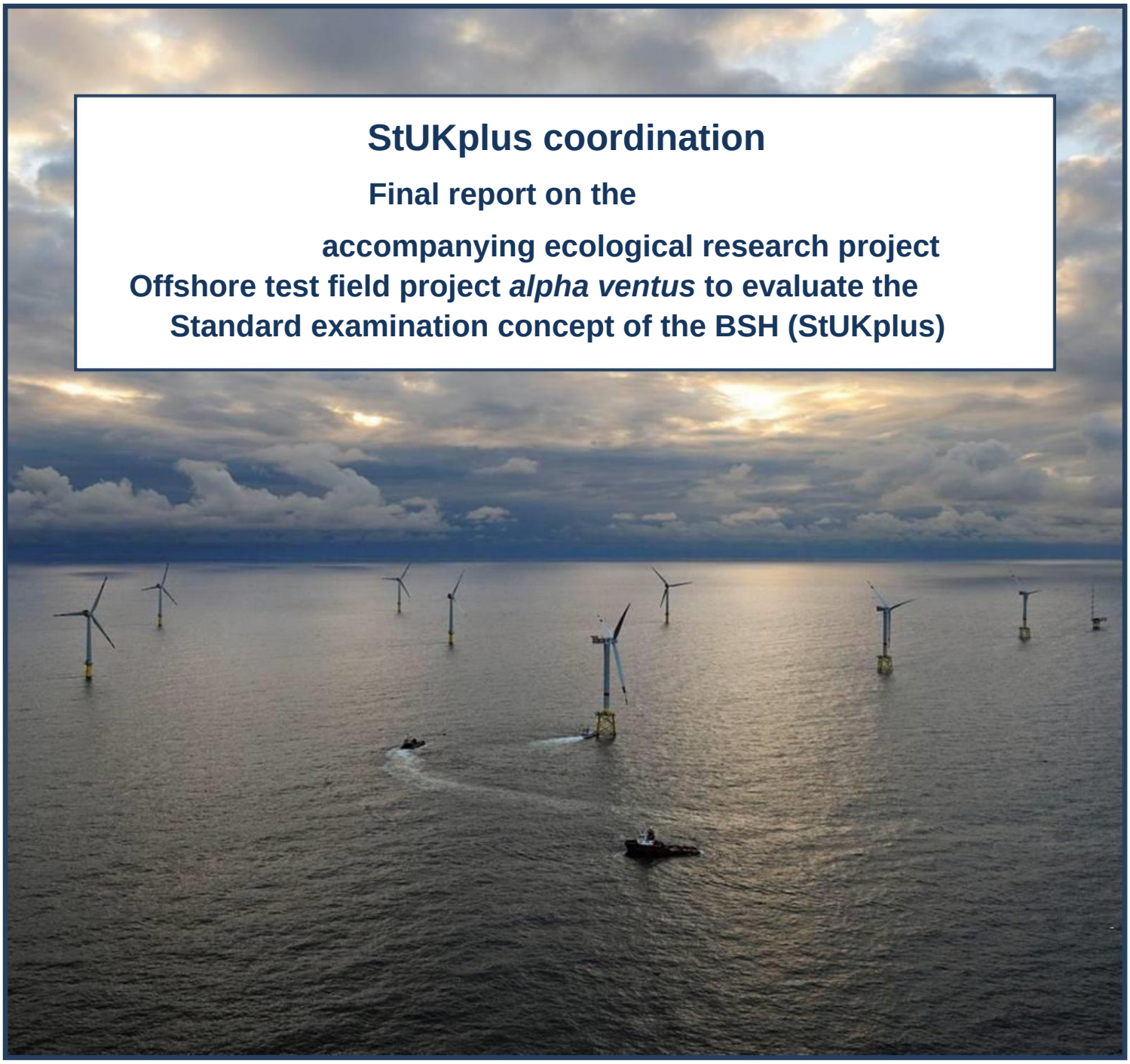
StUKplus coordination

Final report on the

accompanying ecological research project Offshore test field project *alpha ventus* to evaluate the Standard examination concept of the BSH (StUKplus)



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RAVE RESEARCH AT ALPHA VENTUS
Eine Forschungsinitiative des Bundesumweltministeriums

coordination

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Project name

Accompanying ecological research on the offshore test field project *alpha ventus* to evaluate the standard investigation concept of the BSH - StUKplus
(sub-project: coordination)

Duration of the project

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project participants

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1. Summary

In 1999, when the first applications for offshore wind farms were received by the Federal Maritime and Hydrographic Agency (BSH), the competent approval authority for offshore facilities in Germany's Exclusive Economic Zone (AWZ), there was little knowledge of the possible environmental impact. Practical experience in the offshore wind energy sector had already been gained in other European countries (Denmark, Great Britain), but these projects were only slightly comparable to the German projects, because here wind farms were built at a distance of up to 150 km from the coast and water depths of up to 50 m planned. With the number of wind farm areas applied for, the demand for a cumulative consideration of the effects also increased.

The development of the offshore test field alpha ventus was initiated in 2005. As the core of German offshore wind energy research, the test field represents the central platform for technical, ecological and social research projects within the framework of the research initiative "RAVE" (Research at alpha ventus). The RAVE project "StUKplus" considers ecological issues that arise in the related to the construction of offshore wind farms. The aim was to gain a deeper understanding of the actual environmental impact of offshore wind farms using the example of alpha ventus.

The StUKplus research project supplements the environmental monitoring that operators are obliged to carry out in accordance with the standard investigation concept (StUK) of the BSH (standard “Investigation of the effects of offshore wind turbines on the marine environment”). StUKplus considers research-specific issues that go beyond the scope of the StUK. During the extensive field investigations at the alpha ventus test field, new methods and recording techniques were tested, such as digital flight recording for resting birds and marine mammals or new radar devices for recording bird migration.

Based on the results of the accompanying ecological research at alpha ventus, the version of the StUK (StUK3) published by the BSH in February 2007 was evaluated and checked for appropriateness and effectiveness for other offshore wind farm projects and updated. At alpha ventus, the StUK3 was used for the first time in an offshore wind farm during construction and operation. In October 2013, the third update of the standard examination concept, the StUK4, was published by the BSH.

StUKplus is the most important German research project to date that has examined the environmental impact of offshore wind farms.

2. Summary

When the first applications for offshore windfarm projects were submitted to the Federal Maritime and Hydrographic Agency (BSH), many questions concerning possible impacts were far from being answered satisfactory. Although some practical experience had been gained in other European countries (Denmark, UK), concrete data was difficult to obtain and difficult to apply to German projects, which were located up to 150 km offshore and at water depths of up to 50 m. With more approvals being granted and the first windfarms under con struction, cumulative evaluation of possible impacts became more and

Development of the alpha ventus offshore windfarm was initiated in 2005. As the nucleus for Germany's offshore wind energy sector, the test site is a focal point for technical, ecological and social research under the umbrella of the RAVE initiative (Research at alpha ventus). Ecological research at alpha ventus is brought together in the StUKplus research project, funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The purpose of the ecological research was to gain a better understanding of possi ble environmental impacts of offshore windfarms.

StUKplus supplements the mandatory ecological monitoring by windfarm operators accord ing to BSH Standard for Environmental Impact Assessment (StUK). The StUKplus project sets a wider frame in size, scope and content than 'ordinary' monitoring. During the extensive field research programme, novel observation methods and technologies such as aerial digital survey techniques and new bird migration radars were applied for the first time in German waters.

Based on the experience of the ecological research at alpha ventus the second update of the StUK standard (StUK3, BSH February 2007) was updated and verified for appropriateness and effectiveness also for other offshore windfarm projects. It was used for the first time in an offshore windfarm during construction and operation, i.e. in the alpha ventus offshore test site. In October 2013, BSH published the third update of the standard, the StUK4, which is now effective for offshore monitoring procedures.

StUKplus is the most important German research project on potential environmental impacts related to offshore windfarms so far.

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6. List of abbreviations

AWI	Alfred Wegener Institute Helmholtz Center for Polar and Marine Research
AWZ	Exclusive Economic Zone
BfN	Federal Agency for Nature Conservation
BS	Federal Maritime and Hydrographic Agency of Germany
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
C-SUB	Cetacean Porpoise Detector
UNTIL	Research platforms in the North Sea and Baltic Sea
FTZ	Research and Technology Center
IfAÖ	Institute for Applied Ecology GmbH
itap	Institute for Applied Physics GmbH
PtJ	Project Management Juelich
RAVE	Research at alpha ventus
Piece	Standard investigation concept "Investigation of the effects of offshore wind turbines on the marine environment"
Quietly	University of Veterinary Medicine Hanover
FATHER	Federal Environment Agency
UVS	Environmental Impact Studies
WEA	wind turbines

7. Introduction

7.1 general conditions

Great importance is attached to offshore wind energy in the implementation of the energy transition. The Federal Government's offshore strategy provides for wind farms with an installed capacity of 6.5 GW to be built in the North and Baltic Seas by 2020 and wind farms with an installed capacity of 15 GW by 2030 (EEG as of 01 August 2014). Energy scenarios commissioned by the federal government predict that offshore wind energy will account for 20% of all electricity generation by 2050 (Schlesinger et al. 2011).

