

Contents

Expanding Offshore Wind Energy Use in Germany.....	1
1 Offshore Wind Energy Use	3
1.1 Wind Energy Use in Germany	4
1.2 Potential of Offshore Wind Energy Use	5
1.3 Level of Offshore Wind Energy Use	5
2 Strategy of the German Government.....	9
2.1 Key Elements of the Offshore Strategy	9
2.2 Successes and Focal Points for Implementation	10
3 Legal Framework Conditions for the Licensing of Offshore Wind Farms	15
3.1 The Renewable Energy Sources Act – Support Instrument for the Expansion of Renewable Energies.....	15
3.2 Licensing Offshore Wind Farms in the Territorial Sea.....	16
3.3 Licensing of Offshore Wind Farms in the Exclusive Economic Zone (EEZ)	17
4 Protection of the Marine Nature and Environment	21
5 Ecological Research Initiated by the German Federal Government in the North and Baltic Seas	27
5.1 Technological Research and Development.....	31
5.2 Platform Based Research	31
Research on Marine Mammals.....	33
Background.....	35
6 Harbour Porpoises (<i>Phocoena phocoena</i>): Investigation of Density, Distribution Patterns, Habitat Use and Acoustics in the German North and Baltic Seas	37
6.1 Introduction.....	37
6.1.1 Density, Distribution Patterns and Habitat Use	38
6.1.2 Intercalibration.....	39
6.1.3 Impacts of Offshore Windmills	39
6.2 Methods	40
6.2.1 Density and Distribution Patterns	40
6.2.2 Habitat Use	40
6.2.3 Intercalibration.....	43
6.2.4 Impact of Offshore Windmills	46
6.3 Results	47
6.3.1 Density and Distribution Patterns	47
6.3.2 Habitat Use	49

6.3.3	Intercalibration.....	53
6.3.4	Impact of Offshore Windmills	56
6.4	Conclusion	58
6.4.1	Density, Distribution Patterns and Habitat Use in North and Baltic Sea.....	58
6.4.2	Intercalibration.....	60
6.4.3	Impact of Offshore Windmills	60
7	Distribution of Harbour Seals in the German Bight in Relation to Offshore Wind Power Plants	65
7.1	Introduction	65
7.2	Methods	66
7.3	Results	68
7.3.1	MINOS	68
7.3.2	MINOS ⁺	69
7.3.3	Foraging Areas	69
7.3.4	Diving Behaviour	71
7.4	Discussion.....	72
7.5	Summary.....	73
8	Research on Marine Mammals - Summary and Discussion of Research Results	77
8.1	Introduction	77
8.2	MINOS Results on Harbour Seals	78
8.3	MINOS Results on Harbour Porpoises	78
8.3.1	German North Sea	78
8.3.2	German Baltic Sea.....	79
8.3.3	Usefulness of T-PODs	80
8.4	Habitat Loss.....	80
8.4.1	Harbour Porpoises	81
8.4.2	Harbour Seals	82
8.5	Impairment of Hearing	82
8.6	From a Different Angle	84
8.7	Conclusion	84
	Research on Bird Migration	87
	Background.....	89
9	Bird Migration and Offshore Wind Turbines.....	91
9.1	Introduction	91
9.2	Methods and Data	93
9.2.1	Sea-Watching and Passerine Passage Counts	93
9.2.2	Ship Radar	94
9.2.3	Thermal Imaging, Video Camera and Microphone	96
9.2.4	Collision Victims.....	97
9.3	Results	98

