REPORT

Midterm Evaluation WOZEP

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DUTCH GOVERNMENTAL OFFSHORE WIND ECOLOGICAL PROGRAMME

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Enhancing Society Together

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Table of Contents

List of abbreviations

AA	Appropriate assessment
ABM	Agent Based Model
CEAF	Common approach for cumulative effect assessment
C-pod	Continuous porpoise detectors
DEPONS	Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea
DHI	DHI Group
DGWB	Directoraat Generaal Water en Bodem (Directorate General Water and Soil)
EIA	Environmental Impact Assessment
ESAS	European Seabirds At Sea
EZK	Ministerie Economische Zaken en Klimaat (Ministry of Economic and Climate)
IBM	Individual Based Model
iPCoD	Interim Population Consequences of Disturbance
KEC	Framework for Assessing Ecological and Cumulative Effects of offshore wind farms
MSFD	Marine Strategy Framework Directive
LD	Offshore Wind Farm Luchterduinen
LNV	Ministerie van Landbouw, Natuurbeheer en Voedselkwaliteit (Ministry of Agriculture, Nature Management en Food Quality
MEP	Monitoring and Evaluation Plan
MRP	Monitoring and Research Programme 2017 - 2021
OWEZ	Offshore Wind farm Egmond aan Zee
OWFs	Offshore Wind Farms
PAWP	Prinses Amalia Wind Park
PBR	Potential Biological Removal
ROV	Remotely Operated Vehicle
RWS	Rijkswaterstaat

SEANSE	Strategic Environmental Assessment on North Sea Energy
TKI	Topconsortia for Knowledge and Innovation
UvA	University of Amsterdam
WOZEP	Wind op Zee Ecologisch Programma/Offshore Wind Energy Ecological Programme
WMR	Wageningen Marine Research

1 Introduction

1.1 WOZEP

In 2015, the Ministry of Economic Affairs (EZ) decided to set up an integrated monitoring and research programme to study gaps in our knowledge relating to the impact of offshore wind farms on the ecosystem of the North Sea. This generic programme was established in response to a recommendation from Rijkswaterstaat (RWS), that knowledge gaps are primarily generic rather than specific for individual offshore wind farms (OWFs). This conclusion was based on research and monitoring set out for and executed during Round 1 and 2 OWFs. This led to the establishment of the Dutch Offshore Wind Ecological Programme (WOZEP). The scope set out by EZ to RWS was issued in late 2015 for the period 2016 to 2021. In the “Monitoring and Research Programme 2017-2021” (MRP), the outline of the complete research and monitoring programme for the period 2017-2021 is set out. The programme leaves room for flexibility where required. The first research projects were started in 2016. These projects were mostly studies on feasibility or inventories of current methods as preparation and input for the upcoming MRP 2017-2021 research period. The results of the studies in 2016 are used as input for the MRP 2017-2021.

1.2 Midterm evaluation

WOZEP is halfway through its first programme period and the management has asked Royal HaskoningDHV to execute a midterm evaluation. The objective of this midterm evaluation is to inform the Steering Group WOZEP about the current situation of the research projects, the changes that have occurred in the programme and planning, including the reasons for this and the future plans and adaptations that are foreseen. The list of future plans is not limitative and still in process.

To draft this evaluation, Royal HaskoningDHV has interviewed the WOZEP team and five experts that have a relation with WOZEP, two experts have reviewed this evaluation document (see Table 1-1). In Chapter 2 the results of the interviews with the WOZEP team are used to describe the current situation and adaptations in the programme per species group. The results of the interviews with ‘external’ experts are mainly used in the general observations paragraph. In Chapter 3 general observations and overall conclusions are drawn.

The results of this evaluation will be input to the WOZEP team, they will use it to improve the programme where needed. This means that WOZEP will decide what suggested improvements will receive follow-up.

Table 1-1 Overview of experts that have been interviewed

WOZEP team	External experts
Marijke Warnas (technical manager, bats)	Rene Dekeling (ministry of Defence/Infrastructure & Water Management)
Martine Graafland (KEC)	Luuk Folkerts (OWF Gemini)
Maarten Platteeuw (bird displacement, bats)	Peter Herman (Deltares)
Suzanne Lubbe (bird collisions)	Lieke Berkenbosch (Rijkswaterstaat)
Aylin Erkman and Inger van den Bosch (marine mammals)	Rob Gerits (Rijkswaterstaat)
Maarten de Jong (fish and benthos)	Steven Degraer (Royal Belgian Institute of Natural Sciences (RBINS))
	Finlay Bennet (Marine Scotland Science, Scottish Directorate Marine Scotland)

1.3 Developments Offshore Wind

In 2013, the Dutch government signed an Energy Agreement with parties involved in the energy market. It was agreed that 5 OWFs should be completed by 2023 (Roadmap 2023). Together with the existing wind farms, these should ensure a total installed capacity of 4.5 gigawatts. In 2018 the ambitions were increased from 4.5 GW in 2023 to 11.5 GW in 2030. This has led to a new Offshore Wind Energy Roadmap 2030, in which three additional sites have been designated for offshore wind.
In 2018 the Roadmap 2030, in which the plans for OWF development up to 2030 are presented, was formally approved by the Council of Ministers. In addition to the scope of the current WOZEP programme (2016 – 2021), also several subjects that are not part of WOZEP were mentioned in the Roadmap 2030. In response to the Roadmap 2030 the WOZEP team presented a list of subjects that should be looked into in further detail, in consideration of whether the WOZEP scope should be broader.