By January 2014, 128 applications for the approval of offshore wind farms had been received by the Federal Maritime and Hydrographic Agency (BSH) as the responsible approval authority in the German Exclusive Economic Zone (AWZ). In total, the areas applied for cover 5,302 km2 , which makes up an area of approx. 20% of the German EEZ. In the North Sea, 30 projects with 2,010 wind turbines (WT) and in the Baltic Sea three projects with a total of 240 WTs have already been approved. Currently (as of January 2014) seven offshore wind farms are under construction in the North Sea and one offshore wind farm in the Baltic Sea (Figure 1).

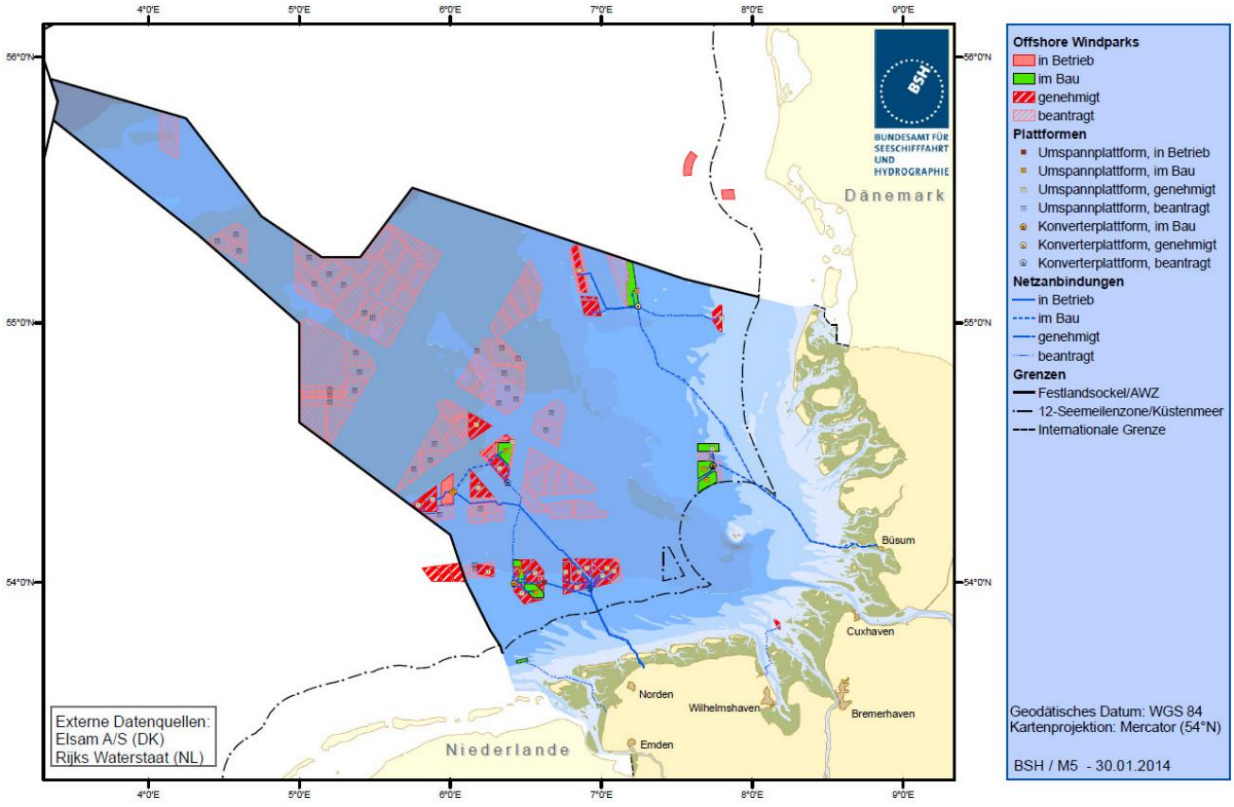

Figure 1: Status of planning for offshore wind farms in the North Sea (source: www.bsh.de).

The conflicts of use between economic interests on the one hand and protection of the marine environment on the other pose a major challenge. An environmentally friendly expansion of offshore wind energy therefore requires an understanding of the expected impact on the marine environment. There are still significant knowledge gaps, especially with regard to the cumulative effects of offshore wind farms. However, only an understanding of the mechanisms behind the changes in the marine system can help to assess possible interference in the marine environment by offshore wind turbines in the future and to find suitable avoidance and minimization measures.

The Alpha Ventus offshore test field (formerly Borkum-West wind farm) (Figure 2) marked the starting point for developing an understanding of the environmentally compatible expansion of renewable energies. Based on an extensive research and monitoring program accompanying construction and operation, it was possible to examine for the first time which possible (predicted) effects on the marine environment actually exist.

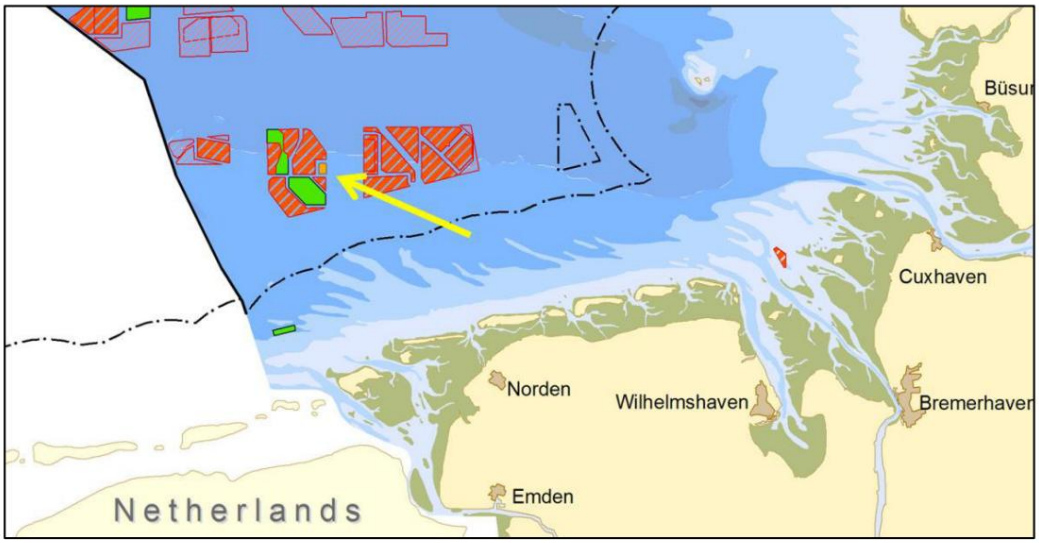

Figure 2: Location of the offshore test field alpha ventus 45 km north of Borkum.

Research topics had been coordinated in a group of experts as part of a preparatory project funded by the BMU to develop a concept for the accompanying ecological studies (FKZ: 0327689). The investigations and research topics presented in the concept were realized as part of the StUKplus project.

The accompanying ecological research at alpha ventus supplements the environmental monitoring that operators are obliged to carry out in accordance with the standard investigation concept of the BSH (standard "Investigation of the effects of offshore wind turbines on the marine environment" - StUK). It contains research-specific questions that go beyond the scope of the StUK's investigation, ie the investigation area was enlarged, the frequency of investigations increased and new recording techniques were tested.

The StUKplus project addresses the following questions:

- How does the habitat for soil organisms and fish change in the area of the foundations? How far does the influence of the artificial hard substrate extend? How changed

will the habitat change as a result of the exclusion of fishing from the wind farm area?

- How do seabirds react to the illuminated offshore structures and the rotating rotors of the offshore wind turbines? Do roosting birds avoid the wind farm area or do they get used to the offshore structures? How high is the risk for migratory birds to collide with the wind turbines?
- What influence do the noise-intensive construction work and operational noise have on sound-sensitive organisms such as marine mammals and fish? Will they continue to use the area as a habitat and how can they be protected from underwater noise?

Both technical and scientific issues have been or are being worked on in various research projects as part of the RAVE research initiative (Research at *alpha ventus)* at the ***alpha ventus*** test field . The StUKplus project is part of the RAVE research ("RAVE Ecology").

7.2 The alpha ventus test field

The offshore test field alpha ventus is located 45 km northwest of the island of Borkum in a water depth of 27 - 30 m in an area that mainly consists of homogeneous fine sand.

The test field includes twelve offshore wind turbines in the 5 MW class with a total output of 60 MW. In 2012 alpha ventus produced around 268 GWh of electricity. The turbines are each approx. 800 m apart and the entire wind farm covers an area of 4 km2 (Figure 3). The six Senvion 5M turbines were founded on jacket foundations and the six AREVA Wind M5000 turbines on tripod foundations (Figure 4).

