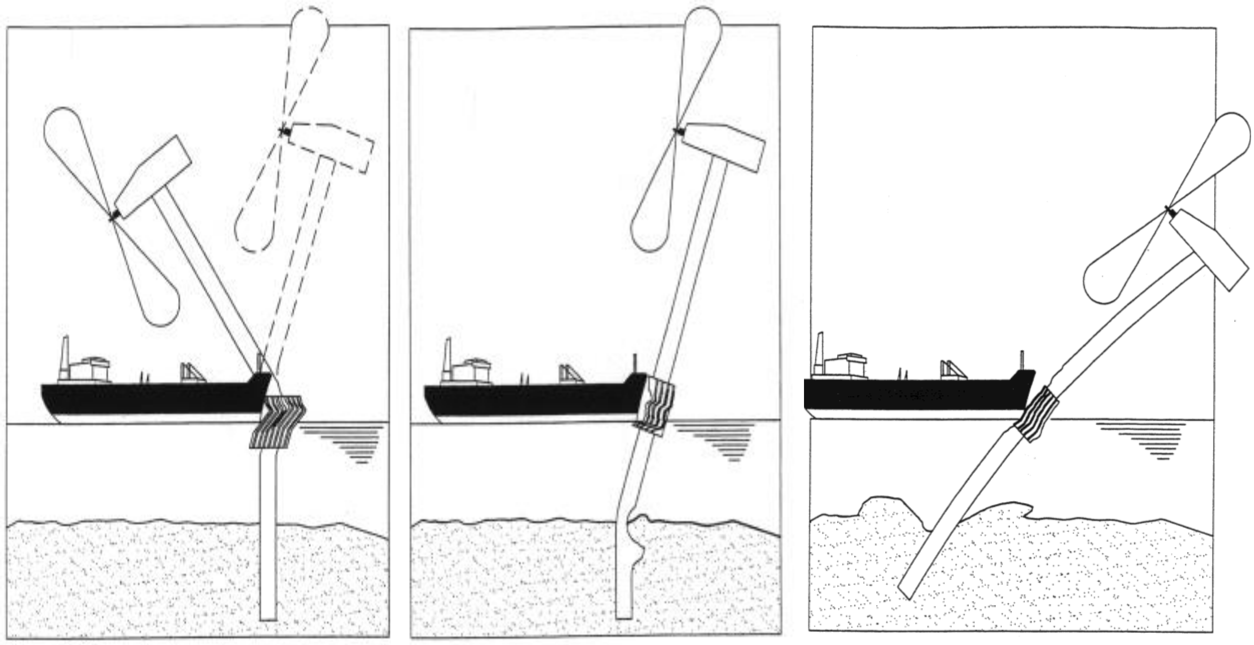

Figure 3-2 Figures of the different collapse shapes, left concerns buckling, middle and right concerns hinging

Which of these two failure modes occurs can only be determined on the basis of a dynamic calculation. Based on their research, experts have estimated the frequency of occurrence for the different failure modes. Where the effects cannot yet be estimated, a conservative viewpoint has been adopted. For example, the mast with nacelle may fall off or onto the ship. What happens in reality depends on many construction values and environmental factors. For the calculations performed now, it is assumed that the mast with nacelle always falls onto the vessel in case of buckling.

Table 3-1 summarises various failure modes due to drifting and powered collision of a wind turbine (< 5MW) by various vessel size. The table also indicates the expected damage to the vessel. This consequential damage table is also used in [Ref 5.] The indicated 'proportion' refers to the probability of a failure mode. The upper part of Table 3-1 applies when the turbine buckles. Small vessels do not have enough mass to buckle the turbine. At propulsion, the energy is insufficient to buckle the turbine.

In frontal and frontal/lateral (shear) collisions, although serious damage will occur to the bow of the ship, no serious damage ("None" in Table 3-1) will occur in the cargo section of the ship. The structure of the ship in front of the collision bulkhead (forepeak bulkhead) is very stiff so damage will be limited to the part of the ship in front of the collision bulkhead where leaking will not result in outflow because there is no cargo or fuel in this part of the ship. Upon impact, the ship's very stiff and flared foredeck will absorb the energy without much damage. However, damage may occur to the deck, in case the mast and/or nacelle falls onto the deck.

Table 3-1 Failure modes with the estimated rates of occurrence and the estimate of the resulting damage to a turbine (< 5MW) and ship.

Failure modes	Ship size (GT)	**Collision (ramming)**						**Collision (drifting)**					
		Frontal (10%)			Shearing (90%)			Lateral midships (100%)			Lateral eccentric (0%)		
		Portion	Damage		Share	Damage		Portion	Damage		Portion	Damage	
			Turbine	Ship		Turbine	Ship		Tur-bine	Ship		Tur-bine	Ship
Buckling	<500	0%	No	None	0%	No	None						
	500-1000	0%	Yes	None	0%	No	None						
	1000-1600	5%	NosMos[1]	Deck	0%	Yes	None						
	1600-10000	10%	NosMos	Deck	5%	NosMos	Deck						
	10000-30000	10%	NosMos	Deck	10%	NosMos	Deck						
	30000-60000	10%	NosMos	Deck	10%	NosMos	Deck						
	60000-100000	10%	NosMos	Deck	10%	NosMos	Deck						
	>100000	10%	NosMos	Deck	10%	NosMos	Deck						
Hinging	<500	100%	No	None	100%	No	None	100%	No	None	100%	No	None
	500-1000	100%	Yes	None	100%	No	None	100%	No	None	100%	No	None
	1000-1600	95%	Yes	None	100%	Yes	None	100%	No	Hull	100%	No	None
	1600-10000	90%	Yes	None	95%	Yes	None	100%	Yes	Hull	100%	No	None
	10000-30000	90%	Yes	None	90%	Yes	None	100%	Yes	Hull	100%	Yes	None
	30000-60000	90%	Yes	None	90%	Yes	None	100%	Yes	Hull	100%	Yes	None
	60000-100000	90%	Yes	None	90%	Yes	None	100%	Yes	Hull	100%	Yes	None
	>100000	90%	Yes	None	91%	Yes	None	100%	Yes	Hull	100%	Yes	None

3.4.2 Determination of personal injury

Personal injury is only to be expected for a collision when the nacelle with mast falls onto the vessel ("NosMos" in Table 3-1).

For these wind turbines, the frequencies of the different damage types were determined, from which the potentially occurring damage in terms of personal injury was determined. Here, a number of worst-case approximations were used.

Based on the number of collisions, the following calculations were made for each ship type and size.

- Number of collisions is multiplied by the corresponding probability of a given failure mode.
- Multiplying by the probability for that form of failure that the nacelle with mast falls onto the ship ("NosMos" in Table 3-1). Since the probability of the mast falling on or off the ship is unknown, a factor of 1 is used here, i.e. the worst-case scenario that the mast always falls on the ship.

[1] NosMos = Nacelle on Ship and Mast on Ship following plastic deformation

- Multiplying by the damage portion of the deck. This includes two worst-case approaches, namely;
  - The mast falls entirely on the ship. However, when impacting, the mast will often tilt diagonally across the deck
  - The area of the mast including the entire rotor blade is taken, i.e. as if the wind turbine falls intact onto the deck while rotating.
- Multiply by the probability of a person being on the damaged area. The probability of a person being anywhere on deck is estimated at 10%. In reality, this probability is much smaller, since almost only fishing vessels have crew on deck, but this group is almost not in the group of vessels that cause the mast to buckle. This 10% also includes those indirectly affected by deck damage extending to the spaces below where persons are present.
- Multiply by the number of people on board; after all, the probability is determined for each person individually.

Personal injury due to people falling from the impact itself has not been modelled, even for the small vessels that sail head-on against the protection of the mast where the vessel (recreational craft) is completely destroyed. For this category of vessels, the probability models are unreliable.

3.4.3 Comments on the modelling of consequential damages

The modelling and damage matrix described above in 3.4.1 and 3.4.2 reflect the modelling as used so far within environmental impact studies on shipping safety around wind farms in the Netherlands, such as Borssele and Hollandse Kust.

Within the study on the cumulative effects of all wind farms combined on shipping safety [Ref 11.], it was concluded that the studies on consequential damage conducted in 2005, no longer fully describe the current situation and that certain scenarios are underexposed due to scaling up of wind turbines and failure to assess effects on smaller ships. Specifically, this study included the following recommendation at the time:

"Damage model; Due to scaling up of wind turbines in combination with the drift characteristics of ships with very large wind catch such as ultra-large cruise and container ships, it is recommended that more research is conducted into the consequences of a collision of a ship with a wind turbine. Here, not only the damage to the wind turbine is important, but also the risk to crew and passengers, damage to the ship and possible environmental pollution."

Additional research into consequential damage in ship-turbine collisions are part of the Dutch program Marine Safety Monitoring and Research Program Wind at Sea (MOSWOZ). This program runs until 2029 and an initial study of consequential damage to a larger 10MW wind turbine has been completed [Ref 13.]. Start-up of follow-up research with larger wind turbines and model validation was planned for the middle of 2022. The first results are however not expected before the summer of 2023. Comments that can be made based on the 2020 study [Ref 13.] on the damage matrix used are:

- An observation from the study is that a Creepline Coaster (1550GT) both sailing and drifting only causes plastic deformation of the wind turbine and not buckling or articulation. The damage matrix used is therefore conservative in nature.
- A large drifting passenger ship or container ship (both >100000GT) could potentially lead to turbine damage with the nacelle falling onto the ship under certain conditions. Elimination of assumptions and a full 3D FE model is needed to draw conclusions here with more certainty and to avoid that these results are due to the limitations of FE modelling. The damage matrix used does not currently foresee that drifting large vessels could result in a nacelle falling on the vessel.

In this study of the effects on shipping safety as part of the EIA, it was chosen not to deviate from previous studies and to quantify the consequential damage with the same assumptions.

Damage to the turbine
It is expected that the larger 15MW wind turbine will require a stronger construction than the smaller (<5MW) wind turbines on which the damage matrix is based. Due to the stronger construction of the monopile, a larger vessel mass is required to cause damage to the wind turbine. Where in the damage matrix a drifting vessel of 1600GT could already cause damage, this limit shifts to a vessel with a larger GT. This is also confirmed by the study carried out by HVR engineering in 2020 [Ref 13.]. The damage matrix used is therefore conservative in nature for turbine damage.

Damage to the vessel
It is expected that the impact of the larger (>15MW) wind turbine could have greater consequences for the ship. The stronger, protruding structural components of wind turbines could puncture the weaker ship's hull. In drift situations where damage to the ship's hull is anticipated, damage is expected to increase. Depending on the type of ship and location of the impact, such drift collision could cause damage. Environmental damage due to fuel tank leakage or personal injury when crew and passenger cabins are located directly behind the ship's hull.

The assumption in most studies is that the wind turbine is not operational at the moment a ship approaches too closely. With the safety system present in the wind farms, the rotor can be stopped when a ship approaches too closely. Failure of this system is not included in the described quantification of consequential damage.

Personal injury
The starting point in this study and previous studies is that personal injury is only to be expected when the nacelle with mast falls on the ship ("NosMos" in Table 3-1). This does not take into account personal injuries that may occur when a vessel strikes a wind turbine at the level of crew or passenger quarters. This effect is also part of the recommendation for follow-up research on the impact of wind turbine collisions and drives.

It is expected that the larger (>15MW) wind turbine will require a stronger structure than the smaller (<5MW) wind turbines on which the damage matrix is based. Due to the stronger construction of the monopile, a larger vessel mass is required to inflict damage to the wind turbine. Where in the current damage matrix a sailing vessel of 1000GT can already cause a falling nacelle on the vessel, this limit shifts to a vessel with a larger GT. The damage matrix used is thus conservative in nature for personal injury due to the falling nacelle.

3.5 Effects on shipping due to change in route structure and cumulative effects

For this study the three wind farms are considered as a whole and no staged development is considered due to the fast construction planning between 2028 and 2030. The transformer platform or ‘MOG II’ is not separately considered in this study but as part of the whole PEZ.

The AIS data is gathered after the realisation of the ‘Eastern Zone’ wind farms. As these wind farms are already operational the effects of these areas on shipping is embedded in the data.

As the wind farms will be closed to shipping traffic, a "prohibited" area will be created for all shipping except repair/maintenance vessels. This will require some vessels to follow a different route than before the construction of the wind farm. This could change the traffic pattern around the wind farm, resulting in a possible change in shipping safety and an increase of CO2 emissions.

The development of offshore windfarms will also have an effect on the visibility of shipping on intersecting courses. The effects on sight lines of offshore wind farm on intersecting traffic have been subject to a separate study on a randomly modelled wind farm in a simulator environment.

4 TRAFFIC ANALYSIS AND MODELING

To get a picture of the exact traffic flows through and around the wind energy area PEZ and how these flows may change due to the construction of wind farms in the lots, an analysis of AIS data was performed. The results of the traffic analysis are shown and described in section 4.1. Section 4.2 describes how route bound traffic is modelled for the current and future situation and section 4.3 shows the traffic database of non-route bound traffic in and around the PEZ wind farms.

4.1 AIS analysis traffic flows

Based on AIS data, shipping traffic can be visualised as density on a map in the area of the PEZ wind farm. By differentiating between different ship types the data shows the diverse utilisation of the area and therefore provides an overview of the expected shipping traffic situation. The overall picture of all shipping traffic in 2021 based on AIS data in the area of the PEZ wind farm can be seen in Figure 4-1. This traffic density map shows that the majority of shipping is already routed around the planned wind farm within the designated traffic separation schemes. A special point of interest will be the anchor area on the south-east side of the PEZ as anchor areas involve a continuous movement of arriving and departing ships, manoeuvring and other operational activities.

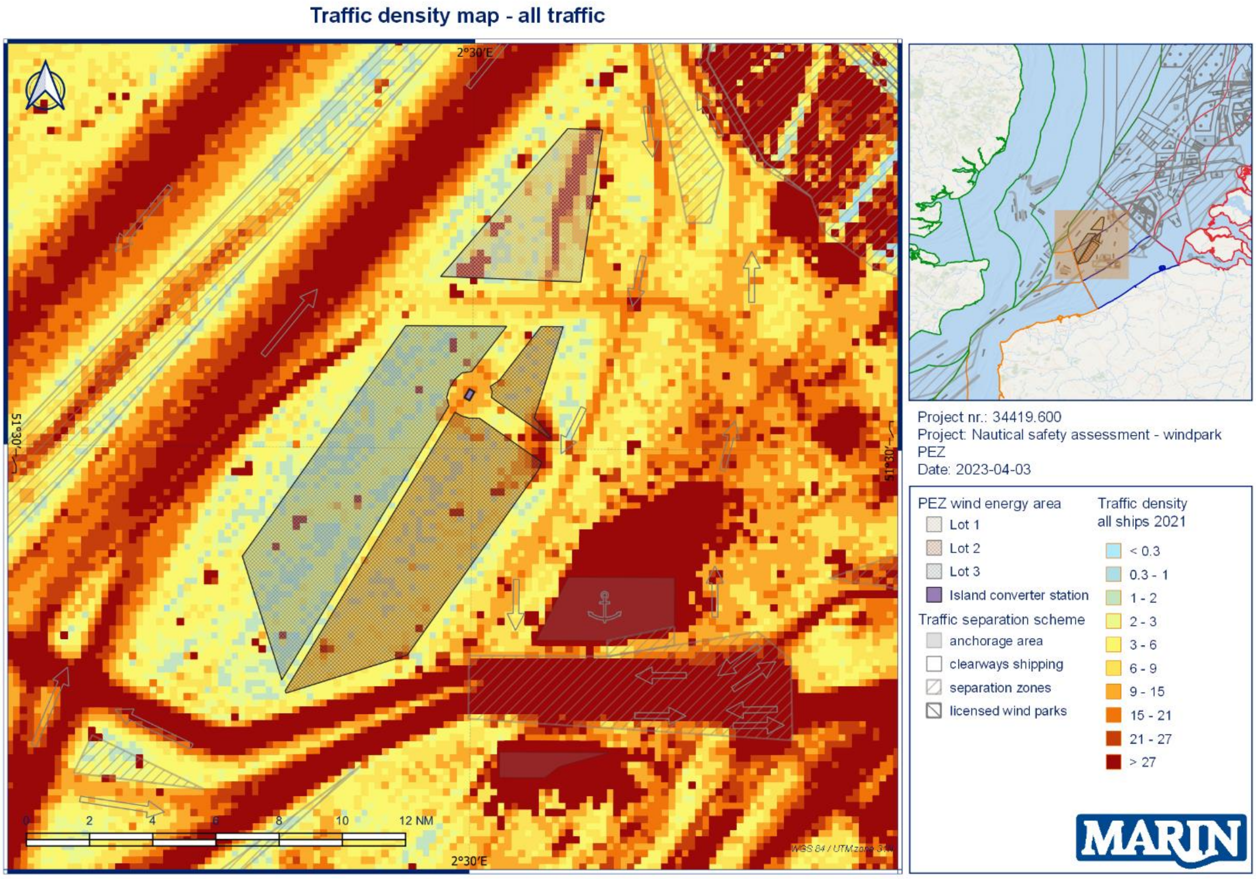

Figure 4-1 Traffic density map of all traffic (based on AIS data of 2021)

In Figure 4-2 only the route bound traffic has been visualised to distinguish between ships sailing between ports and ships with a purpose at sea such as fishing vessels and crew transfer vessels to support offshore wind farms. Within the route bound shipping various ship types can be distinguished as can be seen in Figure 4-3 to Figure 4-6 where respectively Container ships, Passenger ships, Oil and Chemical tankers are shown as density. One remark on the Passenger and Ferry vessels is that most crew transfer vessels are marked as passenger ships and are in fact non-route bound vessels. This can be seen in Figure 4-4 where a high density shipping is visualised within the existing wind farms at the north-east part of the Belgium EEZ.

Route-bound traffic density map

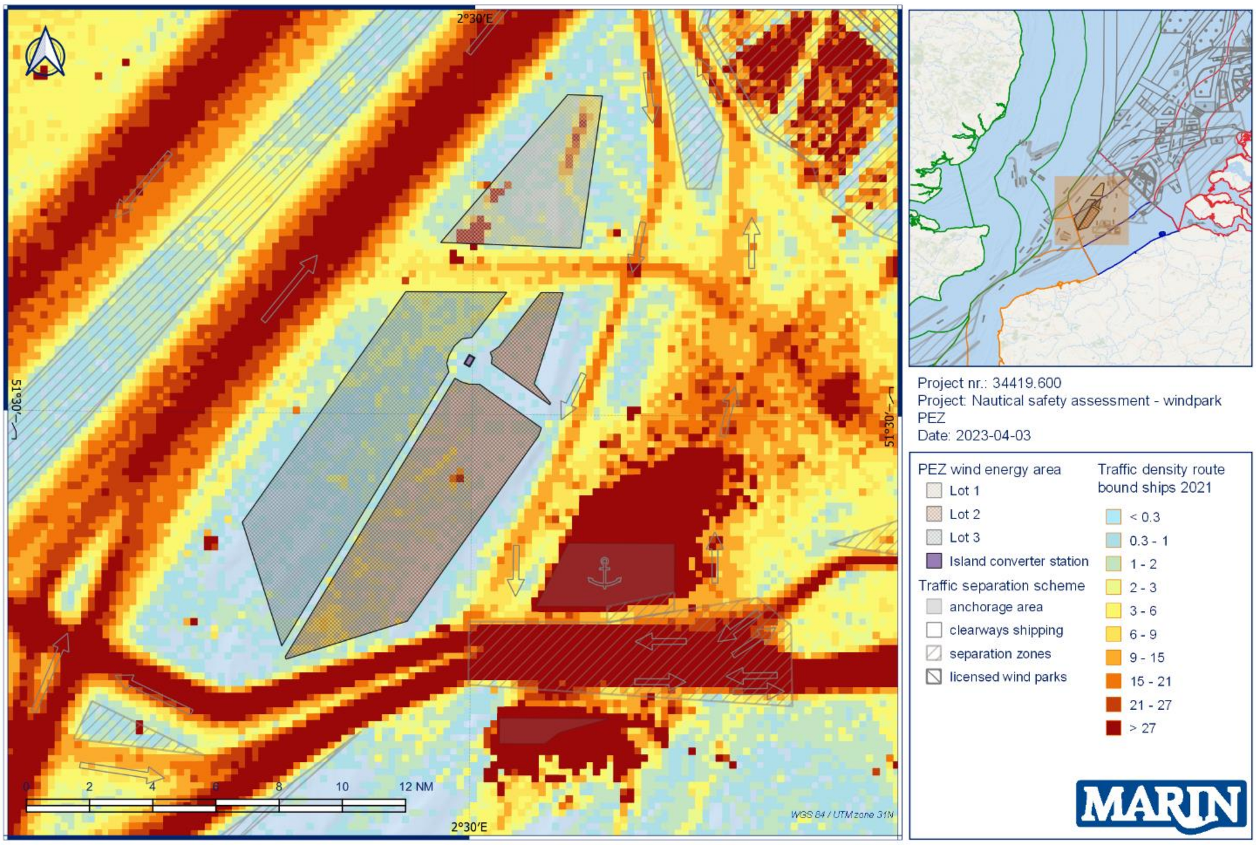

Figure 4-2 Traffic density map of Route-bound traffic (based on AIS data of 2021)

Container transport traffic density map

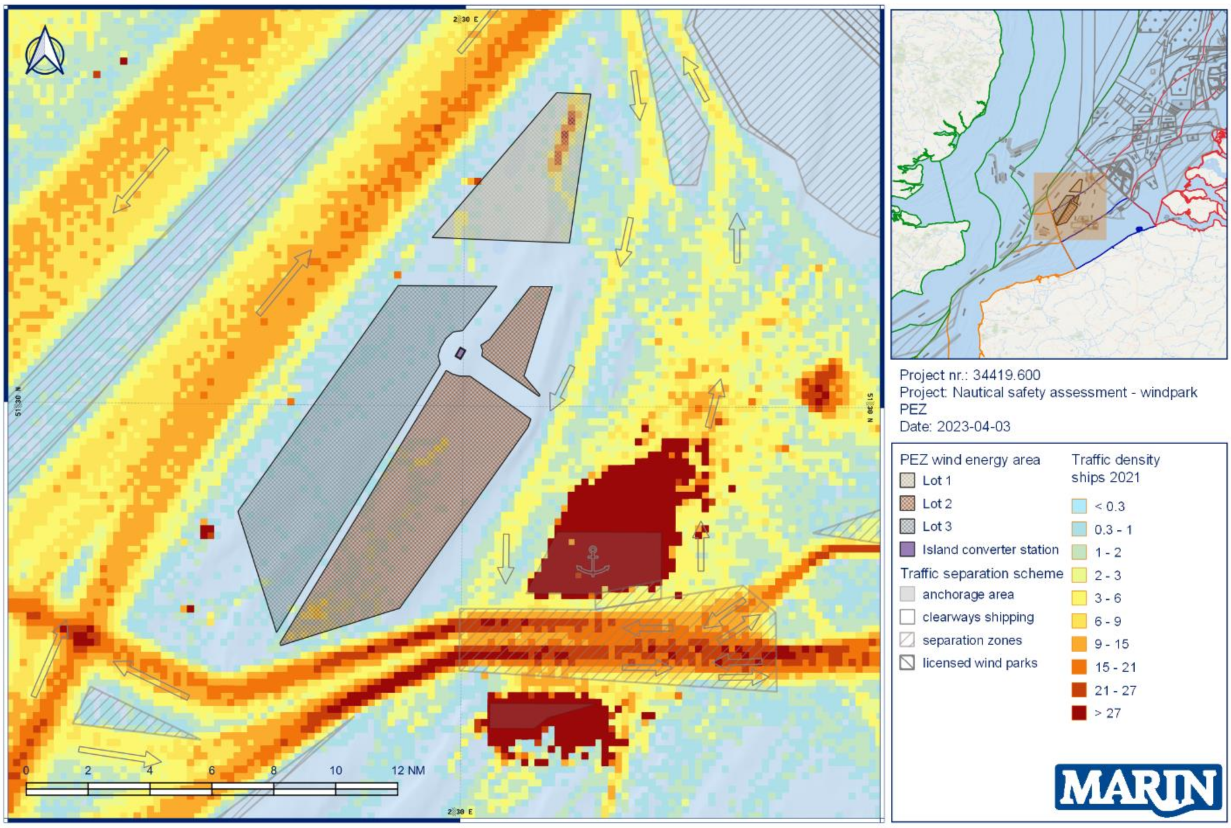

Figure 4-3 Traffic density map of Container vessels (based on AIS data of 2021)

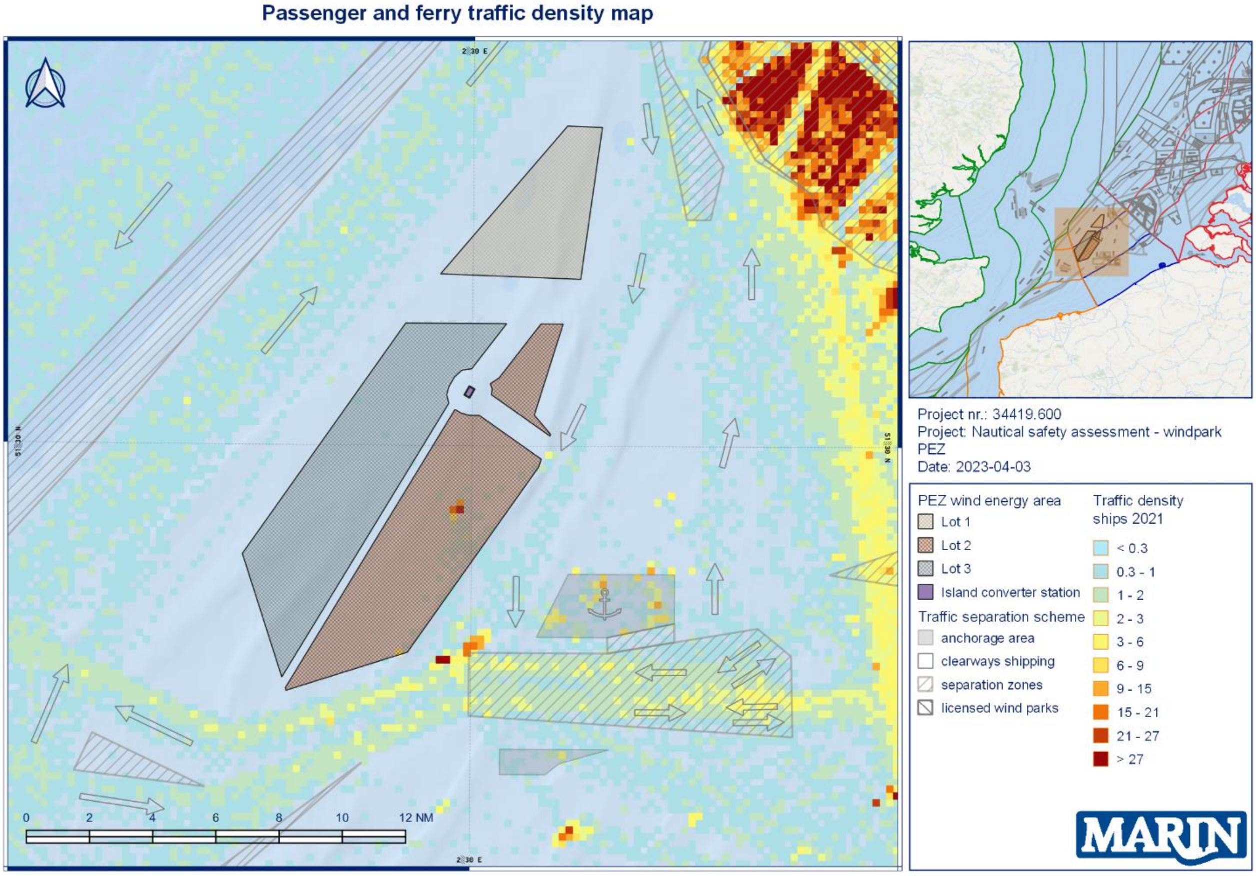

Figure 4-4 Traffic density map of Passenger and Ferry vessels (based on AIS data of 2021)

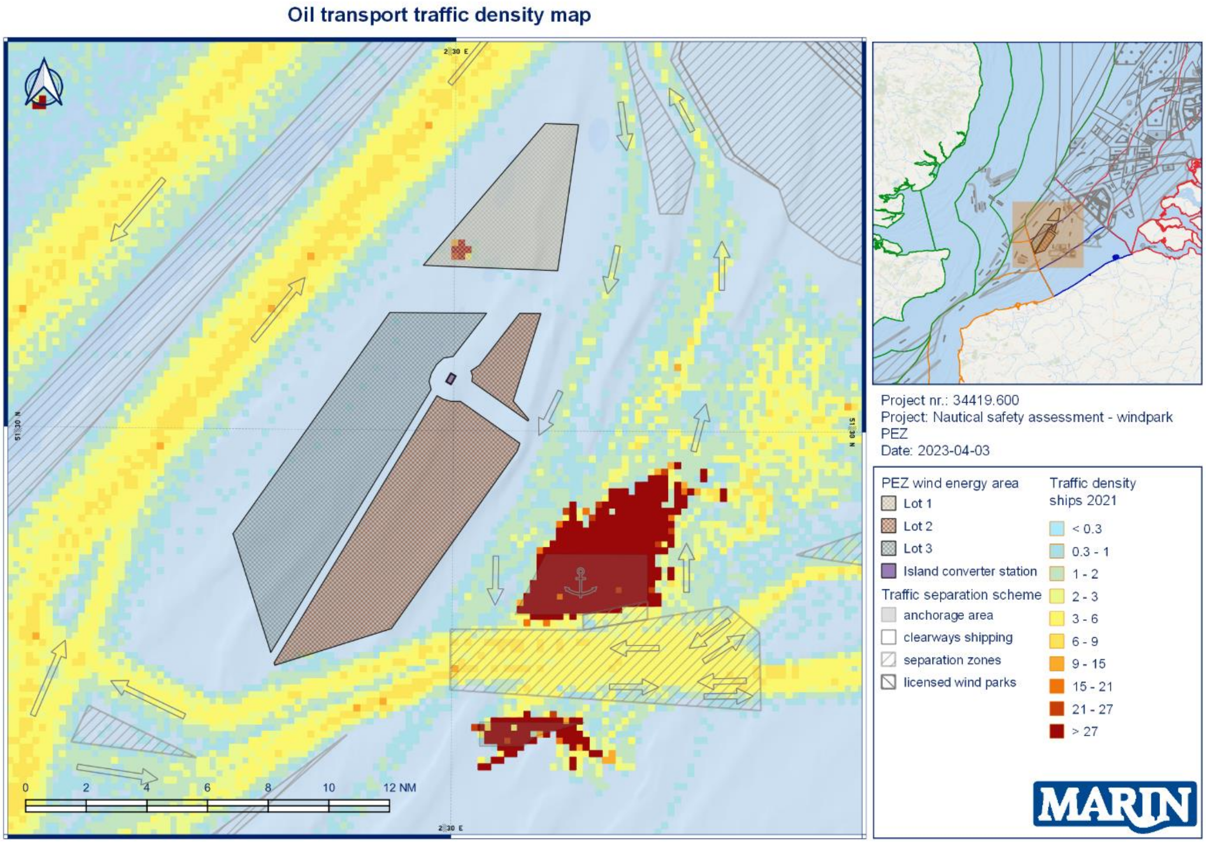

Figure 4-5 Traffic density map of Oil carrying vessels (based on AIS data of 2021)