The steering group WOZEP agreed that the WOZEP team will look at the following subjects:

- ***Data availability in the area north of the Wadden Sea islands.*** In the search for data it was concluded that similar research was done by the ministry of Agriculture, Nature Management and Food Quality (LNV) (project kansenkaarten) and SEANSE. During the steering group meeting in May it was decided not to include this data search in WOZEP.
- ***Ecosystem effects of future upscaling OWFs on the North Sea***. Deltares was asked to execute a pilot based on existing models to see if ecosystem changes can be expected due to expanding areas with OWFs. The preliminary results will be presented in October 2018.
- ***Is further cooperation necessary between WOZEP and Marine Strategy Framework Directive (MSFD)***? Based on discussions between the WOZEP team, DGBW (MSFD) and ministry of LNV (North Sea strategy 2030), it was concluded that there is a common interest in the subject ecosystem changes. Both DGWB and LNV are welcome to use WOZEP results or join projects relevant for them. WOZEP will not take the lead inthis but will always pro-actively look whether WOZEP results can be used by other projects. Possibility of re-use of WOZEP resultswill be discussed in the “Voorbereidingsgroep WOZEP”, in which the relevant organizations are seated (MSFD, OSPAR, North Sea Knowledge agenda).
- ***TKI innovation***. In a discussion with TKI it became clear that there is a lot of development in piling (and therefore the production of underwater noise); the innovation of rotor blades (collisions) goes slower. We decided that contact between WOZEP and TKI should be more frequent to get a good interaction between innovations (what are the most important pressures to innovate on) and research (what changes can we expect with respect to pressures in the cause effect relations we do research on). There will be a workshop on this topic in autumn 2018.

During the steering group meeting, at the end of 2018, a decision will be made if the scope of WOZEP needs to be changed due to the Road map 2030. The subjects of ”cumulative effect assessment” in broad sense (not only offshore wind but also other pressures at sea) and “building with nature” were not investigated by WOZEP. The steering group decided that WOZEP is not the right platform for research on these topics as these should be investigated on a broader scale and not specifically for offshore wind development only.

2 Evaluation

2.1 Birds: displacement from habitat

For some species of offshore seabirds, it has been observed that they tend to avoid areas where OWFs have been constructed. Many ship-based and aerial monitoring surveys have shown that densities of several species of auks, gannets, tubenoses and divers decrease after the installation of wind turbines. It is not known what proportion will be displaced, if this response is temporary (e.g. birds will return following habituation), or if the displacement from habitat is permanent for individuals of these species.

2.1.1 Current situation and results

All planned subprojects for research on displacement of birds have started, and most of the results of these projects will be delivered in the autumn of 2018. Results are and will be used to update the Framework for Assessing Ecological and Cumulative Effects (KEC) and to determine which populations should be used for scenario calculations. The results will have used specifically designed habitat models as well as population dynamics models for a selection of five representative species of seabirds and will also be used to identify crucial remaining knowledge gaps and the define future research and monitoring that is needed to bridge those gaps. Table 2-1 shows an overview of the current subprojects in WOZEP.

Table 2-1 Overview current subprojects, planning and results for birds: displacement from habitat

Subproject	Planning	Results
WOZEP research 2017 - 2021		
Development of population and habitat use models for 5 vulnerable seabird species, including subprojects in MRP (BuWa, WMR)	Small delay, final report November 2018. Delay has no consequences for the programme	Sandwich tern results already published, including suggestions for useful future research, which are being addressed already. No results available yet for the other four species. Information expected on habitat use and consequence for populations. This is important for wind farm developments and mitigation measures. Results of this subproject will give information for further research.
WOZEP research 2016		
1. International working conference highlighting displacement in relation to wind farm configuration and data analysis (international, Alain Zuur)	Workshop 3 – 6 April 2017, data analysis delayed, final report expected in November 2018. Delay has no consequences for the program	The data show that guillemots may avoid OWFs, but this conclusion was not statistical based. Data of only 2 OWFs could be used. Report will contain advice on how monitoring should take place. Results can be used as input for habitat use model
2. Numbers and behaviour of guillemots in existing OWFs (OWEZ, PAWP, LD) (WMR)	Delay in fieldwork because of safety regulations, performed in spring 2018. Report has been delivered in autumn 2018. Delay has no consequences for the programme	Pilot project aimed at assessing options for in situ behavioural research at offshore wind farms. Preliminary results suggest good opportunities. Guillemots and gannets present in and around OWF LUD, but no statistically/scientifically based conclusions possible as yet. International co-operation on future extension of this line of research recommended and advice on how to proceed needed

3. Exploratory study on the survival of seabirds at sea during the year, in relation to a selected area (WMR)	Report delivered in 2017	Report on the possibilities of using existent research, ringing and monitoring data for an analysis on which bird colonies are most vulnerable to OWFs. Conclusion: data are not suitable for this analysis. Data could be used to determine which populations should be used for scenario calculations

2.1.2 Adaptations of the programme

Originally population and habitat use models for 10 vulnerable species would be developed. This has been changed to 5 representative species, because that was deemed to be enough to see the relevant relations.

The regular Dutch monitoring programme for the state of the sea (MWTL) has been adapted to deliver more information on the distribution of seabirds. Additional monitoring of seabirds on the NCP will be executed during the breeding seasons of 2018, 2019 and 2020. The first additional survey (June 2018) has already been carried out.

2.1.3 Future plans

The following subprojects are planned for the future (2018-2019):

- Clarify stochasticity in population parameters to learn more about the nature and causes of the variation in these parameters (necessary to be able to distinguish 'real' effects from 'natural' fluctuations);
- Gather more information on behaviour and avoidance of sandwich tern in relation to current OWFs, by using GPS-loggers or behavioural observations. This will give more insight in the way the birds use or avoid the OWFs and where they forage;
- Gather more information on migration, dispersion and survival of Dutch sandwich terns, to calibrate and validate the population model to be better able to estimate the impact of additional mortality due to habitat loss;
- Establish or at least stimulate the establishment of international monitoring for seabird distribution, by making the data available and create support for an internationally coordinated monitoring programme.
- Follow-up on other recommendations on the other four species, expected in November 2018.

2.1.4 Conclusion

Most planned subprojects have been executed and the results will be delivered in the autumn of 2018. There were some delays in the execution, but there are no consequences for the programme. This does not mean that the research on bird displacement is almost finished. The results of the current subprojects give insight in what information is further needed to answer the research questions. Part of these follow up subprojects are clear now and listed in paragraph 2.1.3.

2.2 Birds: collision risk

Thousands of birds a year are suspected to collide with offshore wind turbines. At present, estimates of collision rates for birds are mainly produced using models such as the Band model. For onshore wind farms, it is possible to determine the number of victims by counting dead birds below the turbines. At sea, it is more difficult to determine the number of victims and therefore to validate the model. Visual observations have proven to be a poor way of observing collisions, since it is precisely when visibility conditions are poor (night, fog, strong winds and rain) that collisions are most likely to occur. Furthermore, radar monitoring on its own is not enough, as it is difficult to detect birds close to wind turbines and identification down to species level with radar is still in its infancy. As a result, automated systems with cameras are needed to monitor collisions.