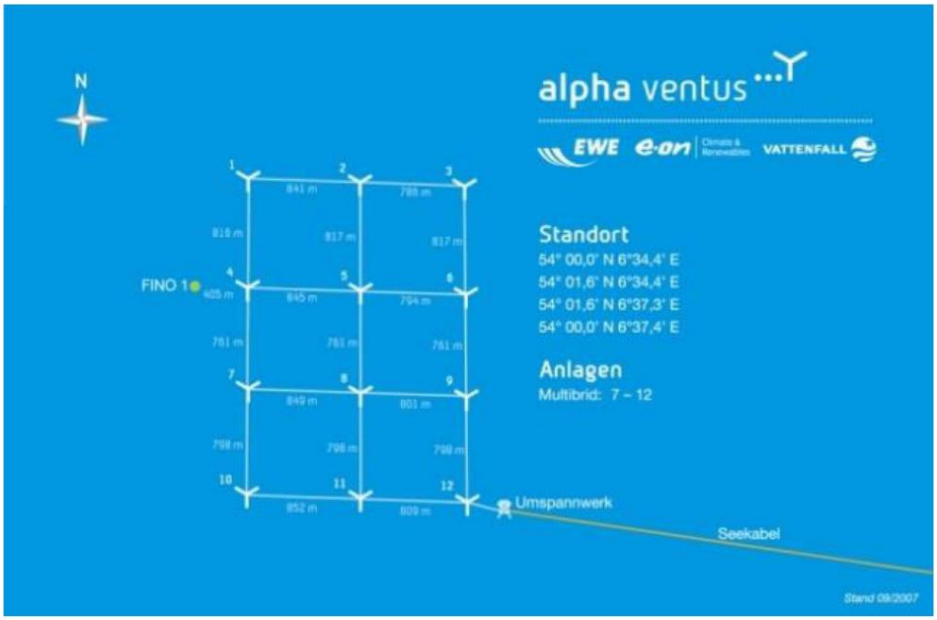

Figure 3: Schematic overview of the alpha ventus test field.

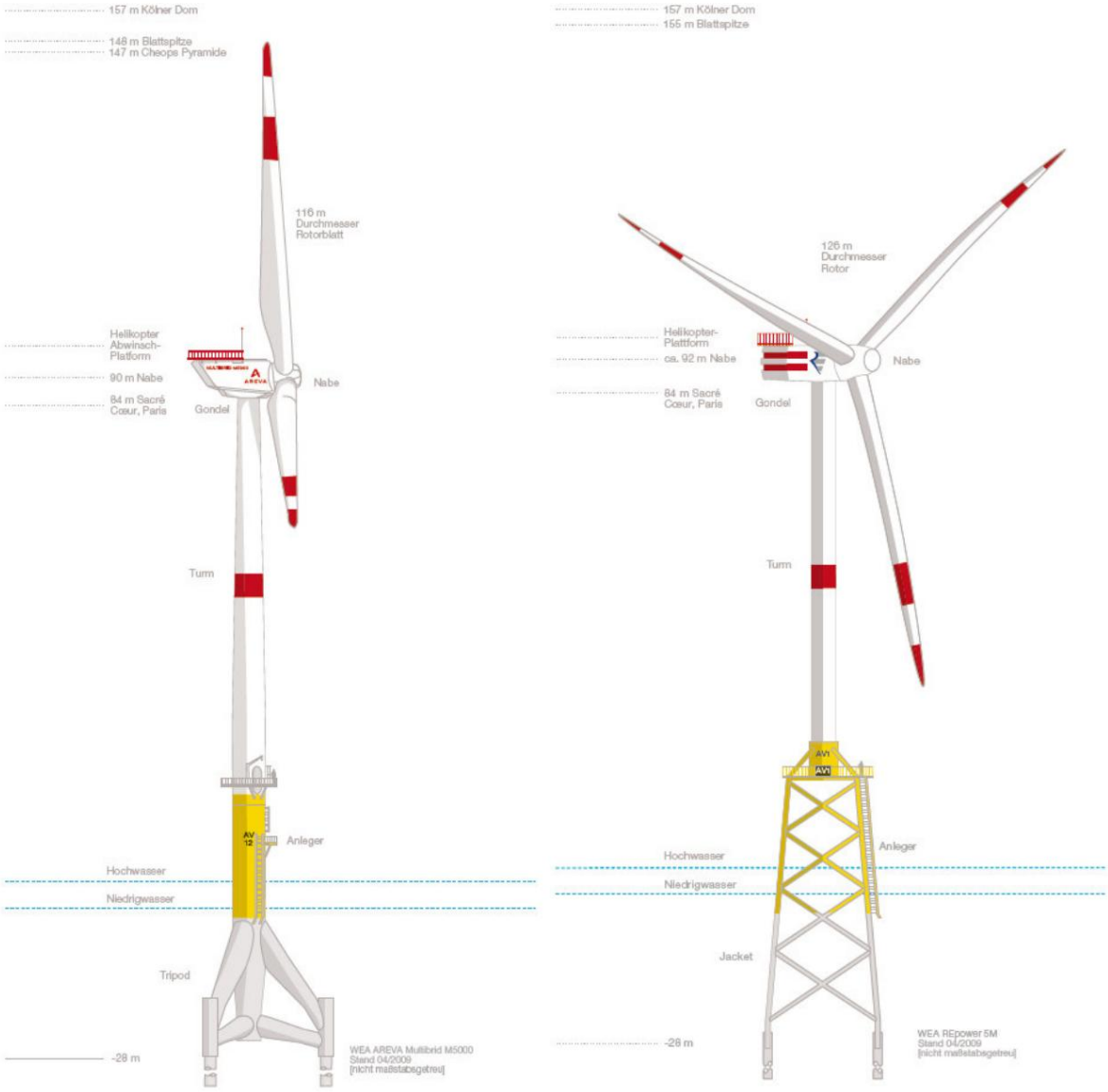

Figure 4: AREVA Wind M5000 (left) and Senvion 5M (right).

The substation for alpha ventus was set up in September 2008 (September 18 - 25, 2008). The establishment of the twelve foundations took place in the period 24.04. - 08/26/2009. alpha ventus was officially inaugurated in April 2010, although the systems were gradually put into operation until the summer of 2010.

The offshore wind farms BARD Offshore 1 (April 5, 2010 - March 13, 2013) and Borkum West II (September 9, 2011 - April 5, 2012) were erected in the area of the western North Sea during the investigation period for the construction and operating phase of alpha ventus.

7.3 Actors in test field research

In 2001, the BSH granted PROKON Nord GmbH approval for the Borkum-West wind farm. The Offshore Wind Energy Foundation was founded in 2005 and the rights of use were sold to the foundation by PROKON Nord GmbH. In 2006, the German Offshore Testfeld- und Infrastructure (DOTI) GmbH & Co. KG was founded to manage the wind farm

realize. In 2006, a lease agreement was also concluded between DOTI and the Offshore Wind Energy Foundation.

The so-called offshore foundation includes banks and financing companies, construction companies and suppliers, energy supply companies, manufacturers of offshore wind turbines, interest groups for wind energy, regional trade associations for wind energy, other associations and associations, insurance companies and the federal ministry responsible for offshore wind energy, the Federal ministry responsible for maritime shipping and maritime transport, representing the ministries of the coastal states of Bremen, Hamburg, Mecklenburg-Western Pomerania, Lower Saxony and Schleswig-Holstein, which are responsible for offshore wind energy and related issues.

The DOTI consortium consists of the operating companies E.ON Energy Projects GmbH, EWE AG and Vattenfall Europe New Energy GmbH. DOTI acquired the wind turbines from the manufacturers Multibrid (later AREVA Wind) and REpower (later Senvion), leased the test field site and concluded maintenance and operation contracts with the wind turbine manufacturers.

7.4 Classification in the RAVE research initiative

To ensure that the German wind energy industry gets the greatest possible benefit from the test field, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) provided extensive funding for various scientific and technical research projects in the period 2007 to 2013, which accompanied the construction and operation of the test field or still does accompany. Since 2008, the Fraunhofer Institute for Wind Energy and Energy System Technology IWES in Kassel has been in charge of the RAVE (Research at alpha ventus) coordination project, in which the individual, associated research projects are networked and represented.

In addition to numerous technical projects, the RAVE research initiative also includes accompanying ecological research ("RAVE Ecology", Figure 5).

