Robin Rigg Offshore Wind Farm
Marine Environmental Monitoring Plan (MEMP):
Ecological Analysis Data




Richard Walls, *Director of Ecology & Hydrology, Natural Power Consultants*
Sally Shenton, *Site Manager, Robin Rigg, E.On Climate & Renewables*

Sharing Good Practice: Marine Renewables, Battleby 03.11.2011

Summary Scope of talk:

1. Introduction to Robin Rigg Offshore Wind Farm
2. Timescales for Robin Rigg, Key Milestones
3. *DVD of Robin Rigg Construction will be playing during the breaks/lunch*
4. EIA predictions, MEMP Focus & RRMG
5. Natural Power - Ecological Analysis of MEMP Biological groups
6. Benthic communities
7. Non-migratory & electro-sensitive fish
8. Marine Mammals: (Harbour porpoise & grey seal)
9. Ornithology: (Red-throated diver, Common scoter, cormorant, guillemot, razorbill, kittiwake, herring gull & gannet)
10. Summary

Robin Rigg OWF, The Solway Firth:

Robin Rigg - Chronology:

- Baseline EIA 2001-2002 – Natural Power
- Granted consent in March 2003
- EON ownership from Sept 2003
- Constructed from January 2008 – Feb 2010
- Operational from March 2010
- OFTO sold in March 2011

Robin Rigg OWF, The Solway Firth:

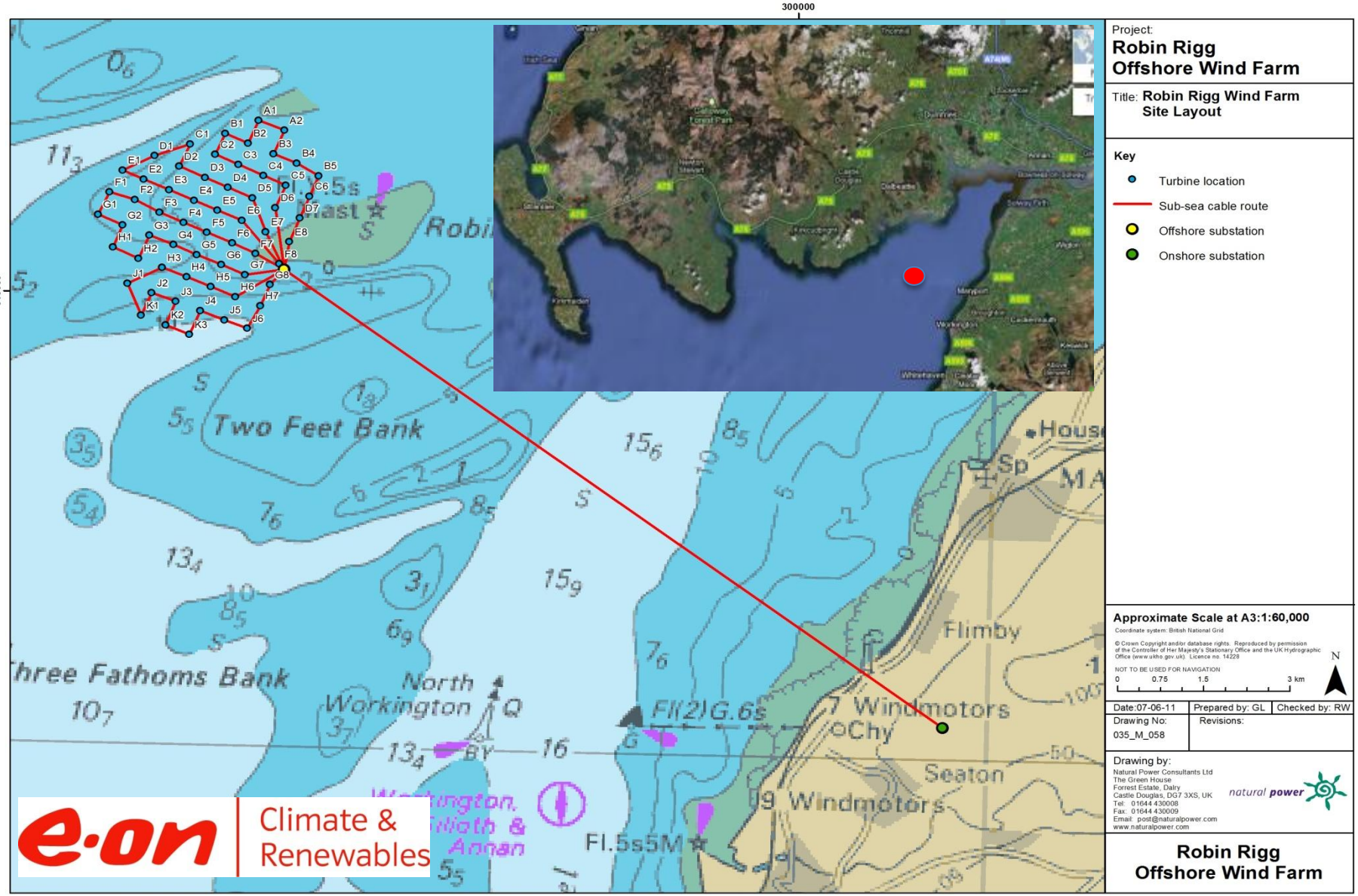
180MW offshore wind farm:

- 60 turbines
- Offshore sub-station
- Onshore sub-station
- Onshore office & maintenance
- 2 x 14 km export cables
- Inter-array cables
- OFTO

e·on Climate & Renewables

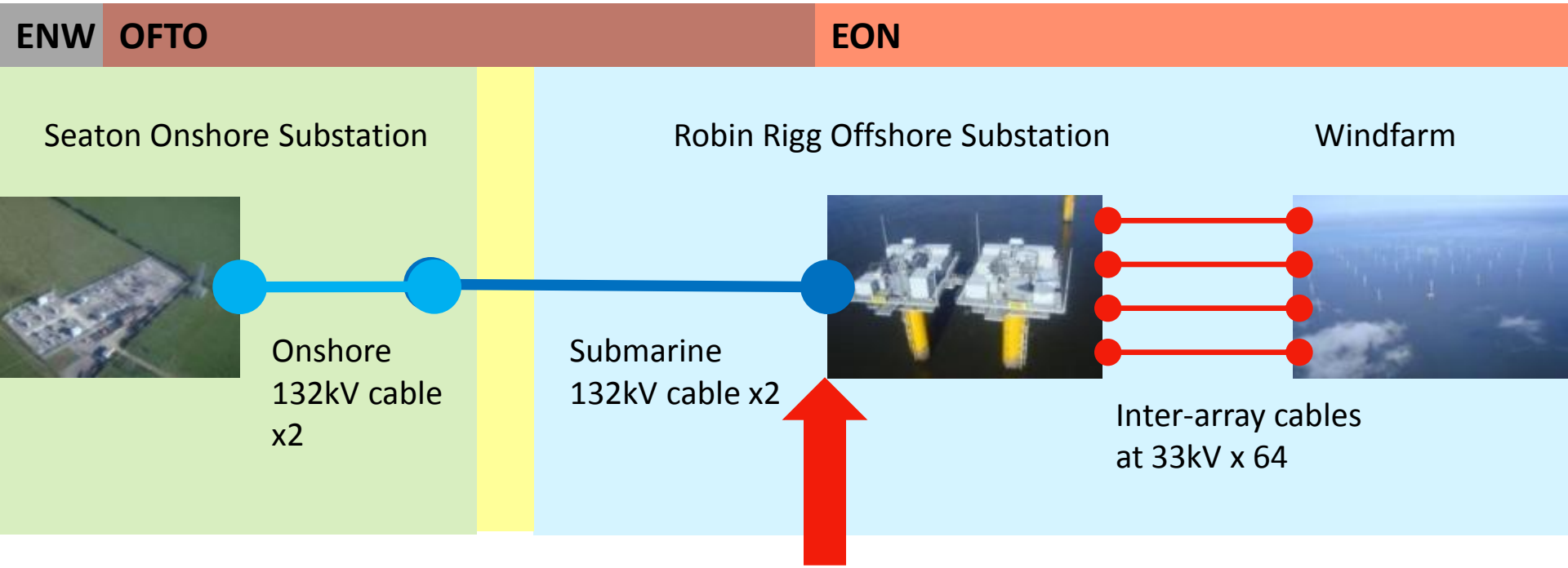
natural power

Robin Rigg, The Solway:



Grid Connection – post-OFTO:

Offshore Transmission Operator



Connection Point 300mm along offshore cable

e·on | Climate & Renewables

Marine Environment Monitoring Programme (MEMP):

MEMP complies with condition 6.4 of Section 36 Consent Condition, of the Electricity Act:

Scope of MEMP:

"The MEMP should be sufficiently robust to detect and/or predict direct and indirect adverse impacts, likely to have a significant effect on the marine environment, arising from pre-construction, construction, operation and decommissioning".