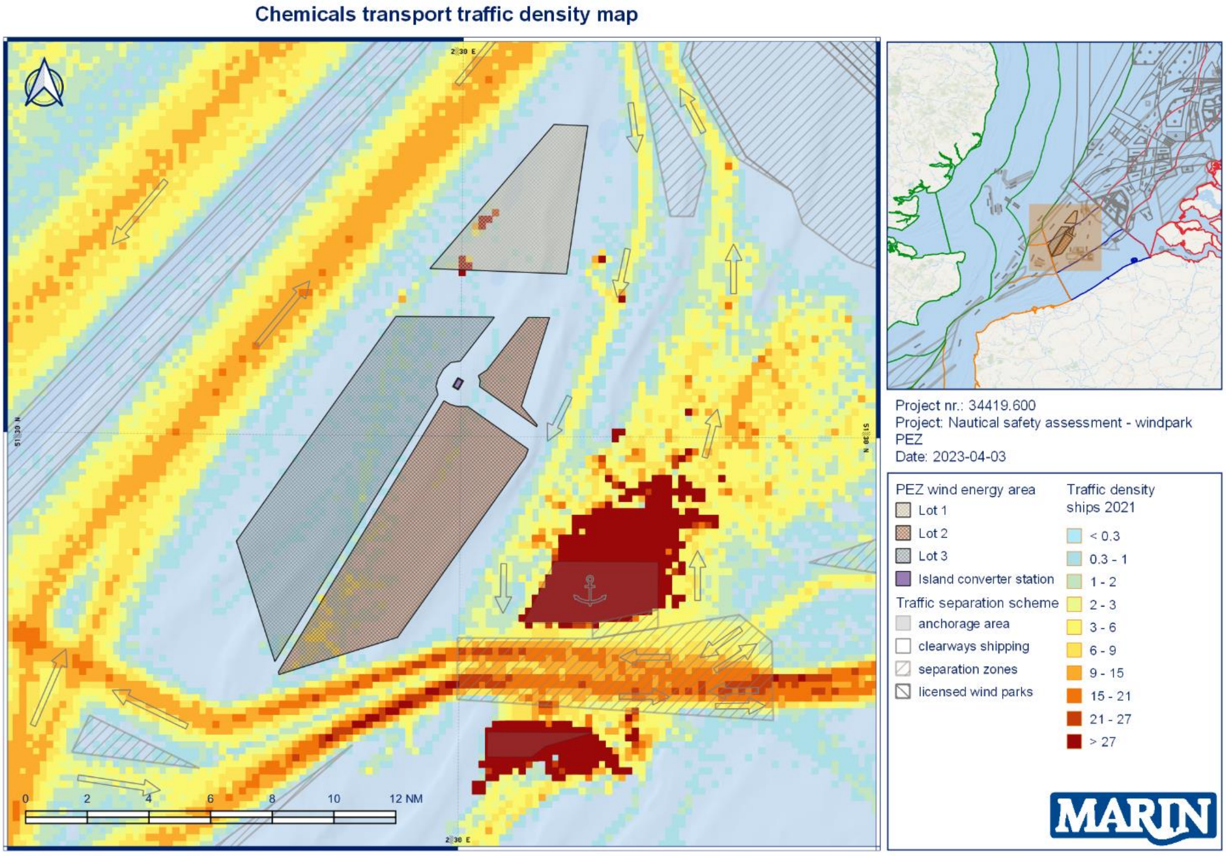

Figure 4-6 Traffic density map of Bulk Chemical vessels (based on AIS data of 2021)

Non-route bound shipping as a group is shown in Figure 4-7 and roughly consists of the categories: Fishing (Figure 4-8), Work vessels (Figure 4-9) and Recreational (Figure 4-10) shipping traffic. Fishing is an activity that takes place wherever there is opportunity which is clearly visible on Figure 4-8. If the wind farm will be closed for other shipping activities and therefore not accessible for Fishing vessels, it can be expected that these activities will move to other areas and therefore increase Fishing traffic density around the wind farm.

Work vessel activities will however increase when the new wind farm is constructed. This can be seen in Figure 4-9 where the traffic density of this category is relatively high within the other wind farms in the Belgium EEZ. Other activities that can be seen in this picture is the Pilot services (Loodskruispost Wandelaar) on the south-east side of the anchorage.

Finally in Figure 4-10 the recreational traffic can be seen. This is not a significant part of the non-route bound traffic as the PEZ is located at a considerable distance from shore where most recreational shipping take place.

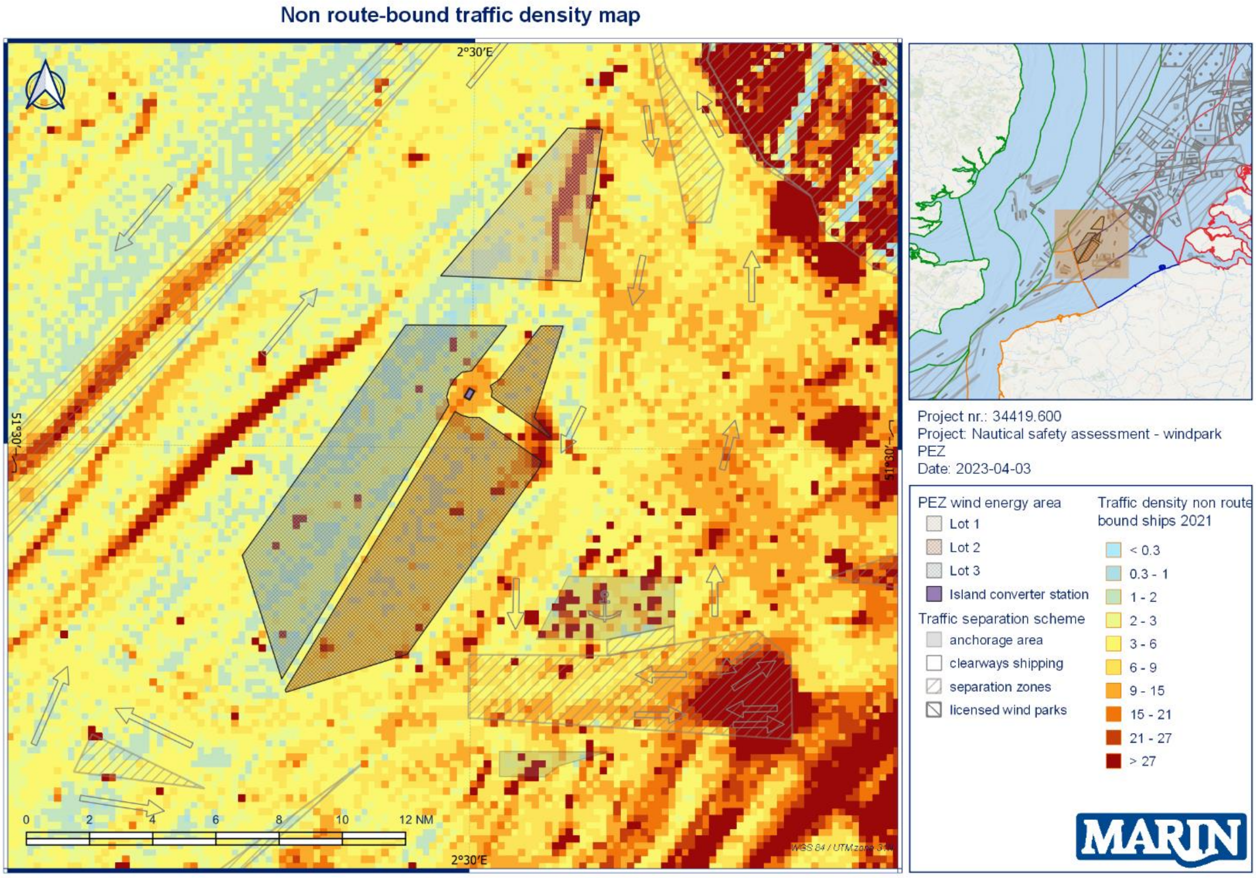

Figure 4-7 Traffic density map of Non route-bound traffic (based on AIS data of 2021)

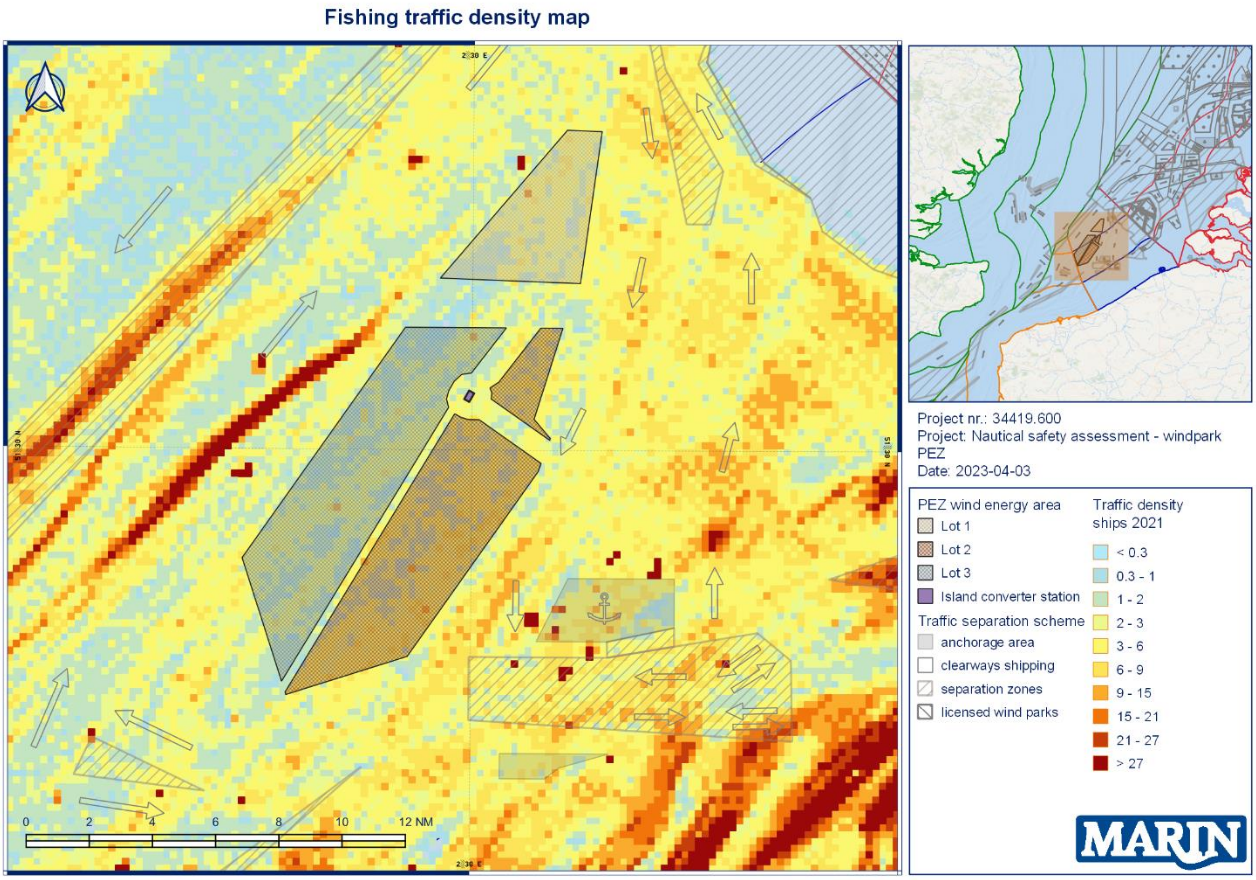

Figure 4-8 Traffic density map of Fishing vessels (based on AIS data of 2021)

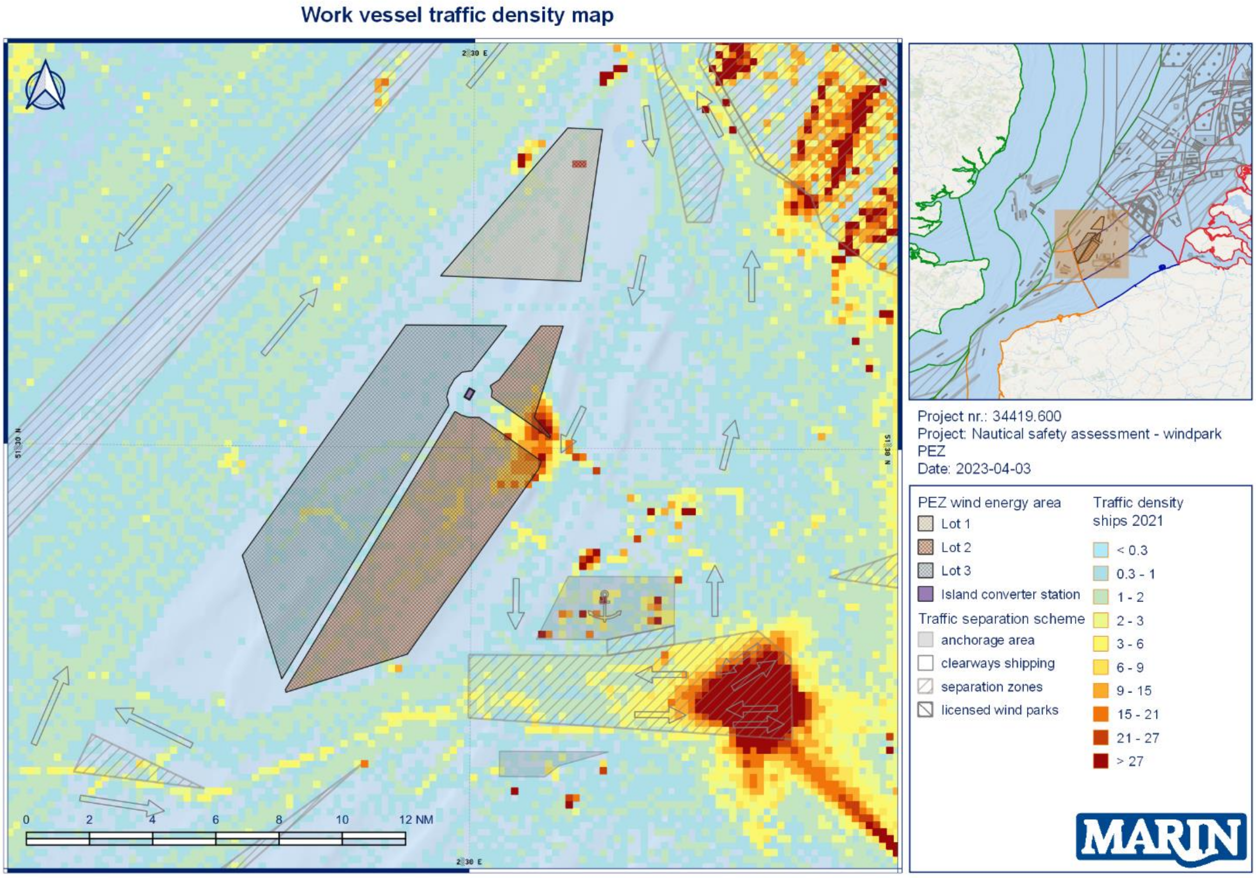

Figure 4-9 Traffic density map of Work vessels (based AIS data of 2021)

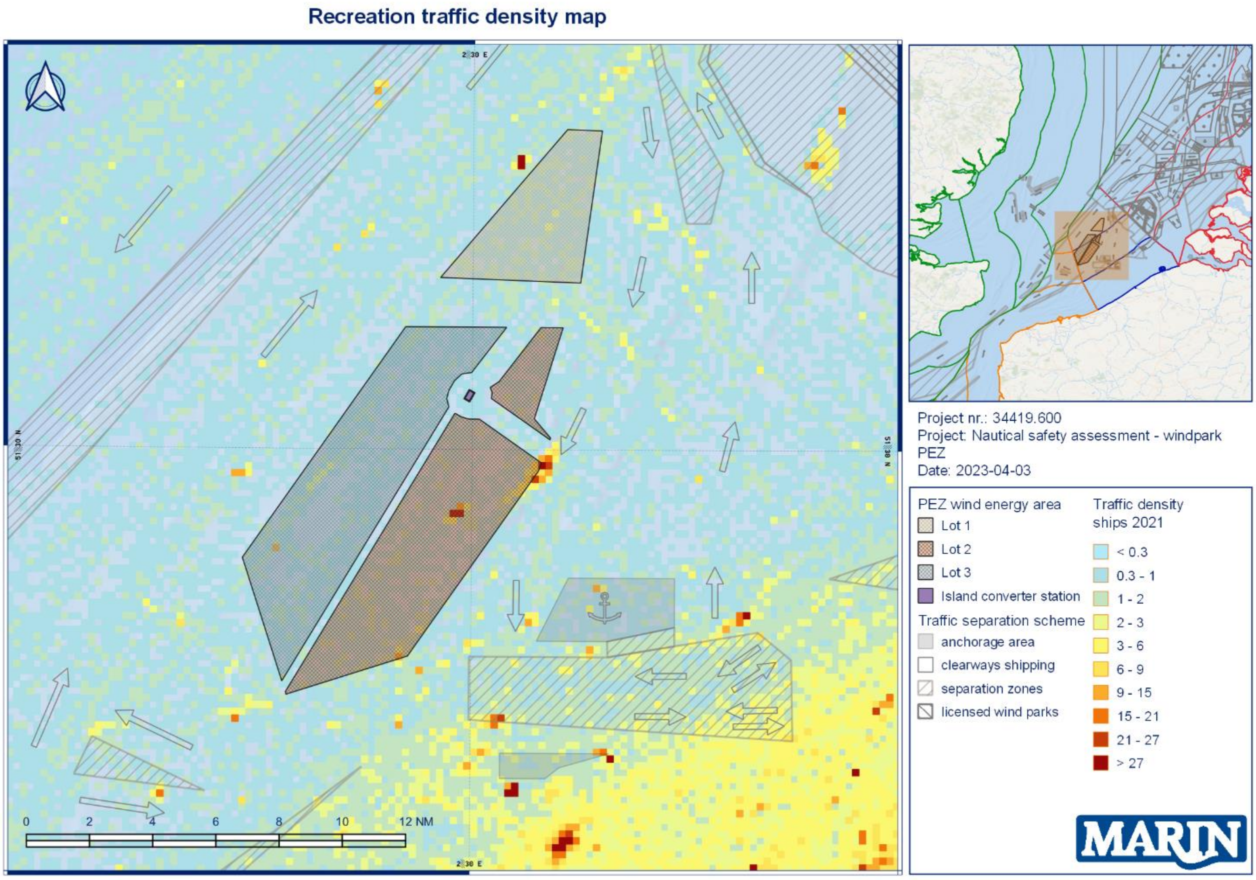

Figure 4-10 Traffic density map of Recreational traffic (based on AIS data on 2021)

4.2 Route-specific traffic database

To calculate the effects of wind farms' presence, a database is made of the shipping traffic in the current situation. Because the PEZ wind farm is positioned in between the current traffic routes a shift in ships routing is not expected. Figure 4-11 shows the traffic modelling for route-based traffic for this situation. The figure shows the existing routes with an indication of the number of ships on each route in the year 2021.

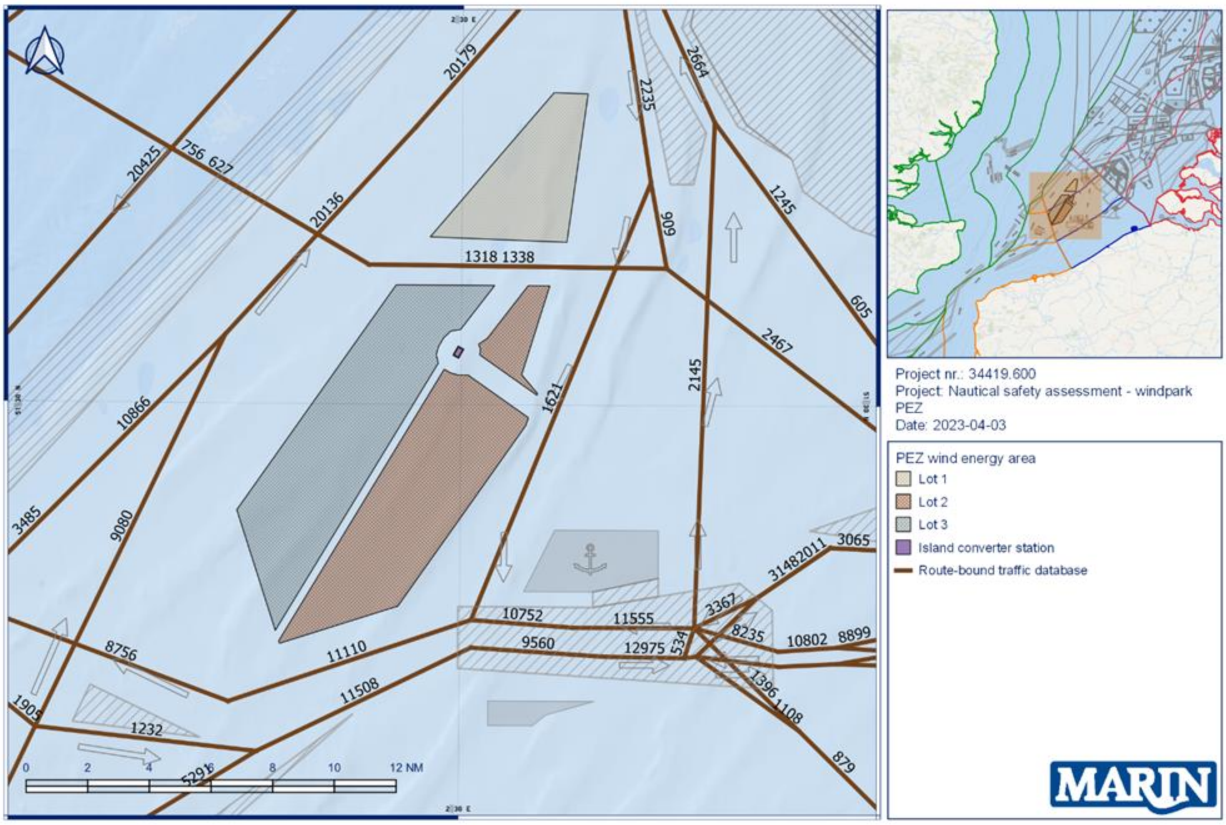

Figure 4-11 Route-bound traffic database (based on AIS data of 2021)

4.3 Non-route bound traffic database

As non-route bound shipping cannot be modelled as route lines, the traffic database for non-route bound traffic is made of traffic density cells instead. Figure 4-12 shows the initial situation in 2021. The image shows the shipping density within blocks of 4 x 4 km.

This study assumes the scenario in which the PEZ will be closed to traffic except for shipping bound for the wind farms (Work and Crew vessels). The initial traffic routing for this scenario is therefore shifted out of the wind farm area into the surroundings. This model is shown in Figure 4-13, which shows no traffic flow through the wind energy area. This situation is however only indicative for the initial non-route bound traffic as new traffic for the support of the wind farm has not been taken into account in the quantitative assessment.

In the EIR it is estimated that PE I, II, and III will have approximately 255 visiting ships each, per year during the operational phase of the wind farms. These activities will have an effect on the collision probability inside the wind farms. As mentioned in section 3.3.1.2 however this cannot be quantified using the SAMSON model as the wind farm bound traffic operational behaviour is considered different than other non-route bound traffic and ships bound for an operational activity in a wind farm are equipped and prepared for operations in the area. There will be an increased risk of incidents with ships and wind turbines due to these activities, but the risk profile is different from other traffic.

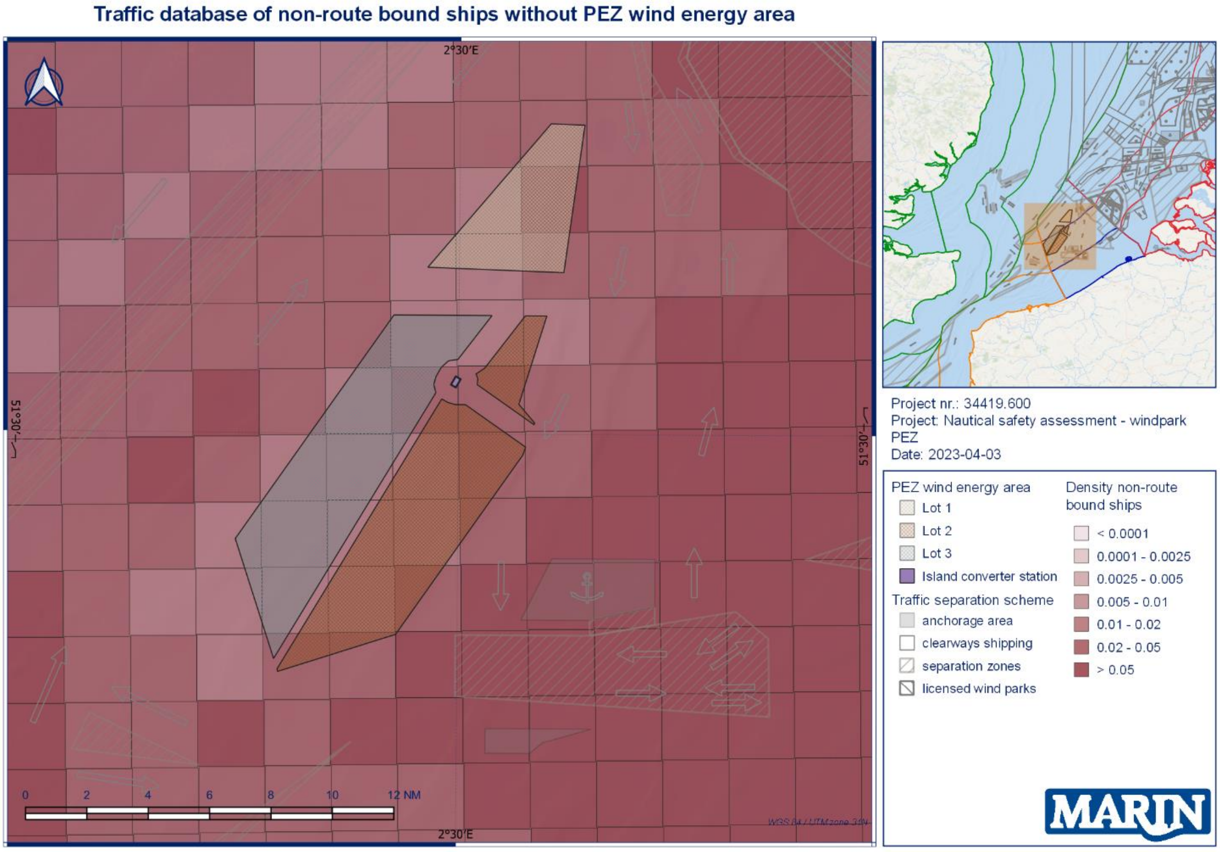

Figure 4-12 Non-route bound traffic database without PEZ (based on AIS data of 2021)

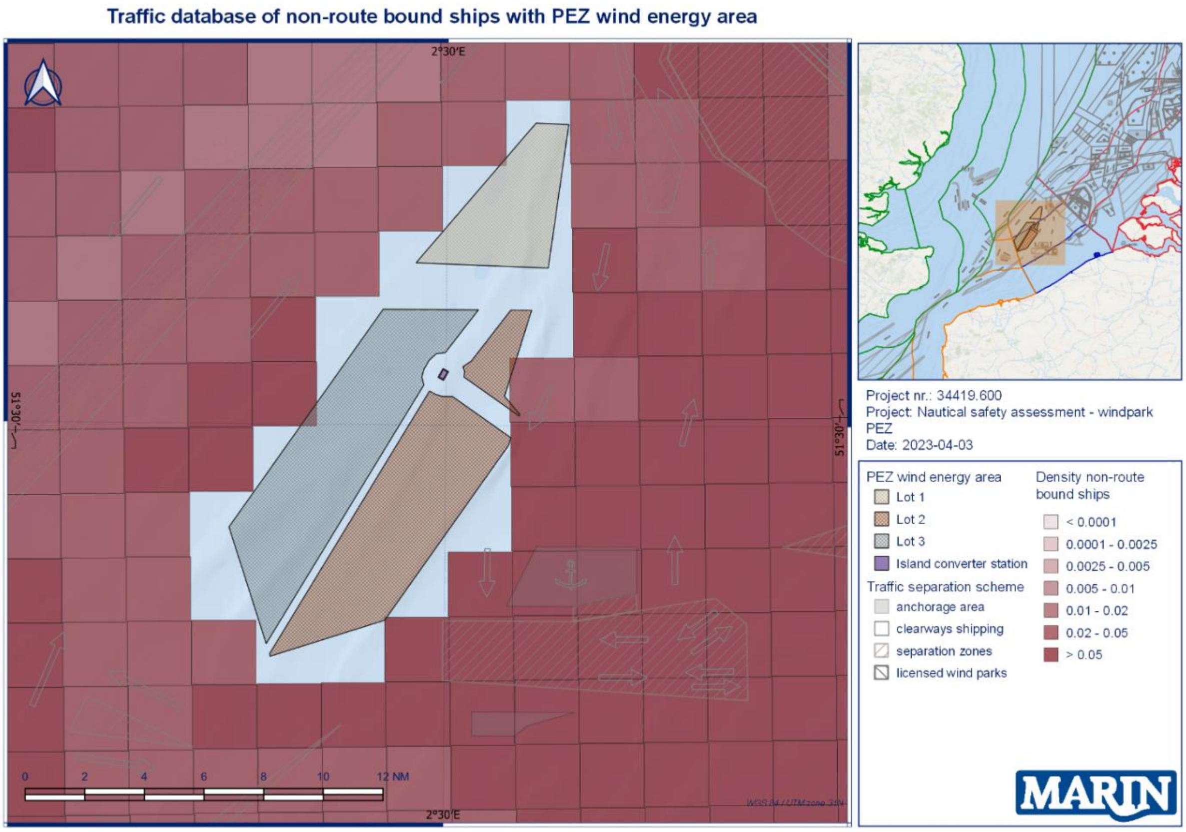

Figure 4-13 Non-route bound traffic database with future PEZ (based on AIS data of 2021)

5 RESULTS

In this section, the configuration of the wind farm scenarios are described first, followed by the collision frequencies and the consequent damage and other effects of the development. Detailed results are given in APPENDIX 1 for scenario 1 and APPENDIX 2 for scenario 2.
Route-bound vessels are abbreviated in the tables as "R-ships" and non-route-bound vessels are referred as "N-ships".