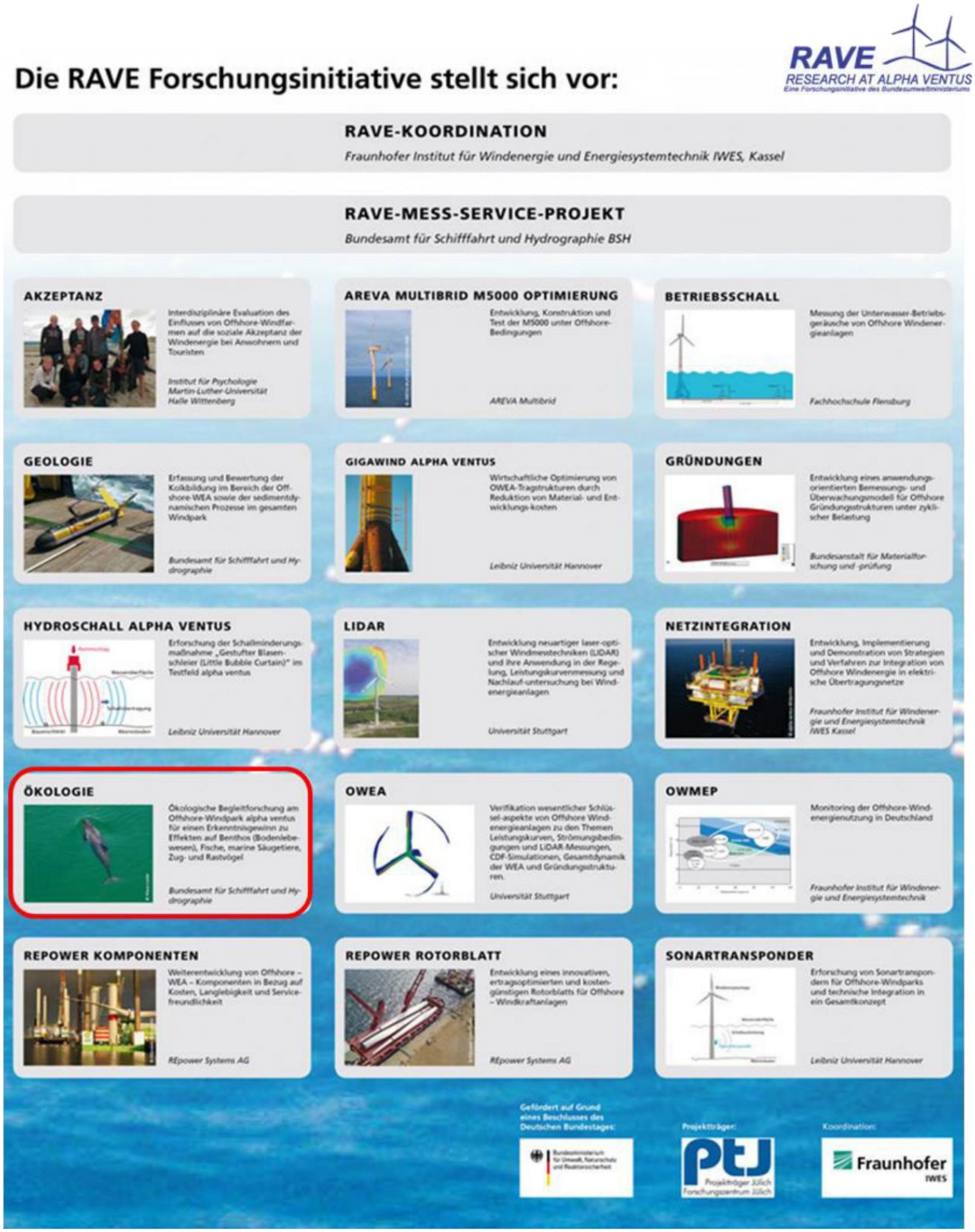

Figure 5: Overview of the RAVE research initiative of the BMU. The StUKplus ("RAVE Ecology") project is part of RAVE (Research at alpha ventus) - see red marking.

8. Objective of the project

In November 2007, the BSH organized a workshop in which representatives of well-known institutions, authorities, institutes and expert offices took part. Research-specific questions and key topics that go beyond the obligatory standard for ecological monitoring during construction and operation (then: StUK3, BSH 2007) were developed.

The main topics for ecological investigations can be named as follows:

- **Monitoring of the benthos communities (in-, epi- and demersal megafauna) as well as the fish stocks on the offshore foundations, in the project area and in the Reference range during the construction and operational phase,**
- **Recording the behavior (evasive movements, attraction) of migratory birds towards the wind farm/individual wind turbines and recording bird strikes, Registration of bird migration intensities and species spectrum,**
- **Recording the behavior (including evasive movements, behavioral associations, flight altitude changes) of resting birds in relation to the wind farm/individual wind turbines,**
- **Monitoring the abundance and distribution of harbor porpoises and seabirds during the construction and operational phase in the immediate and wider vicinity of the test field,**
- **Temporary measurements of the construction and operational noise (noise radiation) at the Wind turbines and in other distance classes,**
- **Development of quality-controlled databases for benthos, fish, resting birds and marine mammals from EIS and research data.**

Most of the substantive work was assigned by the BSH to research institutions or other third parties. The coordination office at the BSH ensured the development of methodical and resource-saving synergy effects, a targeted implementation of the concept and thus the implementation of the accompanying ecological investigations during the construction and operational phase, reporting across all protected assets a technical exchange within the framework of coordination meetings. In addition, there was an interface for the accompanying ecological research to the primarily technically oriented projects, such as the RAVE service project carried out by the BSH, in which parameters describing the marine environment (waves, wind, temperature) were recorded.

The data evaluation was based on the data collected during the course of the project, the large-scale ecological data series from monitoring and research programs available to the BSH, and data available from other state institutions. Collaborations related to protected assets were entered into with the West Coast Research and Technology Center (FTZ) and the Alfred Wegener Institute Helmholtz Center for Polar and Marine Research (AWI), which had long-term data series from research programs at their disposal.

The BSH took on the following tasks to assess the impact of offshore Wind turbines on the biological protected assets true:

- **Consolidation, archiving and evaluation of ecologically relevant data from environmental compatibility studies as well as from effect monitoring and the accompanying research in the alpha ventus test field. The data was kept in a uniform form according to standardized quality criteria of data processing with the aim of the quick availability of quality-assured data and information in the BSH.**
- **Intersection of relevant information from the biology, geology, physics and chemistry of the sea and integration of data to enable a holistic view of the marine ecosystem. Review of forecasts based on new findings**
- **from effect monitoring, the accompanying research measures, the joint evaluation of databases and the overlapping of relevant information should lead to the adjustment of usage strategies if necessary.**

The joint evaluation of data provided the basic information that was necessary for the development or further development of evaluation criteria and for the verification of impact forecasts.

In addition to gaining knowledge about the suspected effects of offshore wind farms on the marine environment, the aim of the project was also to evaluate and update the standard investigation concept of the BSH (then: StUK3, BSH 2007). The BSH, as the responsible licensing authority for offshore wind farms in the German EEZ, has developed the standard "Investigation of the Effects of Offshore Wind Turbines on the Marine Environment (StUK)" for investigating the marine environment. The StUK describes environmental investigations that must be carried out by the applicant or permit holder. The StUK3 published by the BSH in February 2007 was evaluated on the basis of the results of the accompanying ecological investigations at the alpha ventus offshore test field and checked for appropriateness and effectiveness for other offshore wind farm projects. Based on the project results, proposals for an update of the StUK were finally developed.

9. Project structure

9.1 coordination

The BSH coordinated the accompanying ecological research in the *alpha ventus test field.* The coordination office represented an important interface to all those involved in the test field from the fields of research, monitoring, the offshore wind industry and the environmental authorities. An important task was the exchange of information and the transfer of knowledge.

A large number of actors had to be integrated into the process of overall coordination of the ecological investigations. There was a high degree of coordination required for the group of contractors for the accompanying studies. In addition to coordinating the accompanying ecological research, the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) coordinated the associated research projects as part of the RAVE research initiative.

The tasks of the coordination included in detail:

- **Coordination of the contractors of the accompanying ecological investigations during the Construction and operating phase (processes, exchange of information, coordination meetings, project management) as well as participation and collaboration in the overall coordination within the framework of the RAVE project,**
- **Quality assurance of data collection and data management,**
- **coordination of data analysis,**
- **Organization and implementation of workshops, meetings and coordination meetings, participation in seminars, meetings and conferences,**
- **Editorial responsibility and merging the content of the interim and final reports relating to protected assets,**
- **Evaluation and updating of the standard examination concept based on the results from the initial application of StUK3 and StUKplus**
  Research projects for use in other wind farm projects,
- **Organization and implementation of an international final conference to publicize the project results,**
- **Press and public relations work in the project (presentation of the project results in the Lectures, television and radio interviews),**
- **Editorial responsibility for the publication of the StUKplus results in an English-language book.**

All in all, all of the tasks and interfaces described above were processed informally and appropriately in the course of the coordination project and bundled in a targeted manner using the developed concept in the sense of an efficient accompanying investigation. Due to the diversity of topics and actors, this required a careful approach. The structure, systematics and chronological order of the coordination steps had to be prepared as well as the selection and strategic distribution of the investigation work and the corresponding work packages.

Annual interim reports were prepared as part of the accompanying ecological research. The final reports related to protected assets allow for a summary and overall interpretation of the results of the standard investigations and the research projects (www.stukplus.com).

9.2 Work packages of ecological test field research

The accompanying ecological research at the Alpha Ventus test field included the following work packages (Table 1):

Table 1: Overview of the R&D orders issued by the BSH in the project period 2008 - 2014.