2.2.1 Current situation and results

Table 2-2 shows an overview of the current subprojects in WOZEP and related to WOZEP. Part of the planned subprojects for research on collision risk of birds have been executed and reported, most other projects have started in the summer 2018Subproject (1) WT-Bird has not started due to technical and access problems. If it will not start at all, the consequence is that there will be less data available on fluxes and collisions in a nearshore wind farm with relatively small turbines. Instead an alternative option was found in another offshore wind farm, Luchterduinen. As part of the MEP Luchterduinen avoidance and flux measurements are done. Since an adequate alternative option was found this change has no consequences for the programme. Another subproject has started but does not work out as planned: (5b) Capture of gulls at sea. During the breeding season of 2018, it has not yet been possible to catch gulls at sea, despite several attempts. If no gulls can be captured, data on where the birds that fly in the OWFs come from will be lacking. This information is necessary to refine the assessment of the impact, so an alternative project will be needed. Possibly gulls from the coast near IJmuiden and Leiden can be captured and tagged, but it is not sure in advance that they will fly into the OWFs.

Along the Belgian coast several terns and lesser black-backed gulls were tagged, it was observed that some individuals do frequently fly in the OWFs.

The results that have been delivered in 2016 in the GPS study (1) Analysis of international GPS tagging database, have been used to adapt the input parameters of the Band model (flight height, flight speed, nocturnal activity). The results of the (2) Inventory of methods and techniques have been used in the tender for purchasing a new radar.

Table 2-2 Overview current subprojects, planning and results for birds: collision risk

Subproject	Planning	Results
WOZEP research 2017 - 2021		
1. Extension of the operation of WT-Bird system in OWEZ (ECN and Bureau Waardenburg)	Delayed due to technical and access problems. Project has not started yet	Results would give information on fluxes and collisions. OWEZ is not representative for other OWFs because it is close to shore and consists of smaller turbines than the most modern types
2. Flux and avoidance monitoring programme (Bureau Waardenburg)	Start in autumn 2018. Cooperation with Eneco (DHI)	Results will give information on (macro-) avoidance, flight behaviour, flight height and collisions. DHI will focus on micro-avoidance. Data will be used to validate input parameters for the collision model(s) and update EIA and KEC

3. Collision land birds & effectiveness of mitigation measure (UvA, BuWa, A&W)	Start in autumn 2018. Cooperation of Provence of Groningen, EZK and RWS.	Results will give information on fluxes, collisions and start-stop mitigation measure
4. Changes in flight behaviour near wind turbines	Study will be part of other studies (subproject 2, 3, 5b, MEP studies)	-
5a. Feasibility study capturing gulls (A&W)	Report delivered in 2017	Results show that it should be possible to capture gulls at sea, this study is input for 5b
5b. Pilot: field study capturing gulls at sea (*(sub)populations of concern)* (BuWa)	Until now no success in catching gulls. 2 new attempts will be executed in 2018. Results are important to WOZEP, other ways must be found to gather information.	Results should give more information where the gulls that use OWF areas come from and how they behave. Information is needed to refine the assumptions that are used now to assess the impact
6. Development of population models for 10 vulnerable seabird species (*population dynamics and validation PBR*) (BuWa)	Small delay, final report November 2018. Delay has no consequences for the programme	No results available yet, surveys have been executed on input parameters, now the models will be run. Model results will give more information on what indicator the impact assessment should be based on and what is acceptable (validate PBR)
Development GPS altitude meter (UvA)	Not in MRP but part of WOZEP scope, report expected in the beginning of 2019	Transmitters are used in the MEP for Gemini (PhD research) and later probably in IJmuiden. Results will be available for WOZEP
WOZEP research 2016		
1. Analysis of international GPS tagging database	Report delivered in 2016	For 4 out of 11 species data analysis possible. For 2 species collisions go down and for 4 species collisions go up. Input parameters for Band model
2. Inventory of methods and techniques to measure collision numbers (Sjoerd Dirksen Ecology)	Report delivered in 2016	Results show that there are several methods that can be used to measure the numbers of collisions in relation to fluxes.

2.2.2 Adaptations to the programme

The following adaptations of the MRP have been made:

- 3. Collision land birds & effectiveness of mitigation measure: no desk study but only a field study
- 4. Changes in flight behaviour near wind turbines: study will not be executed as a separate subproject, parts will be executed under subprojects 2, 3 and 5b and other MEP studies;
- Extending MWTL monitoring (bird counts) during the summer months.

2.2.3 Future plans

The following subprojects are planned for the future (2018 - 2023):

- Borssele T0 – T5 monitoring;
  - ✓ Research on fluxes, flight paths, avoidance and collisions
  - ✓ Possible combination with aerial counts
- Development of Individual Based Model (IBM)/ Agent Based Model (ABM) collisions: execute feasibility study and present to CEAF for broad support;

- Analysis existing GPS data, European Seabirds at Sea (ESAS) files, ring data for the development of population models as input parameters;
- Possibly New GPS research, on new species and/or increasing sample size;
- Extra attention for new species: little gull and dark-bellied brent goose.

2.2.4 Conclusions

Most of the planned subprojects on bird collisions have started. Many of the projects only recently started thus the amount of results available is still limited. The results of the finished subprojects have been used as input for a model and a tender. The results of the remaining subprojects will follow in the coming two years.

2.3 Bats

There are still many gaps in our knowledge about bat distribution and behaviour at sea. In recent years, preliminary studies looking at bats in the Dutch North Sea have yielded evidence for the assumption that structural migration across the North Sea is found in at least one, but possibly up to three, different bat species. Migration is definitely a characteristic of Nathusius' pipistrelle (*Pipistrellus nathusii*), but possibly also of the parti-coloured bat (*Vespertilio murinus*) and the common noctule (*Nyctalus noctula*). During previous rounds of wind farm construction, it was not yet known that bats can also collide with offshore wind turbines. This subject has been studied in more detail in recent years only. The KEC has suggested that the population of Nathusius' pipistrelles could be adversely affected by the planned OWFs. Because of the precautionary principle, mitigation measures are required in this latest round of wind farm construction to limit bat mortality.