5.1 Configuration

In this study, two configurations were calculated for the PEZ where the total wind farm capacity is approximately 3336 MW for scenario 1 and 3520 MW for scenario 2. A configuration with a larger number (257) of wind turbines with less power, placed on a jacket foundation (90%) and on gravity based structures (10%) (referred to further in this report as scenario 1), and a configuration with a smaller number (160) of wind turbines with more power, placed on monopiles (referred to as scenario 2) were chosen. These two configurations together give a good indication of the range of turbine collision probabilities as scenario 1 has more turbines, but the turbines in scenario 2 have a larger foundation.

The data used per lot (PE I to III) and configuration (scenario 1 and 2) are given in Table 5-1. The turbine positions are shown in detail in Figure 5-1 and Figure 5-2 together with the route bound shipping database. The configurations as shown visualise some empty area's. The most sensitive gravel beds are located within these areas hence no wind turbines will be placed there.

Table 5-1 Configuration of data variants wind energy area PEZ turbine foundation

	Turbines			Foundation	
Variant	Amount	Power	Rotor diameter	Type	Diameter at seabed
Scenario 1					
PE I (1)	54	12/13 MW	220 m	90% jacket / 10% GBF	9 m
PE II (1)	107	12/13 MW	220 m	90% jacket / 10% GBF	9 m
PE III (1)	117	12/13 MW	220 m	90% jacket / 10% GBF	9 m
Scenario 2					
PE I (2)	32	22 MW	300 m	Monopile	15 m
PE II (2)	64	22 MW	300 m	Monopile	15 m
PE III (2)	64	22 MW	300 m	Monopile	15 m

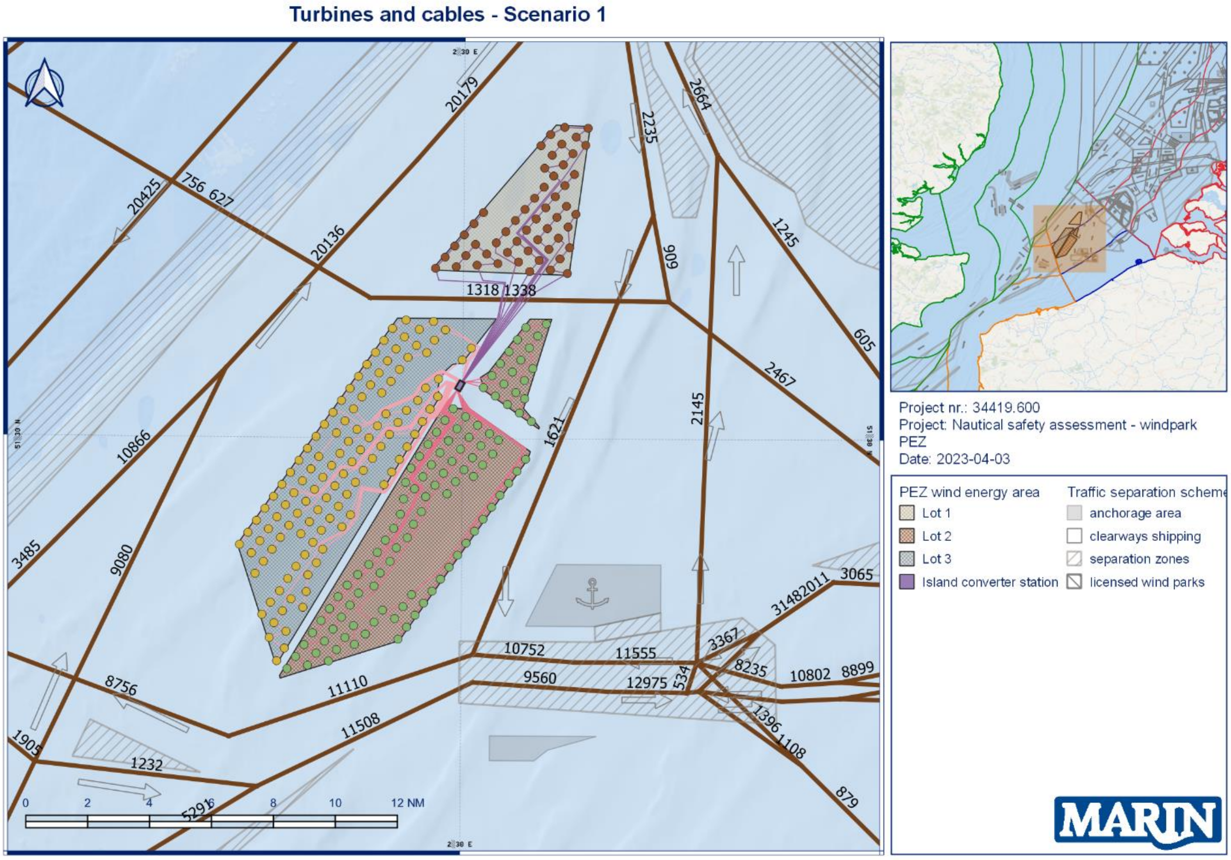

Figure 5-1 Turbines and cables configuration Scenario 1

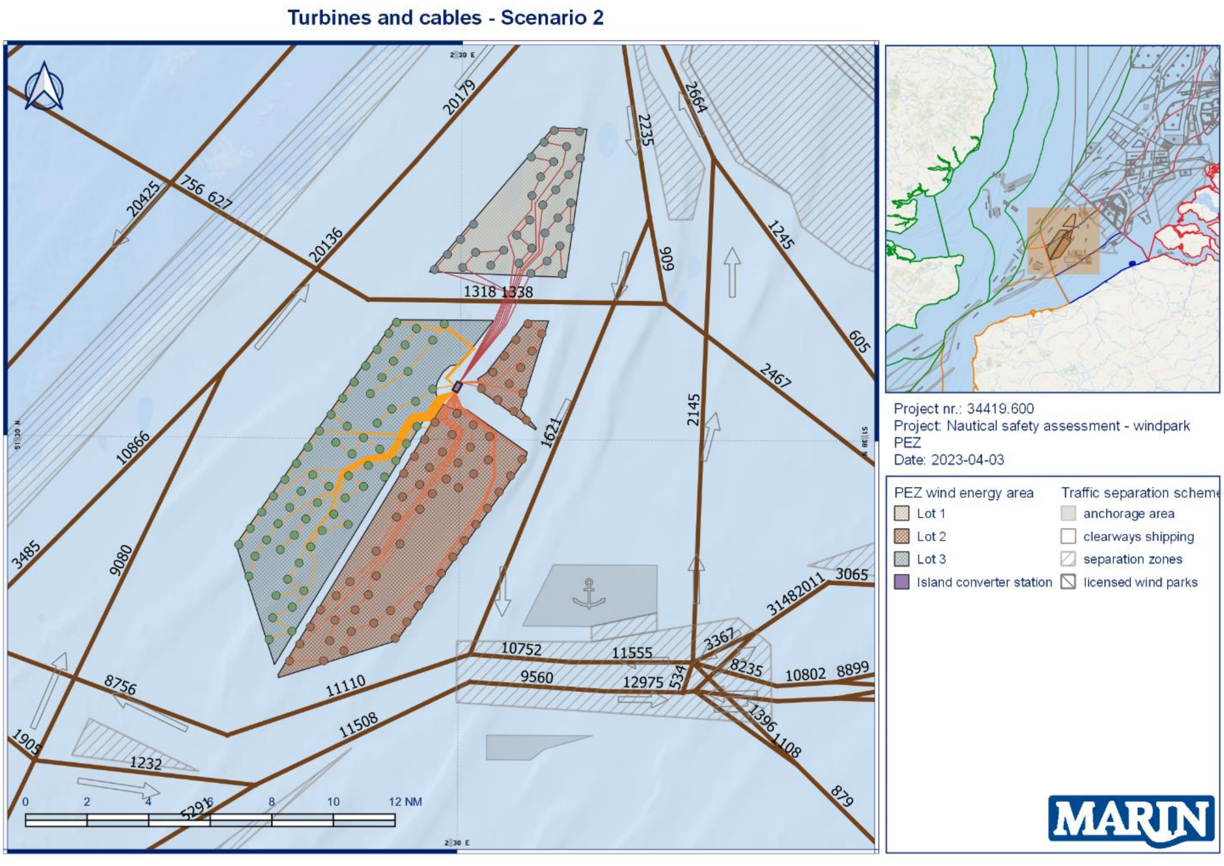

Figure 5-2 Turbines and cables configuration Scenario 2

5.2 Collision frequencies wind energy area

The presence of a wind farm creates a new type of risk at that offshore location, namely the probability of a vessel colliding (ramming or drifting) with one of the wind turbines. The frequencies for these accidents were determined using the SAMSON model. The results of this calculation are given in terms of the number of possible collisions per year for each wind turbine individually and for the entire wind farm. The modelling takes into account the possibility of a single vessel hitting several turbines.

Table A1-1 of APPENDIX 1 and Table A2-1 of APPENDIX 2 show the collision frequencies per wind turbine by all vessels for each scenario.

Figure 5-3 graphically shows the individual collision frequencies for all turbines in scenario 1. The numbers next to the turbines refer to the turbine numbering. The tables and the various figures show that the wind turbines on the north/north-western side, the southern corner and south-east side of the plot have relatively the highest collision frequencies. This is largely caused by the busy Traffic Separation Scheme (TSS) traffic route on all sides of the site combined with the traffic coming from the north on the east side towards the pilot station Wandelaar.

Figure 5-4 and Figure 5-5 present the probability for drifting and powered collisions, respectively, for each turbine. It can be seen that the probability of drifting is particularly linked to traffic on the busy TSS traffic. The drifting probability is more equally divided over the area because drifting vessels can continue drifting through the area and cause a risk for more objects. For a powered collision, the turbines along the south-east side also have a relatively higher probability compared to the turbines not directly adjacent to a waterway.

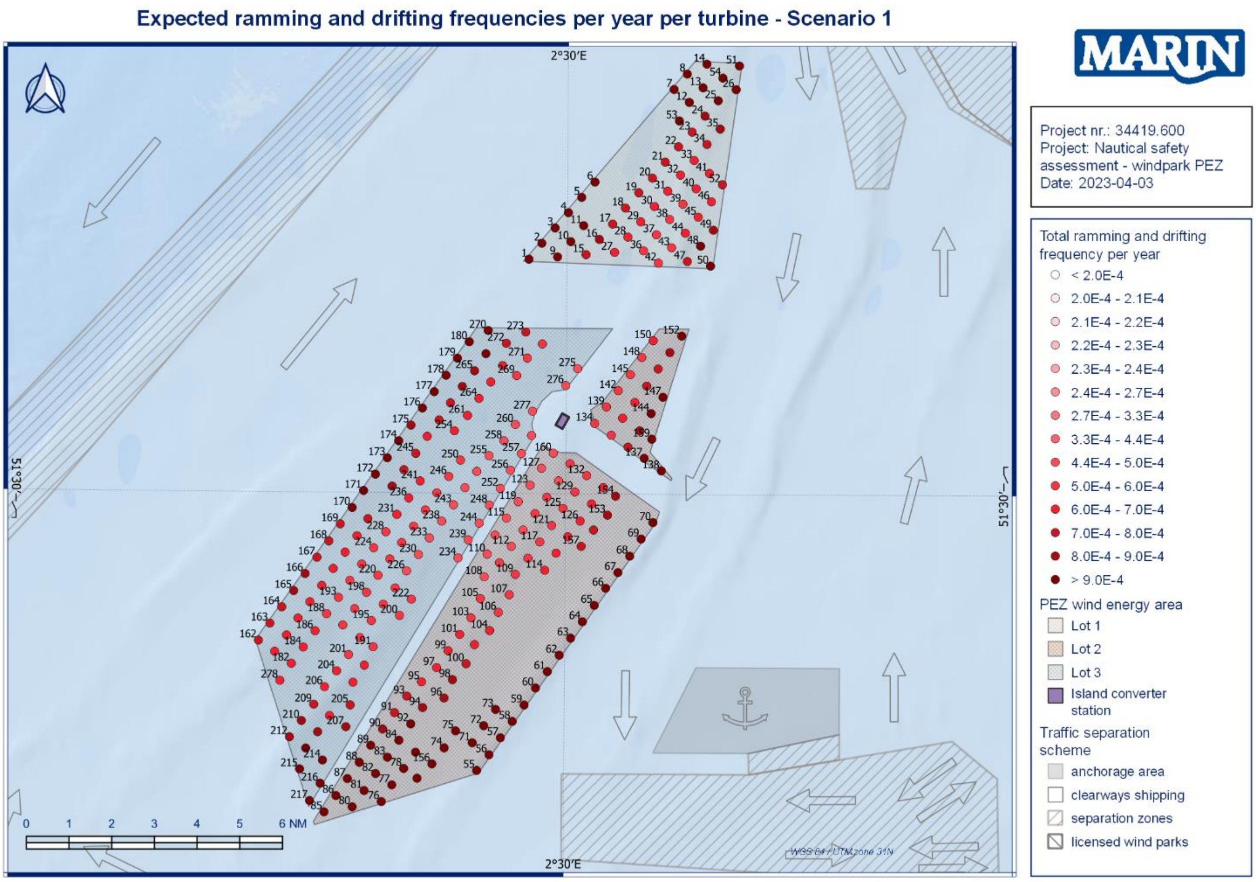

Figure 5-3 Expected combined collision frequencies per turbine per year - Scenario 1

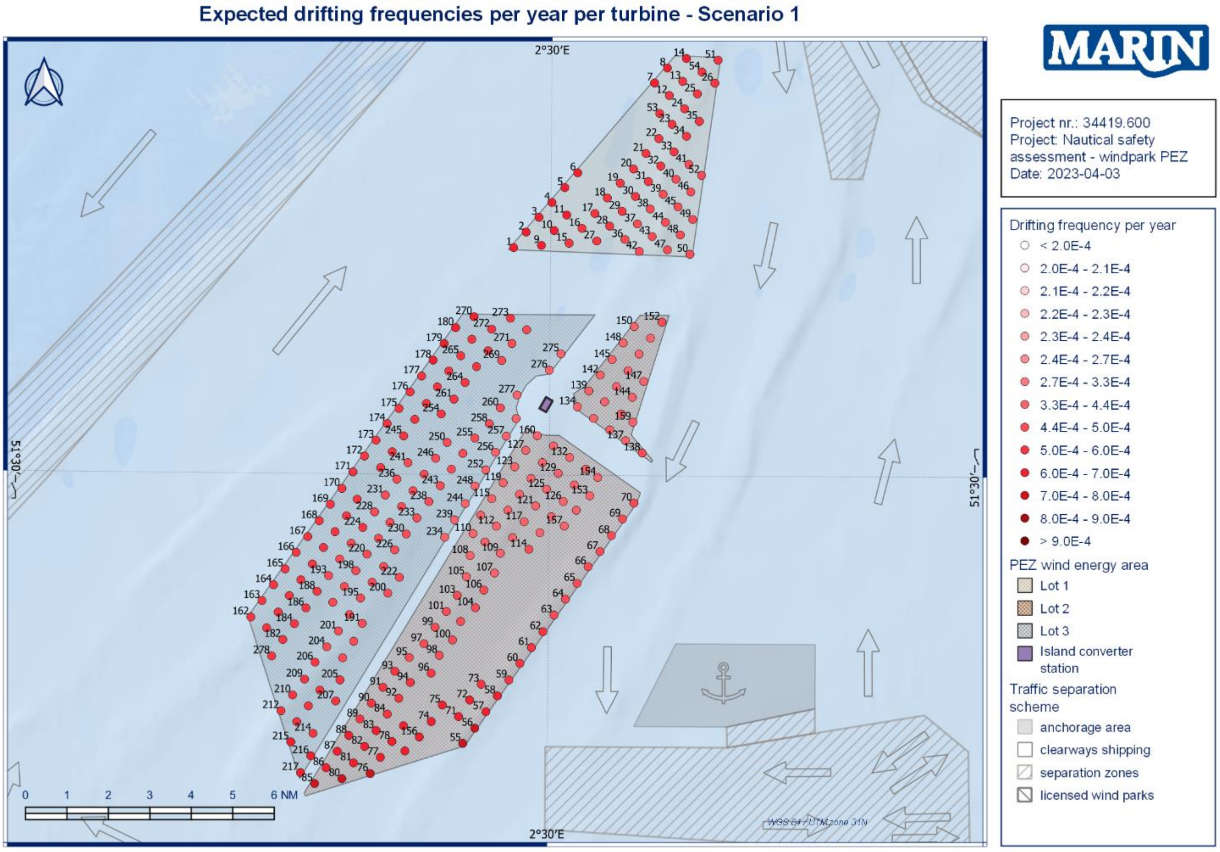

Figure 5-4 Expected collision frequencies (drifting) per turbine per year - Scenario 1

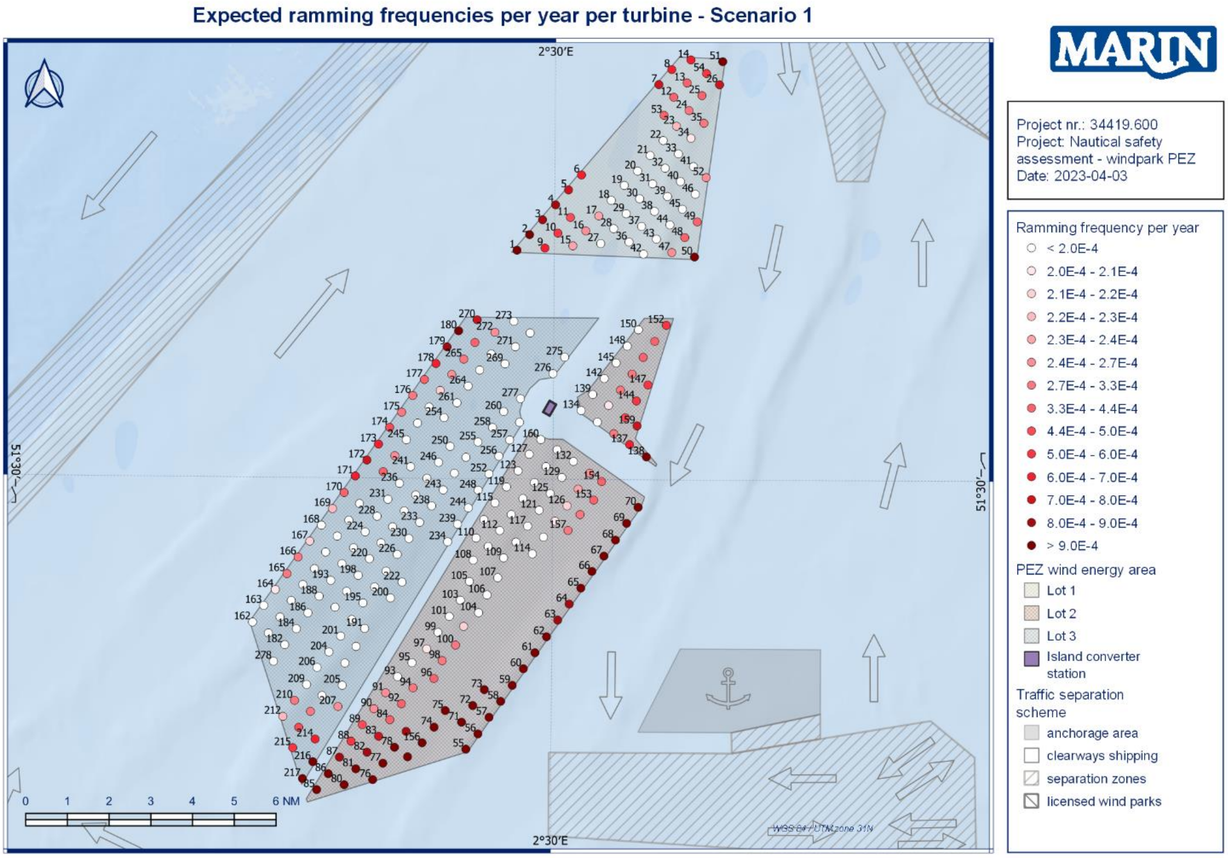

Figure 5-5 Expected collision frequencies (ramming) per turbine per year - Scenario 1

Figure 5-6 graphically shows the individual collision frequencies for all turbines in scenario 2. The figure show that the wind turbines on the north-western side, southern corner and south-east side of the plot have relatively the highest collision frequencies. Similar to scenario 1, this is largely caused by the busy TSS traffic routes.

Figure 5-7 and Figure 5-8 present the probability for collision by drifting and ramming, respectively, for each turbine. It can be seen that the probability of drifting is particularly linked to traffic on the busy TSS traffic on either side of the park. For collision by ramming, the turbines along the south-east side have a relatively higher probability compared to the turbines not directly adjacent to a waterway.

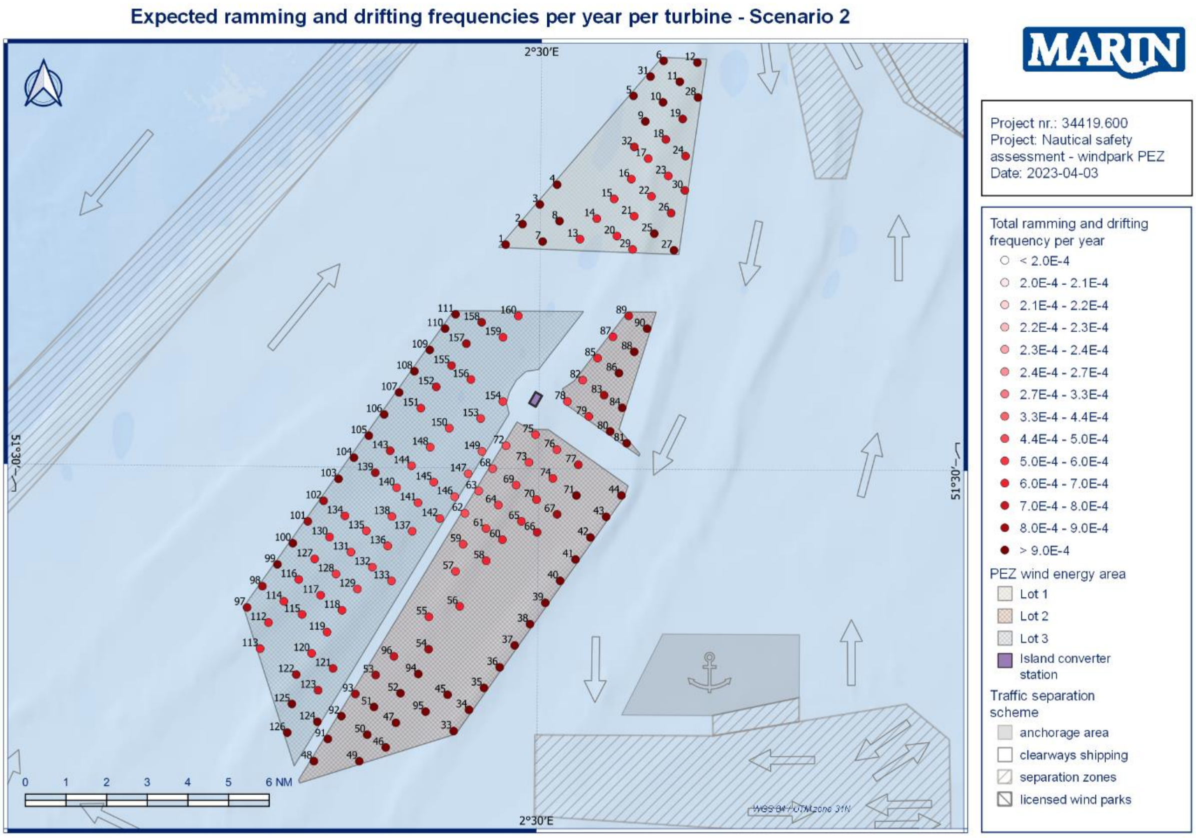

Figure 5-6 Expected combined collision frequencies per turbine per year - Scenario 2

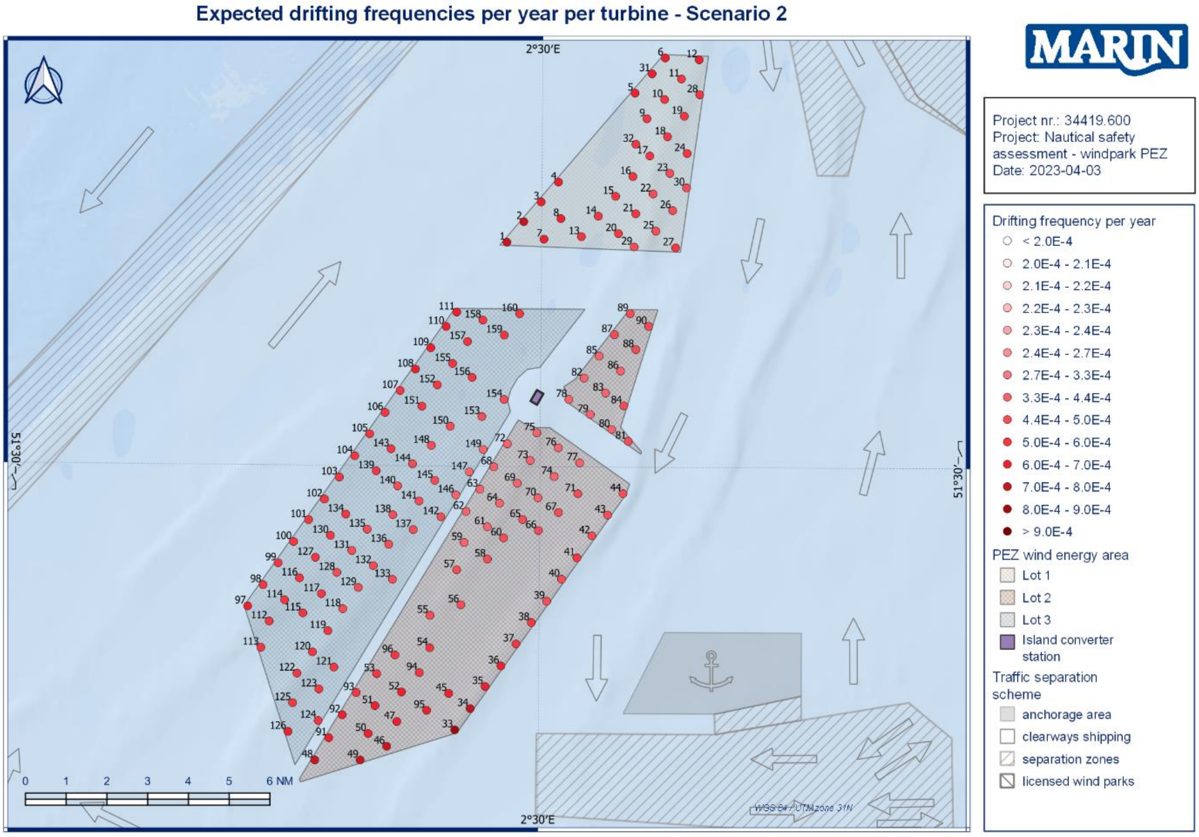

Figure 5-7 Expected collision frequencies (drifting) per turbine per year - Scenario 2

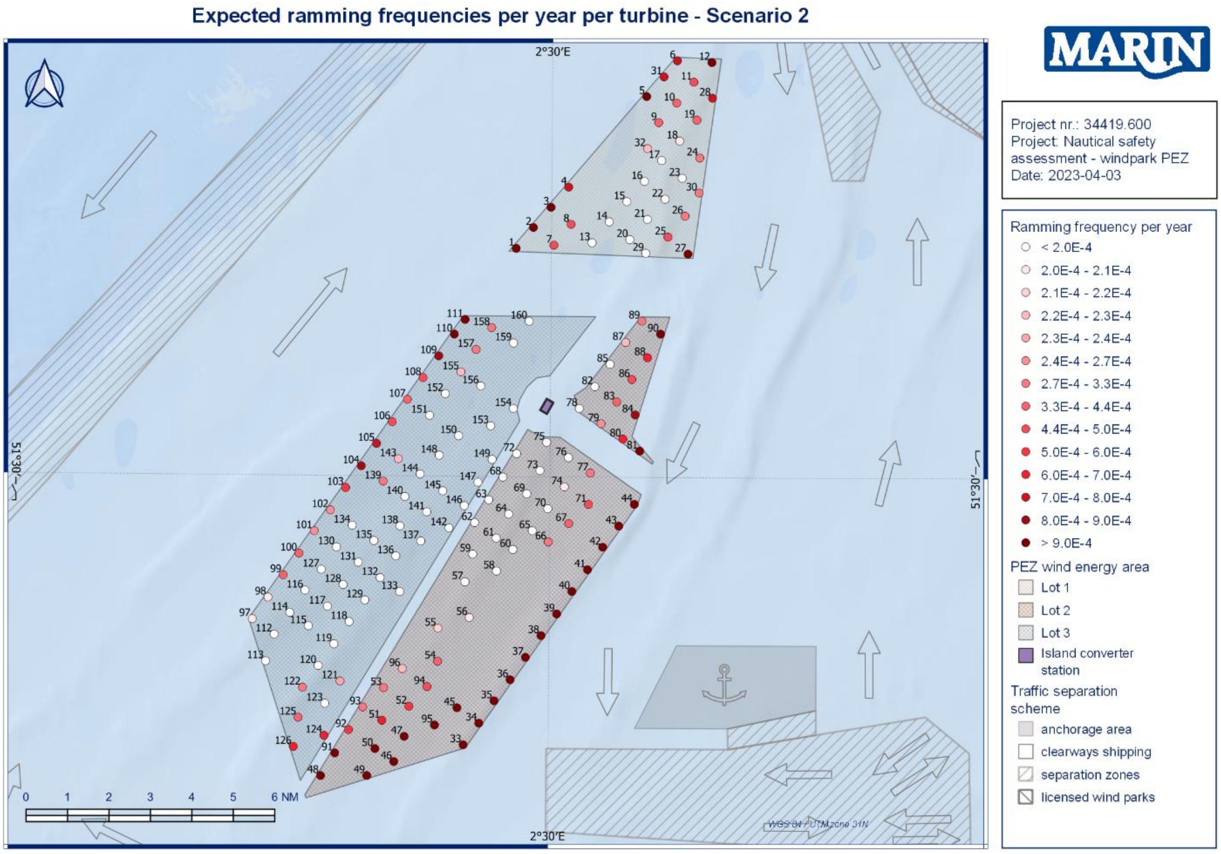

Figure 5-8 Expected collision frequencies (ramming) per turbine per year - Scenario 2

Table 5-1 shows the probability of a collision per year, summed over all wind turbines for each scenario. This therefore shows the total collision frequency by both route and non-route traffic. The total collision frequency (ramming and drifting) for the plot in scenario 1 is 0.2630, which is equivalent to once every 4 years. The total collision frequency (ramming and drifting) for the plot in scenario 2 is 0.1717, which is equivalent to once every 6 years. The table also shows the collision frequencies for each lot separately.