Contractor project designation		project duration
Alfred Wegener Institute Helmholtz Center for Polar and Marine Research	AWI1: Investigation of the effects of wind turbines Fish (A) and vagile megafauna (B) in the *alpha ventus* test field	01.07.2008 - 30.08.2012
	AWI2: Joint evaluation of data on benthos and Fish for ecological effect monitoring in the *alpha ventus* test field	01.09.2008 - 30.04.2012
	AWI3: Completion of the time series during the operational phase and determination of changes in the benthos by expanding the plant-related effect monitoring	01.10.2008 - 30.08.2012
Avitec Research GbR	Avitec Research1: Test field research on bird migration at the *alpha ventus* offshore pilot park	01.07.2008.- 31.08.2013
	Avitec Research2: Evaluation of the bird migration data continuously collected on FINO1 (FINOAVIDATA)	01.08.2009 - 31.08.2013
Institute for Applied Ecology GmbH	IfAÖ1: Detection of bird collisions using the system WHOSE	01.10.2008 - 31.08.2013
	IfAÖ2: Recording of evasive behavior of migratory birds with tels Pencil Beam Radar	01.10.2008 - 31.08.2013
research and Technology Center West Coast, University of Kiel	FTZ2: Joint evaluation of data on seabirds for ecological effect monitoring at the *Alpha Ventus* test site (SEABIRD-DATA)	01.06.2008 - 30.09.2013
	FTZ3: Studies on possible habitat loss and possible behavioral changes in seabirds offshore Wind energy test field (TESTBIRD)	01.10.2009 - 30.09.2013
veterinary University Hanover	TiHo1: Supplementary studies on the effect of construction and Operating phase in the offshore test field *alpha ventus* on marine mammals	01.06.2008 - 30.11.2013
	TiHo2: Joint evaluation of data on marine mammals for ecological effect monitoring at the *Alpha Ventus* test site	01.06.2008 - 30.08.2012
DHI/DHI-WASY	Evaluation of data of marine mammals and ecological Habitat modeling at the *alpha ventus* test field	01.01.2012 - 30.09.2013
itap GmbH	Measurement of pile driving and operational noise at further distances from the *alpha ventus* test field and processing using a model	01.07.2008 - 31.08.2011
Müller-BBM GmbH	Underwater noise from offshore wind turbines - harmonization of terminology, procedures and evaluation with regard to demand-oriented target values	01.10.2010 - 30.11.2011
sea media	Editorial supervision of the production of an English-language book on the StUKplus project	01.12.2012. - 28.02.2014

10. Brief summary of the sub-projects

The research contents and results presented below refer to the investigations that go beyond the contents of the StUK3 monitoring and are exclusively attributable to the StUKplus research.

10.1 Project AWI1: Investigation of the effects of wind turbines Fish and vagile megafauna in the alpha ventus test field

10.1.1 Work package A: Impact studies on pelagic fish

In this work package, the possible effects of offshore wind farms on pelagic fish were investigated and the investigation methods used were evaluated and further developed. The investigations were based on hydroacoustic measurement methods, net catch sampling and gastric content analysis of fish caught in alpha ventus and in a reference area. The project also included the development of a stationary, hydroacoustic measuring system for long-term measurements of fish distribution and abundance as well as a detachable equipment carrier with a movable equipment head with imaging sonar (lander system) for investigating the fish distribution on the foundation structures. The investigation covered a period before the construction phase, the construction phase (2009) and the operational phase (2010 - 2011).

The results show a strong relative reduction in fish stocks in alpha ventus during the construction phase, which suggests a scaring effect on pelagic fish from the piling and other construction activities. For the operational phase (2010 - 2011), based on the ship-based, hydroacoustic surveys carried out, no repelling or attractive effect on pelagic fish caused by Alpha ventus can be determined.

For more information see:

S. Krägefsky (2014): Final report on the StUKplus sub-project "Investigation of the effects of wind turbines on fish and vagile megafauna in the alpha ventus test field" - AP A: Pelagic fish. Bremerhaven, May 2014, www.stukplus.com.

10.1.2 Work package B: Investigating the impact on demersal fish and megazoobenthos

In this work package, the mobile demersal megafauna (crabs and fish), which settled on the foundations of the wind turbines and in their immediate vicinity, were systematically recorded by research divers. To this end, it was determined to what extent the mobile, demersal megafauna communities on the foundations differed from those on the undeveloped seabed and what abundances the stocks reached in the operational phase (2010 - 2011). The colonization of the jacket and tripod foundations was compared with each other and with the colonization of shipwrecks.

The results show that species with an affinity for hard substrate reached up to a hundred times higher abundances on the foundations than on the undeveloped soft soil in the reference area. The edible crab (Cancer pagurus) reached a maximum abundance of up to

on individual foundations (2011). Large accumulations of hermit crabs (Pagurus bernhardus), horse mackerel (Trachurus trachurus) and French cod (Trisopterus luscus) were also found on the foundations.

For more information see:

R. Krone (2014): Final report on the StUKplus sub-project "Investigation of the effects of wind turbines on fish and vagile megafauna in the alpha ventus test field" - AP B: Demer sale megafauna". Bremerhaven, April 2014, www.stukplus.com.

10.2 Project AWI2: Joint evaluation of data on benthos and Fishing for ecological effect monitoring at the alpha ventus test field

The aim of this sub-project was to carry out, for the first time, large-scale and spatially high-resolution analyzes of the benthic system with regard to spatial and temporal variability in the German EEZ. These analyzes form the basis for evaluating the results of the effect monitoring in the alpha ventus test field and the potential cumulative effects of offshore wind farms in connection with other anthropogenic effects such as fisheries in the future and for examining the spatial and temporal variability of the benthic system to be able to

For the analyses, existing data from environmental compatibility studies and monitoring of wind farm projects during construction and operation as well as from AWI research projects on the occurrence of benthic invertebrates and demersal fish in the German EEZ were evaluated, harmonized and analysed. For the first time, an extensive, standardized and quality-tested database containing information on the marine environment was set This contains data sets with information on the respective investigations, the relevant abiotic data and biological data on benthic invertebrates and demersal fish.

For more information see:

J. Dannheim, A. Schröder, K. Wätjen, M. Gusky (2013): Final report on the StUKplus sub-project "Joint evaluation of data on benthos and fish for ecological effect monitoring at the offshore test field alpha ventus". Bremerhaven, June 2013, www.stukplus.com.

10.3 Project AWI3: Completion of the time series of the StUK during the operational phase and determination of changes in the benthos by expanding the plant-related effect monitoring

In two work packages, the investigations prescribed by StUK were expanded spatially and temporally in order to check whether effects on the benthic system could be detected that could not be shown with the investigations according to StUK3 (BSH, 2007). The StUK3 investigations included extensive sampling of the benthic in- and epifauna of the seabed in the wind farm and on suitable reference areas. Plant-related effect monitoring was also carried out. For this purpose, the benthic infauna of the seabed was recorded at a distance of 100, 200 and 400 m from selected offshore wind turbines in the alpha ventus test field. The in fauna was sampled with the help of a van Veen grab, the epifauna was sampled with a beam trawl

recorded. In addition, the epifauna on the underwater structures of individual wind turbines at different water depths was documented during diving operations using scratch samples and digital underwater photography. The StUK investigations covered a preliminary investigation before the construction of a wind farm, the entire construction phase and the 1st, 3rd and 5th year of the operating phase of the offshore wind farm.

In the first work package, an additional, complete sampling was carried out in the second year of the operational phase in addition to the StUK3 investigation program. The results indicate different temporal developments of the benthic communities and the sedimentological parameters in the wind farm and in the reference area. However, these differences were due to transient fluctuations in the parameters studied (species diversity, total abundance and biomass). Long-term, directed changes in the benthos as a result of the construction and operation of alpha ventus could not be identified. Biomass and the number of species growing on the foundation structures for the offshore wind turbines have increased continuously since they were erected.

In the second sub-project, the system-related effect monitoring of the benthic communities on the sea floor was extended to the entire distance (800 m) between two neighboring offshore wind turbines. Due to the spatial expansion, no effects of the wind turbines on the benthos and the seabed were detected. The selected spatial resolution was not suitable for capturing the processes in the vicinity of the foundation structures.

For more information see:

L Gutow, K Teschke, M Gusky, S Preuss, S Breyer, R Fürst, R Bönsch, A Schmidt (2014). Final report on the StUKplus sub-project "Completion of the time series of the StUK during the operational phase and determination of changes in the benthos through the expansion of the plant-related effect monitoring". Bremerhaven, June 2014, www.stukplus.com.

10.4 Project FTZ2: Joint evaluation of data on seabirds for ecological effect monitoring at the Alpha Ventus test field (SEABIRD-DATA)

The aim of this sub-project was to carry out large-scale analyzes of the distribution of seabirds with regard to spatial and temporal variability in the German EEZ. For this purpose, the data from investigations of environmental compatibility studies, construction and operational monitoring of offshore wind farms and research projects of the FTZ were harmonised, quality controlled and brought together in a database. This uniform database forms the basis for being able to evaluate the results from the effect monitoring in the alpha ventus test field (TESTBIRD project) and the potential cumulative effects of offshore wind farms, including in connection with other anthropogenic effects

Based on the database developed in this project, distribution maps for the individual species-specific seasons were prepared for twelve seabird species in the German North Sea. Particular attention was paid to the description of the species listed in Appendix 1 of the Birds Directive (Directive 2009/147/EC). The database enabled the determination of densities and distribution patterns to designate sensitive areas for seabirds with regard to potential habitat loss from offshore wind farms.

For more information see:

H Schwemmer, J Kotzerka, B Mendel, S Garthe (2014). Final report on the StUKplus sub-project "Joint evaluation of seabird data for ecological effect monitoring at the alpha ventus test field (SEABIRD-DATA)". Büsum, August 2014, www.stukplus.com.

10.5 Project FTZ3: Investigations on possible habitat loss and possible behavioral changes in seabirds in the offshore Test field (TESTBIRD)

The aim of this sub-project was to examine for the first time in German waters the effects of an offshore wind farm that had already been constructed on seabirds. Two main goals were defined: 1) the determination of a possible loss of habitat for seabirds due to the constructed facilities of alpha ventus and 2) the description and quantification of possible changes in behavior including flight altitudes of seabirds in the vicinity of alpha ventus.