2.3.1 Current situation and results

The Netherlands are a frontrunner in research on bats at sea, but in other countries the urgency is not (yet) felt to prioritise research on the impact of OWFs. Table 2-3 shows an overview of the current subprojects that are being executed in WOZEP. The subprojects will give more insight into the way bats use the North Sea and the possible impact of OWFs. If enough receivers will be placed at sea in the project Automated Radio Telemetry (1), the flight paths of bats at sea will become clear. To learn more on flight behaviour of bats the Bat detector research (2) needs to be continued and expanded, this is not decided yet. Also, the continuation of the study on thermal imaging cameras (3) is needed to learn more on behaviour, collisions and to refine mitigation measures. First a plan of action will be drafted and finances for the continuation must be found. The continuation of population survey and desk study (4) is put on hold, because of the wide variation in population size that was shown in the 2016 desk study. It would be worthwhile to look at the population in the UK, but continuation of this study depends on the results of other studies (telemetry study (1)). The analysis of existing data, will be executed by a master student and (5) will be reported later this year.

Table 2-3 Overview current subprojects, planning and results for bats

Subproject	Planning	Results
WOZEP research 2017 - 2021		
1. Automated Radio Telemetry (WMR)	Pilot study in 2016, test with transmitters in autumn 2017, 100 transmitters on bats in autumn 2018. Delivery report end of 2020	The pilot study was successful, a lot of bats were registered. Results will show how and when bats fly over the sea. More receivers at sea are necessary to give a good overview of flightpaths

2. Continuation and expansion of bat detector research (WMR)	Continuation of former research, possible extension until end of WOZEP	First results show that wind speed and temperature are more important than wind direction. More data needed to determine flight behaviour in OWFs. Input for effectiveness mitigation measure
3. Continuation study on thermal imaging cameras (WMR)	Not planned yet because more expensive than expected. First a plan of action will be drafted, this is delayed because of low capacity at WMR, but is being taken up in early October 2018	Plan of action will give an overview of method, alternative methods and international cooperation. Results are important to learn more on behaviour, collisions and to refine mitigation measures
4. Continuation population survey and desk study (WMR)	Not started yet because of the wide variation in population size, depends on results of other subprojects; a more dedicated approach to at least pinpoint the size of the UK population is being considered	If populations sizes are not known, it is not possible to estimate cumulative effects
5. Analysis existing bat data (WMR)	Two months delay in delivery of report, expected in October 2018	Results will give more biological information on bats; first results show that females migrate to the UK and males have a more specific territory. Bats that live in trees are more likely to migrate over sea than species that live in buildings
Effectiveness of mitigation measure bats (BuWa)	Not in MRP, delivery of report in autumn 2018	Results will show whether the stand-still mitigation measure can be refined and in what way
WOZEP research 2016		
Desk study on population size (Zoogdierwerkgroep, WMR)	Report delivered 2017	Results show that there is a wide variation in population numbers. More observations are necessary to make the database useful (4)
Pilot thermal imaging cameras and telemetry study for behaviour and collisions (WMR, Wageningen Food & Biobased Research (WFBR)	Report delivered 2017	Results show that telemetry is successful to survey bats, but to identify bat species with thermal camera more research is needed (3)

2.3.2 Adaptations to the programme

A study on the effectiveness of mitigation measures for bats is added to the programme. Based on the bat detector data on migration intensity as function of weather conditions that have been collected until now, an analysis is being executed to determine whether the stand-still mitigation measure can be refined and in what way. The purpose is to limit the down-time of turbines as much as possible, within the limits of the currently accepted potential impact on bats.

2.3.3 Future plans

The following subprojects are planned for the future (2019-2021):

- Continuation bat detector research
- Thermal imaging research

2.3.4 Conclusions

The research on bats at sea is rather new, but in the last few years a lot of knowledge is gained on this topic within WOZEP. The results of the current projects will deliver information on the way bats migrate over sea, on efficient mitigation measures and follow-up research if needed.

2.4 Marine mammals

Over the past 10 years research was focused on the impact of impulsive underwater sound on marine mammals. The research has shown that marine mammals such as harbour porpoise and seals are sensitive to underwater sound that is produced by pile driving. Experiments under laboratory conditions have been done to determine the individual behavioural response of marine mammals to underwater sound and to determine their hearing thresholds. Sound propagation models were developed to determine the distance at which sound thresholds for marine mammals are met. In some cases, field measurements have been done to determine the underwater noise and harbour porpoise behaviour during construction of an offshore wind farm. The field measurements in some cases show a discrepancy with the laboratory condition experiments. And finally, population models have been developed to try and determine the impact of offshore wind farms on the harbour porpoise populations. These developments have led to new questions to get a better understanding of the impact of underwater noise on marine mammals.

2.4.1 Current situation and results

Table 2-4 shows an overview of the current subprojects for marine mammals under WOZEP. Part of the planned subprojects for research on marine mammals has been executed and reported, another part will start in autumn 2018. Four of the 13 proposed projects have not started, including (3) Other relevant species to be affected by underwater noise, (5) Pilot tagging study, (11) Maximum permissible impact in relation to carrying capacity (prey availability) and (13) Underwater noise by non-piled foundation types, due to various reasons.

Subprojects (3) and (13) have not started yet because the urgency for these studies is low. Currently other marine mammal species which are not included in the programme occur in very low numbers on the Dutch North Sea, especially in coastal waters where the current development sites are located. Also, other foundation types are not commercially implemented yet in current offshore wind farms. These proposed projects will probably not be executed within WOZEP 2017-2021.

Due to ethical and practical reasons project (5) has been delayed. If it is not possible to tag harbour porpoises in The Netherlands, research using a C-pod network can be used as alternative. This will however result in less detailed information on behaviour of harbour porpoises in relation to underwater noise than the potential results from the tagging study. Tagging harbour porpoises still remains a possibility but will most likely occur on a smaller scale than originally planned.