9.3.1	Species Composition.....	98
9.3.2	Seasonal Migration Intensities	99
9.3.3	Daily Variation of Migration Intensities	103
9.3.4	Daytime Variation of Migration Intensities	105
9.3.5	Migration Altitude	105
9.3.6	Reverse Migration.....	106
9.3.7	Spatial Distribution	107
9.3.8	Collisions	107
9.4	Discussion.....	109
9.4.1	Advantages and Disadvantages of Methods	109
9.4.2	Migration Intensity, Altitude and Direction.....	110
9.4.3	Spatial Distribution	111
9.4.4	Collisions	112
9.5	Conclusions.....	113
Research on Resting and Breeding Birds		117
Background.....		119
10	Possible Conflicts between Offshore Wind Farms and Seabirds in the German Sectors of North Sea and Baltic Sea.....	121
10.1	Introduction.....	121
10.2	Distribution of Seabirds	122
10.3	Assessing the Vulnerability of Seabirds to Offshore Wind Farms	128
10.4	Assessing the Possible Impact of Offshore Wind Farms on Seabirds ..	131
10.5	Conclusion	141
Research on Fish		145
Background.....		147
11	Distribution and Assemblages of Fish Species in the German Waters of North and Baltic Seas and Potential Impact of Wind Parks	149
11.1	Introduction.....	149
11.2	Material and Methods	151
11.3	Results for the North Sea - Assemblages at Different Spatial and Temporal Scales.....	156
11.3.1	German North Sea Waters: 1958 - 2005	156
11.3.2	German North Sea: Year of 2004	160
11.3.3	Potential Wind Park Sites and Marine Protected Areas: 1982 - 2002...	163
11.3.4	Box A: 1987 - 2005	166
11.4	Results for the Baltic Sea - Assemblages at Different Spatial and Temporal Scales.....	169
11.4.1	Entire German Baltic Sea: 1977 - 2005	169
11.4.2	Potential Wind Park Sites and Marine Protected Areas: 1990 - 2002...	169

11.5	Discussion.....	174
11.5.1	Potential Impact of Wind Turbine Construction on Fish Assemblages	176

Research on Benthic Associations 181

Background..... 183

12 Benthos in the Vicinity of Piles: FINO 1 (North Sea)..... 185

12.1	Marine Ecological Research at the FINO 1 Platform	186
12.2	Fauna on Artificial Hard Substrate	187
12.2.1	First Arrivals.....	187
12.2.2	Fighting for Space	188
12.2.3	The Shallow and the Deep.....	190
12.2.4	Accumulation of Biomass.....	192
12.3	Soft Bottom Fauna.....	193
12.3.1	Alterations of Sediments.....	195
12.3.2	Changes in Faunal Communities	195
12.4	Conclusions	198

13 The Impact of Wind Turbine Construction on Benthic Growth Patterns in the Western Baltic..... 201

13.1	Introduction	201
13.2	Material and Methods	203
13.2.1	Investigation Area.....	203
13.2.2	Design of the Sampling	204
13.3	Results	206
13.3.1	Hydrographical Boundary Conditions	206
13.3.2	Colonisation of the Basement Model Substrates by Epifauna	208
13.3.3	Impact on Sediment Structure and its Living Community.....	214
13.4	Discussion.....	215

14 Effect of Electromagnetic Fields on Marine Organisms..... 223

14.1	Technical and Physical Background of Magnetic Fields.....	223
14.2	Geomagnetic Field Detection in Marine Organisms.....	224
14.3	Effects of Static Magnetic Field on Biological Systems.....	225
14.4	Long-term Exposure of Marine Benthic Animals to Static Magnetic Fields	226
14.5	Short-term Exposure of Marine Benthic Animals to Static Magnetic Fields	226
14.6	Oxygen Consumption of <i>Crangon crangon</i> and <i>Palaemon squilla</i>	230
14.7	Conclusions	232