In order to investigate the occurrence of seabirds in alpha ventus and its surroundings, surveys were carried out from aircraft and ship during the operational phase (2010 - 2012). In addition, the UVS data compiled as part of the StUKplus sub-project SEABIRD-DATA were used to evaluate the baseline survey and construction phase of alpha ventus. During the ship surveys, the behavior of seabirds and their associations with wind turbines, for example, were documented in detail. This information enables the observed birds to be clearly assigned to specific structures or hydrographic conditions. In addition, flight altitudes of seabirds were measured visually and using a laser-based distance measuring device (range finder) and areas of overlap with the rotors of the wind turbines were determined.

The results show that the abundance of six of the eight species or species groups examined in the project area was lower after the construction of alpha ventus than before construction (e.g. for lesser black-backed gull Larus fiscus, kittiwake Rissa tridactyla and northern gannet Morus bassanus). Within a radius of 5 km it could be shown that Lesser Black-backed Gulls have a significantly lower abundance up to a distance of 1.5 km than the mean calculated for them. For auks and loons, the model showed a significant increase in abundance from about 2.5 km away.

The analysis of the flight altitudes measured by the range finder could be carried out for seven different species. The great gulls Herring Gulls, Lesser Black-backed Gulls and Great Black-backed Gulls were often caught near the rotor blades. Lesser gulls, kittiwakes, common gulls and northern gannets mostly flew below the rotor blades (< 30 m).

For more information see:

B Mendel, J Sommerfeld, N Sonntag, J Kotzerka, S Müller, H Schwemmer, S Garthe (2014). Final report on the StUKplus sub-project "Investigations into possible habitat loss and possible behavioral changes in seabirds in the offshore wind energy test field (TESTBIRD)". Büsum, September 2014, www.stukplus.com.

10.6 Project TiHo1: Additional investigations into the effect of construction and Operating phase in the offshore test field alpha ventus on marine mammals

Within the framework of this project, the effects of the construction and operation phase of alpha ventus on marine mammals were examined. In addition to the operator's StUK3 monitoring, additional flight surveys were carried out in a large area under investigation and further C-POD measurement positions deployed. These were recorded on a small scale using combined visual and acoustic (towed hydrophones)
Ship surveys in the vicinity of *alpha ventus* added.

The results of the construction phase show that harbor porpoises (Phocoena phocoena) largely avoided the area during the noisy piling work. The evaluation of the C POD data showed a negative impact (ie reduced registration rates) up to a distance of 10.8 km from the construction site. On the other hand, increased registration rates could be determined at stations in 25 and 50 km. Furthermore, it was found that the length of the absence of harbor porpoises was correlated with the duration of the piling: the longer the piling activities lasted, the longer it took for the porpoises to return to the study area. The mean absence of harbor porpoises during the piling was 16.8 hours for monitoring stations within a radius of 25 km.

The flight surveys also revealed an effect of the piling work, but this was not clear due to the often lacking temporal overlap between the aerial survey and the piling activity. Between 2008 and 2012, 1,999 sightings of harbor porpoise groups with 2,392 individuals (107 of them calves) were recorded with an effective search effort of 23,338 km. In 2009 (construction phase) the lowest density of harbor porpoises was found in the area, in 2011 (2nd year of operation phase) the highest.
Statistical analyzes based on an enlarged data set from the period 2002 to 2012 describe a positive trend in the overall density of harbor porpoises in the southern German Bight since 2005. The investigation of the operational phase revealed no effect of the test field on harbor porpoises.

For more information see:

A. Gilles, M. Dähne, K. Ronnenberg, S. Viquerat, S. Adler, O. Meyer-Klaeden, V. Peschko, U. Siebert (2014). Final report on the StUKplus sub-project "Supplementary investigations into the effect of the construction and operating phase in the offshore test field alpha ventus on marine mammals Büsum, October 2014, www.stukplus.com.

10.7 Project TiHo2: Joint evaluation of data on marine Mammals for ecological effect monitoring at the Alpha Ventus test field

As part of the joint evaluation of data from visual surveys (airborne surveys of marine mammals) and acoustic investigations of marine mammals, the data from environmental compatibility studies and monitoring of offshore wind farms during construction and operation were checked, harmonized and compared with the visual survey data at Alpha Ventus (Effects Monitoring) summarized. The aim was to create a uniform database from all available data (research

projects, monitoring data, EIS). This quality-tested database is intended to determine large-scale distribution patterns of harbor porpoises in the North Sea EEZ and to verify impact forecasts.

The common database is based on 19 data sets from the StUK monitoring and the visual flight recordings for marine mammals carried out as part of the TiHo1 project.

For more information see:

Siebert U, Peschko V, Ruser A, Dähne M, Giewat H, Viquerat S, Adler S, Klaeden O Meyer, Ronnenberg K, Gilles A (2014). Final report on the StUKplus sub-project "Joint evaluation of data on marine mammals for ecological effect monitoring at the Alpha Ventus test field". Büsum, June 2014, www.stukplus.com.

10.8 Project DHI/DHI-WASY: Evaluation of data from marine mammals and ecological habitat modeling at the Alpha Ventus test field

The aim of this project was to bring together all available data from environmental compatibility studies, construction and operational monitoring and research projects (StUKplus and MINOS/MINOSplus) with hydrodynamic models in a quality-tested database. For the first time, this database enabled the large-scale representation of the distribution of harbor porpoises in the vicinity of alpha ventus and the German Bight, the identification of potentially sensitive concentration areas and the explanation of their occurrence in relation to, for example, current conditions, fronts and anthropogenic noise inputs (shipping traffic).

For the analyses, observations of harbor porpoises from aerial surveys during the summer (June - August) and winter (September - May) were statistically linked to oceanographic conditions from numerical models. A high-resolution 2D model was used as a numerical model to depict flow-relevant parameters.
In addition, a 3D model was used to calculate stratification-relevant data.
Potential anthropogenic disturbances from ship-induced noise were calculated using AIS data.

With the help of GAM modelling, distribution maps showing the probability of occurrence of harbor porpoises in the German EEZ were created for both summer and winter. Three regions with high densities of harbor porpoises could be identified in this way for the summer: The largest concentration area stretches from Helgoland along the 30 m depth line in a northwesterly direction. A second concentration area can be seen on the south-western edge of the German EEZ, also at the 30 m depth contour. A third, small concentration area is located in the area of the Dogger Bank at the extreme edge of the German EEZ. In winter, the distribution patterns are basically the same, but with significantly lower numbers of individuals. The results of the GAM modeling also show a correlation of harbor porpoise occurrence with hydrodynamic, geological and bathymetric characteristics, which in turn could be an indication for the occurrence of prey.

For more information see:

S. Heinänen, H. Skov, DA Hansen, F. Ladage, B. Schlenz, R. Žydelis, F. Thomsen, A. Hammrich (2014). Final report on the StUKplus sub-project "Analysis of long-term data and modeling of the distribution of harbor porpoises in the *alpha* ventus test area as a basis for decision-making aids in marine spatial planning". Syke, June 2014, www.stukplus.com.

10.9 Project itap GmbH: Measurement of pile driving and operational noise at greater distances from the alpha ventus test field and processing using a model

In this project, hydro-noise emissions caused by the construction and operation of the Alpha Ventus offshore test field were measured at various distances from the pile-driving sites or from the installed offshore wind turbines. At the start of the project, no current emission data was available for the construction and operation of offshore wind turbines that are based on tripod and jacket foundations. Further data should be gained through the investigations, with the help of which reliable calculation models for the prognosis of the construction and operational noise can be created.
The project supplemented the noise monitoring according to StUK3 with additional measurement positions and a more extensive evaluation. Particular focus was placed on examining and evaluating the practicability of the regulations at the time. The hydrosound measurements also provided valuable information to explain the behavioral patterns of sound-sensitive groups of organisms, such as harbor porpoises or fish, observed in other sub-projects.

During the construction phase, the hydronoise emissions at various distances from alpha ventus were recorded by three automatic underwater measuring stations. The distances of the three measuring points to the wind farm were in the range of 1 - 15 km. The furthest measurement was taken at a greater distance in the Borkum-Riffgrund FFH area. In addition, manual measurements were carried out by an escort ship. The measurement time included all piling work on the foundations and on the substation. Furthermore, the noise reduction tests (small bubble curtain) during the erection of the foundation for the offshore wind turbine AV9 were measured and the signal of the acoustic deterrence device (seal scarer) used was measured. After the test field was commissioned in May and June 2011, the noise exposure caused by the operation of the offshore wind turbines was measured under water over a period of four weeks.

The results of the construction phase showed that without a noise abatement system, the noise protection value of 160 dB single event level (SEL) was generally exceeded at a distance of 750 m from the ramming site. The excess was a maximum of 14 dB and typically 10 dB. The tests for noise reduction with the small bubble curtain showed that the limit value could generally be complied with under favorable circumstances (among other things, bubbles not being expelled in the flow). The measured reduction in the single event level was up to 12 dB.

During the operating phase, only a small proportion of the recorded noises could be assigned to the wind turbines. The highest sound levels were measured at a distance of 100 m from the AV10 (tripod). This was a tonal noise component at 90 Hz with a level of up to 120 dB re 1 µPa (minute average).

For more information see:

K Betke, R Matuschek (2012). Final report on the StUKplus sub-project "Measurement of pile driving and operational noise at further distances from the alpha ventus test field and processing hand of a model". Oldenburg 2012, www.stukplus.com.