Under Project (11) a desk study on harbour porpoise prey species, data availability and prey availability in relation to harbour porpoise habitat use and offshore wind development will be conducted at the end of 2018/early 2019.

The results of the projects and future studies are discussed in the Underwater Noise and Marine Mammals working group which meets 2-3 times per year. In this way the results of the project are reviewed by experts. The results are and will be used for the update of the KEC and improving population models.

Table 2-4 Overview current subprojects, planning and results for marine mammals

Subproject	Planning	Results
WOZEP research 2017-2021		
1. Update sound propagation model(s) Aquarius	In 2018 the sound propagation model Aquarius was validated against measured sound levels during the construction of two OWFs. However, it has not been updated yet to include frequency weighting.	The sound measurements in the field showed that the sound propagation model(s) underestimated the noise levels at larger distances (above 30 km). The Aquarius model has been updated to improve the predictions. However, the new knowledge on frequency weighting has not been applied yet. Aquarius model 4.0 is set up to be able to calculate noise propagation using frequency weighting.
2. Desk study to establish sensitivity of seals compared to harbour porpoise	This study will not be executed within WOZEP because of new insights	It was assumed that seals were less sensitive than harbour porpoise to underwater sound. Recent research results give indications that seals might be more sensitive to underwater noise than was assumed. To investigate this further a more elaborate research on seals is being set up.
3. Other relevant species to be affected by underwater noise	Not started because there are only very low numbers of other marine mammals in the (Dutch) North Sea now	Impact on population level is not expected now because the developments are mainly in the coastal zone, but if development of offshore wind moved further offshore this research direction will become more urgent
4. Advice on frequency weighting for effect assessment (TNO)	This project is ongoing and started in 2017.	For hearing injury TTS and PTS, frequency weighting should be used. For disturbance a frequency weighting has not been established yet because there are not enough empirical data to support this. The results on TTS and PTS will be presented at ESOMM conference in September 2018. Plan was to organize an international workshop on disturbance, but this has failed because noise modelling data have often not been made publicly available.
5. Pilot harbour porpoise tagging	Not started yet because of logistical problems, maybe start at the end of 2018 or beginning of 2019. Chance is very low that tagging will be possible on the initially expected scale/method within WOZEP but a first attempt in cooperation with other parties is still a possibility. .	Results are necessary to combine received levels of underwater noise, shipping sound and information on behaviour and distribution. If tagging is not possible, an alternative could be found in using C-PODs (10) but C-PODs will not provide the same amount of information that tagging could.
6. Effect of underwater noise on energetics porpoises	Research was done in 2016. Report on fasting study was published in January 2018	Study of old husbandry data of two captive harbour porpoise to gain more insight into long term energetics. Also, a fasting study was done. The food intake of a harbour porpoise changes

		depending on the season and the water temperature. Food consumption peaks in the winter. Seasonality is important to include in the iPCoD model
7. Translate results of energetic research to population models	Executed as part of MEP Gemini, and not in WOZEP	In June 2018 a symposium (INPAS) was held and an expert elicitation to improve the iPCoD model. Based on this elicitation the iPCoD model will be updated. Experts say that harbour porpoises are disturbed until 6 hours after piling instead of 24 hours. Although the effects of 24 hours of fasting do have a (potentially large) effect on porpoises (depending on the season and initial body condition), they will not die (unless their initial body condition was already very deteriorated). The effects of recovery or longer periods remains unknown. These results will be incorporated in the model.
8. Investigate the changes in food availability before, during and after the construction of an OWF (WMR)	Report expected in autumn 2018	Harbour porpoise feeding buzzes from C-POD data of MEP Gemini are used to determine feeding behaviour within and close to the park. Results will give more insight in the quality of the offshore wind farm site as foraging area for harbour porpoise.
9. Individual Based Model seals	Executed in MEP Gemini, not in WOZEP	There are thoughts of tagging seals within WOZEP, see future plans in paragraph 3.4.3.
10. Importance of North Sea Regions in relation to abundance by foraging, breeding, migration (C-pod network)	Planned to start in autumn 2018	In autumn a desk study will be executed to determine the feasibility and possible methods (CPOD array layout etc.) which can be used to determine the importance of different areas on the Dutch North Sea for the harbour porpoise. Based on this feasibility study a CPOD array will be developed and implemented over the next years. Additionally, harbour porpoise habitat use is being modelled as part of a PhD project at RWS/WUR).
11. Maximum permissible impact in relation to carrying capacity (prey availability)	Not in WOZEP yet	Student from WUR will start with desk study in September 2018 on what information is available for prey species, what data is available and what additional data might be needed. This to give an idea of predator species in relation to their prey and the effect of offshore wind development hereon. In addition, University of Leiden executes research on effects of underwater noise on cod (see Fish 2.5.1)
12. Other stressors to marine mammals, confounding impact analysis of OWFs	Report delivered summer 2017, not peer reviewed yet.	Results show that females load a large portion of PCB to their first young via

(contaminant research stranded porpoises)		lactation, levels decline with every lactation period. Males contain higher levels of PCB than females. First born young are more vulnerable because of high PCB levels. Stranded porpoises in NL are smaller than porpoises in Scotland
13. Underwater noise by non-piled foundation types	Not started because there no other piling techniques are being implemented on a significant scale at this moment	Will start when promising new techniques are available
Underwater noise around water surface by seals	Co-financed by WOZEP, report delivered but not peer review yet	Results show that sound levels when the seal sticks its head out of the water are comparable with levels at 1 m depth when the seal is completely submerged.

2.4.2 Adaptations of the programme

The following adaptations of the programme were made:

- Because it is difficult to tag harbour porpoises in the Netherlands an alternative study is needed. Therefore, it has become more urgent to implement the initial plans of, installing a C-pod network;
- Subproject 2 will not be executed. Instead there are plans to tag seals and monitor them during the construction of OWF Borssele.

There were no further adaptations to the programme. Some of the proposed subprojects have however been executed outside WOZEP and conducted as part of the MEP Gemini. This includes the seal tagging study for development of the seal individual-based model and translating results on energetics into the population model iPCoD.