Technical Analyses.....	235
15 Installation and Operation of the Research Platform	
FINO 1 in the North Sea	237
15.1 Background.....	237
15.2 Goals	239
15.3 Location in the North Sea	239
15.4 Life Cycle	240
15.5 Structure of the Platform.....	242
15.5.1 Foundation	242
15.5.2 Sub-Structure	243
15.5.3 Platform Deck	243
15.5.4 Helicopter Pad	244
15.5.5 Wind Measurement Mast.....	244
15.5.6 Equipment.....	244
15.6 Construction and Installation	245
15.7 Measurements and Investigations.....	247
15.7.1 Meteorology.....	247
15.7.2 Oceanography	248
15.7.3 Further Technical Measurements.....	248
15.7.4 Biological Investigations	249
15.8 Data Transfer	250
15.9 Platform Operation	250
15.10 Summary and Outlook.....	251
16 Standard Procedures for the Determination and Assessment	
of Noise Impact on Sea Life by Offshore Wind Farms.....	255
16.1 Introduction.....	255
16.2 Physical-technical Principles	256
16.3 Measurements of Underwater Noise.....	257
16.3.1 Measurements of Construction Noise	257
16.3.2 Measurement of Turbine Operating Noise.....	262
16.4 Acoustic Noise Prediction	265
16.4.1 Numerical Simulation of Underwater Noise.....	265
16.4.2 Prediction of Wind Farm Operating Noise	269
16.4.3 Prediction of Turbine Operating Noise with Transfer Functions.....	271
16.5 Biological Relevance	272
16.6 Standards for the Assessment of Acoustic Emissions of Offshore	
Wind Farms	272
16.6.1 Prognosis Procedure	274
16.6.2 Measurements of the Hydro Acoustic Background	274
16.6.3 Measurements in the Operating Phase	275
16.6.4 Construction Phase	276
16.7 Summary.....	277

17	Collisions of Ships with Offshore Wind Turbines: Calculation and Risk Evaluation	281
17.1	Introduction	281
17.2	Technical Bases and Numerical Modelling	282
17.2.1	Collision of Ships	282
17.2.2	Foundation Structures of Offshore Wind Energy Turbines	282
17.2.3	Collision of Ships and Offshore Wind Turbines.....	283
17.2.4	Numerical Modelling.....	283
17.3	Results	292
17.3.1	Monopile.....	292
17.3.2	Jacket	294
17.3.3	Tripod	296
17.3.4	Comparison.....	298
17.4	Recommendations	299
17.4.1	FSA: Risk Matrix.....	299
17.4.2	Recommendations for Monopiles, Jackets and Tripods	301
17.4.3	Measures to Increase Active Safety	301
17.5	Conclusions	302
	Planning Aspects	305
18	Environmental Impact Assessment in the Approval of Offshore Wind Farms in the German Exclusive Economic Zone.....	307
18.1	Introduction	307
18.2	Legal Standards for the Assessment of Environmental Impacts in the Approval of Offshore Wind Farms.....	308
18.3	Demands upon the Environmental Impact Assessment in the Context of the Authorisation Procedure	309
18.3.1	Effects of Offshore Wind Farms on the Marine Environment.....	310
18.3.2	Derivation of Effect Correlations Relevant for the Decision-Making Process	312
18.3.3	Prognosis and Assessment of the Effects of Offshore Wind Farms	317
18.3.4	Prognosis of the Effects	318
18.3.5	Assessment of the Effects	320
18.3.6	Threshold of "Endangerment of the Marine Environment"	323
18.4	Demands upon Data Acquisition in the Context of Environmental Impact Studies	325
18.5	Results	325

International Ecological Research	329
19 European Review of Environmental Research on Offshore Wind Energy.....	331
19.1 Introduction.....	331
19.2 Environmental Research on Offshore Wind Energy.....	332
19.2.1 Denmark	333
19.2.2 United Kingdom	334
19.2.3 Netherlands	336
19.2.4 Sweden.....	338
19.3 Summary.....	339
Conclusion and Perspective	343
20 Conclusion and Perspective	345
20.1 Feared Effects	345
20.2 Current Knowledge and Consequences of the Gained Information	346
20.3 Further Research and Future Ecological Accompanying Research	349
20.4 International Coordination of Research and Exchange of the Information	351
Annex.....	353
Index	361