10.10 Project Müller-BBM GmbH: Underwater noise at offshore Wind turbines - harmonization of terminology, procedures and evaluation with regard to demand-oriented target values

The temporal and spatial extent of the noise investigations to be carried out as part of the approval, construction and operation of offshore wind farms is described in the StUK. For this purpose, underwater noise measurements are to be carried out in the run-up to the construction phase, during the construction phase and in the operating phase. Within the framework of this sub-project, measurement and evaluation methods for hydro-sound investigations for offshore projects were examined in more detail. The aim was to develop clear definitions and determine criteria for possible assessment methods in order to enable a comparison of technical specifications and forecasts with regard to the assessment of underwater noise on the marine environment, especially on porpoises.

The previous measurement method according to StUK3 was revised and summarized in a detailed measurement specification (measurement specification for underwater noise measurements, BSH 2011). The measurement specification is now part of the StUK4 (BSH 2013) and is listed there as an appendix. The measurement regulation describes the general procedure for measurements of underwater noise in connection with the construction and operation of offshore wind farms. The metrological investigations described therein cover all four phases of the approval and enforcement procedures for offshore wind farms in the German EEZ:

a) Base recording

b) Bauphase

c) operational phase

d) dismantling phase.

For more information see:

A Mueller, C Zerbs (2011). Final report on the StUKplus sub-project "Underwater noise in offshore wind turbines - harmonization of terminology, procedures and evaluation with regard to demand-oriented target values". Hamburg, October 2011, www.stukplus.com.

10.11 Sea media project: Editorial supervision of the production of an English-language book on the StUKplus project

The results of the accompanying ecological research at *alpha ventus* were summarized in a book publication in addition to the publication in final reports related to protected assets. The aim of this sub-project was to prepare the results of German offshore research for a broad readership and to make them known throughout Europe and internationally. In order to ensure a cross-border exchange of research and monitoring results, English-language publications are

compels. The production of a book in English represents a first step in this direction for ecological offshore research in Germany.

The StUKplus book was published in March 2014 by Springer Spektrum under the title "Ecological Research at the Offshore Windfarm *alpha ventus* - Challenges, Results and Perspectives" (Figure 6). Publishers are BSH and BMU; the authors are made up of the StUKplus research partners and representatives of RAVE research, BfN, UBA and BSH.

In addition to the results of StUKplus research, the book also presents the legal and nature conservation framework for offshore wind farms in Germany, the RAVE research initiative and the history of *alpha ventus* . The focus of the book publication is also the consideration of possible cumulative effects of offshore wind farms and the presentation of noise reduction systems to protect sound-sensitive organisms.

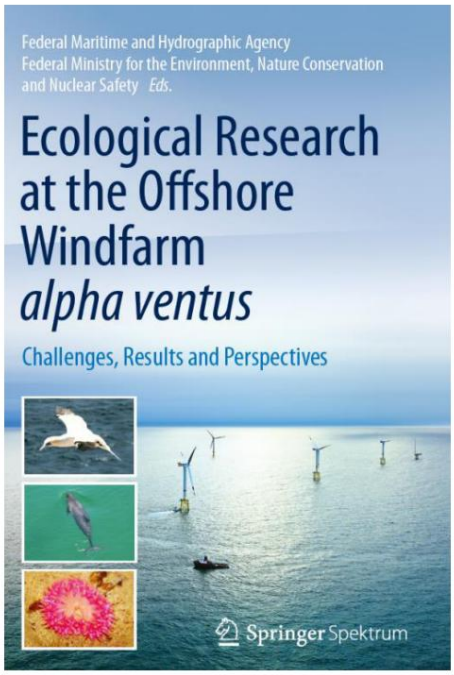

Figure 6: StUKplus book publication "Ecological Research at the Offshore Windfarm alpha ventus" (BSH & BMU, March 2014).

11. StUK Evaluation

The BSH, as the responsible licensing authority for offshore wind farms in the German EEZ, has developed the standard “Investigation of the Effects of Offshore Wind Turbines on the Marine Environment (StUK)” for investigating the marine environment. The StUK describes environmental investigations that must be carried out by the applicant or permit holder. A first version of the standard investigation concept (StUK1) was published in 2001 to ensure a uniform implementation and analysis of environmental investigations at offshore wind farms. 2003 and 2007 were

updates of the standard (StUK2, StUK3) adapted to the current state of knowledge are published.

Delays in the expansion of offshore wind energy in Germany meant that the specifications contained in the StUK3 for monitoring the construction and operating phases came into effect for the first time in the course of the construction of the offshore test field alpha ventus . Against this background, one focus of the StUKplus project was the evaluation of the examination framework described in StUK3 with regard to the criteria "appropriateness" and "effectiveness". The results of the StUKplus project were also used to develop proposals for updating the StUK.

The evaluation of the StUK3 took place between November 2011 and July 2013 in thematic working groups made up of experts from StUKplus research, StUK monitoring, the authorities involved BfN, UBA and BSH as well as various scientific institutions and expert offices. In addition to checking the adequacy and effectiveness of the stipulated investigations, a particular focus was on the implementation of new investigation methods and recording technologies, such as the digital visual recording of resting birds and marine mammals or the recording of migratory birds with new radar devices and camera technologies. In the area of protected goods benthos and fish, the focus was in particular on the standardization of the examination devices/methods and standardization of the evaluation analyses.

Findings from the consultation process carried out in August 2013 with the environmental associations NABU, WWF, Greenpeace and BUND, the Offshore Wind Energy Foundation and the Wind Power Plant Industry Association were incorporated into the finalization of the StUK4.

Figure 7: Standard investigation of the effects of offshore wind turbines on the marine environment: StUK3 (BSH February 2007, left) and StUK4 (BSH October 2013, right) - see www.bsh.de/de/Products/ Buecher/Standard.

Since it was announced at the StUKplus conference in October 2013 in Berlin, the StUK4 has been regarded as a binding standard for carrying out the UVS, construction and operational monitoring of offshore wind farms.

Significant innovations in StUK4 can be listed as follows:

General conditions:

- **If there are more than five years between the end of the basic study and the start of construction, a complete, two-year basic study must be carried out again.**
  If the results of the investigations show that there has been no significant change in site conditions, it is possible after six months to submit an interim report and apply for the investigations to be shortened to one year.

- **As far as various offshore construction sites or projects in the natural environment and**
  -are carried out at the same time, the aim should be for the investigations to be carried out jointly by the project developers (cluster investigation). For the protected goods benthos and fish, the investigations are to be carried out individually in the respective project areas. The reference areas can be used jointly by one or more project sponsors.

Benthos:

- **Suspension of monitoring during the construction phase.**
- **Investigation of the benthos, the biotope structure and the biotope types as part of the laying of cable routes for the connection of offshore wind farms.**
- **Strict standardization of the examinations, introduction of procedural instructions to achieve better data comparability.**

Fish:

- **Suspension of monitoring during the construction phase.**
- **Analyzes include investigations with the beam trawl in the North Sea and with the otter trawl in the Baltic Sea. Information on the weather, depth, salinity, temperature and oxygen content must also be determined and recorded.**
- **System-related investigations are to be carried out according to the state of the art (e.g. fish echo sounder) and the safety regulations of the wind farm.**

migratory birds:

- **Consideration of reactions of flying birds towards the wind turbines (avoidance movements/ attraction events). In consultation with the BSH, birds should be recorded in the rotor area using state-of-the-art methods (optical systems, radar devices).**

Marine Mammals and Resting Birds (Visual Examination):

- **Aircraft transect investigation: 8 - 10 digital aircraft counts (video/photo) are to be carried out all year round, depending on the project or area and the seasonal occurrence of the species. The digital video or photo recording is carried out using suitable methods in coordination with the BSH.**

- **Ship transect investigation: One ship census per month is to be carried out at regular intervals throughout the year. Depending on the site or project-specific features, at least 6 additional ship censuses per year are to be carried out depending on the seasonal occurrence of the species.**

Marine mammals (acoustic survey):

- **Limit passive acoustic monitoring to 1 C-POD station per project.
  min. 2 C-POD stations are to be set up if the project is close (< 20 km) to a protected area that is important for harbor porpoises.**

• In order to determine possible displacement effects during the noise-intensive construction work, 4 - 5 stationary individual C-PODs are to be deployed at suitable distances from the wind turbines, depending on the underwater noise actually emitted.

• During the noise-intensive piling work, 2 mobile individual C-PODs are to be deployed at a distance of 750 m and 1,500 m from the ramming site for random efficiency checks of the deterrence.

• During the operating phase, depending on the size of the wind farm, at least 3 stationary individual C-PODs are to be deployed in the wind farm.

underwater noise:

- **The guide “Offshore wind farms: measurement regulations for underwater noise measurements” (BSH 2011) applies.**
- **The guideline "Offshore wind farms: Forecasts for underwater noise - minimum level of documentation" (BSH 2013) applies.**
- **The guide “Offshore wind farms: Instructions for the quantitative determination of the effectiveness of noise insulation measures” (BSH 2013) applies.**

bats:

- **Recording of the bat migration events (including species spectrum, frequency of events, activity maxima) to determine the importance of the study area as a migration area for bats in the offshore area of the Baltic Sea during the baseline survey. The investigations are to be carried out parallel to the nocturnal call recording of migratory birds on windless nights (up to 3 Bft).**

12. StUKplus conference

From October 30th to 31st, 2013, the BSH organized the StUKplus conference in the representation of the state of Lower Saxony in Berlin with 250 participants from eleven countries (Figure 8). The focus of the conference was the presentation of the results from StUKplus research in the areas of benthos, fish, resting and migratory birds, marine mammals and underwater noise. In addition, the results of oceanographic and geological research at *alpha ventus,* FINO research and results in connection with other German offshore wind farm projects (BARD Offshore 1, Trianel Windpark Borkum) were presented. Guest speakers from the Netherlands, Belgium, Great Britain and Denmark presented the results of offshore research and investigation methods there. In addition to the lectures

further results of European offshore research were presented on 40 posters. A particular focus here was on the presentation of noise reduction systems and models for modeling underwater noise.