2.4.3 Future plans

The following subprojects are planned for the future (2018-2021):

- Seal tagging study Borssele to determine noise exposure of the seals during (mitigated) construction of an offshore wind farm. The results from this study can be used as input for a seal population model. This study will be similar to the study that was done for OWF Gemini. However, in this case there will probably be a larger chance that tagged seals will be exposed to the underwater noise since the haul out locations are closer to the wind farm;
- Frequency weighting: develop extra TTS curve for harbour porpoise; Too little is known about the effects on TTS and PTS when taking frequency weighting into account. More accurate measurements on the specific weighted exposure sound levels that can cause TTS are required.
- Determine whether there are sub populations of harbour porpoise by conducting a DNA analysis of stranded harbour porpoise; This is important to determine what the possible vulnerable sub-populations could be that will be used in subsequent PCoD modelling. An alternative could also be to run PCoD with the use of vulnerable sub-population characteristics already used in the DEPONS model.
- Habitat use and use of existing wind farms by harbour porpoises will be done through a C-pod network study; This study will be more elaborate than was initially proposed because the harbour porpoise tagging study will not be able to be executed on a large scale.
- Running new versions of iPCoD and DEPONS to determine the differences between the model and the application of these models for future purposes.

2.4.4 Conclusions

Some of the subprojects on underwater sound and marine mammals have been finished. Many projects are still ongoing, and the remaining projects will start in autumn 2018 or beginning of 2019. The results of the finished projects are used to update the KEC and update the iPCoD model and can be used for other models such as DEPONS. Coming results will give information on the effects of underwater sound on population level and on behaviour of harbour porpoises within or near OWFs.

2.5 Fish

Although general information is available concerning the distribution of fish species in the North Sea, a lot remains unclear. Data about the presence and densities of marine fish populations are lacking. In addition, there are questions about the effects of OWFs on fish in the short term (acoustic disturbance and sediment dispersion) and in the long term (habitat change, operational underwater sound, electromagnetic fields (EMF) and changes in fishing methods and fishing intensity due to the presence of operational offshore wind farms). Furthermore, more information is needed about the extent to which the impact on fish has a knock-on effect in the food chain (including accumulated effects) on marine mammals and seabirds that depend mainly or even exclusively on fish. It is therefore important to have, and acquire, basic information about fish populations in order to make a proper estimate of cumulative effects. For now there is a focus on the effects of EMF on fish.

2.5.1 Current situation and results

The subproject research on EMF has recently started. Other subprojects that were planned for fish are on hold or are partly covered by the EMF study that is being executed. Possibly the EMF study will lead to new questions. The projects that are on hold at the moment should be reassessed whether they are still relevant. Table 2-5 shows an overview of the current subprojects in WOZEP and related to WOZEP.

The results from the pilot and EMF study are used in environmental impact assessment for OWFs in the North Sea.

Table 2-5 Overview current subprojects, planning and results for fish

Subproject	Planning	Results
WOZEP 2017-2012		
1. Disruption of fish behaviour by EMFs	On hold, this study was meant as a follow up from the pilot in 2016 looking at effect of EMF.	
2. Carry out field measurements of EMFs	Start August 2018	Field validation of EMF and filming of megafauna (attraction of fauna, distinct behaviour). Results will be used as input for models
3. Population effects of EMFs on fish	On hold	Depending on the results of Research on EMF lab effects, this subproject might be executed.
4. Effect bottom trawling exclusion on local fish stocks	On hold	Results of MEP (OWEZ and PAWP) show little change in flatfish (such as sole, plaice, flounder etc) community before and after building the OWF. Near the base of the turbines and the scour protection there were some differences in the fish diversity. No big differences

		are expected in the fish community, so this research will probably not be executed within WOZEP.
Effects of underwater sound on cod	WOZEP participates	University of Leiden executes research on effects of underwater noise on cod (11. Marine mammals)
WOZEP research 2016		
Pilot looking at effects of EMF	Report delivered in 2016	Literature study, results show that low EMFs do not have a lower impact than high EMFs. Results were input for Research on EMF.

2.5.2 Adaptations of the programme

At the moment there are no adaptations of the programme. The subprojects that are on hold should be revaluated. The project (1) and (2) are partly covered by the EMF study (0). Possibly this study will lead to new questions.

2.5.3 Future plans

The following projects are planned for the future (2018-2021):

- Effects of OWFs on (non) commercial fish species

Other future projects that were suggested:

- Impact of OWFs on sandeel distribution. The current windfarms are planned partly in sand eel hotspots. Sand eel is also an important food source for harbour porpoise and birds such as terns;

2.5.4 Conclusions

The research on fish in WOZEP has a lower priority than other themes because no severe impact is expected. At the moment the research is focussed on the effects of EMF, in august of this year the EMF survey will start.

2.6 Benthos

Though the Environmental Impact assessment (EIA), Appropriate Assessment (AA) and KEC did not identify any significant effects requiring mitigation, it is often argued that OWFs may have a positive effect on biodiversity and even cause an increase in biomass due to the introduction of a hard substrate environment and by keeping out fishing activities that disturb the seabed. These benthic habitat effects are thought to reflect on improving foraging opportunities of species higher up in the food web, like predatory fish, birds and marine mammals. This is the main reason to spend monitoring effort on the long-term development of benthic habitats.

2.6.1 Current situation and results

Most of the subprojects have been finished besides subproject (2) Long term monitoring of hard substrate benthos. Because preparation of this project took more time than was initially expected (fieldwork more expensive than expected and access problems), this subproject is still in the start-up phase. In 2019 the actual field work will start. This delay doesn't have any consequences for the program. Table 2-6 shows an overview of the current subprojects in WOZEP.