Table 5-1 Expected number of collisions per year for the wind energy area

Scenario 1									
Variant	Number of turbines	Number of collisions (ramming) per year			Number of collisions (drifting) per year			Total number per year	Once in … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
PEZ total	278	0,0748	0,0460	0,1208	0,1300	0,0122	0,1422	0,2630	4
Lot 1	54	0,0161	0,0049	0,0210	0,0274	0,0020	0,0294	0,0504	20
Lot 2	107	0,0454	0,0305	0,0759	0,0474	0,0056	0,0530	0,1289	8
Lot 3	117	0,0132	0,0106	0,0239	0,0552	0,0046	0,0598	0,0836	12

Scenario 2									
Variant	Number of turbines	Number of collisions (ramming) per year			Number of collisions (drifting) per year			Total number per year	Once in … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
PEZ total	160	0,0533	0,0331	0,0865	0,0776	0,0076	0,0852	0,1717	6
Lot 1	32	0,0130	0,0040	0,0170	0,0169	0,0013	0,0182	0,0352	28
Lot 2	64	0,0317	0,0221	0,0538	0,0292	0,0036	0,0328	0,0866	12
Lot 3	64	0,0087	0,0071	0,0157	0,0315	0,0027	0,0342	0,0499	20

As the probabilities also depend on the number of turbines, the average probabilities per turbine are given in Table 5-2. This shows the average probability of collision per turbine for each lot in scenario 1. The table also gives the frequencies for the turbine with the highest and lowest total frequency to show the total spread. Table 5-3 gives the same overview for scenario 2 and Table 5-4 for each scenario the expected number of collisions average per turbine for the entire wind park.

Table 5-2 Expected number of collisions, average per turbine. Scenario 1

PEZ Lot 1									
Variant	turbines	Number of collisions (ramming) per year per turbine			Number of collisions (drifting) per year per turbine			Total amount per year	Once per … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
Average all turbines wind park	278	2,69E-04	1,66E-04	4,35E-04	4,68E-04	4,37E-05	5,11E-04	9,46E-04	1057
Average all turbines lot	54	2,99E-04	9,08E-05	3,90E-04	5,08E-04	3,63E-05	5,44E-04	9,34E-04	1071
Turbine with maximum frequency	Nr:1	1,81E-03	8,00E-05	1,89E-03	6,67E-04	3,14E-05	6,98E-04	2,59E-03	386
Turbine with minimum frequency	Nr:42	5,62E-05	2,90E-05	8,52E-05	4,27E-04	3,30E-05	4,60E-04	5,45E-04	1835

PEZ Lot 2									
Variant	turbines	Number of collisions (ramming) per year per turbine			Number of collisions (drifting) per year per turbine			Total amount per year	Once per … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
Average all turbines wind park	278	2,69E-04	1,66E-04	4,35E-04	4,68E-04	4,37E-05	5,11E-04	9,46E-04	1057
Average all turbines lot	107	8,41E-04	5,65E-04	1,41E-03	8,77E-04	1,04E-04	9,81E-04	2,39E-03	419
Turbine with maximum frequency	Nr:55	3,21E-03	1,53E-03	4,74E-03	7,04E-04	8,80E-05	7,92E-04	5,53E-03	181
Turbine with minimum frequency	Nr:127	7,39E-06	5,88E-05	6,62E-05	3,68E-04	3,58E-05	4,04E-04	4,70E-04	2126

PEZ Lot 3									
Variant	turbines	Number of collisions (ramming) per year per turbine			Number of collisions (drifting) per year per turbine			Total amount per year	Once per … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
Average all turbines wind park	278	2,69E-04	1,66E-04	4,35E-04	4,68E-04	4,37E-05	5,11E-04	9,46E-04	1057
Average all turbines lot	117	2,45E-04	1,97E-04	4,42E-04	1,02E-03	8,50E-05	1,11E-03	1,55E-03	646
Turbine with maximum frequency	Nr:217	9,11E-04	5,03E-04	1,41E-03	6,16E-04	6,40E-05	6,80E-04	2,09E-03	478
Turbine with minimum frequency	Nr:252	7,60E-06	4,01E-05	4,77E-05	3,80E-04	3,56E-05	4,16E-04	4,63E-04	2158

Table 5-3 Expected number of collisions, average per turbine. Scenario 2

PEZ Lot 1									
Variant	turbines	Number of collisions (ramming) per year per turbine			Number of collisions (drifting) per year per turbine			Total amount per year	Once per … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
Average all turbines wind park	160	3,33E-04	2,07E-04	5,40E-04	4,85E-04	4,77E-05	5,33E-04	1,07E-03	932
Average all turbines lot	32	4,06E-04	1,24E-04	5,30E-04	5,29E-04	4,01E-05	5,69E-04	1,10E-03	910
Turbine with maximum frequency	Nr:27	2,24E-03	1,12E-04	2,36E-03	4,68E-04	4,17E-05	5,10E-04	2,87E-03	349
Turbine with minimum frequency	Nr:20	7,71E-05	2,83E-05	1,05E-04	4,66E-04	3,43E-05	5,00E-04	6,06E-04	1651

PEZ Lot 2									
Variant	turbines	Number of collisions (ramming) per year per turbine			Number of collisions (drifting) per year per turbine			Total amount per year	Once per … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
Average all turbines wind park	160	3,33E-04	2,07E-04	5,40E-04	4,85E-04	4,77E-05	5,33E-04	1,07E-03	932
Average all turbines lot	64	9,90E-04	6,91E-04	1,68E-03	9,13E-04	1,14E-04	1,03E-03	2,71E-03	369

Turbine with maximum frequency	Nr:33	3,55E-03	1,74E-03	5,30E-03	7,26E-04	9,43E-05	8,20E-04	6,12E-03	163
Turbine with minimum frequency	Nr:63	6,24E-06	5,90E-05	6,53E-05	3,85E-04	3,93E-05	4,25E-04	4,90E-04	2041

PEZ Lot 3									
Variant	turbines	Number of collisions (ramming) per year per turbine			Number of collisions (drifting) per year per turbine			Total amount per year	Once per … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
Average all turbines wind park	160	3,33E-04	2,07E-04	5,40E-04	4,85E-04	4,77E-05	5,33E-04	1,07E-03	932
Average all turbines lot	64	2,71E-04	2,21E-04	4,92E-04	9,83E-04	8,50E-05	1,07E-03	1,56E-03	641
Turbine with maximum frequency	Nr:111	1,36E-03	1,21E-04	1,48E-03	6,33E-04	3,60E-05	6,69E-04	2,15E-03	464
Turbine with minimum frequency	Nr:147	7,98E-06	4,67E-05	5,47E-05	3,95E-04	3,79E-05	4,33E-04	4,87E-04	2052

Table 5-4 Expected number of collisions average per turbine for the entire wind park.

Scenario 1									
Variant	turbines	Number of collisions (ramming) per year per turbine			Number of collisions (drifting) per year per turbine			Total amount per year	Once per … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
Average all turbines Lot	278	0,074787	0,0460436	0,1208307	0,1300078	0,012159	0,1421668	2,63E-01	4
Turbine with maximum frequency	Nr:55	3,21E-03	1,53E-03	4,74E-03	7,04E-04	8,80E-05	7,92E-04	5,53E-03	181
Turbine with minimum frequency	Nr:252	7,60E-06	4,01E-05	4,77E-05	3,80E-04	3,56E-05	4,16E-04	4,63E-04	2158

Scenario 2									
Variant	turbines	Number of collisions (ramming) per year per turbine			Number of collisions (drifting) per year per turbine			Total amount per year	Once per … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
Average all turbines Lot	160	0,0533486	0,0331189	0,0864675	0,0776066	0,0076386	0,0852453	1,72E-01	6
Turbine with maximum frequency	Nr:33	3,55E-03	1,74E-03	5,30E-03	7,26E-04	9,43E-05	8,20E-04	6,12E-03	163
Turbine with minimum frequency	Nr:147	7,98E-06	4,67E-05	5,47E-05	3,95E-04	3,79E-05	4,33E-04	4,87E-04	2052

The turbine with the highest collision probability depends on the scenario. For scenario 1 this is turbine nr. 55 which is located at the south-eastern corner of the plot (see Figure 5-3). In particular, the probability of ramming dominates for this turbine, which is different from the probabilities for the plot as a whole where drifting has a higher frequency. These high collision probabilities are mainly due to the regular route bound traffic sailing in western direction. Ships have to alter their course in close vicinity of this turbine which increases the collision likelihood

For scenario 2 turbine nr. 33 has the highest collision probability. Nr 33 which is located at the same place as nr. 55 in scenario 1 on the south-eastern corner of the plot (see Figure 5-6) and therefore has the same reason for a high collision likelihood.

5.3 Consequential damage

This section focuses on detailing the findings of a quantitative analysis conducted on consequential damage. Section 3.4 provides additional clarification and highlights specific aspects to consider regarding the quantification of consequential damage. Any anticipated deviations resulting these highlighted aspects will be addressed in this section.

5.3.1 Damage to the ship

Three types of consequential damage to the ship are distinguished: 1) damage to the ship in the event that the nacelle and mast section falls on the ship after the collision, 2) damage to the hull only and 3) no damage (see 3.4.1). The frequency of each type of damage to the ship is given for the respective scenarios in Table A1-5 in APPENDIX 1 and Table A2-5 in APPENDIX 2. The frequencies are given for seven different ship types.

In Table 5-5, the distribution of damage type per ship type relative to the total frequency is given for each lot in scenario 1. For example, it can be seen that about 40% of collisions in PEZ Lot 1 and 2 and 30% in Lot 3 involve damage to the hull of a container/RoRo[2] vessel. It also can be seen that damage to the ship's hull in the PEZ occurs in over 89% of collisions or drifts by all ship types. In Table 5-6 the same overview can be seen for scenario 2.

Table 5-5 Share of total collision frequency for each Lot, by ship type and type of damage. Scenario 1

	PEZ Lot 1			
	Damage type			
Ship type	NosMos[3]	Damage to ships hull	no damage	Total
Oil tanker	0,3%	10,8%	0,0%	11,1%
Chemical tanker	0,1%	11,8%	0,0%	11,9%
Gas tanker	0,1%	4,0%	0,0%	4,1%
Container+ RoRo	2,5%	37,8%	0,0%	40,2%
Ferry	0,0%	0,5%	0,1%	0,6%
Other R-ships	0,3%	17,9%	0,4%	18,5%
N-ships	0,4%	6,6%	6,6%	13,6%
All ships	3,6%	89,3%	7,1%	100,0%

[2] Roll-on Roll-off. A type of vessel where cars and lorries can drive on and off in port.
[3] Nacelle and mast part fall on ship after plastic deformation

Ship type	PEZ Lot 2			
	Damage type			Total
	NosMos	Damage to ships hull	no damage	
Oil tanker	0,1%	5,6%	0,0%	5,7%
Chemical tanker	0,1%	9,6%	0,0%	9,7%
Gas tanker	0,2%	4,0%	0,0%	4,2%
Container+ RoRo	2,8%	36,6%	0,0%	39,4%
Ferry	0,0%	0,5%	0,1%	0,6%
Other R-ships	0,2%	11,8%	0,2%	12,3%
N-ships	1,9%	21,0%	5,1%	28,0%
All ships	5,4%	89,2%	5,4%	100,0%

Ship type	PEZ Lot 3			
	Damage type			Total
	NosMos	Damage to ships hull	no damage	
Oil tanker	0,1%	10,4%	0,0%	10,5%
Chemical tanker	0,0%	14,9%	0,0%	14,9%
Gas tanker	0,1%	4,3%	0,0%	4,4%
Container+ RoRo	1,3%	29,0%	0,0%	30,3%
Ferry	0,0%	0,5%	0,1%	0,6%
Other R-ships	0,1%	20,6%	0,4%	21,1%
N-ships	0,7%	10,3%	7,1%	18,2%
All ships	2,3%	90,0%	7,7%	100,0%

Table 5-6 Share of total collision frequency by variant, by ship type and type of damage. Scenario 2

Ship type	PEZ Lot 1			
	Damage type			Total
	NosMos	Damage to ships hull	no damage	
Oil tanker	0,3%	9,9%	0,0%	10,1%
Chemical tanker	0,1%	10,6%	0,0%	10,7%
Gas tanker	0,1%	3,6%	0,0%	3,8%
Container+ RoRo	2,9%	40,1%	0,0%	43,0%
Ferry	0,0%	0,5%	0,1%	0,6%
Other R-ships	0,3%	16,3%	0,3%	16,9%
N-ships	0,4%	6,9%	7,6%	14,9%
All ships	4,1%	87,9%	8,0%	100,0%

	PEZ Lot 2			
Ship type	Damage type			Total
	NosMos	Damage to ships hull	no damage	
Oil tanker	0,1%	5,3%	0,0%	5,4%
Chemical tanker	0,2%	9,0%	0,0%	9,2%
Gas tanker	0,2%	3,9%	0,0%	4,0%
Container+ RoRo	2,9%	36,6%	0,0%	39,5%
Ferry	0,0%	0,5%	0,1%	0,6%
Other R-ships	0,2%	11,2%	0,2%	11,6%
N-ships	2,0%	22,0%	5,7%	29,7%
All ships	5,6%	88,4%	6,0%	100,0%

	PEZ Lot 3			
Ship type	Damage type			Total
	NosMos	Damage to ships hull	no damage	
Oil tanker	0,1%	10,0%	0,0%	10,1%
Chemical tanker	0,0%	14,2%	0,0%	14,3%
Gas tanker	0,1%	4,1%	0,0%	4,2%
Container+ RoRo	1,5%	29,4%	0,0%	30,9%
Ferry	0,0%	0,5%	0,1%	0,6%
Other R-ships	0,1%	19,9%	0,4%	20,5%
N-ships	0,7%	10,6%	8,3%	19,6%
All ships	2,5%	88,7%	8,8%	100,0%

5.3.2 Damage to the wind turbines

Four types of the consequential damage to the wind turbines are distinguished: 1) no damage, 2) the turbine can become skewed, 3) the turbine can fall over, and 4) the nacelle and mast can fall on the ship. The frequency of these different types is summed up for the entire wind farm in Table A1-6 in APPENDIX 1 and Table A2-6 in APPENDIX 2. Table 5-7 shows the share of the total collision frequency for each type of consequential damage per Lot for scenario 1. This shows, for example, that for approximately 49% of collisions in scenario 1, Lot 1, the turbine is skewed as a result. For Lot 2 this is 61% and Lot 3; 44%. Table 5-8 shows the same for scenario 2.

Table 5-7 Share in the total collision frequency per variant and type of damage to the turbine. Scenario 1

	PEZ Lot 1	
Damage to turbine	Number per year	Share in frequency
None	0,003581	7%
Skewed	0,024847	49%
Toppled	0,020202	40%
NosMos	0,001812	4%
Total	0,050442	100%

	PEZ Lot 2	
Damage to turbine	Number per year	Share in frequency
None	0,006972	5%
Skewed	0,079058	61%
Toppled	0,035941	28%
NosMos	0,006944	5%
Total	0,128916	100%

	PEZ Lot 3	
Damage to turbine	Number per year	Share in frequency
None	0,006408	8%
Skewed	0,036409	44%
Toppled	0,038882	46%
NosMos	0,001941	2%
Total	0,083640	100%

Table 5-8 Share in the total collision frequency per variant and type of damage to the turbine. Scenario 2

	PEZ Lot 1	
Damage to turbine	Number per year	Share in frequency
None	0,002825	8%
Skewed	0,018345	52%
Toppled	0,012574	36%
NosMos	0,001437	4%
Total	0,035181	100%

	PEZ Lot 2	
Damage to turbine	Number per year	Share in frequency
None	0,005230	6%
Skewed	0,054078	62%
Toppled	0,022478	26%
NosMos	0,004832	6%
Total	0,086618	100%

	PEZ Lot 3	
Damage to turbine	Number per year	Share in frequency
None	0,004399	9%
Skewed	0,022179	44%
Toppled	0,022099	44%
NosMos	0,001236	2%
Total	0,049914	100%

Based on the average mass of a given vessel type and size and the average speed, the kinetic energy can be determined at the time of 'impact'. The distribution of collision frequencies for the different impact energy levels is given in Table A1-8. It can be derived that in scenario 1 for Lot 1, about 58% of turbine contacts are caused by drifting, and 41% by ramming. For scenario 2 these figures are given in Table A2-8 of APPENDIX 2.

As the previous section described the share of the total collision frequency by ship type and type of damage, the damage to wind turbines depends on the mass of these ships. Because ships are different in size and mass, the impact energy as a result of a drifting or powered contact will be a measure of the damage to the turbines. The actual damage to the turbine will depend on the type and size but the collision frequencies per kinetic energy level will remain the same.

Figure 5-9 shows an example of the collision frequencies per certain kinetic energy level graph for scenario 1. This figure shows how often collisions with a particular impact occur. The number of collisions that have an impact above a certain energy value will decrease as that threshold value (on the y-axis) increases. So the lines run towards the y-axis. The orange line coincides with the y-axis at 291 MJ. This means that drifting collisions with an impact greater than 291 MJ never take place. The blue and grey lines coincide from that energy level onwards. So only ramming collisions have an impact of more than 291 MJ. The rest of the figures for different lots and scenario are available in Appendix 1 and 2.

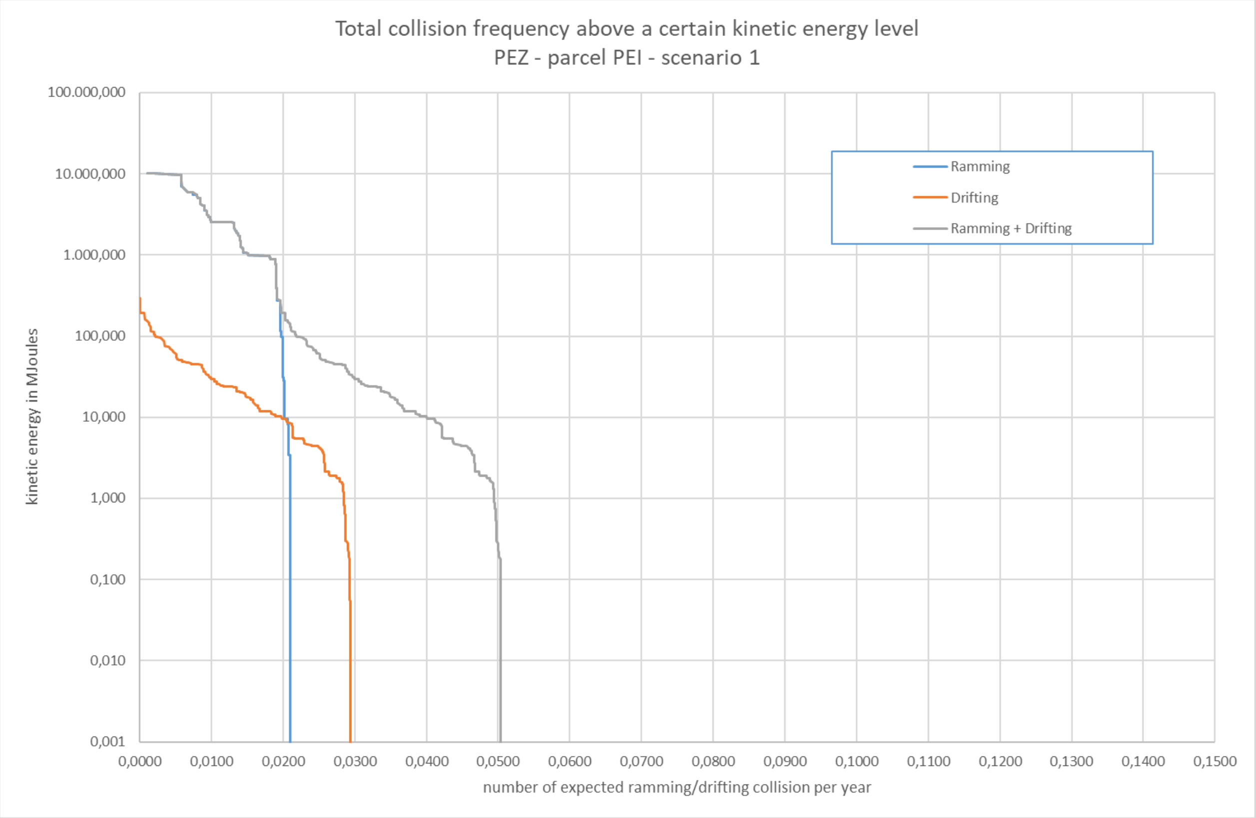

Figure 5-9 Total collision frequency above a certain kinetic energy level - PEZ Lot 1

5.3.3 Personal injury

Personal injuries are caused because the nacelle and mast may fall onto the deck of a vessel due to collision with a turbine. Table A1-7 and Table A2-7 summarises the number of direct fatalities resulting from nacelle and mast falling onto the deck for the entire PEZ. These tables show that the personal injury risk for cargo vessels are relatively low. Only passenger ships (ferries) have a higher injury risk due to the amount of people on board.

Personal injury because people fall as a result of the impact itself has not been modelled, even for the small vessels that sail head-on against the protection of the mast where the vessel (recreational craft) is completely destroyed. For this category of vessels, the probability models are unreliable.

In addition to the possibility of people falling from a mast or nacelle, other scenarios are also possible where there are consequences for people on board. For instance when a passenger vessel scrapes past a turbine and damages the hull at the sleeping quarters level. These consequences were not considered in the study conducted in 2005 on consequential damage. Therefore, the impact on people on board is certainly an important component in follow-up research on damage to ship and turbine after a collision. During the conduct of the study for the PEZ, there was not yet sufficient knowledge available for a proper quantitative consideration of the consequences other than injuries resulting from a falling nacelle and mast on the ship.

5.4 Effects lines of sight intersecting traffic

Vessels approaching each other with intersecting headings should be able to determine in time whether there is a danger of collision and should have sufficient opportunity and/or space to prevent a possible collision. To this end, they should have a good view of each other, both visually and via radar. Wind farms, however, can obstruct this view. Both visually (wind turbines block view of the ship's navigation lights) and on the radar (shielding, false echoes, wind turbines give thick echoes on the screen, among other things). This is in particularly the case where there are many wind turbines between the two ships. However, at the point where there are only a few wind turbines between the two ships, the ships may already be close to each other. The "Provisions for the Prevention of Collision at Sea" [Ref 8.] (Article 8) require timely and clear action based on reliable information. This section examines the extent to which it is possible to take timely action based on reliable information.

To gain more insight into the issues, a random wind farm was modelled in the outer image of MARIN's full-scale manoeuvring simulator in the past. In this image, two intersecting ships are modelled each time. The navigator controls the ship sailing on the west side of the park from south to north and has to perform a "collision avoidance manoeuvre" for the other ship sailing on the north side of the park from east to west. The simulator run was constructed so that if both ships did nothing, a collision will occur. This intersection of crossing course lines is further referred to as 'intersection'. The navigator has all means of navigation (except AIS) at his disposal. The wind farm and the interference of the wind farm on objects behind it, are modelled. The question was whether the navigator was able to detect the other vessel early, determine its course and speed and possibly initiate a manoeuvre to avoid the collision.

This scenario was specifically chosen because in the encounter situation a ship will initially alter its course to starboard to avoid a collision. In such a situation a problem arises because the wind farm is on this (starboard) side. Figure 5-10 and Figure 5-11 are two shots of what can be seen from the bridge of the own vessel. The own vessel is the vessel for which the outside image is projected in the simulator and which is operable. In Figure 5-10 the other ship is not yet present, in Figure 5-11 the ship is recognisable by the red dot just below the horizon, to the left of the row of wind turbines on 3/4 of the figure.

The following parameters were varied for this scenario:

1. Day and night;
2. Wind farm configuration;
3. Distance from the wind farm.

Three wind farms were modelled on the simulator:

1. a wind farm with the wind turbines on the vertices of squares;
2. a wind farm with a staggered arrangement;
3. a wind farm as in the first option, but with a sharp point of 45°.

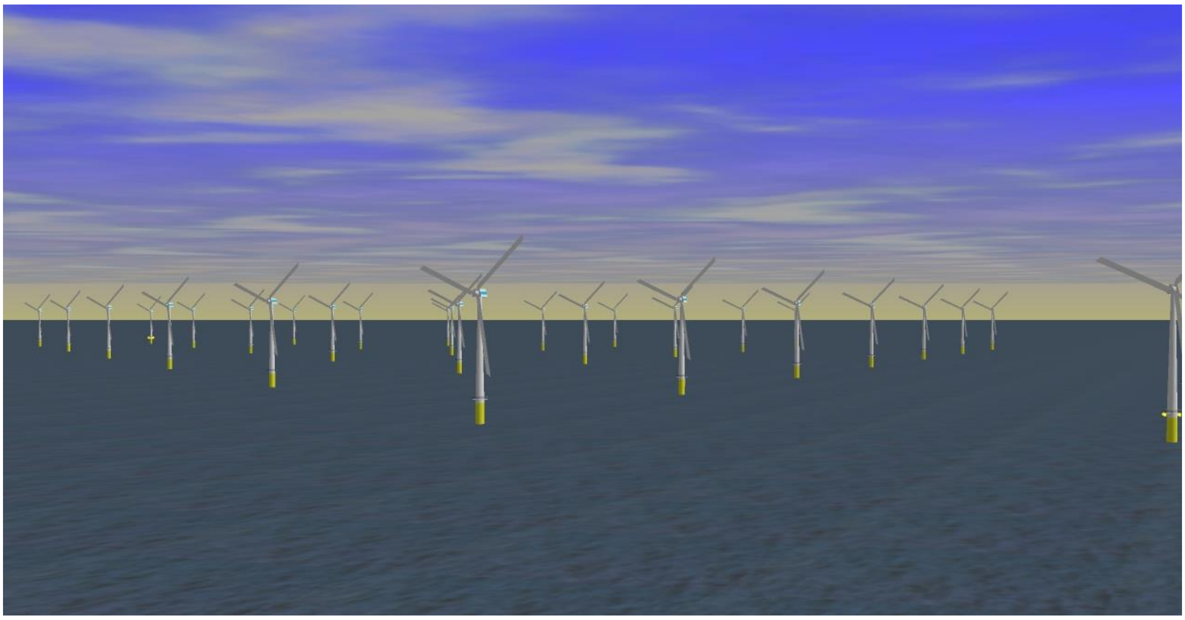

Figure 5-10 Wind farm as seen from own ship

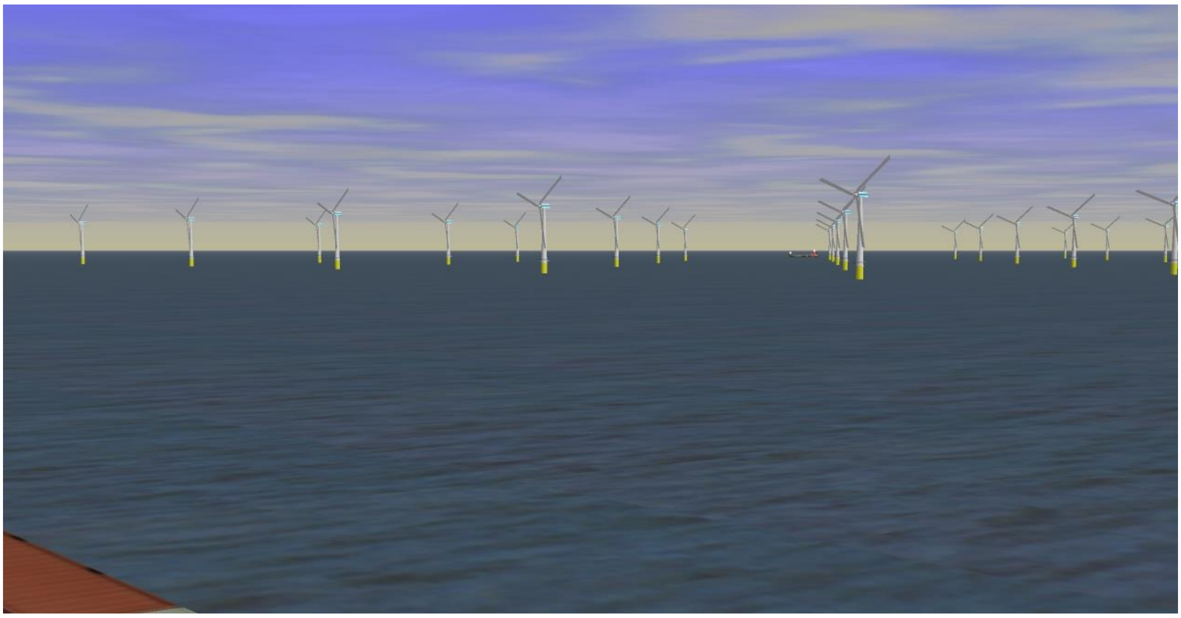

Figure 5-11 Wind farm as seen from the ship with a small vessel in the outside view

The runs were performed for a passage distance of 500 m and 1000 m for both ships. In the many runs performed on the simulator, the ship could always be spotted in time, both visually and on radar. However, this is no guarantee for practice as it is difficult to exactly simulate all conditions under which radar interference and false echoes occur. Moreover, in practice, there may be more ships sailing that can complicate the evasive manoeuvre. Moreover, on the simulator, it is known that there is a ship sailing behind the wind farm, so people pay better attention and react earlier than in practice. It should also be noted that, although the legal passing distance is (maximum) 500 m, in practice one will sail past the wind farm at a greater distance, precisely to ensure that one can swerve to starboard ("Preparedness" is an important attribute for good seamanship). This will certainly be done by vessels that are difficult to manoeuvre. Moreover, the situation described here by no means occurs at every wind farm. At many wind farms, given the origin and destination, normal vessel manoeuvring often creates greater distances to the wind farm than the 500 and 1000 m used in the simulator runs.

Using a simulator study, qualitative statements can be made, but it is impossible to quantify a particular risk. In the simulator study, the disruption of the visibility and radar image was not so great as to directly cause insurmountable problems, but it is uncertain whether this would also be the case in fog and precipitation.