At the StUKplus conference, the StUK4 was presented and published in German and English for the first time.

The conference documents (agenda, lectures, posters) can be viewed at: www.stukplusconference.com.

Figure 8: StUKplus conference in Berlin from October 30th to 31st, 2014 in the representation of the state of Lower Saxony.

13. outlook

Almost six years of accompanying ecological research at alpha ventus provided extensive sources of knowledge about the actual environmental impact of offshore wind farms and the opportunity to check the forecasts made before the wind farm was built and operated. Initial fears that there could be a mass strike by birds or that marine mammals would lose their habitat have not come true. The project also provided insights into measures to ensure that the construction and operation of offshore wind farms do not lead to a significant threat to the marine environment, such as the use of noise reduction systems. Nevertheless, the test field consists of only twelve wind turbines and future investigations will show whether the results found here are confirmed in wind farms with 80 wind turbines.

The results of the research activities of the last six years are summarized in quality-tested databases. They serve as a basis for the long-term, large-scale analysis and assessment of marine habitats. In this way, criteria can be established that can be used to identify sensitive areas for the marine environment.

In particular, the StUKplus project provided insights into efficient, needs-based investigation measures accompanying construction and operation, which made it possible to evaluate and update the standard investigation concept without losing the high quality standard.

14. lectures

Beiersdorf, A. (2014). Environmental impacts of offshore wind farms: A review from RAVE (Research at *alpha ventus).* Besuch der Jacobs University Hannover. BSH Hamburg, 27.01.2014.

Beiersdorf, A. (2013). Standard Investigations of the Effects of Offshore Wind Turbines on the Marine Environment (StUK4). Presentation of the StUK4 at the FOWEUM meeting. BSH Hamburg, October 22, 2013.

Beiersdorf, A. (2013). Standard Investigations of the Effects of Offshore Wind Turbines on the Marine Environment (StUK4). Consultation on the StUK4. BSH, Hamburg, September 19, 2013.

Beiersdorf, A. (2013). Investigation of seabirds and marine mammals according to StUK3 and StUK4 monitoring standards. Workshop on digital survey methods. BSH Hamburg, 12.09.2013.

Beiersdorf, A. (2013). Accompanying ecological research at the offshore test field *alpha ventus* to evaluate the standard investigation concept of the BSH. RAVE internal workshop. BSH Hamburg, 03.06.2013.

Beiersdorf, A. (2013). Legal Framework for Construction and EIA for Offshore Windfarms in Germany. MARMONI Workshop on EIA methods. Riga, 21.05.2013.

Beiersdorf, A. (2013). Environmental impacts of offshore wind farms: A review from RAVE (Research at *alpha ventus).* Summer School, Jacobs University Hannover. BSH, Ham burg. 29.01.2013.

Beiersdorf, A. (2012). Environmental impacts of offshore wind farms on the basis of post investment monitoring - A review from RAVE (Research at *alpha ventus).* International Offshore Conference and Exhibition. Sopot, 11.10.2012.

Beiersdorf, A. (2012). Accompanying ecological research at the offshore test field *alpha ventus* to evaluate the standard investigation concept of the BSH. BMU strategy talks on wind energy. Berlin, September 28, 2012.

Beiersdorf, A. (2012). Impacts of offshore wind farms on biotic elements of the marine envi ronment - A review from RAVE (research at *alpha ventus).* Workshop on Environmen tal research for offshore wind farms in Poland. Danzig, 03.08.2012.

Beiersdorf, A. (2012). Accompanying ecological research at the offshore test field *alpha ventus* (StUKplus) - interim results. BSH Marine Environment Symposium 2012. Hamburg, May 22, 2012.

Blasche, K. (2011). Energy transition - How can GMES services contribute to an environmentally friendly and safe establishment of offshore wind energy? Requirements from the point of view of the approval authority. GMES theme days. Munich, Novembe

Blasche, K. (2011). Offshore wind farms: Approval procedures and enforcement and accompanying ecological research. Conference of the TU Hamburg-Harburg offshore wind, wave and current power plants. Hamburg, October 4th, 2011.

Blasche, K. (2011). Coordination of ecological research accompanying the *alpha ventus* pro ject. International Conference *Marine Resources and Beyond.* Bremerhaven, 06.09.2011.

Blasche, K. (2010). Accompanying ecological research on *alpha ventus,* the first German offshore wind farm in the North Sea. dena regional workshop. Stralsund, 11/11/2010.

Blasche, K. (2010). Accompanying ecological research at the offshore test field *alpha ventus.* AWI WAB Workshop. Bremerhaven, November 9th, 2010.

Blasche, K. (2010). Results of the accompanying offshore research at *alpha ventus.* BLANO discussion group on marine and coastal nature conservation, Federal Agency for Nature Conservation, Island of Vilm, 25.11.2010.

Blasche, K. (2010). Accompanying ecological research at *alpha ventus* - first results, first findings. BMU strategy talks on wind energy research. Hamburg, 06.10.2010.

Blasche, K. (2010). Ecology, safety and acceptance. RAVE intermediate workshops. Oldenburg, September 13, 2010.

Blasche, K. (2010). offshore wind turbines and sea fishing. German fishing day. Munich. 08/31/2010.

Blasche, K. (2010). Status of accompanying ecological research in the offshore test field *alpha ventus.* Marine Environment Symposium of the BSH. Hamburg, 06/02/2010.

Blasche, K. (2010). Status of ecological monitoring and accompanying research in the *alpha ventus project.* Forum offshore wind energy and environmental protection. Hamburg, 05/20/2010.

Koch, A. (2013). StUK4 - General innovations and special monitoring requirements for submarine cable projects in the EEZ. Conference "Prospects for a nature-friendly grid connection for offshore wind energy in the German EEZ". Leipzig, November 22, 2013.

Nolte, N. & Beiersdorf, A. (2013). Combining ecological research with the development of guidelines for environmental offshore monitoring. StUKplus Conference. Berlin, 30.10.2013.

15. publications

BSH & BMU (2014). Ecological Research at the Offshore Windfarm alpha ventus - Challeng es, Results and Perspectives. Federal Maritime and Hydrographic Agency (BSH), Min istry for the Environment, Nature Conservation and Nuclear Safety (BMU). Springer Spektrum. 200 pp.

BSH (2013). Five Years of Ecological Research at alpha ventus - Challenges, Results and Perspectives. Book of Abstracts of the StUKplus Conference. Berlin, 30. - 31.10.2013. http:// stukplusconference.com/wp-content/uploads/2013/12/StUKplus-Conference 2013_Book-of-Abstracts.pdf

BSH (2013). Standard investigation of the effects of offshore wind turbines on the marine environment (StUK4), Hamburg and Rostock, Federal Maritime and Hydrographic Agency (BSH): 86 pp. http://www.bsh.de/ de/Products/Buecher/Standard/index .jsp

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report sheet

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for offshore wind farms were received by the Federal Maritime and Hydrographic Agency (BSH) as the competent approval authority for offshore plants in the German exclusive economic zone (AWZ), the only a few findings on the possible environmental impacts are available. Practical experience in the offshore wind energy sector had already been gained in other European countries (Denmark, Great Britain), but these projects were only slightly comparable to the German projects, because here wind farms were built at a distance of up to 150 km from the coast and water depths of up to 50 m planned. With the number of wind farm areas applied for, the demand for a cumulative consideration of the effects also increased.

The development of the offshore test field "alpha ventus" was initiated in 2005. As the core of German offshore wind energy research, the test field represents the central platform for technical, ecological and social research projects within the framework of the research initiative "RAVE" (Research at alpha ventus). The RAVE project "StUKplus" considers ecological issues that are related to the construction of offshore wind farms. The aim was to gain a deeper understanding of the actual environmental impact of offshore wind farms using the example of "alpha ventus".

The StUKplus research project supplements the environmental monitoring that operators are obliged to carry out in accordance with the standard investigation concept (StUK) of the BSH (standard "Investigation of the effects of offshore wind turbines on the marine environment"). StUKplus considers research-specific questions that go beyond the scope of the StUK. During the extensive field investigations at the "alpha ventus" test field, new methods and recording techniques were tested, such as digital flight recording for resting birds and marine mammals or new radar devices for recording bird migration.

Based on the results of the accompanying ecological research at "alpha ventus", the version of the StUK (StUK3) published by the BSH in February 2007 was evaluated and checked for suitability and effectiveness for further offshore wind farm projects and updated. The StUK3 was used for the first time in an offshore wind farm during construction and operation at "alpha ventus". In October 2013, the third update of the standard examination concept, StUK4, was published by the BSH. StUKplus is the most important German research project to date that has examined the environmental impact of offshore wind farms.

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