Table 2-6 Overview current subprojects, planning and results for benthos

Subproject	Planning	Results
WOZEP 2017-2012		
1. Long-term monitoring of soft substrate benthos	Survey executed in 2017, report delivered in 2018	Monitoring only in PAWP and not in OWEZ. After 10 years no differences could be demonstrated before and after building the OWF. No differences were found inside the wind farm compared to outside the wind farm
2. Long term monitoring of hard substrate benthos	Preparation in 2018, start fieldwork in 2019. Was originally planned in 2017, but because no ship was available it was delayed. This has no consequences for the program	Continuation of MEP research (T12). Former research was performed with divers, due to a change in legislation diving is prohibited and ROV must be used
3. Biogenic structures	Reported in 2017	Pilot with side-scan sonar in PAWP. Results showed no biogenic structures.
WOZEP research 2016		
International data analysis for benthos	Report delivered in 2018, it was delayed due to bad quality of the first draft.	Availability of data was a problem and a comparable project was executed at the same time (UNDINE). A literature study was executed, no data analysis. Results show that there are differences before and after building the OWF for hard substrate and not for soft substrate fauna, although a difference was found in Belgium (by measuring closer to the wind turbines)
Feasibility benthos survey	Report delivered in 2016	Power analysis of the monitoring programs for hard and soft substrate benthos. Results showed that there a quite some errors in the program. The results were used to change some parts of the program, like sample size

2.6.2 Adaptations of the programme

There were a few adaptations of the benthos programme:

- The combined benthos survey was only executed in PAWP and not in OWEZ;
- For the soft substrate survey the reference areas were changed and measurement of the fishing intensity was added in order to tell more on the effect of no fishing on benthos.

2.6.3 Future plans

The following projects are planned for the future (> 2018):

- Impact of underwater noise from piling on bivalves;
- Long term effects on soft substrate: a monitoring survey of soft substrate in 2020 in OWEZ/PAWP 15 years after construction;
- Baseline study (T0) of benthos and sandeel in future wind farm zones (WOZEP 2.0).

2.6.4 Conclusions

The research on benthos in WOZEP is mainly a follow-up of the MEP studies. In august the long term hard substrate survey will start. Many developments within the benthos survey are quite unique. The soft substrate benthos survey is the first survey that has monitored the changes in substrate 12 years (T12) after the wind farm is built. The hard substrate survey will be done using ROV, this has also not been done before.

2.7 Ecosystem Effects

The past few years of research on impact of OWFs on the marine environment has focussed on individual wind turbines and wind farms. The cumulative impact has also been addressed because a potential significant impact at population level will only become visible as more wind farms are built and larger areas of the North Sea become occupied by operational wind farms. Long-term plans, aiming for 2050, foresee an implementation of over 60 GW of offshore wind capacity in the Dutch part of the North Sea. Also, other countries surrounding the southern North Sea are planning to build large OWFs. Furthermore, the turbines in the offshore wind farms have shown a large increase in dimensions. The expectations are that this increase may continue in the coming decades. Once all these wind farms are built and operational, they will (potentially) interfere with the atmosphere (wake effects). But how and to what extent this will affect the wind climate, the hydrodynamic climate (waves, currents and surge) and the ecological functioning of the southern North Sea is poorly known. Possibly other ecological receptor species, apart from those that are currently identified as species at risk, will be identified as being vulnerable to the offshore wind developments.

This new theme ‘Ecosystem effects’ has been added to the WOZEP program to investigate the impacts of large scale offshore wind developments on an ecosystem level.

2.7.1 Current situation

This theme was not part of the MRP. In 2018 Rijkswaterstaat has asked Deltares and WMR to execute an assessment of the ecosystem effects of large-scale implementation of offshore wind in the southern North Sea. In the first phase a qualitative schematization will be drafted of the factors that affect the Dutch part of the North Sea ecosystem and are likely to change as a result of more offshore wind energy and how these factors depend on each other. In autumn 2018 the final report will be delivered, this will be the basis for the further assessment.

The emphasis in the second phase is on the physical and water quality impacts of the offshore wind farms, i.e. the effects on wind, waves, currents and tide, mixing of nutrients and suspended matter, lateral transport of suspended matter and sand, and primary production. The third phase qualitatively describes the transfer of physical-chemical effects of the offshore wind farms on the biological components of the North Sea, starting with plankton and benthos, and to some extent the higher trophic levels, such as fish, birds and marine mammals.

2.7.2 Adaptations of the programme

This is not applicable, as this project in itself is an adaptation of the WOZEP programme.

2.7.3 Future plans

The following projects are planned for the future (2019-2023):

- Translate results from the initial assessment of impacts to higher trophic levels;
- Acquire more data on physical and ecological data, based on the assessment by Deltares/WMR.

- Research on impact of underwater noise caused by pile driving on plankton. Research done for seismic surveys show that all plankton near the airgun does not survive;Effects of OWFs on lower trophic levels in combination with oceanographic parameters
-

2.7.4 Conclusion

Ecosystem effects is a relatively new theme in the program. The first preliminary assessment has been executed. Depending on the results of this study more studies will be executed. Probably it will not be possible to finish these studies within the first WOZEP period.

3 General observations

In this paragraph some general observations have been made about the KEC and international cooperation. In addition, a few suggestions are made about possible adaptations to the program.

3.1 KEC

The Framework for Assessing Ecological and Cumulative Effects (KEC in Dutch) has been drawn up to determine how to deal with the cumulative ecological effects of the development of offshore wind farms in the southern North Sea. It provides a guideline on how to cope, as quantitatively as possible, with assessing cumulative effects of offshore wind farms on the (population) level of receptor species that are potentially vulnerable and is based on existing publicly available scientific knowledge which it applies to the Roadmap in order to identify the cumulative effects, in combination with other developments in the biologically relevant regions and to assess how serious they are. The results from the WOZEP projects are used to update the KEC.

KEC update
The KEC, as an assessment tool, is updated for new policy developments such as the Roadmap 2030, EIA's, or ifhthe results from WOZEP give a reason to do so. There is no regular planning for the updates. Desired updates of KEC calculations, e.g. because new scenarios are being developed (either within current policies or beyond the scope of them), can be carried out at any given moment using the most up-to-date version of the assessment tool. At this moment the KEC is being updated as well as re-run, because on the one hand several projects have provided interesting results which could change the assumptions and outcome of the KEC, and on the other hand the new Roadmap 2030 requires assessment estimates of new development scenarios.

3.2 International collaboration and developments

Collaboration
The WOZEP monitoring and research programme greatly values international collaboration. After all, the species concerned are not bound by national borders, and neither are the impacts. Therefore, several of the proposed research projects for the Programme 2017-2021 logically have a strong international component. In the MRP the ambition is to build an international network of experts in these projects by hosting international workshops, organising and contributing to/participating in international joint research projects and by making all data internationally accessible through the WOZEP data lab.