When looking specifically at the situation around PEZ, it can be seen that, given the various traffic routes and traffic flows around the park, there are few situations where the PEZ affects sightlines. The passage south of Lot 1 (red arrow in Figure 5-12) is likely to be affected but only a few ships will pass that route (see Figure 5-1 and Figure 5-2). It is assumed that no direct passage through the wind energy area should take place. However, destination/working boat traffic is to be expected. These are expected to be well manoeuvrable vessels for which the 2nm to the TSS, and 500m to other non-route traffic, is sufficient in terms of visibility.

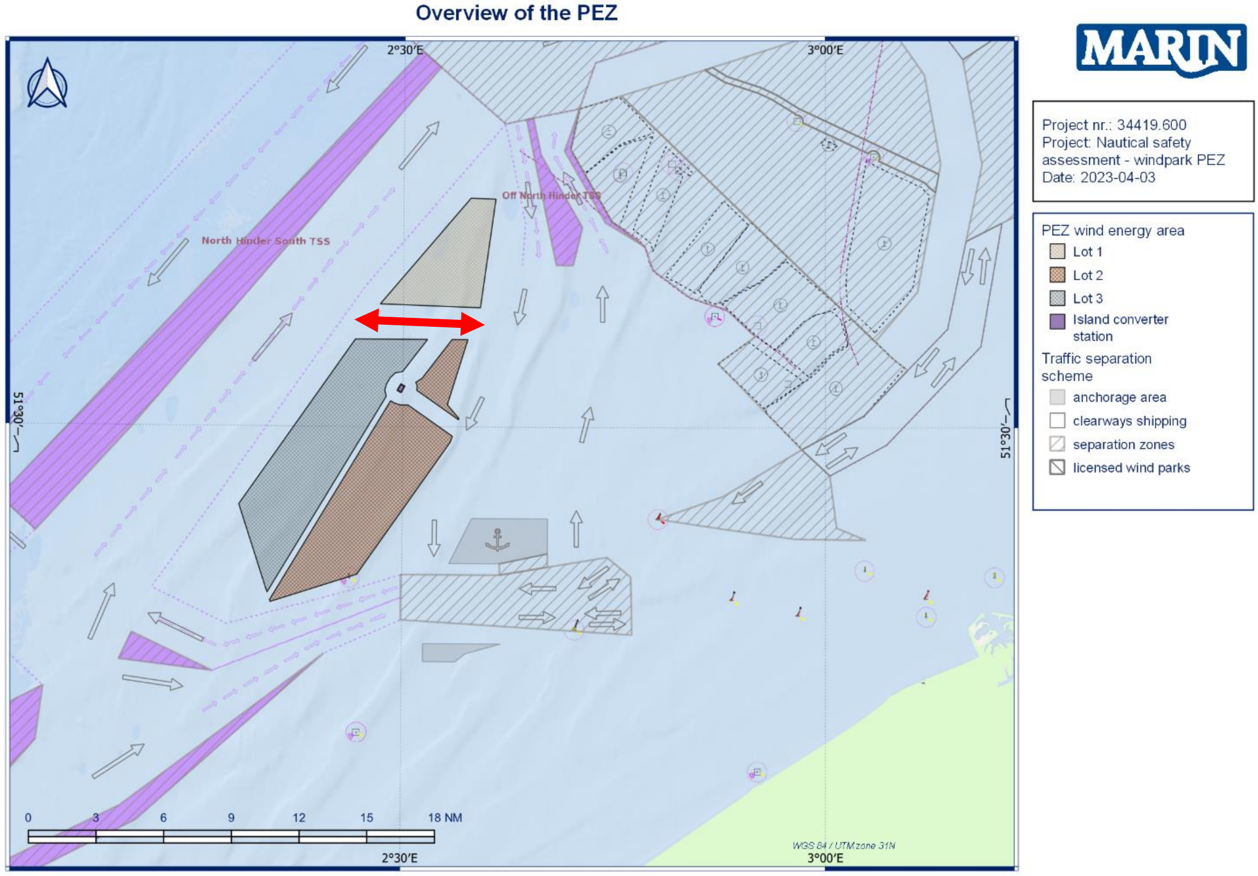

Figure 5-12 Overview of the PEZ with the defined shipping routes

5.5 Effects and other risks to shipping due to a change in route structure

The PEZ wind farms have been planned in between existing shipping routes. The areas in between these routes are only utilised by non-route bound shipping and in particular by Fishing vessels. Any change in routing structure is therefore not foreseen in relation to the development of the PEZ. Due to the location of the PEZ in relation to the existing shipping lanes (TSS), the construction of the wind farms neither has an impact on the route structure in the North Sea.

Fishing activities that take place in the planned PEZ area will have to relocate and may create a higher traffic density in adjacent areas. In addition it can be expected that an increased amount of shipping for the construction, operation and maintenance of the wind farm will become active in this area. Client estimates that PE I, II, and III will have approximately 255 visiting ships each, per year during the operational phase of the wind farms. These activities will have an effect on the collision probability inside the wind farms and will create an overall higher shipping density in the Belgium EEZ.

5.6 Effect on CO2 emissions

It is not expected that route bound shipping will have to use other routes due to the development of the PEZ wind farms. Therefore no additional traffic miles have to be taken into account which means that, compared to the current situation, no additional CO2 emissions as a result of the PEZ development is to be expected.

Non-route bound traffic will have to relocate but additional shipping traffic to support the wind farm operations can be expected within the boundaries of the area. Because this traffic bound for the wind farm is an addition to the current situation this will have an effect on CO2 emission. In the EIR it is estimated that approximately 765 ships will enter the PEZ annually during the operational phase, equally divided between the three lots (255 each). These activities are considered “personnel” transfer which can be a small crew transfer vessel (CTV) for daily commuting or a larger service operations vessel (SOV) which can stay, dynamically positioned, in the area for a longer period.

6 MEASURES

To reduce the effects on shipping safety, several measures are possible. Determining possible measures and establishing their effectiveness was part of the cumulative effects study [Ref 11.] and several expert sessions. Not all measures proposed within [Ref 11.] are included in this chapter, because these measures are particularly effective and relevant when looking at the total picture of all parks together. For "just" one park, some measures may be less relevant but should be seen in the larger perspective of ensuring shipping safety in the North Sea. A number of relevant proposed measures have been included below.

6.1 Measures for ship’s crew

6.1.1 AIS-base station and VHF-antenna

Since 1 January 2005, all seagoing vessels over 300 GT have been legally obliged to carry an AIS (Automatic Identification System) transponder, which continuously transmits the ship's position, on board. Nearby vessels can receive these signals with their own AIS which will reveal the position, course and speed of the other vessel. If the AIS coverage or capacity of infrastructure is insufficient for the shipping demand, the positions of ships on navigation aids will not be accurate for all users, including VTS/Custodian and sailing ships. In such cases, AIS will prioritize its updates using its own algorithms. Consequently, some vessels may not appear on the display, while others will be shown with a time delay. This deviation from reality and radar positions occurs due to the limitations in AIS caused by inadequate coverage or capacity. To prevent these issues, it is advisable to install an AIS base station at the wind farm. Additionally, it is recommended to create a radar image that covers the wind farm area, along with an AIS image, covering a zone of at least 2 nautical miles. Lastly, installing a VHF antenna within the wind farm will enable communication between the Coast Guard and ships in the area.

6.1.2 Vessel Traffic Management (VTM)

The expert session [Ref 11.] expressed the expectation that VTM in the southern North Sea could have a minor positive impact and reduce the number of collisions (slightly). VTM has a positive contribution to the safe handling of traffic; it can warn traffic of unexpected or abnormal conditions or imminent danger and can coordinate action in the event of an emergency. It should be noted that VTM is not expected to be effective in the case of a drifting vessel other than coordinating assistance and informing other vessels in the area. When imposing passage restrictions in the wind farms, VTM may also be the means to enforce compliance and make entering and exiting traffic in/out of the TSS more coordinated which may reduce the likelihood of collisions.

A proper design and implementation of VTM is of great importance. This concerns not only the effectuation at the Coast Guard, but also the sensors that can be used. VTM only works well in combination with other measures (AIS and VHF use and coverage throughout the area). Expanding the coverage of VTM sensors (including radar, AIS, VHF) is a prerequisite for this. To further enhance the effect of a VTM, additional monitoring and enforcement has been mentioned to increase the effect on behavioural influence and alertness.

Although the positive effects of VTM to reduce collisions may be expected by experts, there are currently no wind parks in the southern North Sea with an established VTM, and relevant scientific literature is limited to support this claim in case of a safety measure around offshore wind farms.

6.1.3 Additional marking and identification of wind turbines in wind farms

The experts session [Ref 11.] also expressed that good lighting, marking and identification of wind turbines has a preventive effect on collisions with wind turbines especially for working, fishing and recreational navigation. This could, for example, be included as a precondition in a spatial planning permit.

6.2 Mitigating measures

6.2.1 ERTV (Emergency Rescue Towing Vessel)

As shown by the calculations, drifting collisions constitutes a significant part of the risk. A collision, as a result of a propulsion failure is prevented if the ship can be anchored or the failure fixed in time. These processes have been taken into account in the calculation.
A third possibility by which the failure does not result in a drifting collision is when the drifter is assisted by a tug at an early stage.

An Emergency Rescue Towing Vessel (ERTV) could be deployed to a drifter as soon as a report is received by the Coast Guard. Such an ERTV can prevent a collision if the vessel can reach the drifter before a wind turbine is hit.

It is generally supported that the deployment of one or more ERTVs in the area is effective in accommodating drifting vessels and has a mitigating effect on collisions with other vessels and or wind turbines [Ref 11.]. However, it should be noted that ERTVs have little effect for ships that make steering errors or suffer technical failure close to wind farms. Then the available response time is too short. However, an ERTV could be effective in preventing a ship from drifting further into a wind farm, thus preventing more damage. Further research is needed to determine its effectiveness. Adjusting the distance between wind farms and shipping lanes (rearranging wind farms) also has an effect on the number of ERTVs needed and thus the cost of ERTVs. The use of ERTVs is considered the most expensive mitigation measure at the moment. In Belgian waters the deployment of an ERTV is not foreseen at the time of this analysis.

6.2.2 Additional SAR-capacity

Search And Rescue (SAR) is the search for and provision of aid to people who are in distress or imminent danger.
This has a particular impact on the consequences of accidents for crews of ships and workers in the wind farms. It is effective for all vessels but, from the expert group's point of view [Ref 11.], recreational shipping is the main focus, as this group is often the least self-reliant compared to other shipping. SAR capacity close to the coast is well provided with the deployment of a rescue team/lifeguard (VBZR[4]) and the SAR helicopter. Incidents further offshore and especially in wind farms in poor conditions, when helicopter deployment is limited, may require additional facilities. Approach times then become limited. This can be remedied by realising SAR capacity on board ERTVs or on board other vessels such as, for example, a Coast Guard or Naval vessel in the area.

6.2.3 Oil spill prevention

The risk of oil pollution (after incidents) will increase slightly due to an increase in the likelihood of collisions between ships and turbines. Additional oil control capacity can be achieved by equipping the ERTV with oil spill containment equipment.

[4] Vrijwillige Blankenbergse Zeereddingsdienst (VBZR)

6.2.4 Physical safety of wind farms

MARIN is currently conducting research in the open innovation project 'crash barriers at sea' into a barrier as one of the possible mitigating measures for preventing collisions with offshore wind farms. The aim here is to investigate whether collisions between ships and offshore energy farms can be prevented with a barrier between the shipping lane (or anchorage area) and an energy farm (see Figure 6-1).

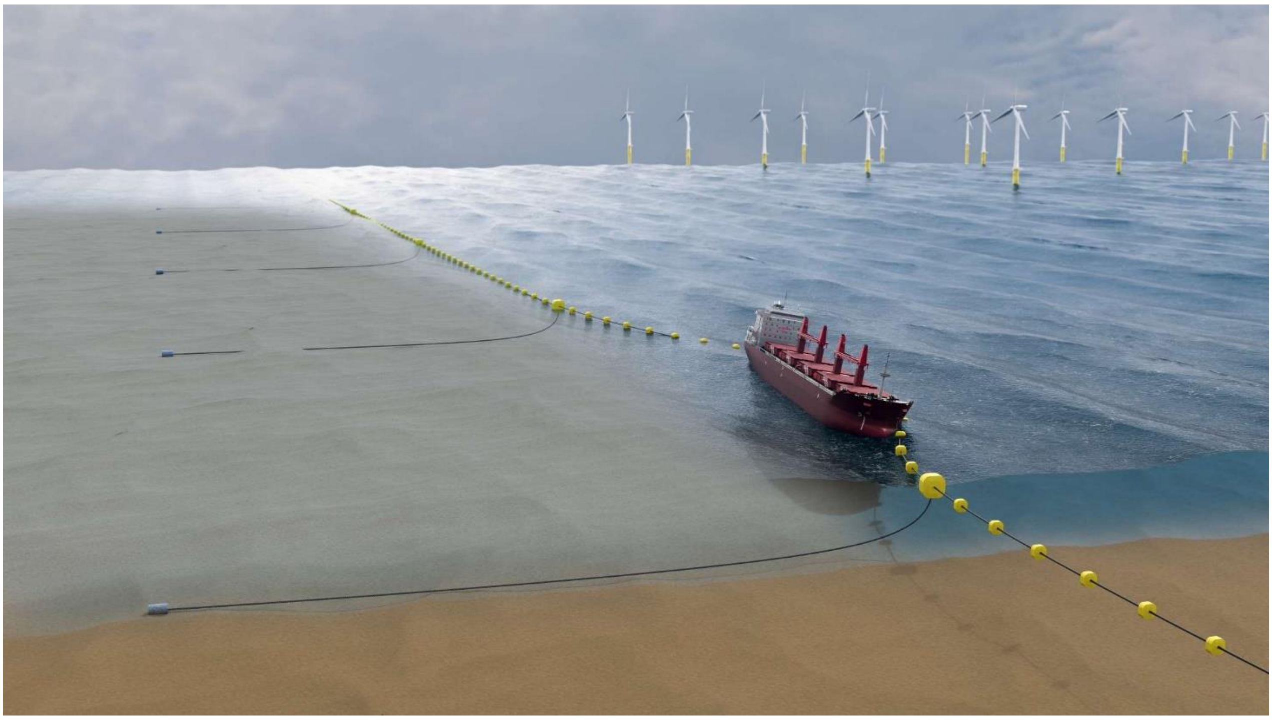

Figure 6-1 MARIN project "Crash barrier at sea"

7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusions

For the three PEZ lots, calculations were carried out based on two configuration scenarios.
These configurations were calculated with the total wind farm capacity of approximately 3336 MW for scenario 1 and 3520 MW for scenario 2. A configuration with a larger number (257) of wind turbines with less power (12/13MW), placed on a jacket foundation (90%) and on gravity based structures (10%) (referred to further in this report as scenario 1), and a configuration with a smaller number (160) of wind turbines with more power (22MW), placed on monopiles (referred to as scenario 2) were chosen.

An important assumption in this traffic database is that no integral traffic passage or dedicated traffic passages for smaller vessels in PEZ is considered, so all passing traffic sails outside and around the wind farms. Only destination traffic (work, crew, survey, etc. vessels) will sail within the wind farms in the future, but these vessels are not included in the analysis.

Table 7-1 gives the total collision frequencies for each scenario. For the entire PEZ in scenario 1 the expected number of collisions is once every 4 years. Scenario 2 has a slightly lower frequency at once in 6 year. For both scenarios, the average collision frequency per turbine for Lot 2 is slightly higher than the average frequency per turbine for Lot 1 and 3 because this lot is closest to an area with dense shipping traffic. As the PEZ area is located in between various traffic separation schemes with a high shipping density the calculated collision frequency is relatively high. This is in particularly the case in the south-east corner of the area as this is located near a shipping lane junction. As a comparison, the Borssele wind farm with 173 turbines has a similar position in relation to shipping traffic and has a total collision frequency of once in 9 years [Ref 14.].

Because the PEZ area is planned between existing shipping routes it is not expected that current shipping routes will have to be changed. Non-route bound traffic will have to relocate to the surrounding area. The majority of this type consist of Fishing vessels. Work-vessels for the support of the wind farms is expected to be approximately 765 crew vessels a year divided over the three lots (255 each). These activities have not been taken into account in the collision frequency calculation due to the limitations of the model.

Table 7-1 Expected number of collisions per year for the PEZ wind farms

Scenario 1									
Variant	Number of turbines	Number of collisions (ramming) per year			Number of collisions (drifting) per year			Total number per year	Once in … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
PEZ total	278	0,0748	0,0460	0,1208	0,1300	0,0122	0,1422	0,2630	4
Lot 1	54	0,0161	0,0049	0,0210	0,0274	0,0020	0,0294	0,0504	20
Lot 2	107	0,0454	0,0305	0,0759	0,0474	0,0056	0,0530	0,1289	8
Lot 3	117	0,0132	0,0106	0,0239	0,0552	0,0046	0,0598	0,0836	12

Scenario 2									
Variant	Number of turbines	Number of collisions (ramming) per year			Number of collisions (drifting) per year			Total number per year	Once in … year
		R-ships	N-ships	Total	R-ships	N-ships	Total		
PEZ total	160	0,0533	0,0331	0,0865	0,0776	0,0076	0,0852	0,1717	6
Lot 1	32	0,0130	0,0040	0,0170	0,0169	0,0013	0,0182	0,0352	28
Lot 2	64	0,0317	0,0221	0,0538	0,0292	0,0036	0,0328	0,0866	12
Lot 3	64	0,0087	0,0071	0,0157	0,0315	0,0027	0,0342	0,0499	20

7.2 Recommendations

Regarding preventive and mitigation measures, the insights from previous wind farm studies in Belgium and the Netherlands are still valid. Details of these measures are given in Chapter 6.
Current results are based on the current plans not to allow integral passage in the wind farm. If it is decided in the future to allow integral passage or shared use in the PEZ, this study will have to be reconsidered or adapted.

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APPENDICES

APPENDIX 1 RESULTS WINDPARK PEZ SCENARIO 1

Table A1-1 Locations and collision frequency per turbine, all traffic for Lot1

Wind turbine	Ramming		Drifting		Total	Once in … year
	R-ships	N-ships	R-ships	N-ships		
kavel1_wt1	1,8115E-03	8,0042E-05	6,6650E-04	3,1388E-05	2,5894E-03	386
kavel1_wt2	1,0534E-03	1,0481E-04	6,5010E-04	3,1929E-05	1,8402E-03	543
kavel1_wt3	7,0048E-04	1,6150E-04	6,4265E-04	3,2946E-05	1,5376E-03	650
kavel1_wt4	5,8258E-04	2,3181E-04	6,3391E-04	3,5780E-05	1,4841E-03	674
kavel1_wt5	5,4664E-04	1,8300E-04	6,2170E-04	3,5877E-05	1,3872E-03	721
kavel1_wt6	5,4650E-04	1,0318E-04	6,1399E-04	3,5906E-05	1,2996E-03	769
kavel1_wt7	5,6080E-04	1,6503E-04	6,0221E-04	4,2945E-05	1,3710E-03	729
kavel1_wt8	5,6739E-04	1,1952E-04	6,0790E-04	4,3113E-05	1,3379E-03	747
kavel1_wt9	5,7018E-04	5,1702E-05	5,8942E-04	2,9240E-05	1,2405E-03	806
kavel1_wt10	5,0451E-04	6,9764E-05	5,8572E-04	3,1508E-05	1,1915E-03	839
kavel1_wt11	3,7495E-04	8,5979E-05	5,8063E-04	3,2625E-05	1,0742E-03	931
kavel1_wt12	2,9652E-04	8,8582E-05	5,4383E-04	4,1182E-05	9,7012E-04	1031
kavel1_wt13	3,1740E-04	9,8744E-05	5,4369E-04	4,2650E-05	1,0025E-03	998
kavel1_wt14	4,6140E-04	1,4793E-04	5,7948E-04	4,4367E-05	1,2332E-03	811
kavel1_wt15	1,9542E-04	3,6632E-05	5,2568E-04	3,0710E-05	7,8844E-04	1268
kavel1_wt16	2,0698E-04	4,0595E-05	5,3050E-04	3,0961E-05	8,0903E-04	1236
kavel1_wt17	1,9909E-04	3,7652E-05	5,3066E-04	3,1880E-05	7,9928E-04	1251
kavel1_wt18	1,6110E-04	3,4143E-05	5,2015E-04	3,1264E-05	7,4665E-04	1339
kavel1_wt19	1,4121E-04	3,1823E-05	5,0702E-04	3,2409E-05	7,1247E-04	1404
kavel1_wt20	1,2981E-04	3,7935E-05	5,0364E-04	3,3563E-05	7,0495E-04	1419
kavel1_wt21	1,3489E-04	4,1211E-05	5,0138E-04	3,4423E-05	7,1190E-04	1405
kavel1_wt22	1,4317E-04	5,5047E-05	5,0087E-04	3,5979E-05	7,3507E-04	1360
kavel1_wt23	1,5515E-04	6,6630E-05	4,9853E-04	3,8360E-05	7,5867E-04	1318
kavel1_wt24	1,8655E-04	9,0946E-05	5,0136E-04	4,0661E-05	8,1952E-04	1220
kavel1_wt25	2,3241E-04	1,5539E-04	5,0701E-04	4,2851E-05	9,3766E-04	1066
kavel1_wt26	3,5175E-04	3,6471E-04	5,0463E-04	4,7193E-05	1,2683E-03	788
kavel1_wt27	8,6127E-05	2,6328E-05	4,8062E-04	3,0753E-05	6,2383E-04	1603
kavel1_wt28	8,3809E-05	2,8748E-05	4,8631E-04	3,1189E-05	6,3006E-04	1587
kavel1_wt29	8,2460E-05	2,7341E-05	4,7423E-04	3,1604E-05	6,1563E-04	1624
kavel1_wt30	8,4599E-05	2,7696E-05	4,7535E-04	3,2416E-05	6,2006E-04	1613
kavel1_wt31	8,3198E-05	3,1056E-05	4,7327E-04	3,3757E-05	6,2128E-04	1610
kavel1_wt32	8,3327E-05	3,8712E-05	4,7199E-04	3,5210E-05	6,2924E-04	1589
kavel1_wt33	9,1406E-05	5,3839E-05	4,6932E-04	3,7064E-05	6,5163E-04	1535
kavel1_wt34	1,1481E-04	8,5434E-05	4,7083E-04	3,8889E-05	7,0996E-04	1409
kavel1_wt35	1,5720E-04	1,5898E-04	4,7945E-04	4,1521E-05	8,3714E-04	1195
kavel1_wt36	4,5278E-05	2,4332E-05	4,5279E-04	3,1382E-05	5,5379E-04	1806
kavel1_wt37	5,8876E-05	2,8097E-05	4,4582E-04	3,2857E-05	5,6565E-04	1768
kavel1_wt38	8,2713E-05	2,9696E-05	4,4993E-04	3,2403E-05	5,9474E-04	1681
kavel1_wt39	7,9740E-05	3,7169E-05	4,4650E-04	3,4835E-05	5,9824E-04	1672

kavel1_wt40	7,0389E-05	5,2822E-05	4,4195E-04	3,6394E-05	6,0156E-04	1662
kavel1_wt41	8,1847E-05	8,6321E-05	4,4636E-04	3,8100E-05	6,5263E-04	1532
kavel1_wt42	5,6243E-05	2,8991E-05	4,2678E-04	3,2975E-05	5,4499E-04	1835
kavel1_wt43	9,3304E-05	3,2330E-05	4,2948E-04	3,3647E-05	5,8876E-04	1698
kavel1_wt44	1,5606E-04	4,0713E-05	4,3231E-04	3,4285E-05	6,6338E-04	1507
kavel1_wt45	1,2022E-04	5,7250E-05	4,2850E-04	3,5701E-05	6,4167E-04	1558
kavel1_wt46	8,5485E-05	9,4490E-05	4,2824E-04	3,8106E-05	6,4632E-04	1547
kavel1_wt47	2,2032E-04	4,6519E-05	4,2235E-04	3,5349E-05	7,2454E-04	1380
kavel1_wt48	3,7124E-04	6,7392E-05	4,3214E-04	3,7193E-05	9,0797E-04	1101
kavel1_wt49	2,4844E-04	1,0978E-04	4,2112E-04	3,8145E-05	8,1749E-04	1223
kavel1_wt50	1,1685E-03	1,0698E-04	4,4397E-04	3,9145E-05	1,7586E-03	569
kavel1_wt51	5,1561E-04	4,2619E-04	5,3058E-04	4,8832E-05	1,5212E-03	657
kavel1_wt52	9,5671E-05	1,6393E-04	4,2896E-04	3,9854E-05	7,2842E-04	1373
kavel1_wt53	2,5204E-04	9,0615E-05	5,2853E-04	3,9384E-05	9,1056E-04	1098
kavel1_wt54	3,3494E-04	2,1867E-04	5,3255E-04	4,5033E-05	1,1312E-03	884
Total per year	1,6136E-02	4,9047E-03	2,7443E-02	1,9577E-03	5,0442E-02	20
This is once in … year	62	204	36	511	20	

Table A1-2 Locations and collision frequency per turbine, all traffic for lot 2

Wind turbine	Ramming		Drifting		Total	Once in … year
	R-ships	N-ships	R-ships	N-ships		
kavel2_wt55	3,2115E-03	1,5256E-03	7,0442E-04	8,7981E-05	5,5294E-03	181
kavel2_wt56	2,9495E-03	1,1279E-03	6,5549E-04	8,2716E-05	4,8155E-03	208
kavel2_wt57	2,3623E-03	8,3625E-04	6,1728E-04	7,8889E-05	3,8948E-03	257
kavel2_wt58	1,3850E-03	7,0138E-04	5,5898E-04	7,7356E-05	2,7228E-03	367
kavel2_wt59	6,5757E-04	6,0891E-04	5,1525E-04	7,8086E-05	1,8598E-03	538
kavel2_wt60	4,6246E-04	6,3589E-04	4,7601E-04	7,5505E-05	1,6499E-03	606
kavel2_wt61	2,8574E-04	6,9215E-04	4,5191E-04	7,2669E-05	1,5025E-03	666
kavel2_wt62	2,7663E-04	6,8434E-04	4,2681E-04	7,3901E-05	1,4617E-03	684
kavel2_wt63	2,8862E-04	5,3716E-04	4,1551E-04	7,4559E-05	1,3158E-03	760
kavel2_wt64	3,1887E-04	5,5388E-04	3,9755E-04	6,8869E-05	1,3392E-03	747
kavel2_wt65	3,7227E-04	5,6347E-04	3,9569E-04	6,7880E-05	1,3993E-03	715
kavel2_wt66	4,3577E-04	6,4363E-04	4,1325E-04	6,8019E-05	1,5607E-03	641
kavel2_wt67	5,3782E-04	7,3573E-04	3,9102E-04	7,0893E-05	1,7355E-03	576
kavel2_wt68	6,2234E-04	8,5867E-04	3,7596E-04	7,0067E-05	1,9270E-03	519
kavel2_wt69	7,1433E-04	1,0196E-03	3,7532E-04	7,2258E-05	2,1815E-03	458
kavel2_wt70	8,2230E-04	1,2050E-03	3,7765E-04	7,3626E-05	2,4786E-03	403
kavel2_wt71	1,1523E-03	5,5370E-04	5,9958E-04	6,7962E-05	2,3736E-03	421
kavel2_wt72	1,3001E-03	4,7584E-04	5,5257E-04	6,5897E-05	2,3944E-03	418
kavel2_wt73	8,5967E-04	3,8115E-04	5,0015E-04	6,7492E-05	1,8085E-03	553
kavel2_wt74	7,4001E-04	3,6423E-04	5,8683E-04	6,3186E-05	1,7543E-03	570
kavel2_wt75	6,5788E-04	3,2297E-04	5,4804E-04	6,0838E-05	1,5897E-03	629
kavel2_wt76	3,2078E-03	2,9311E-04	7,0695E-04	6,3934E-05	4,2718E-03	234
kavel2_wt77	1,7749E-03	2,4741E-04	6,2811E-04	6,3623E-05	2,7140E-03	368