Based on the interviews we found that the WOZEP team has good connections with researchers in the other North Sea countries that work on the effects of offshore wind. WOZEP results are being presented at international conferences, knowledge is being shared between researchers and research projects are aligned between countries.

At the moment WOZEP specifically looks at research/monitoring in one specific country (the Netherlands) and mostly looks at effects within one particular OWF (for efficiency reasons), but some monitoring should be done on a North Sea ecosystem level. The different parts of the North Sea are not comparable, it is not always possible to translate effects from one location to another. For example: in the offshore areas the water column is much more stratified than in the coastal zone, which influence the primary production and the rest of the food chain. Germany and the UK are doing research on this topic.

CEAF and SEANSE
North Sea countries are working together on a common approach for cumulative effect assessment (CEAF) of offshore renewable energy. The Netherlands and WOZEP team members play an important

leading role in CEAF and the EU project SEANSE, where CEAF will be tested in several international case studies. The time that WOZEP team members have to cooperate with other countries could be optimized to have a better result.

Hamburg meeting
In January 2018 a first international meeting was held in Hamburg. This was very successful meeting and there was a lot of enthusiasm and awareness on the importance of international collaboration. During this meeting knowledge was shared and the discussion on working together on an international level was discussed but has not yet led to concrete actions.

MSFD and OSPAR
WOZEP is now focussed on Natura 2000 species. For the future it may be necessary or worthwhile to focus also on MSFD indicators and/or on OSPAR because:

- Even though the MSFD is not legally enforceable yet, we cannot ignore it because it will for example become part of the EIA procedure;
- OSPAR might become more important in the future for countries bordering the North Sea as Norway and UK (after Brexit) are not part of the EU and thus do not have to abide to EU policies such as Natura 2000.

WOZEP already has offered data to the MSFD team at DGBW to use this in the developments around MSFD (see chapter 1).

Differences with other countries
On some topics the Netherlands is a front runner or has its own way to practice research:

- Behaviour of seabirds in OWFs is often not investigated in other countries, models and breeding success are used to determine the impact;
- Long term benthos and fish monitoring is much longer in The Netherlands, T12 against T4 as maximum in other countries;
- New monitoring techniques are developed such as the ROV for hard substrate sampling;
- Research on bats is not yet executed in other countries.

3.3 Suggested improvements

During the interviews with people are linked to the WOZEP project (either closely linked, or further away; either more linked to the use of the results or more from a scientific point of view) several suggestions were done to improve the programme. These suggestions will be considered by the WOZEP team in a later stage, they will decide if and how they will be incorporated in WOZEP.

The following suggestions were mentioned:

- In general, the opinion is that WOZEP executes the right research projects in the right way;
- Several external experts stated that the international collaboration is not optimal and should be improved by setting up a more international coordinated monitoring program. This will be more effective and cost-efficient;
- Make a decision on the continuation or termination of projects that do not work out as planned: tagging of harbour porpoises and gulls, thermal imaging monitoring on bats. The question is whether data will be delivered that will be useful to answer the research questions;
- Align the KEC updates with the planning of the subprojects, where possible;
- Be prouder of WOZEP and more actively promote to the outside world. Improve the WOZEP website, see for example Sand nourishment Buitendelta Ameland;

- Setting the priorities at the beginning of WOZEP is done well, now it is time to revise the priorities: more focus is needed on benthos (benthic component of ecosystem function and trophic level change) and fish and on continuous noise (in addition to impulse noise), these subjects will be of greater importance when the upscaling becomes larger;
- Make a better link to the DGnoise projects to avoid duplicating research on the same topic being done for underwater noise;
- Put more focus on the relation with the objectives of MSFD and OSPAR, this will be more important in the future;
- The research on EMF should also look into static EMF caused by the cathodic protection. Also, particle motion could be an important factor for fish and benthos;
- The Belgian research on offshore wind show some interesting results that could be useful for the Dutch situation:
    - terns are attracted to OWFs and common terns forage more actively inside OWFs then outside OWFs;
    - soft substrate benthos is richer (higher biomass and biodiversity) around wind turbines until around 50 m of distance;
- Put more effort in the preparation of the market consultation meetings and the WOZEP feedback meetings, because the meetings are not always very useful to a large part of the participants. Take greater consideration of the information needs of the participants and give concrete instructions to the presenters to relate better to the participants;
- To be able to assess the impact of the upscaling of offshore wind energy it is necessary to upgrade the current monitoring program to a more ecosystem-based monitoring program. This must be based on a North Sea ecosystem approach; therefore, an internationally coordinated monitoring program is needed. It is advised to use the existing infrastructures for that, like the SCANS project;
- Make clear to the outside world how the quality control of the products is realized;
- Instead of assessing the impact of plans it would be interesting to use opportunity maps, to see what the places with the least impact are to develop OWFs. The development of opportunity maps needs to be taken a step further to be able to use them in the decision process.

3.4 Overall conclusions and considerations

- For the sub themes birds displacement, birds collision risk and marine mammals most of the projects are being executed or are (almost) finished. Some results are already available and have been applied, however many results will become available in the near future. It is too early to say what the outcome will be. The research on bats is rather new, the projects are still ongoing, but a lot of new insights have already been gained on this topic. The sub themes fish and benthos have clearly been given a lower priority at the beginning of WOZEP. The projects within these themes have taken longer to set up. However, most of the projects have recently started this summer.
- A new sub theme has been added to the programme: ‘ecosystem effects’. Most likely the results of this new theme will not be available before the end of the WOZEP programme. However, this addition to the programme is a valuable and in line with what is needed when considering the offshore wind developments that are expected in the future.
- Generally, the people that were interviewed think WOZEP is a good monitoring programme that will deliver valuable information on offshore wind energy.
- There are some doubts whether the data will be suitable to give information on large scale offshore wind;
- A lot of people have the opinion that a more ecosystem-based approach is needed, on a national and an international level;

- Some people mentioned that not only international collaboration is needed, but an internationally coordinated monitoring program is needed. This is a difficult path to take, but one or two countries must take the lead in this to make it happen.