kavel2_wt78	8,4228E-04	2,1522E-04	5,8246E-04	6,2322E-05	1,7023E-03	587
kavel2_wt79	6,4103E-04	2,2307E-04	5,6733E-04	5,8473E-05	1,4899E-03	671
kavel2_wt80	2,5033E-03	4,1073E-04	6,8194E-04	6,4178E-05	3,6601E-03	273
kavel2_wt81	1,6264E-03	2,4954E-04	6,1749E-04	6,0383E-05	2,5539E-03	392
kavel2_wt82	6,4726E-04	2,1872E-04	5,6386E-04	5,8250E-05	1,4881E-03	672
kavel2_wt83	5,5292E-04	1,8305E-04	5,5308E-04	5,6733E-05	1,3458E-03	743
kavel2_wt84	2,6984E-04	1,5397E-04	5,3423E-04	5,5548E-05	1,0136E-03	987
kavel2_wt85	1,9590E-03	5,5995E-04	6,6328E-04	6,7411E-05	3,2496E-03	308
kavel2_wt86	1,3727E-03	3,1149E-04	6,0734E-04	6,0528E-05	2,3520E-03	425
kavel2_wt87	6,0050E-04	2,3152E-04	5,7446E-04	5,9025E-05	1,4655E-03	682
kavel2_wt88	3,9676E-04	1,8367E-04	5,4851E-04	5,4170E-05	1,1831E-03	845
kavel2_wt89	2,8912E-04	1,5613E-04	5,2761E-04	5,1841E-05	1,0247E-03	976
kavel2_wt90	1,3904E-04	1,1000E-04	5,0754E-04	4,9265E-05	8,0585E-04	1241
kavel2_wt91	1,4889E-04	9,8517E-05	4,7038E-04	4,8820E-05	7,6661E-04	1304
kavel2_wt92	2,2392E-04	1,3865E-04	4,9745E-04	5,2562E-05	9,1258E-04	1096
kavel2_wt93	1,0014E-04	9,6088E-05	4,5554E-04	4,8411E-05	7,0018E-04	1428
kavel2_wt94	1,6451E-04	1,3388E-04	4,7073E-04	5,0925E-05	8,2004E-04	1219
kavel2_wt95	9,4616E-05	9,6955E-05	4,4001E-04	4,7884E-05	6,7946E-04	1472
kavel2_wt96	1,9390E-04	1,5934E-04	4,6633E-04	5,2479E-05	8,7206E-04	1147
kavel2_wt97	1,0890E-04	9,6362E-05	4,2691E-04	4,5802E-05	6,7798E-04	1475
kavel2_wt98	1,7073E-04	1,4439E-04	4,4692E-04	5,0829E-05	8,1287E-04	1230
kavel2_wt99	9,8324E-05	9,0405E-05	4,1190E-04	4,5804E-05	6,4643E-04	1547
kavel2_wt100	1,4719E-04	1,4660E-04	4,3229E-04	4,9725E-05	7,7581E-04	1289
kavel2_wt101	6,4574E-05	9,5045E-05	4,0303E-04	4,5991E-05	6,0864E-04	1643
kavel2_wt102	8,5856E-05	1,2707E-04	4,1597E-04	4,9645E-05	6,7854E-04	1474
kavel2_wt103	2,5974E-05	8,5262E-05	3,9732E-04	4,2723E-05	5,5128E-04	1814
kavel2_wt104	3,7901E-05	1,3299E-04	4,1580E-04	4,8071E-05	6,3476E-04	1575
kavel2_wt105	1,7096E-05	8,1014E-05	3,8612E-04	4,0962E-05	5,2519E-04	1904
kavel2_wt106	2,6381E-05	1,1952E-04	4,0124E-04	4,3675E-05	5,9082E-04	1693
kavel2_wt107	1,9788E-05	1,2098E-04	3,9263E-04	4,3767E-05	5,7716E-04	1733
kavel2_wt108	1,0987E-05	6,8272E-05	3,8146E-04	3,8618E-05	4,9933E-04	2003
kavel2_wt109	1,4835E-05	1,0323E-04	3,9055E-04	4,1688E-05	5,5030E-04	1817
kavel2_wt110	6,9655E-06	6,2718E-05	3,8300E-04	3,8046E-05	4,9073E-04	2038
kavel2_wt111	5,6946E-06	5,6226E-05	3,7681E-04	3,7122E-05	4,7585E-04	2101
kavel2_wt112	8,2111E-06	7,7006E-05	3,7247E-04	3,9247E-05	4,9694E-04	2012
kavel2_wt113	1,4912E-05	1,1492E-04	3,8536E-04	4,3335E-05	5,5852E-04	1790
kavel2_wt114	2,6114E-05	1,6743E-04	4,0204E-04	4,7563E-05	6,4315E-04	1555
kavel2_wt115	5,9890E-06	5,5994E-05	3,7398E-04	3,6727E-05	4,7269E-04	2116
kavel2_wt116	9,3703E-06	7,9757E-05	3,6957E-04	3,9600E-05	4,9830E-04	2007
kavel2_wt117	1,7018E-05	1,1951E-04	3,7688E-04	4,3437E-05	5,5685E-04	1796
kavel2_wt118	2,7848E-05	1,7081E-04	3,8720E-04	4,7081E-05	6,3294E-04	1580
kavel2_wt119	6,0341E-06	6,0844E-05	3,6926E-04	3,7428E-05	4,7356E-04	2112
kavel2_wt120	9,2990E-06	8,5746E-05	3,6612E-04	4,0344E-05	5,0151E-04	1994
kavel2_wt121	1,5872E-05	1,1911E-04	3,7396E-04	4,2552E-05	5,5150E-04	1813
kavel2_wt122	3,0159E-05	1,7652E-04	3,8255E-04	4,7946E-05	6,3717E-04	1569
kavel2_wt123	6,0567E-06	5,8821E-05	3,6911E-04	3,6884E-05	4,7087E-04	2124

kavel2_wt124	9,4826E-06	8,8903E-05	3,6385E-04	3,9397E-05	5,0163E-04	1993
kavel2_wt125	1,5548E-05	1,2417E-04	3,7005E-04	4,1463E-05	5,5123E-04	1814
kavel2_wt126	3,1092E-05	1,8686E-04	3,7272E-04	4,7660E-05	6,3834E-04	1567
kavel2_wt127	7,3899E-06	5,8824E-05	3,6829E-04	3,5757E-05	4,7026E-04	2126
kavel2_wt128	1,0678E-05	8,5071E-05	3,6332E-04	3,7854E-05	4,9692E-04	2012
kavel2_wt129	1,7703E-05	1,3599E-04	3,6566E-04	4,4067E-05	5,6342E-04	1775
kavel2_wt130	3,4747E-05	1,9947E-04	3,7391E-04	4,7189E-05	6,5531E-04	1526
kavel2_wt131	1,4085E-05	9,0240E-05	3,6458E-04	4,0592E-05	5,0950E-04	1963
kavel2_wt132	2,1791E-05	1,3435E-04	3,6699E-04	4,3439E-05	5,6657E-04	1765
kavel2_wt133	4,1943E-05	2,0597E-04	3,6703E-04	4,8506E-05	6,6346E-04	1507
kavel2_wt134	1,8669E-05	8,6959E-05	3,6902E-04	3,9192E-05	5,1384E-04	1946
kavel2_wt135	3,4014E-05	1,4574E-04	3,6778E-04	4,3859E-05	5,9140E-04	1691
kavel2_wt136	6,0269E-05	2,6401E-04	3,6875E-04	4,8405E-05	7,4143E-04	1349
kavel2_wt137	1,5060E-04	5,2826E-04	3,6941E-04	5,5553E-05	1,1038E-03	906
kavel2_wt138	4,8609E-04	9,2618E-04	3,7692E-04	6,6598E-05	1,8558E-03	539
kavel2_wt139	2,5605E-05	9,2947E-05	3,7591E-04	3,9667E-05	5,3413E-04	1872
kavel2_wt140	4,7165E-05	1,6191E-04	3,7409E-04	4,3226E-05	6,2638E-04	1596
kavel2_wt141	8,1853E-05	3,5969E-04	3,7565E-04	4,9412E-05	8,6660E-04	1154
kavel2_wt142	3,8106E-05	9,4048E-05	3,7919E-04	3,7652E-05	5,4899E-04	1822
kavel2_wt143	7,8592E-05	1,9305E-04	3,8025E-04	4,4548E-05	6,9644E-04	1436
kavel2_wt144	1,2493E-04	4,2400E-04	3,7406E-04	5,0400E-05	9,7339E-04	1027
kavel2_wt145	5,3216E-05	9,2853E-05	3,8283E-04	3,7885E-05	5,6679E-04	1764
kavel2_wt146	1,3477E-04	1,8529E-04	3,8464E-04	4,1170E-05	7,4587E-04	1341
kavel2_wt147	1,9679E-04	3,6904E-04	3,7773E-04	4,8537E-05	9,9210E-04	1008
kavel2_wt148	7,5684E-05	7,9194E-05	3,8809E-04	3,7187E-05	5,8015E-04	1724
kavel2_wt149	2,0918E-04	1,3293E-04	3,9028E-04	4,1240E-05	7,7363E-04	1293
kavel2_wt150	1,0616E-04	6,8758E-05	3,9245E-04	3,7396E-05	6,0476E-04	1654
kavel2_wt151	3,1064E-04	1,0372E-04	3,9761E-04	4,1765E-05	8,5373E-04	1171
kavel2_wt152	4,8306E-04	8,2274E-05	4,0315E-04	4,1032E-05	1,0095E-03	991
kavel2_wt153	7,6857E-05	3,0683E-04	3,8391E-04	5,3060E-05	8,2065E-04	1219
kavel2_wt154	7,7231E-05	3,1620E-04	3,7053E-04	5,2986E-05	8,1695E-04	1224
kavel2_wt155	1,7141E-03	3,0800E-04	6,2658E-04	6,6471E-05	2,7152E-03	368
kavel2_wt156	1,1593E-03	3,4242E-04	5,9848E-04	6,4972E-05	2,1652E-03	462
kavel2_wt157	5,5860E-05	2,4304E-04	3,8613E-04	5,2559E-05	7,3758E-04	1356
kavel2_wt158	6,1200E-05	2,6820E-04	3,8402E-04	5,1096E-05	7,6452E-04	1308
kavel2_wt159	1,6161E-04	5,6633E-04	3,7553E-04	5,3399E-05	1,1569E-03	864
kavel2_wt160	9,2821E-06	6,3176E-05	3,6889E-04	3,6462E-05	4,7781E-04	2093
kavel2_wt161	8,8069E-06	7,9359E-05	3,8283E-04	3,9450E-05	5,1044E-04	1959
Total per year	4,5424E-02	3,0509E-02	4,7371E-02	5,6111E-03	1,2892E-01	8
This is once in … year	22	33	21	178	8	

Table A1-3 Locations and collision frequency per turbine, all traffic for Lot 3

Wind turbine	Ramming		Drifting		Total	Once in … year
	R-ships	N-ships	R-ships	N-ships		
kavel3_wt162	1,1093E-04	7,6062E-05	5,3960E-04	4,7250E-05	7,7384E-04	1292

kavel3_wt163	9,9382E-05	9,4138E-05	5,3591E-04	4,5240E-05	7,7467E-04	1291
kavel3_wt164	7,9649E-05	1,2255E-04	5,2112E-04	4,4620E-05	7,6795E-04	1302
kavel3_wt165	7,9346E-05	2,1946E-04	5,1795E-04	4,5134E-05	8,6189E-04	1160
kavel3_wt166	7,6270E-05	2,3106E-04	5,1358E-04	4,4821E-05	8,6572E-04	1155
kavel3_wt167	7,7036E-05	1,3647E-04	5,0903E-04	4,3344E-05	7,6588E-04	1306
kavel3_wt168	7,6934E-05	1,1374E-04	5,2389E-04	4,2456E-05	7,5702E-04	1321
kavel3_wt169	7,6649E-05	1,4353E-04	5,2155E-04	4,2410E-05	7,8414E-04	1275
kavel3_wt170	7,9289E-05	2,7466E-04	5,1520E-04	4,3404E-05	9,1255E-04	1096
kavel3_wt171	8,7821E-05	6,0391E-04	5,1372E-04	4,6396E-05	1,2519E-03	799
kavel3_wt172	9,2047E-05	6,3993E-04	5,2113E-04	4,7549E-05	1,3007E-03	769
kavel3_wt173	1,0248E-04	5,0162E-04	5,2728E-04	4,7147E-05	1,1785E-03	849
kavel3_wt174	1,2388E-04	3,2659E-04	5,2980E-04	4,4141E-05	1,0244E-03	976
kavel3_wt175	1,5324E-04	1,6467E-04	5,2938E-04	4,0858E-05	8,8816E-04	1126
kavel3_wt176	2,2300E-04	9,9232E-05	5,4230E-04	3,9567E-05	9,0409E-04	1106
kavel3_wt177	3,4778E-04	6,7830E-05	5,5529E-04	3,4662E-05	1,0056E-03	994
kavel3_wt178	5,4921E-04	5,3736E-05	5,7038E-04	3,2729E-05	1,2061E-03	829
kavel3_wt179	7,9718E-04	6,3491E-05	5,9668E-04	3,2473E-05	1,4898E-03	671
kavel3_wt180	1,1215E-03	7,9796E-05	6,0995E-04	3,2580E-05	1,8438E-03	542
kavel3_wt181	7,6054E-05	5,0586E-05	5,0873E-04	4,4376E-05	6,7975E-04	1471
kavel3_wt182	6,2566E-05	4,6714E-05	4,8671E-04	4,2451E-05	6,3844E-04	1566
kavel3_wt183	7,4044E-05	5,3923E-05	5,0221E-04	4,2604E-05	6,7278E-04	1486
kavel3_wt184	7,3246E-05	4,2085E-05	4,7171E-04	4,2100E-05	6,2914E-04	1589
kavel3_wt185	5,5034E-05	6,3415E-05	5,0409E-04	4,2160E-05	6,6470E-04	1504
kavel3_wt186	4,9482E-05	4,1614E-05	4,6857E-04	4,1781E-05	6,0145E-04	1663
kavel3_wt187	5,6787E-05	8,5266E-05	4,8851E-04	4,1145E-05	6,7171E-04	1489
kavel3_wt188	4,8247E-05	4,5770E-05	4,6340E-04	4,0845E-05	5,9826E-04	1672
kavel3_wt189	5,1351E-05	3,2310E-05	4,4574E-04	4,0292E-05	5,6969E-04	1755
kavel3_wt190	6,8778E-05	3,5862E-05	4,3762E-04	3,9564E-05	5,8182E-04	1719
kavel3_wt191	7,5333E-05	4,2233E-05	4,3138E-04	3,9911E-05	5,8886E-04	1698
kavel3_wt192	4,9398E-05	7,9576E-05	4,8040E-04	4,1675E-05	6,5105E-04	1536
kavel3_wt193	4,1201E-05	4,2960E-05	4,5059E-04	3,9645E-05	5,7440E-04	1741
kavel3_wt194	4,1516E-05	3,4605E-05	4,3093E-04	3,7627E-05	5,4467E-04	1836
kavel3_wt195	4,7416E-05	3,2788E-05	4,3060E-04	3,8963E-05	5,4977E-04	1819
kavel3_wt196	4,4544E-05	6,1848E-05	4,7574E-04	4,0576E-05	6,2271E-04	1606
kavel3_wt197	3,3294E-05	3,8512E-05	4,4428E-04	3,8825E-05	5,5491E-04	1802
kavel3_wt198	3,1468E-05	3,3347E-05	4,2412E-04	3,6480E-05	5,2541E-04	1903
kavel3_wt199	3,4237E-05	3,4920E-05	4,1677E-04	3,6436E-05	5,2237E-04	1914
kavel3_wt200	4,1110E-05	3,7442E-05	4,1146E-04	3,9145E-05	5,2915E-04	1890
kavel3_wt201	7,2667E-05	3,8603E-05	4,3855E-04	4,0383E-05	5,9021E-04	1694
kavel3_wt202	8,0048E-05	4,4924E-05	4,3882E-04	4,0916E-05	6,0471E-04	1654
kavel3_wt203	8,1836E-05	5,2193E-05	4,4342E-04	4,2730E-05	6,2018E-04	1612
kavel3_wt204	1,1437E-04	4,1343E-05	4,4339E-04	4,1254E-05	6,4036E-04	1562
kavel3_wt205	1,2687E-04	6,6884E-05	4,7080E-04	4,4737E-05	7,0930E-04	1410
kavel3_wt206	4,4056E-05	5,7322E-05	4,6206E-04	4,3767E-05	6,0721E-04	1647
kavel3_wt207	1,6055E-04	8,9937E-05	5,1011E-04	4,8727E-05	8,0933E-04	1236
kavel3_wt208	5,1136E-05	7,3165E-05	4,9352E-04	4,5708E-05	6,6353E-04	1507

kavel3_wt209	1,1277E-04	6,9531E-05	4,7926E-04	4,5515E-05	7,0708E-04	1414
kavel3_wt210	2,3048E-04	8,4921E-05	5,0340E-04	4,7826E-05	8,6663E-04	1154
kavel3_wt211	2,2193E-04	1,0034E-04	5,0336E-04	4,9846E-05	8,7548E-04	1142
kavel3_wt212	8,5517E-05	1,3607E-04	5,3529E-04	5,1106E-05	8,0798E-04	1238
kavel3_wt213	2,8457E-04	2,0732E-04	5,2261E-04	5,3447E-05	1,0680E-03	936
kavel3_wt214	4,2403E-04	2,0641E-04	5,1819E-04	5,5522E-05	1,2042E-03	830
kavel3_wt215	1,9209E-04	3,2788E-04	5,6063E-04	6,0341E-05	1,1409E-03	876
kavel3_wt216	7,6740E-04	3,0192E-04	5,5678E-04	6,0401E-05	1,6865E-03	593
kavel3_wt217	9,1064E-04	5,0302E-04	6,1561E-04	6,4018E-05	2,0933E-03	478
kavel3_wt218	4,1766E-05	7,4075E-05	4,8081E-04	3,9772E-05	6,3643E-04	1571
avel3_wt219	2,7324E-05	3,6013E-05	4,4779E-04	3,7450E-05	5,4858E-04	1823
kavel3_wt220	2,3504E-05	3,1339E-05	4,2095E-04	3,5966E-05	5,1176E-04	1954
kavel3_wt221	2,3373E-05	3,3593E-05	4,0919E-04	3,8474E-05	5,0463E-04	1982
kavel3_wt222	2,6535E-05	3,8531E-05	4,0702E-04	3,8206E-05	5,1029E-04	1960
kavel3_wt223	4,0471E-05	7,2608E-05	4,9139E-04	3,8944E-05	6,4341E-04	1554
kavel3_wt224	2,2568E-05	5,3084E-05	4,6715E-04	3,6881E-05	5,7968E-04	1725
kavel3_wt225	1,5597E-05	3,3419E-05	4,3102E-04	3,7071E-05	5,1710E-04	1934
kavel3_wt226	1,2795E-05	3,2547E-05	4,0782E-04	3,7360E-05	4,9052E-04	2039
kavel3_wt227	4,3250E-05	1,5589E-04	4,8437E-04	3,9942E-05	7,2345E-04	1382
kavel3_wt228	2,4388E-05	5,5972E-05	4,5904E-04	3,7937E-05	5,7734E-04	1732
kavel3_wt229	1,4138E-05	4,2190E-05	4,4560E-04	3,7075E-05	5,3900E-04	1855
kavel3_wt230	1,0590E-05	3,4864E-05	4,1499E-04	3,7130E-05	4,9758E-04	2010
kavel3_wt231	2,5702E-05	9,2062E-05	4,5128E-04	3,8363E-05	6,0741E-04	1646
kavel3_wt232	1,3921E-05	4,5446E-05	4,3202E-04	3,7017E-05	5,2841E-04	1892
kavel3_wt233	9,5776E-06	3,6096E-05	4,1040E-04	3,7098E-05	4,9318E-04	2028
kavel3_wt234	7,5875E-06	4,5606E-05	3,9504E-04	3,7538E-05	4,8577E-04	2059
kavel3_wt235	4,8348E-05	3,1802E-04	4,8508E-04	4,2459E-05	8,9390E-04	1119
kavel3_wt236	2,7180E-05	1,0140E-04	4,5496E-04	3,7846E-05	6,2138E-04	1609
kavel3_wt237	1,5319E-05	4,7404E-05	4,3358E-04	3,6456E-05	5,3276E-04	1877
kavel3_wt238	9,2812E-06	3,5242E-05	4,1044E-04	3,6318E-05	4,9128E-04	2036
kavel3_wt239	5,8840E-06	4,0591E-05	3,8837E-04	3,6744E-05	4,7159E-04	2121
kavel3_wt240	5,2890E-05	2,1148E-04	4,9053E-04	4,0578E-05	7,9548E-04	1257
kavel3_wt241	3,0854E-05	7,8274E-05	4,5935E-04	3,6254E-05	6,0473E-04	1654
kavel3_wt242	1,8102E-05	4,4599E-05	4,3222E-04	3,5339E-05	5,3026E-04	1886
kavel3_wt243	1,0873E-05	3,6276E-05	4,0793E-04	3,5269E-05	4,9035E-04	2039
kavel3_wt244	5,6842E-06	4,3834E-05	3,8491E-04	3,5660E-05	4,7009E-04	2127
kavel3_wt245	6,2522E-05	1,1738E-04	4,8950E-04	3,8723E-05	7,0813E-04	1412
kavel3_wt246	2,1459E-05	3,7698E-05	4,3656E-04	3,4259E-05	5,2998E-04	1887
kavel3_wt247	1,3336E-05	3,3503E-05	4,1038E-04	3,3914E-05	4,9113E-04	2036
kavel3_wt248	6,6351E-06	4,2859E-05	3,7996E-04	3,5502E-05	4,6496E-04	2151
kavel3_wt249	8,4835E-05	7,4831E-05	4,9574E-04	3,7808E-05	6,9321E-04	1443
kavel3_wt250	2,5549E-05	3,3622E-05	4,3217E-04	3,3794E-05	5,2513E-04	1904
kavel3_wt251	1,5149E-05	3,1743E-05	4,1105E-04	3,3833E-05	4,9178E-04	2033
kavel3_wt252	7,5989E-06	4,0149E-05	3,7999E-04	3,5643E-05	4,6338E-04	2158
kavel3_wt253	1,1504E-04	5,7117E-05	4,9755E-04	3,6283E-05	7,0599E-04	1416
kavel3_wt254	6,1791E-05	3,5390E-05	4,7038E-04	3,4602E-05	6,0216E-04	1661

kavel3_wt255	1,6197E-05	3,0851E-05	4,1432E-04	3,3368E-05	4,9473E-04	2021
kavel3_wt256	8,9369E-06	4,0832E-05	3,8251E-04	3,4584E-05	4,6687E-04	2142
kavel3_wt257	1,0387E-05	4,1981E-05	3,8477E-04	3,4622E-05	4,7176E-04	2120
kavel3_wt258	1,6548E-05	3,1802E-05	4,0839E-04	3,3488E-05	4,9023E-04	2040
kavel3_wt259	1,1076E-05	3,9630E-05	3,8537E-04	3,4094E-05	4,7017E-04	2127
kavel3_wt260	1,8772E-05	3,1083E-05	4,0925E-04	3,3485E-05	4,9259E-04	2030
kavel3_wt261	7,3317E-05	3,3175E-05	4,7636E-04	3,3002E-05	6,1585E-04	1624
kavel3_wt262	1,6627E-04	4,4721E-05	5,1399E-04	3,4506E-05	7,5949E-04	1317
kavel3_wt263	2,2324E-04	3,8358E-05	5,2142E-04	3,0997E-05	8,1401E-04	1228
kavel3_wt264	9,0869E-05	3,0506E-05	4,8387E-04	3,0927E-05	6,3617E-04	1572
kavel3_wt265	2,8280E-04	3,7019E-05	5,3766E-04	3,1872E-05	8,8935E-04	1124
kavel3_wt266	1,1284E-04	2,9567E-05	4,9105E-04	3,0467E-05	6,6392E-04	1506
kavel3_wt267	3,3958E-04	4,3110E-05	5,4091E-04	3,0845E-05	9,5445E-04	1048
kavel3_wt268	1,2307E-04	3,0557E-05	4,9062E-04	3,0552E-05	6,7480E-04	1482
kavel3_wt269	5,6317E-05	2,6652E-05	4,5567E-04	3,0262E-05	5,6890E-04	1758
kavel3_wt270	7,1416E-04	7,7758E-05	5,8622E-04	3,2246E-05	1,4104E-03	709
kavel3_wt271	6,9176E-05	2,7594E-05	4,6456E-04	2,9711E-05	5,9104E-04	1692
kavel3_wt272	2,1223E-04	3,7445E-05	5,1930E-04	3,0979E-05	7,9996E-04	1250
kavel3_wt273	1,4976E-04	3,5821E-05	5,0710E-04	2,9725E-05	7,2241E-04	1384
kavel3_wt274	6,5437E-05	2,6194E-05	4,5913E-04	2,9201E-05	5,7996E-04	1724
kavel3_wt275	1,4040E-05	3,7043E-05	3,9423E-04	3,2273E-05	4,7758E-04	2094
kavel3_wt276	1,2984E-05	3,8433E-05	3,9469E-04	3,2255E-05	4,7837E-04	2090
kavel3_wt277	1,5709E-05	3,3140E-05	4,0403E-04	3,2880E-05	4,8576E-04	2059
kavel3_wt278	3,2462E-05	6,1668E-05	4,9783E-04	4,4687E-05	6,3665E-04	1571
Total per year	1,3227E-02	1,0630E-02	5,5193E-02	4,5902E-03	8,3640E-02	12
This is once in … year	76	94	18	218	12	

Table A1-4 Total collisions (ramming and drifting) of all traffic

PEZ Lot 1						
Ships type	Ramming		Drifting		Total	
	Times per year	Once in … year	Times per year	Once in … year	Time per year	Once in … year
R-ships	0,01614	62	0,02744	36	0,04358	23
N-ships	0,00490	204	0,00196	511	0,00686	146
Total	0,02104	48	0,02940	34	0,05044	20

PEZ Lot 2						
Ships type	Ramming		Drifting		Total	
	Times per year	Once in … year	Times per year	Once in … year	Time per year	Once in … year
R-ships	0,04542	22	0,04737	21	0,09280	11
N-ships	0,03051	33	0,00561	178	0,03612	28
Total	0,07593	13	0,05298	19	0,12892	8

PEZ Lot 3

Ships type	Ramming		Drifting		Total	
	Times per year	Once in … year	Times per year	Once in … year	Time per year	Once in … year
R-ships	0,01323	76	0,05519	18	0,06842	15
N-ships	0,01063	94	0,00459	218	0,01522	66
Total	0,02386	42	0,05978	17	0,08364	12

Table A1-5 Probability of a particular type of damage caused by the different ship types

	PEZ - Lot 1			
Ships type	Damage type			Total
	NosMos	Damage to ship's hull	No damage	
Oil	1,4258E-04	5,4439E-03	1,1256E-06	5,5876E-03
Chemicals	2,8308E-05	5,9439E-03	7,3909E-06	5,9796E-03
Gas	5,4978E-05	1,9994E-03	0,0000E+00	2,0544E-03
Container+ RoRo	1,2408E-03	1,9054E-02	5,9307E-07	2,0295E-02
Ferry	1,0919E-05	2,5786E-04	5,3454E-05	3,2223E-04
Other R-ships	1,3075E-04	9,0297E-03	1,7967E-04	9,3402E-03
N-ships	2,0312E-04	3,3209E-03	3,3384E-03	6,8625E-03
All ships	1,8115E-03	4,5049E-02	3,5806E-03	5,0442E-02

	PEZ - Lot 2			
Ships type	Damage type			Total
	NosMos	Damage to ship's hull	No damage	
Oil	1,7160E-04	7,2230E-03	5,9733E-06	7,4006E-03
Chemicals	1,8676E-04	1,2367E-02	7,5665E-06	1,2561E-02
Gas	2,2770E-04	5,1786E-03	0,0000E+00	5,4063E-03
Container+ RoRo	3,6226E-03	4,7195E-02	5,9030E-07	5,0818E-02
Ferry	3,3638E-05	6,3924E-04	8,1422E-05	7,5430E-04
Other R-ships	2,6823E-04	1,5274E-02	3,1355E-04	1,5856E-02
N-ships	2,4338E-03	2,7123E-02	6,5633E-03	3,6120E-02
All ships	6,9443E-03	1,1500E-01	6,9724E-03	1,2892E-01

	PEZ - Lot 3			
Ships type	Damage type			Total
	NosMos	Damage to ship's hull	No damage	
Oil	7,5806E-05	8,6745E-03	4,4925E-06	8,7548E-03

Chemicals	1,5245E-05	1,2436E-02	1,0694E-05	1,2462E-02
Gas	4,4026E-05	3,6149E-03	0,0000E+00	3,6589E-03
Container+ RoRo	1,1081E-03	2,4255E-02	9,7027E-07	2,5364E-02
Ferry	8,3570E-06	4,2096E-04	6,5614E-05	4,9493E-04
Other R-ships	6,9545E-05	1,7244E-02	3,7282E-04	1,7686E-02
N-ships	6,1988E-04	8,6462E-03	5,9539E-03	1,5220E-02
All ships	1,9410E-03	7,5291E-02	6,4084E-03	8,3640E-02

Table A1- 6 Damage to the wind park

PEZ Lot 1										
Damage to turbine	Ramming				Drifting		Total		Number per year	Once in … year
	frontal		Scrape							
	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships		
None	0,00E+00	1,12E-04	1,19E-08	1,53E-03	2,42E-04	1,70E-03	2,42E-04	3,34E-03	3,58E-03	279
Skewed	1,32E-09	5,82E-05	0,00E+00	9,16E-04	8,10E-03	1,38E-04	8,10E-03	1,11E-03	9,21E-03	109
Topples	1,45E-03	2,93E-04	1,31E-02	1,79E-03	1,91E-02	1,24E-04	3,36E-02	2,21E-03	3,58E-02	28
NosMos[1]	1,61E-04	2,70E-05	1,45E-03	1,76E-04	0,00E+00	0,00E+00	1,61E-03	2,03E-04	1,81E-03	552
Total	1,61E-03	4,90E-04	1,45E-02	4,41E-03	2,74E-02	1,96E-03	4,36E-02	6,86E-03	5,04E-02	20

PEZ Lot 2										
Damage to turbine	Ramming				Drifting		Total		Number per year	Once in … year
	frontal		Scrape							
	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships		
None	0,00E+00	1,84E-04	1,53E-07	2,43E-03	4,09E-04	3,95E-03	4,09E-04	6,56E-03	6,97E-03	143
Skewed	1,70E-08	8,55E-05	0,00E+00	2,11E-03	1,41E-02	7,62E-04	1,41E-02	2,96E-03	1,71E-02	59
Topples	4,09E-03	2,51E-03	3,68E-02	2,08E-02	3,28E-02	8,97E-04	7,38E-02	2,42E-02	9,79E-02	10
NosMos1	4,54E-04	2,66E-04	4,06E-03	2,17E-03	0,00E+00	0,00E+00	4,51E-03	2,43E-03	6,94E-03	144
Total	4,54E-03	3,05E-03	4,09E-02	2,75E-02	4,74E-02	5,61E-03	9,28E-02	3,61E-02	1,29E-01	8

PEZ Lot 3										
Damage to turbine	Ramming				Drifting		Total		Number per year	Once in … year
	frontal		Scrape							
	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships		
None	0,00E+00	2,26E-04	5,24E-10	2,39E-03	4,55E-04	3,34E-03	4,55E-04	5,95E-03	6,41E-03	156
Skewed	5,82E-11	3,94E-05	0,00E+00	8,45E-04	1,74E-02	5,99E-04	1,74E-02	1,48E-03	1,89E-02	53
Topples	1,19E-03	7,23E-04	1,07E-02	5,79E-03	3,73E-02	6,52E-04	4,93E-02	7,16E-03	5,64E-02	18
NosMos1	1,32E-04	7,51E-05	1,19E-03	5,45E-04	0,00E+00	0,00E+00	1,32E-03	6,20E-04	1,94E-03	515

Total	1,32E-03	1,06E-03	1,19E-02	9,57E-03	5,52E-02	4,59E-03	6,84E-02	1,52E-02	8,36E-02	12

Table A1-7 Risk of fatality in the event of a collision with a wind turbine where the mast and nacelle falls on the ship

PEZ Lot 1					
Ships type	Collision type Number per year		Combined once in …year	Direct fatalities	
	Frontal	Scrape		Average number of fatalities at a time	Average number of fatalities per year
Oil	1,4265E-05	1,2832E-04	7013	1,5104	0,000215
Chemicals	2,9108E-06	2,5397E-05	35326	1,6776	0,000047
Gas	5,5375E-06	4,9440E-05	18189	1,4390	0,000079
Container + RoRo	1,2429E-04	1,1166E-03	806	10,0505	0,012471
Ferry	1,0923E-06	9,8263E-06	91587	98,3165	0,001073
Other R-ships	1,3247E-05	1,1751E-04	7648	1,5620	0,000204
N-ships	2,6953E-05	1,7617E-04	4923	0,1153	0,000023
Total	1,8829E-04	1,6232E-03	552	7,7915	0,014114

PEX Lot 2					
Ships type	Collision type Number per year		Combined once in …year	Direct fatalities	
	Frontal	Scrape		Average number of fatalities at a time	Average number of fatalities per year
Oil	1,7204E-05	1,5440E-04	5828	1,6266	0,000279
Chemicals	1,9565E-05	1,6719E-04	5355	1,6616	0,000310
Gas	2,3180E-05	2,0452E-04	4392	1,4791	0,000337
Container + RoRo	3,6299E-04	3,2596E-03	276	3,8251	0,013857
Ferry	3,3721E-06	3,0266E-05	29728	84,6361	0,002847
Other R-ships	2,7920E-05	2,4031E-04	3728	1,6417	0,000440
N-ships	2,6639E-04	2,1674E-03	411	0,0582	0,000142
Total	7,2062E-04	6,2237E-03	144	2,6226	0,018212

PEZ Lot 3					
Ships type	Collision type Number per year		Combined once in …year	Direct fatalities	
	Frontal	Scrape		Average number of fatalities at a time	Average number of fatalities per year

Oil	7,5827E-06	6,8223E-05	13192	1,5079	0,000114
Chemicals	1,5592E-06	1,3685E-05	65597	1,6820	0,000026
Gas	4,4153E-06	3,9611E-05	22714	1,4380	0,000063
Container + RoRo	1,1085E-04	9,9727E-04	902	7,5241	0,008338
Ferry	8,3589E-07	7,5211E-06	119660	99,0035	0,000827
Other R-ships	7,0183E-06	6,2527E-05	14379	1,5592	0,000108
N-ships	7,5063E-05	5,4482E-04	1613	0,1572	0,000097
Total	2,0733E-04	1,7337E-03	515	4,9326	0,009574

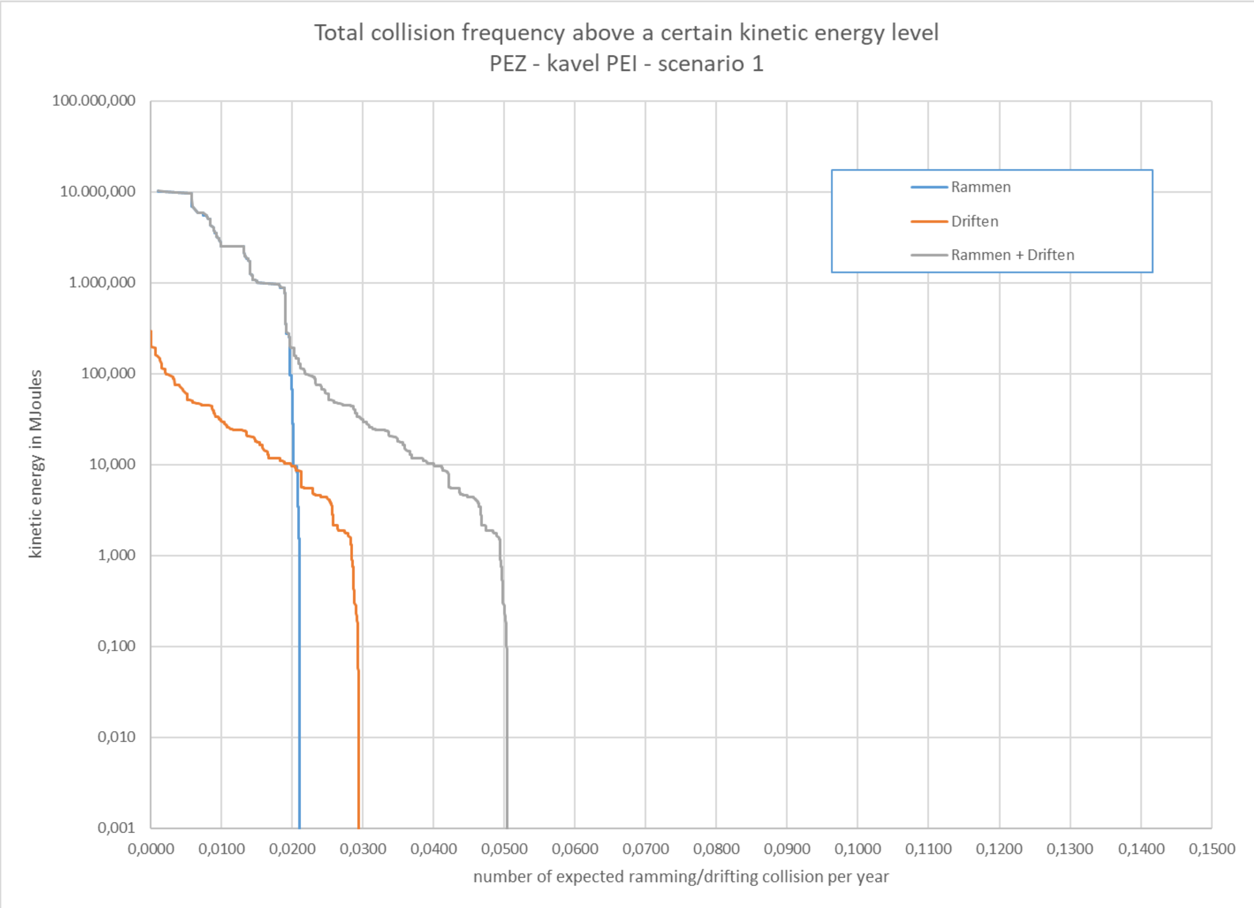

Figure A1-1 Total collision frequency above a certain kinetic energy level - PEZ Lot 1

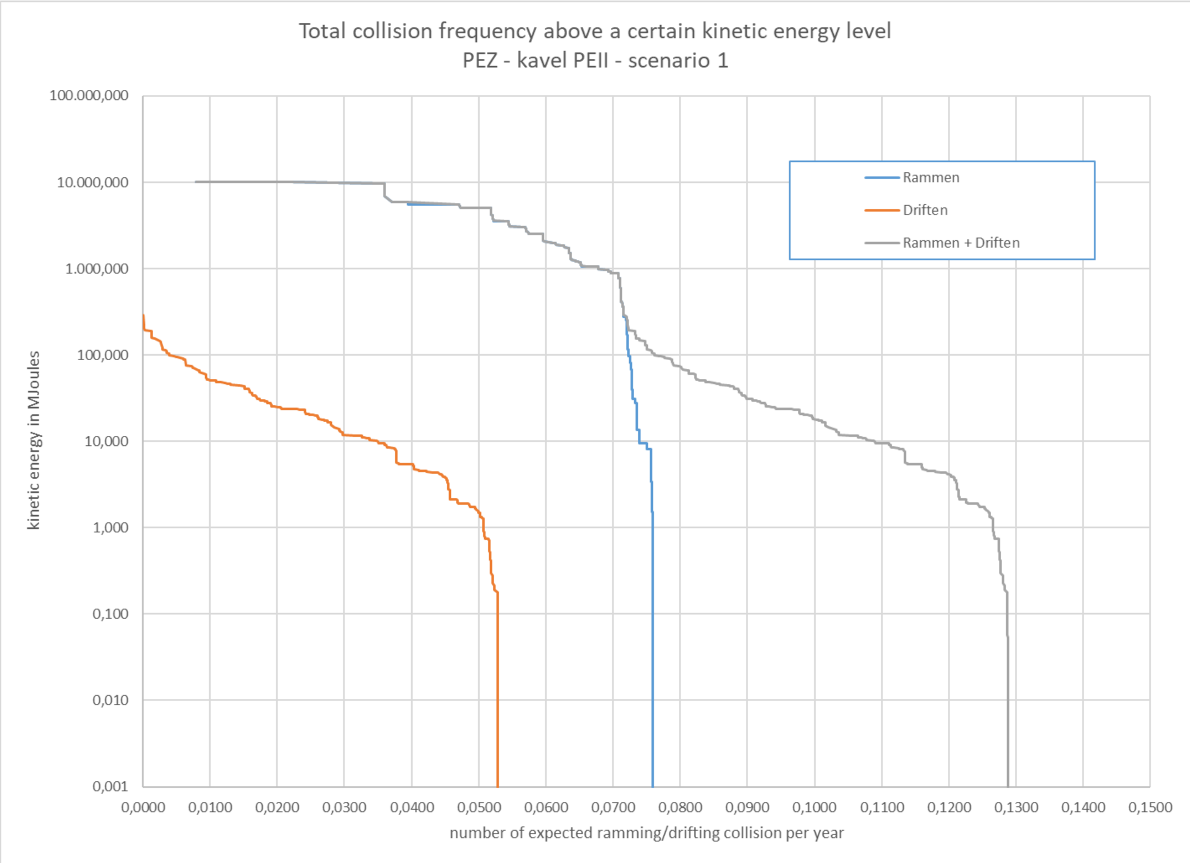

Figure A1-2 Total collision frequency above a certain kinetic energy level - PEZ Lot 2

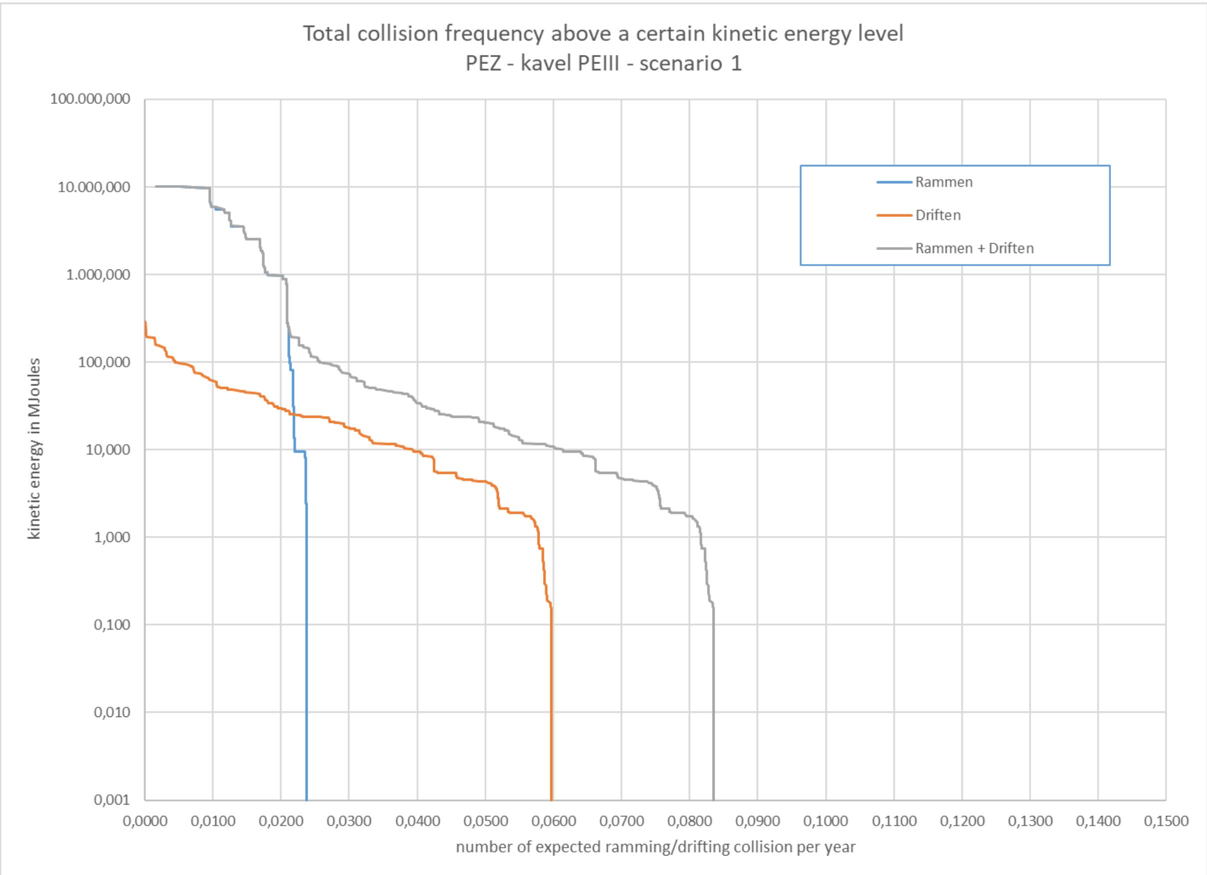

Figure A1-3 Total collision frequency above a certain kinetic energy level - PEZ Lot 3

Table A1- 8 Distribution of collision chances between ship type and energy class for all wind turbines

PEZ Lot 1									
Kinetic energy in MJ	Ramming			Drifting			Total		
	R-ships	N-ships	Total	R-ships	N-ships	Total	R-ships	N-ships	Total
<1	0,0%	0,0%	0,0%	0,2%	1,7%	1,9%	0,2%	1,8%	1,9%
1-3	0,0%	0,1%	0,1%	4,6%	0,9%	5,4%	4,6%	1,0%	5,6%
3-5	0,0%	0,3%	0,3%	5,2%	0,4%	5,5%	5,2%	0,7%	5,8%
5-10	0,0%	1,2%	1,2%	6,0%	0,2%	6,2%	6,0%	1,4%	7,4%
10-15	0,0%	0,1%	0,1%	7,7%	0,2%	7,9%	7,7%	0,3%	8,0%
15-50	0,0%	0,3%	0,3%	19,3%	0,3%	19,5%	19,3%	0,5%	19,8%
50-100	0,0%	0,6%	0,6%	7,5%	0,1%	7,6%	7,5%	0,7%	8,2%
100-200	0,0%	0,1%	0,2%	3,9%	0,1%	4,0%	3,9%	0,2%	4,2%
>200	31,9%	6,9%	38,9%	0,2%	0,0%	0,2%	32,1%	7,0%	39,1%
Total	32,0%	9,7%	41,7%	54,4%	3,9%	58,3%	86,4%	13,6%	100,0%

PEZ Lot 2									
Kinetic energy in MJ	Ramming			Drifting			Total		
	R-ships	N-ships	Total	R-ships	N-ships	Total	R-ships	N-ships	Total
<1	0,0%	0,0%	0,0%	0,1%	1,6%	1,8%	0,1%	1,7%	1,8%
1-3	0,0%	0,1%	0,1%	3,2%	0,9%	4,1%	3,2%	1,0%	4,2%
3-5	0,0%	0,0%	0,0%	3,7%	0,3%	4,0%	3,7%	0,4%	4,1%
5-10	0,0%	1,3%	1,3%	4,0%	0,2%	4,2%	4,0%	1,5%	5,6%
10-15	0,0%	0,3%	0,3%	5,1%	0,3%	5,3%	5,1%	0,6%	5,6%
15-50	0,0%	0,6%	0,6%	12,8%	0,4%	13,2%	12,8%	1,0%	13,8%
50-100	0,0%	0,4%	0,5%	5,2%	0,3%	5,5%	5,2%	0,7%	5,9%
100-200	0,1%	0,0%	0,1%	2,6%	0,3%	2,9%	2,7%	0,3%	3,0%
>200	35,1%	20,8%	55,9%	0,1%	0,0%	0,1%	35,2%	20,9%	56,0%
Total	35,2%	23,7%	58,9%	36,7%	4,4%	41,1%	72,0%	28,0%	100,0%

PEZ Lot 3									
Kinetic energy in MJ	Ramming			Drifting			Total		
	R-ships	N-ships	Total	R-ships	N-ships	Total	R-ships	N-ships	Total
<1	0,0%	0,0%	0,0%	0,2%	2,2%	2,4%	0,2%	2,2%	2,4%
1-3	0,0%	0,2%	0,2%	6,1%	1,1%	7,1%	6,1%	1,2%	7,3%
3-5	0,0%	0,0%	0,0%	6,9%	0,4%	7,3%	6,9%	0,4%	7,3%
5-10	0,0%	1,9%	1,9%	7,6%	0,3%	7,9%	7,6%	2,1%	9,7%
10-15	0,0%	0,1%	0,1%	8,9%	0,3%	9,2%	8,9%	0,5%	9,4%
15-50	0,0%	0,3%	0,3%	22,5%	0,6%	23,0%	22,5%	0,8%	23,3%
50-100	0,0%	0,6%	0,6%	9,0%	0,3%	9,3%	9,0%	0,9%	9,9%
100-200	0,0%	0,1%	0,1%	4,7%	0,3%	5,1%	4,7%	0,4%	5,1%
>200	15,8%	9,5%	25,3%	0,2%	0,1%	0,3%	16,0%	9,5%	25,6%
Total	15,8%	12,7%	28,5%	66,0%	5,5%	71,5%	81,8%	18,2%	100,0%

APPENDIX 2 RESULTS WINDPARK PEZ SCENARIO 2

Table A2-9 Locations and collision frequency per turbine, all traffic for Lot1

Wind turbine	Ramming		Drifting		Total	Once in … year
	R-ships	N-ships	R-ships	N-ships		
kavel1_wt1	1,9373E-03	9,2038E-05	6,8378E-04	3,4139E-05	2,7473E-03	364
kavel1_wt2	9,4990E-04	1,6455E-04	6,6618E-04	3,5001E-05	1,8156E-03	551
kavel1_wt3	6,4576E-04	2,5917E-04	6,5689E-04	3,8140E-05	1,6000E-03	625
kavel1_wt4	5,8169E-04	1,9092E-04	6,4181E-04	3,8933E-05	1,4534E-03	688
kavel1_wt5	6,2034E-04	2,8920E-04	6,1561E-04	4,6850E-05	1,5720E-03	636
kavel1_wt6	5,8374E-04	1,6288E-04	6,2758E-04	4,7954E-05	1,4222E-03	703
kavel1_wt7	4,2074E-04	5,3130E-05	5,7951E-04	3,3163E-05	1,0865E-03	920
kavel1_wt8	3,8566E-04	7,2968E-05	5,8127E-04	3,4492E-05	1,0744E-03	931
kavel1_wt9	2,4260E-04	9,7479E-05	5,3904E-04	4,1478E-05	9,2060E-04	1086
kavel1_wt10	2,5552E-04	9,7810E-05	5,3956E-04	4,4599E-05	9,3749E-04	1067
kavel1_wt11	3,1894E-04	1,7021E-04	5,4670E-04	4,7619E-05	1,0835E-03	923
kavel1_wt12	4,8161E-04	4,3679E-04	5,5730E-04	5,1814E-05	1,5275E-03	655
kavel1_wt13	1,1528E-04	3,1985E-05	5,0289E-04	3,3715E-05	6,8387E-04	1462
kavel1_wt14	1,1512E-04	3,3451E-05	5,1250E-04	3,4044E-05	6,9512E-04	1439
kavel1_wt15	1,1774E-04	3,2265E-05	5,0204E-04	3,4083E-05	6,8612E-04	1457
kavel1_wt16	1,0030E-04	3,4208E-05	4,9419E-04	3,6714E-05	6,6541E-04	1503
kavel1_wt17	1,0166E-04	4,7984E-05	4,9482E-04	3,8305E-05	6,8277E-04	1465
kavel1_wt18	1,2060E-04	8,0267E-05	4,9240E-04	4,1433E-05	7,3470E-04	1361
kavel1_wt19	1,7543E-04	1,6639E-04	5,0072E-04	4,4495E-05	8,8703E-04	1127
kavel1_wt20	7,7077E-05	2,8285E-05	4,6595E-04	3,4271E-05	6,0558E-04	1651
kavel1_wt21	1,3886E-04	3,3224E-05	4,6660E-04	3,5874E-05	6,7455E-04	1482
kavel1_wt22	1,0087E-04	4,4337E-05	4,5900E-04	3,7434E-05	6,4164E-04	1559
kavel1_wt23	7,9545E-05	7,5887E-05	4,5924E-04	4,0193E-05	6,5487E-04	1527
kavel1_wt24	1,1403E-04	1,7863E-04	4,6207E-04	4,4065E-05	7,9880E-04	1252
kavel1_wt25	4,1981E-04	5,1075E-05	4,5119E-04	3,7756E-05	9,5984E-04	1042
kavel1_wt26	2,1485E-04	8,9150E-05	4,3749E-04	3,9573E-05	7,8106E-04	1280
kavel1_wt27	2,2440E-03	1,1238E-04	4,6793E-04	4,1694E-05	2,8660E-03	349
kavel1_wt28	3,0877E-04	4,1140E-04	5,0921E-04	4,9978E-05	1,2794E-03	782
kavel1_wt29	1,5616E-04	3,5686E-05	4,4771E-04	3,6352E-05	6,7591E-04	1479
kavel1_wt30	1,0464E-04	1,7229E-04	4,3956E-04	4,3238E-05	7,5972E-04	1316
kavel1_wt31	6,0115E-04	1,5572E-04	6,1569E-04	4,6936E-05	1,4195E-03	704
kavel1_wt32	1,6885E-04	5,7857E-05	5,2442E-04	3,7948E-05	7,8908E-04	1267
Total per year	1,2998E-02	3,9596E-03	1,6941E-02	1,2823E-03	3,5181E-02	28
This is once in … year	77	253	59	780	28	

Table A2-10 Locations and collision frequency per turbine, all traffic for lot 2

Wind turbine	Ramming		Drifting		Total	Once in … year
	R-ships	N-ships	R-ships	N-ships		
kavel2_wt33	3,5527E-03	1,7440E-03	7,2584E-04	9,4298E-05	6,1168E-03	163
kavel2_wt34	3,2361E-03	1,0957E-03	6,6017E-04	8,5727E-05	5,0777E-03	197
kavel2_wt35	1,8101E-03	7,7505E-04	5,9033E-04	8,1521E-05	3,2570E-03	307
kavel2_wt36	6,6792E-04	6,7362E-04	5,2479E-04	8,2960E-05	1,9493E-03	513
kavel2_wt37	3,8015E-04	7,4839E-04	4,7429E-04	8,0653E-05	1,6835E-03	594
kavel2_wt38	2,9898E-04	7,6953E-04	4,4306E-04	7,8595E-05	1,5902E-03	629
kavel2_wt39	3,2424E-04	5,9898E-04	4,2313E-04	7,6136E-05	1,4225E-03	703
kavel2_wt40	3,6943E-04	5,9801E-04	4,0870E-04	7,2482E-05	1,4486E-03	690
kavel2_wt41	4,8024E-04	7,0290E-04	4,2695E-04	7,3589E-05	1,6837E-03	594
kavel2_wt42	5,9180E-04	8,3280E-04	3,9481E-04	7,4246E-05	1,8937E-03	528
kavel2_wt43	7,4581E-04	1,0625E-03	3,8754E-04	7,6584E-05	2,2725E-03	440
kavel2_wt44	9,1736E-04	1,4214E-03	3,9146E-04	7,8944E-05	2,8092E-03	356
kavel2_wt45	1,1660E-03	4,8204E-04	5,8636E-04	6,8459E-05	2,3029E-03	434
kavel2_wt46	2,9755E-03	3,2487E-04	6,8116E-04	7,0952E-05	4,0525E-03	247
kavel2_wt47	8,8886E-04	2,8250E-04	5,9784E-04	6,5896E-05	1,8351E-03	545
kavel2_wt48	1,6041E-03	4,0673E-04	6,4631E-04	6,7798E-05	2,7250E-03	367
kavel2_wt49	3,1082E-03	3,3633E-04	7,2645E-04	6,8472E-05	4,2395E-03	236
kavel2_wt50	9,4576E-04	2,5870E-04	5,8447E-04	6,3407E-05	1,8523E-03	540
kavel2_wt51	4,1951E-04	1,8877E-04	5,6117E-04	5,9641E-05	1,2291E-03	814
kavel2_wt52	3,4456E-04	1,8659E-04	5,4625E-04	5,9914E-05	1,1373E-03	879
kavel2_wt53	1,6761E-04	1,0808E-04	4,8413E-04	5,2234E-05	8,1206E-04	1231
kavel2_wt54	2,0046E-04	1,6055E-04	4,6743E-04	5,4833E-05	8,8327E-04	1132
kavel2_wt55	1,0980E-04	1,0565E-04	4,2557E-04	4,9566E-05	6,9059E-04	1448
kavel2_wt56	6,6016E-05	1,4065E-04	4,3253E-04	5,3297E-05	6,9249E-04	1444
kavel2_wt57	2,0067E-05	9,4750E-05	4,0083E-04	4,4162E-05	5,5981E-04	1786
kavel2_wt58	2,0484E-05	1,3481E-04	4,0334E-04	4,6927E-05	6,0556E-04	1651
kavel2_wt59	1,1165E-05	7,8068E-05	3,9635E-04	4,1895E-05	5,2748E-04	1896
kavel2_wt60	1,7433E-05	1,4043E-04	4,1358E-04	4,7201E-05	6,1864E-04	1616
kavel2_wt61	1,0034E-05	9,6776E-05	3,9523E-04	4,3617E-05	5,4566E-04	1833
kavel2_wt62	6,3417E-06	5,8535E-05	3,9355E-04	3,9885E-05	4,9831E-04	2007
kavel2_wt63	6,2384E-06	5,9029E-05	3,8528E-04	3,9299E-05	4,8984E-04	2041
kavel2_wt64	1,0973E-05	9,0561E-05	3,8339E-04	4,2897E-05	5,2782E-04	1895
kavel2_wt65	2,4342E-05	1,6110E-04	3,9851E-04	4,8967E-05	6,3292E-04	1580
kavel2_wt66	4,7599E-05	2,4468E-04	4,1343E-04	5,3284E-05	7,5899E-04	1318
kavel2_wt67	6,5822E-05	2,8537E-04	4,0002E-04	5,6395E-05	8,0760E-04	1238
kavel2_wt68	6,2734E-06	6,4029E-05	3,8345E-04	4,0712E-05	4,9447E-04	2022
kavel2_wt69	1,1732E-05	1,0168E-04	3,8022E-04	4,3984E-05	5,3762E-04	1860
kavel2_wt70	2,4735E-05	1,6420E-04	3,9128E-04	4,7148E-05	6,2736E-04	1594
kavel2_wt71	9,1992E-05	3,6114E-04	3,9526E-04	5,7948E-05	9,0634E-04	1103
kavel2_wt72	7,8763E-06	5,9380E-05	3,8572E-04	3,8541E-05	4,9151E-04	2035
kavel2_wt73	1,1580E-05	9,3974E-05	3,7706E-04	4,2045E-05	5,2465E-04	1906
kavel2_wt74	2,8325E-05	1,7979E-04	3,8129E-04	4,8830E-05	6,3824E-04	1567

kavel2_wt75	1,3201E-05	8,4620E-05	3,7842E-04	4,0212E-05	5,1646E-04	1936
kavel2_wt76	2,3062E-05	1,4315E-04	3,8225E-04	4,6628E-05	5,9509E-04	1680
kavel2_wt77	5,6243E-05	2,5606E-04	3,7850E-04	5,4498E-05	7,4530E-04	1342
kavel2_wt78	2,2950E-05	1,0106E-04	3,8365E-04	4,2562E-05	5,5022E-04	1817
kavel2_wt79	4,6740E-05	2,0648E-04	3,7941E-04	4,8302E-05	6,8093E-04	1469
kavel2_wt80	1,4540E-04	5,4887E-04	3,8227E-04	5,7517E-05	1,1341E-03	882
kavel2_wt81	4,6781E-04	1,0264E-03	3,8899E-04	6,7830E-05	1,9511E-03	513
kavel2_wt82	4,4426E-05	1,1075E-04	3,9299E-04	4,3016E-05	5,9118E-04	1692
kavel2_wt83	8,0850E-05	2,8679E-04	3,8834E-04	4,9604E-05	8,0558E-04	1241
kavel2_wt84	1,8993E-04	6,6500E-04	3,8815E-04	5,7474E-05	1,3005E-03	769
kavel2_wt85	7,0838E-05	1,0603E-04	3,9809E-04	4,0537E-05	6,1549E-04	1625
kavel2_wt86	1,7291E-04	3,0174E-04	3,9230E-04	4,7568E-05	9,1452E-04	1093
kavel2_wt87	1,3552E-04	8,6630E-05	4,0593E-04	4,0222E-05	6,6830E-04	1496
kavel2_wt88	4,2606E-04	1,7864E-04	4,0614E-04	4,6422E-05	1,0573E-03	946
kavel2_wt89	2,5352E-04	7,0087E-05	4,1541E-04	4,1488E-05	7,8051E-04	1281
kavel2_wt90	1,1452E-03	1,2278E-04	4,2854E-04	4,5969E-05	1,7425E-03	574
kavel2_wt91	7,5257E-04	2,6467E-04	5,8189E-04	6,3839E-05	1,6630E-03	601
kavel2_wt92	3,5234E-04	1,9685E-04	5,6165E-04	5,6649E-05	1,1675E-03	857
kavel2_wt93	1,6605E-04	1,1229E-04	5,2929E-04	5,3438E-05	8,6107E-04	1161
kavel2_wt94	2,5428E-04	1,9461E-04	4,9907E-04	5,7047E-05	1,0050E-03	995
kavel2_wt95	9,3961E-04	4,5450E-04	6,1509E-04	6,9081E-05	2,0783E-03	481
kavel2_wt96	1,1494E-04	1,0893E-04	4,6794E-04	5,3005E-05	7,4481E-04	1343
Total per year	3,1669E-02	2,2100E-02	2,9213E-02	3,6368E-03	8,6618E-02	12
This is once in … year	32	45	34	275	12	

Table A2-11 Locations and collision frequency per turbine, all traffic for Lot 3

Wind turbine	Ramming		Drifting		Total	Once in … year
	R-ships	N-ships	R-ships	N-ships		
kavel3_wt97	1,2081E-04	8,8009E-05	5,5744E-04	5,1177E-05	8,1743E-04	1223
kavel3_wt98	9,9724E-05	1,0657E-04	5,5084E-04	4,8428E-05	8,0556E-04	1241
kavel3_wt99	8,4854E-05	2,5730E-04	5,3747E-04	4,8895E-05	9,2852E-04	1077
kavel3_wt100	8,1102E-05	2,7228E-04	5,3102E-04	4,8123E-05	9,3253E-04	1072
kavel3_wt101	8,2881E-05	1,5838E-04	5,2849E-04	4,6484E-05	8,1623E-04	1225
kavel3_wt102	7,9158E-05	1,7283E-04	5,3945E-04	4,6072E-05	8,3751E-04	1194
kavel3_wt103	8,5887E-05	4,4666E-04	5,3177E-04	4,7847E-05	1,1122E-03	899
kavel3_wt104	9,2392E-05	7,7870E-04	5,3750E-04	5,0694E-05	1,4593E-03	685
kavel3_wt105	1,0959E-04	6,4937E-04	5,4497E-04	5,0852E-05	1,3548E-03	738
kavel3_wt106	1,3727E-04	3,1300E-04	5,4744E-04	4,6442E-05	1,0441E-03	958
kavel3_wt107	2,1736E-04	1,3749E-04	5,5541E-04	4,3471E-05	9,5372E-04	1049
kavel3_wt108	3,9507E-04	7,7565E-05	5,7464E-04	3,7615E-05	1,0849E-03	922
kavel3_wt109	7,4384E-04	5,7826E-05	6,0197E-04	3,5481E-05	1,4391E-03	695
kavel3_wt110	1,1511E-03	7,5200E-05	6,2203E-04	3,4988E-05	1,8833E-03	531
kavel3_wt111	1,3627E-03	1,2107E-04	6,3341E-04	3,6016E-05	2,1532E-03	464
kavel3_wt112	8,0290E-05	5,3944E-05	5,1802E-04	4,6389E-05	6,9864E-04	1431
kavel3_wt113	5,0577E-05	7,4211E-05	5,1877E-04	4,8885E-05	6,9244E-04	1444

kavel3_wt114	7,0013E-05	5,3483E-05	5,0742E-04	4,5135E-05	6,7605E-04	1479
kavel3_wt115	7,3984E-05	4,4991E-05	4,6900E-04	4,4673E-05	6,3265E-04	1581
kavel3_wt116	5,3883E-05	6,9848E-05	4,9586E-04	4,3833E-05	6,6343E-04	1507
kavel3_wt117	5,4431E-05	3,8542E-05	4,6549E-04	4,4066E-05	6,0252E-04	1660
kavel3_wt118	7,8104E-05	4,1870E-05	4,5349E-04	4,2982E-05	6,1645E-04	1622
kavel3_wt119	1,1387E-04	4,5219E-05	4,5645E-04	4,4490E-05	6,6002E-04	1515
kavel3_wt120	4,5625E-05	6,1189E-05	4,7632E-04	4,7184E-05	6,3031E-04	1587
kavel3_wt121	1,6544E-04	7,3269E-05	4,8976E-04	4,7999E-05	7,7647E-04	1288
kavel3_wt122	2,3560E-04	8,7609E-05	5,0414E-04	4,9782E-05	8,7713E-04	1140
kavel3_wt123	9,1756E-05	9,8952E-05	5,2890E-04	5,2194E-05	7,7180E-04	1296
kavel3_wt124	4,6124E-04	2,1851E-04	5,3600E-04	5,8561E-05	1,2743E-03	785
kavel3_wt125	2,2238E-04	1,5649E-04	5,4001E-04	5,6204E-05	9,7509E-04	1026
kavel3_wt126	2,2197E-04	3,9349E-04	5,7352E-04	6,5331E-05	1,2543E-03	797
kavel3_wt127	4,7445E-05	6,2467E-05	4,8486E-04	4,4221E-05	6,3899E-04	1565
kavel3_wt128	4,3509E-05	4,0413E-05	4,5175E-04	4,0616E-05	5,7628E-04	1735
kavel3_wt129	5,1591E-05	3,7354E-05	4,4433E-04	4,2241E-05	5,7552E-04	1738
kavel3_wt130	3,9731E-05	5,3042E-05	4,7782E-04	4,2734E-05	6,1333E-04	1630
kavel3_wt131	3,1406E-05	3,6998E-05	4,4509E-04	4,0047E-05	5,5354E-04	1807
kavel3_wt132	3,3669E-05	3,8024E-05	4,2756E-04	4,1257E-05	5,4051E-04	1850
kavel3_wt133	4,1412E-05	4,5725E-05	4,2119E-04	4,1831E-05	5,5016E-04	1818
kavel3_wt134	3,4316E-05	7,4705E-05	4,9809E-04	4,1565E-05	6,4867E-04	1542
kavel3_wt135	1,8603E-05	3,7715E-05	4,5017E-04	4,0104E-05	5,4659E-04	1830
kavel3_wt136	1,4573E-05	3,7368E-05	4,2273E-04	4,0203E-05	5,1488E-04	1942
kavel3_wt137	1,0827E-05	4,0511E-05	4,1755E-04	4,0101E-05	5,0899E-04	1965
kavel3_wt138	1,3062E-05	4,3915E-05	4,4638E-04	3,9892E-05	5,4325E-04	1841
kavel3_wt139	3,9989E-05	2,4652E-04	4,8852E-04	4,4011E-05	8,1903E-04	1221
kavel3_wt140	1,8500E-05	6,4315E-05	4,5502E-04	3,9655E-05	5,7749E-04	1732
kavel3_wt141	9,7492E-06	4,0262E-05	4,2118E-04	3,9928E-05	5,1112E-04	1956
kavel3_wt142	7,0695E-06	4,7356E-05	4,0649E-04	4,0464E-05	5,0138E-04	1994
kavel3_wt143	4,6112E-05	1,7926E-04	4,9449E-04	4,2029E-05	7,6189E-04	1313
kavel3_wt144	2,2698E-05	5,7873E-05	4,5845E-04	3,8706E-05	5,7773E-04	1731
kavel3_wt145	1,0574E-05	4,0621E-05	4,2020E-04	3,8239E-05	5,0963E-04	1962
kavel3_wt146	6,2430E-06	4,7505E-05	3,9955E-04	3,8388E-05	4,9169E-04	2034
kavel3_wt147	7,9839E-06	4,6732E-05	3,9462E-04	3,7930E-05	4,8726E-04	2052
kavel3_wt148	2,5395E-05	4,1911E-05	4,5105E-04	3,6790E-05	5,5514E-04	1801
kavel3_wt149	9,5620E-06	4,3690E-05	3,9753E-04	3,7397E-05	4,8818E-04	2048
kavel3_wt150	2,8401E-05	3,3889E-05	4,4509E-04	3,6033E-05	5,4341E-04	1840
kavel3_wt151	8,8762E-05	5,8028E-05	5,0060E-04	3,8817E-05	6,8621E-04	1457
kavel3_wt152	1,3914E-04	4,4096E-05	5,1262E-04	3,6739E-05	7,3259E-04	1365
kavel3_wt153	1,8344E-05	3,5720E-05	4,2313E-04	3,6331E-05	5,1353E-04	1947
kavel3_wt154	1,5982E-05	3,8103E-05	4,1288E-04	3,6217E-05	5,0318E-04	1987
kavel3_wt155	1,8626E-04	3,7798E-05	5,2567E-04	3,3698E-05	7,8343E-04	1276
kavel3_wt156	6,7064E-05	3,0931E-05	4,7869E-04	3,2753E-05	6,0944E-04	1641
kavel3_wt157	2,4633E-04	4,2091E-05	5,3795E-04	3,3101E-05	8,5948E-04	1163
kavel3_wt158	2,7428E-04	4,4814E-05	5,4338E-04	3,3432E-05	8,9591E-04	1116
kavel3_wt159	7,9768E-05	3,1396E-05	4,8295E-04	3,2044E-05	6,2616E-04	1597

kavel3_wt160	9,0133E-05	3,4681E-05	4,8835E-04	3,1713E-05	6,4488E-04	1551
Total per year	8,6814E-03	7,0597E-03	3,1453E-02	2,7195E-03	4,9914E-02	20
This is once in … year	115	142	32	368	20	

Table A2-12 Total collisions (ramming and drifting) of all traffic

PEZ Lot 1						
Ships type	Ramming		Drifting		Total	
	Times per year	Once in … year	Times per year	Once in … year	Time per year	Once in … year
R-ships	0,01300	77	0,01694	59	0,02994	33
N-ships	0,00396	253	0,00128	780	0,00524	191
Total	0,01696	59	0,01822	55	0,03518	28

PEZ Lot 2						
Ships type	Ramming		Drifting		Total	
	Times per year	Once in … year	Times per year	Once in … year	Time per year	Once in … year
R-ships	0,03167	32	0,02921	34	0,06088	16
N-ships	0,02210	45	0,00364	275	0,02574	39
Total	0,05377	19	0,03285	30	0,08662	12

PEZ Lot 3						
Ships type	Ramming		Drifting		Total	
	Times per year	Once in … year	Times per year	Once in … year	Time per year	Once in … year
R-ships	0,00868	115	0,03145	32	0,04013	25
N-ships	0,00706	142	0,00272	368	0,00978	102
Total	0,01574	64	0,03417	29	0,04991	20

Table A2-13 Probability of a particular type of damage caused by the different ship types

	PEZ - Lot 1			
Ships type	Damage type			Total
	NosMos	Damage to ship's hull	No damage	
Oil	1,0276E-04	3,4655E-03	7,1916E-07	3,5690E-03
Chemicals	2,1683E-05	3,7216E-03	4,7210E-06	3,7480E-03
Gas	3,9114E-05	1,2803E-03	0,0000E+00	1,3195E-03
Container+ RoRo	1,0280E-03	1,4108E-02	3,8183E-07	1,5136E-02
Ferry	7,7634E-06	1,6747E-04	3,6164E-05	2,1140E-04
Other R-ships	9,6043E-05	5,7438E-03	1,1528E-04	5,9551E-03
N-ships	1,4204E-04	2,4318E-03	2,6680E-03	5,2419E-03
All ships	1,4374E-03	3,0919E-02	2,8253E-03	3,5181E-02

	PEZ - Lot 2			
Ships type	Damage type			Total
	NosMos	Damage to ship's hull	No damage	
Oil	1,1974E-04	4,5509E-03	3,7530E-06	4,6744E-03
Chemicals	1,3538E-04	7,8230E-03	4,8930E-06	7,9633E-03
Gas	1,5705E-04	3,3488E-03	0,0000E+00	3,5058E-03
Container+ RoRo	2,5188E-03	3,1669E-02	3,8571E-07	3,4188E-02
Ferry	2,2664E-05	4,0925E-04	5,5308E-05	4,8722E-04
Other R-ships	1,8847E-04	9,6739E-03	2,0053E-04	1,0063E-02
N-ships	1,6900E-03	1,9081E-02	4,9653E-03	2,5736E-02
All ships	4,8321E-03	7,6556E-02	5,2301E-03	8,6618E-02

	PEZ - Lot 3			
Ships type	Damage type			Total
	NosMos	Damage to ship's hull	No damage	
Oil	4,8903E-05	4,9691E-03	2,6281E-06	5,0206E-03
Chemicals	8,0087E-06	7,1072E-03	6,2970E-06	7,1215E-03
Gas	2,4973E-05	2,0533E-03	0,0000E+00	2,0783E-03
Container+ RoRo	7,3682E-04	1,4685E-02	5,7964E-07	1,5422E-02
Ferry	4,8748E-06	2,3854E-04	3,9553E-05	2,8297E-04
Other R-ships	4,3547E-05	9,9447E-03	2,2078E-04	1,0209E-02
N-ships	3,6866E-04	5,2811E-03	4,1294E-03	9,7792E-03

All ships	1,2358E-03	4,4278E-02	4,3993E-03	4,9914E-02

Table A2-14 Damage to the wind park

PEZ Lot 1										
Damage to turbine	Ramming				Drifting		Total		Number per year	Once in … year
	frontal		Scrape							
	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships		
None	0,00E+00	1,11E-04	1,74E-08	1,44E-03	1,57E-04	1,12E-03	1,57E-04	2,67E-03	2,83E-03	354
Skewed	1,93E-09	4,88E-05	0,00E+00	7,40E-04	5,07E-03	8,49E-05	5,07E-03	8,74E-04	5,95E-03	168
Topples	1,17E-03	2,17E-04	1,05E-02	1,27E-03	1,17E-02	7,51E-05	2,34E-02	1,56E-03	2,50E-02	40
NosMos[1]	1,30E-04	1,95E-05	1,17E-03	1,22E-04	0,00E+00	0,00E+00	1,30E-03	1,42E-04	1,44E-03	696
Total	1,30E-03	3,96E-04	1,17E-02	3,56E-03	1,69E-02	1,28E-03	2,99E-02	5,24E-03	3,52E-02	28

PEZ Lot 2										
Damage to turbine	Ramming				Drifting		Total		Number per year	Once in … year
	frontal		Scrape							
	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships		
None	0,00E+00	1,72E-04	1,50E-07	2,19E-03	2,65E-04	2,61E-03	2,65E-04	4,97E-03	5,23E-03	191
Skewed	1,66E-08	7,15E-05	0,00E+00	1,71E-03	8,81E-03	4,81E-04	8,81E-03	2,27E-03	1,11E-02	90
Topples	2,85E-03	1,78E-03	2,57E-02	1,45E-02	2,01E-02	5,50E-04	4,87E-02	1,68E-02	6,55E-02	15
NosMos1	3,17E-04	1,87E-04	2,83E-03	1,50E-03	0,00E+00	0,00E+00	3,14E-03	1,69E-03	4,83E-03	207
Total	3,17E-03	2,21E-03	2,85E-02	1,99E-02	2,92E-02	3,64E-03	6,09E-02	2,57E-02	8,66E-02	12

PEZ Lot 3										
Damage to turbine	Ramming				Drifting		Total		Number per year	Once in … year
	frontal		Scrape							
	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships	R-ships	N-ships		
None	0,00E+00	1,86E-04	1,44E-09	1,93E-03	2,70E-04	2,01E-03	2,70E-04	4,13E-03	4,40E-03	227
Skewed	1,60E-10	2,90E-05	0,00E+00	5,91E-04	1,01E-02	3,44E-04	1,01E-02	9,64E-04	1,10E-02	91
Topples	7,81E-04	4,45E-04	7,03E-03	3,51E-03	2,11E-02	3,66E-04	2,89E-02	4,32E-03	3,32E-02	30
NosMos1	8,68E-05	4,58E-05	7,80E-04	3,23E-04	0,00E+00	0,00E+00	8,67E-04	3,69E-04	1,24E-03	809
Total	8,68E-04	7,06E-04	7,81E-03	6,35E-03	3,15E-02	2,72E-03	4,01E-02	9,78E-03	4,99E-02	20

Table A2-15 Risk of fatality in the event of a collision with a wind turbine where the mast and nacelle falls on the ship

PEZ Lot 1					
Ships type	Collision type Number per year		Combined once in …year	Direct fatalities	
	Frontal	Scrape		Average number of fatalities at a time	Average number of fatalities per year
Oil	1,0281E-05	9,2475E-05	9732	1,5136	0,000156
Chemicals	2,2347E-06	1,9448E-05	46120	1,6755	0,000036
Gas	3,9471E-06	3,5167E-05	25566	1,4398	0,000056
Container + RoRo	1,0295E-04	9,2507E-04	973	11,1154	0,011427
Ferry	7,7664E-07	6,9868E-06	128809	98,0820	0,000761
Other R-ships	9,7636E-06	8,6279E-05	10412	1,5650	0,000150
N-ships	1,9540E-05	1,2250E-04	7040	0,1290	0,000018
Total	1,4949E-04	1,2879E-03	696	8,7693	0,012605

PEX Lot 2					
Ships type	Collision type Number per year		Combined once in …year	Direct fatalities	
	Frontal	Scrape		Average number of fatalities at a time	Average number of fatalities per year
Oil	1,2009E-05	1,0773E-04	8351	1,6272	0,000195
Chemicals	1,4217E-05	1,2116E-04	7387	1,6594	0,000225
Gas	1,6040E-05	1,4101E-04	6367	1,4824	0,000233
Container + RoRo	2,5245E-04	2,2664E-03	397	4,3614	0,010986
Ferry	2,2729E-06	2,0391E-05	44124	83,4969	0,001892
Other R-ships	1,9685E-05	1,6878E-04	5306	1,6395	0,000309
N-ships	1,8717E-04	1,5028E-03	592	0,0644	0,000109
Total	5,0384E-04	4,3283E-03	207	2,8865	0,013948

PEZ Lot 3					
Ships type	Collision type Number per year		Combined once in …year	Direct fatalities	
	Frontal	Scrape		Average number of fatalities at a time	Average number of fatalities per year
Oil	4,8915E-06	4,4011E-05	20449	1,5035	0,000074
Chemicals	8,1713E-07	7,1916E-06	124864	1,6837	0,000013

Gas	2,5050E-06	2,2468E-05	40043	1,4338	0,000036
Container + RoRo	7,3706E-05	6,6312E-04	1357	9,1825	0,006766
Ferry	4,8753E-07	4,3872E-06	205138	100,1014	0,000488
Other R-ships	4,3954E-06	3,9152E-05	22964	1,5530	0,000068
N-ships	4,5829E-05	3,2283E-04	2713	0,1789	0,000066
Total	1,3263E-04	1,1032E-03	809	6,0773	0,007510

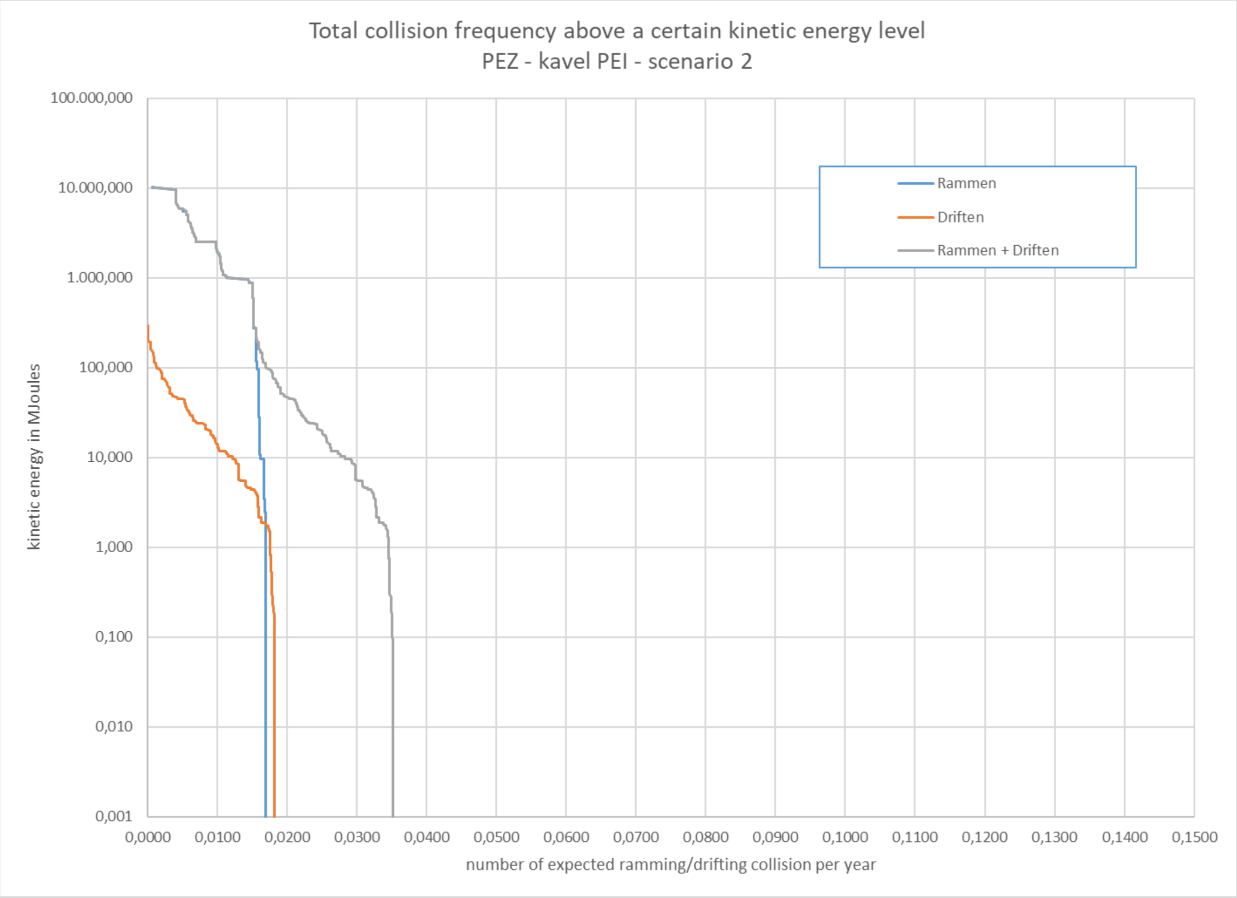

Figure A2-4 Total collision frequency above a certain kinetic energy level - PEZ Lot 1

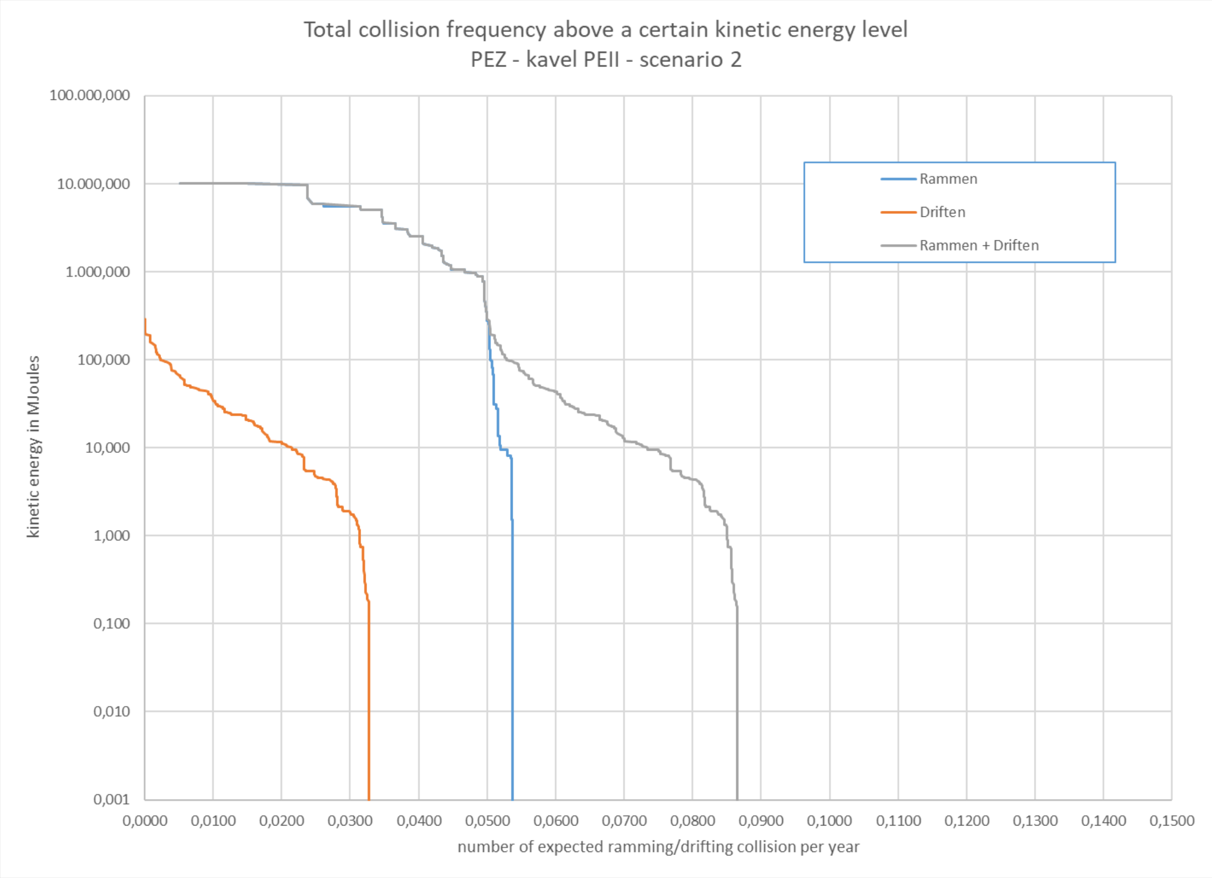

Figure A2-5 Total collision frequency above a certain kinetic energy level - PEZ Lot 2

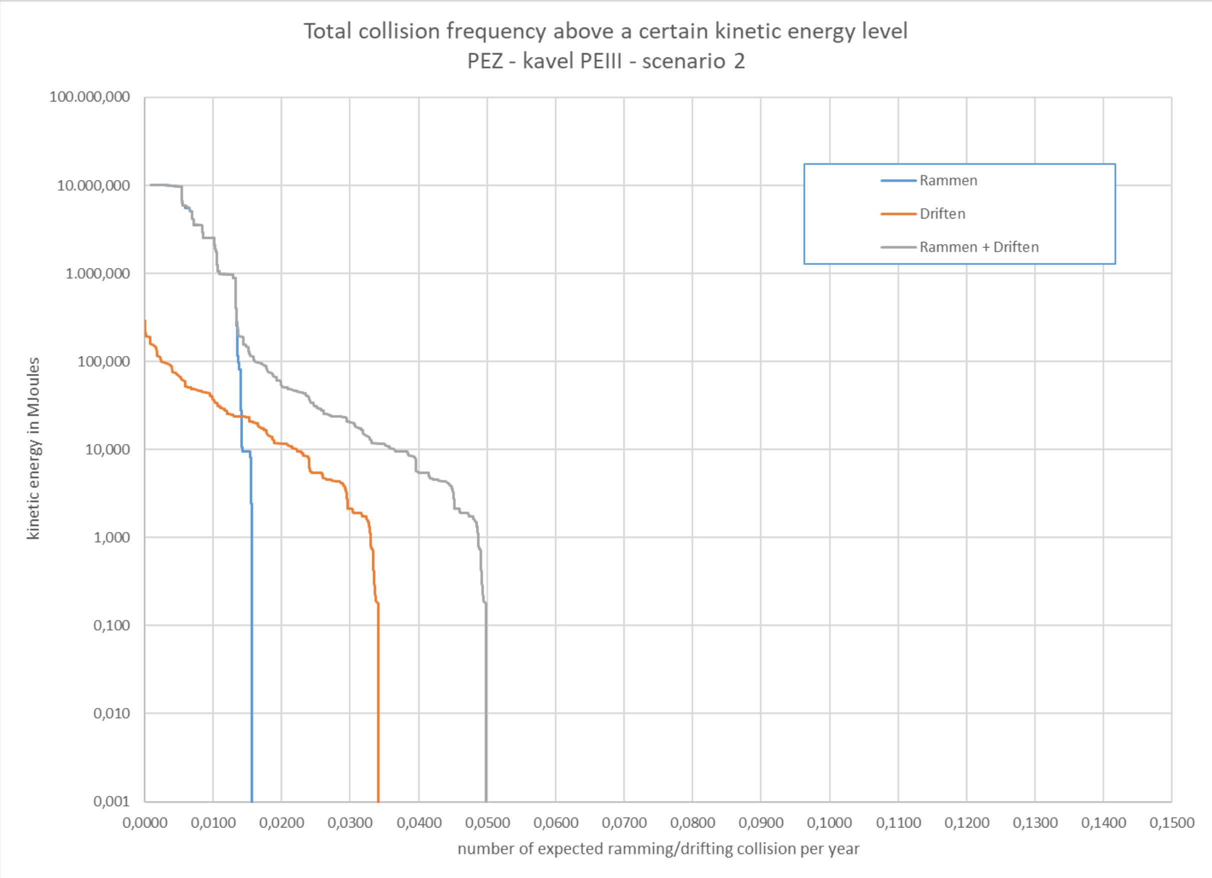

Figure A2-6 Total collision frequency above a certain kinetic energy level - PEZ Lot 3

Table A2- 16 Distribution of collision chances between ship type and energy class for all wind turbines

PEZ Lot 1									
Kinetic energy in MJ	Ramming			Drifting			Total		
	R-ships	N-ships	Total	R-ships	N-ships	Total	R-ships	N-ships	Total
<1	0,0%	0,1%	0,1%	0,2%	1,7%	1,8%	0,2%	1,8%	1,9%
1-3	0,0%	0,2%	0,2%	4,1%	0,8%	4,9%	4,1%	1,0%	5,1%
3-5	0,0%	0,4%	0,4%	4,6%	0,4%	5,0%	4,6%	0,8%	5,4%
5-10	0,0%	1,7%	1,7%	5,4%	0,2%	5,6%	5,4%	1,9%	7,3%
10-15	0,0%	0,2%	0,2%	6,8%	0,2%	7,0%	6,8%	0,4%	7,2%
15-50	0,0%	0,4%	0,4%	17,0%	0,2%	17,2%	17,0%	0,6%	17,6%
50-100	0,0%	0,8%	0,8%	6,5%	0,1%	6,6%	6,5%	0,9%	7,4%
100-200	0,0%	0,2%	0,2%	3,4%	0,1%	3,5%	3,4%	0,3%	3,7%
>200	36,9%	7,4%	44,3%	0,2%	0,0%	0,2%	37,0%	7,4%	44,4%
Total	36,9%	11,3%	48,2%	48,2%	3,6%	51,8%	85,1%	14,9%	100,0%

PEZ Lot 2									
Kinetic energy in MJ	Ramming			Drifting			Total		
	R-ships	N-ships	Total	R-ships	N-ships	Total	R-ships	N-ships	Total
<1	0,0%	0,0%	0,0%	0,1%	1,6%	1,8%	0,1%	1,7%	1,8%
1-3	0,0%	0,2%	0,2%	3,0%	0,8%	3,8%	3,0%	1,0%	4,0%
3-5	0,0%	0,1%	0,1%	3,4%	0,3%	3,7%	3,4%	0,4%	3,8%
5-10	0,0%	1,8%	1,8%	3,8%	0,2%	3,9%	3,8%	2,0%	5,8%
10-15	0,0%	0,4%	0,4%	4,6%	0,3%	4,9%	4,6%	0,6%	5,3%
15-50	0,0%	0,7%	0,7%	11,7%	0,4%	12,1%	11,7%	1,1%	12,8%
50-100	0,1%	0,5%	0,6%	4,7%	0,3%	5,0%	4,7%	0,8%	5,5%
100-200	0,1%	0,0%	0,2%	2,3%	0,3%	2,6%	2,4%	0,3%	2,8%
>200	36,4%	21,7%	58,1%	0,1%	0,0%	0,1%	36,5%	21,8%	58,3%
Total	36,6%	25,5%	62,1%	33,7%	4,2%	37,9%	70,3%	29,7%	100,0%

PEZ Lot 3									
Kinetic energy in MJ	Ramming			Drifting			Total		
	R-ships	N-ships	Total	R-ships	N-ships	Total	R-ships	N-ships	Total
<1	0,0%	0,1%	0,1%	0,2%	2,2%	2,5%	0,2%	2,3%	2,5%
1-3	0,0%	0,3%	0,3%	5,9%	1,1%	7,0%	5,9%	1,3%	7,2%
3-5	0,0%	0,1%	0,1%	6,6%	0,4%	7,0%	6,6%	0,4%	7,1%
5-10	0,0%	2,6%	2,6%	7,3%	0,3%	7,6%	7,3%	2,9%	10,2%
10-15	0,0%	0,2%	0,2%	8,5%	0,3%	8,8%	8,5%	0,5%	9,0%
15-50	0,0%	0,3%	0,3%	21,3%	0,5%	21,9%	21,3%	0,8%	22,2%
50-100	0,0%	0,8%	0,8%	8,4%	0,3%	8,7%	8,4%	1,1%	9,5%
100-200	0,0%	0,1%	0,1%	4,4%	0,3%	4,7%	4,4%	0,4%	4,9%
>200	17,4%	9,8%	27,2%	0,2%	0,1%	0,2%	17,6%	9,8%	27,4%
Total	17,4%	14,1%	31,5%	63,0%	5,4%	68,5%	80,4%	19,6%	100,0%

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