The MEMP states:

"The remit of the Monitoring Programme will be to allow changes to the physical and ecological environment caused by the construction and operation of the wind farm to be recorded principally in areas where there is some uncertainty in the effects of the wind farm on the receiving environment, where those effects are potentially damaging. The monitoring programme should be designed so that if potentially adverse significant impacts are predicted which can be reasonably attributed to the wind farm, mitigation measures can be adopted in time to avoid irreversible significant impacts"

marinescotland

Scottish Natural Heritage
All of nature for all of Scotland

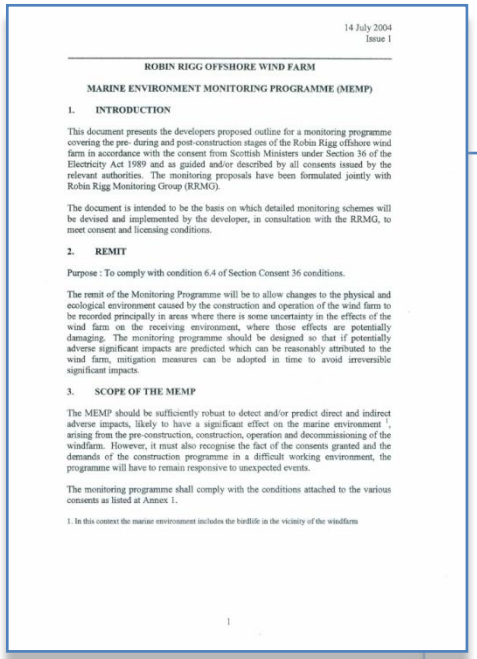
Marine Environmental Monitoring Plan (MEMP):

Structure of the MEMP into Ecological Groups:

Key Areas of Ecological focus from the ES predictions MEMP constructed in 2004.

- Benthic Communities (OWF & Cable)
- Non-migratory Fish
- Electro-sensitive Fish
- Birds (RH, CX, Seabirds)
- Marine Mammals (Harbour porpoise & seals)
- Migratory Fish
- Managed and overseen by the RRMG – Robin Rigg Management Group, akin to an onshore steering group or management group.

Reporting on MEMP & Ecological Marine Monitoring, data & analysis to RRMG by EON/Natural Power



14 July 2004
Issue 1

ROBIN RIGG OFFSHORE WIND FARM

MARINE ENVIRONMENT MONITORING PROGRAMME (MEMP)

1. INTRODUCTION

This document presents the developers proposed outline for a monitoring programme covering the pre- during and post-construction stages of the Robin Rigg offshore wind farm in accordance with the consent from Scottish Ministers under Section 36 of the Electricity Act 1989 and as guided and/or described by all consents issued by the relevant authorities. The monitoring proposals have been formulated jointly with Robin Rigg Monitoring Group (RRMG).

The document is intended to be the basis on which detailed monitoring schemes will be devised and implemented by the developer, in consultation with the RRMG, to meet consent and licensing conditions.

2. REMIT

Purpose : To comply with condition 6.4 of Section Consent 36 conditions.

The remit of the Monitoring Programme will be to allow changes to the physical and ecological environment caused by the construction and operation of the wind farm to be recorded principally in areas where there is some uncertainty in the effects of the wind farm on the receiving environment, where those effects are potentially damaging. The monitoring programme should be designed so that if potentially adverse significant impacts are predicted which can be reasonably attributed to the wind farm, mitigation measures can be adopted in time to avoid irreversible significant impacts.

3. SCOPE OF THE MEMP

The MEMP should be sufficiently robust to detect and/or predict direct and indirect adverse impacts, likely to have a significant effect on the marine environment [1], arising from the pre-construction, construction, operation and decommissioning of the windfarm. However, it must also recognise the fact of the consents granted and the demands of the construction programme in a difficult working environment, the programme will have to remain responsive to unexpected events.

The monitoring programme shall comply with the conditions attached to the various consents as listed at Annex 1.

1. In this context the marine environment includes the birdlife in the vicinity of the windfarm

e·on Climate & Renewables

natural power

Robin Rigg Offshore Wind Farm, Scotland
EON Climate & Renewables
Analysis of MEMP Ecological data
(Pre-construction & construction phases)

Executive Summary

e·on Climate & Renewables

natural power

MEMP: Benthic communities

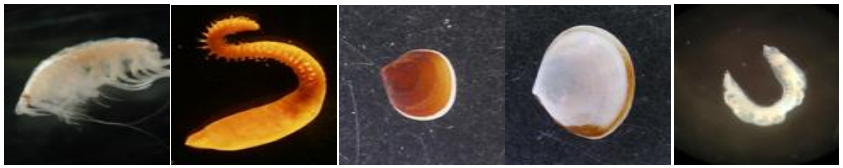
marinescotland

Scottish Natural Heritage
All of nature for all of Scotland

Benthic survey dataset & Timescales:

Benthic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001										Benthic	Benthic	Benthic
2002		Benthic	Benthic									
2003												
2004												
2005			Intertidal									
2006												
2007							Benthic (WFS)				Benthic (CR)	
2008			Benthic (WFS); Intertidal		Benthic (CR)						Benthic (WFS & CR)	
2009			Intertidal			Benthic (WFS & CR)			Intertidal			
2010			Intertidal		Benthic (WFS & CR)				Intertidal			
2011	Intertidal reef maping	Intertidal reef maping	Intertidal reef maping	Benthic (WFS & CR)								

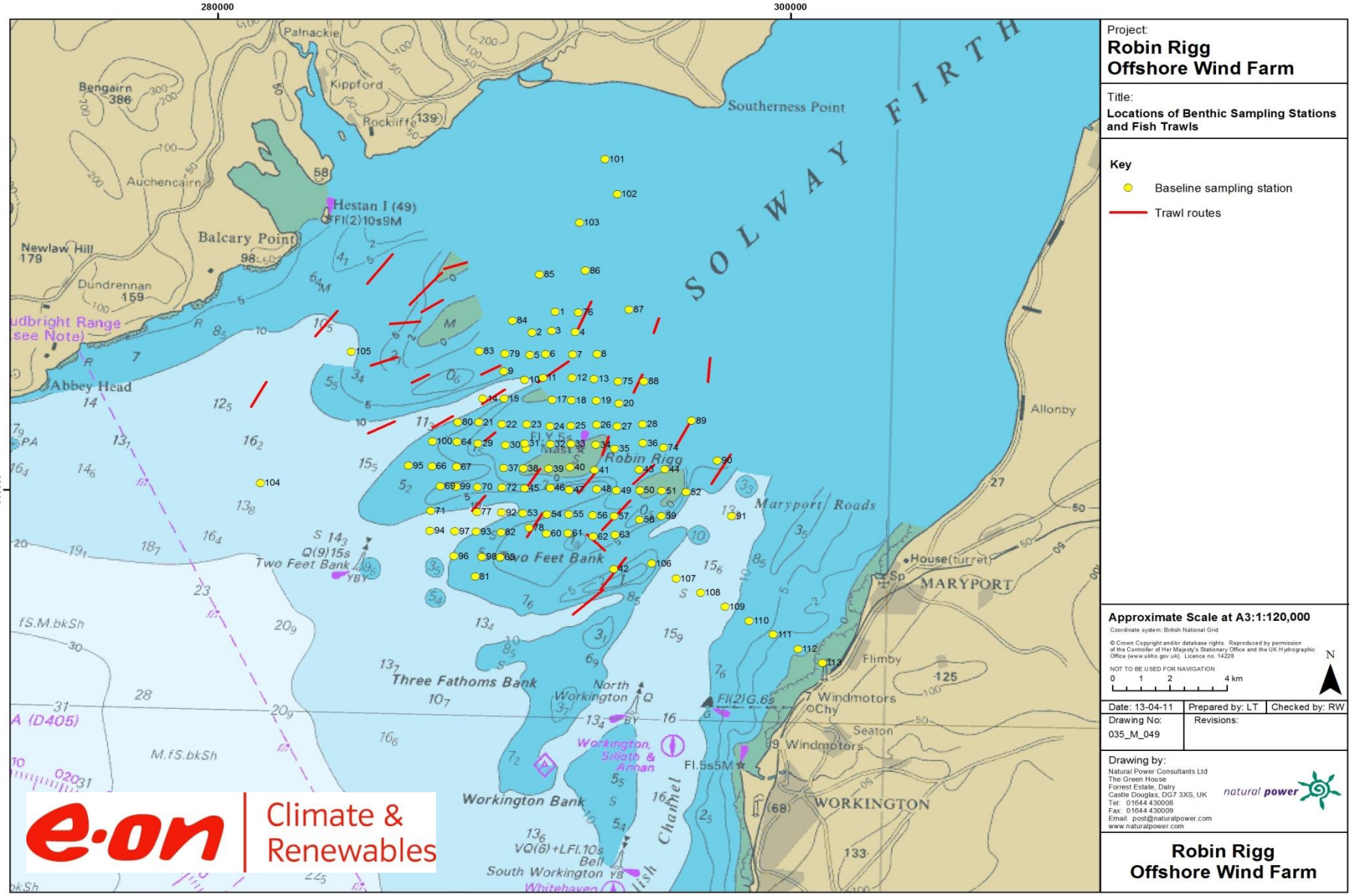
EIA	Pre-construction	Construction	Operation



e·on | Climate & Renewables

natural power

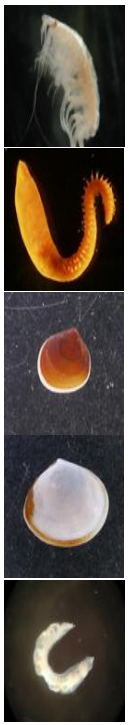
Benthic communities:

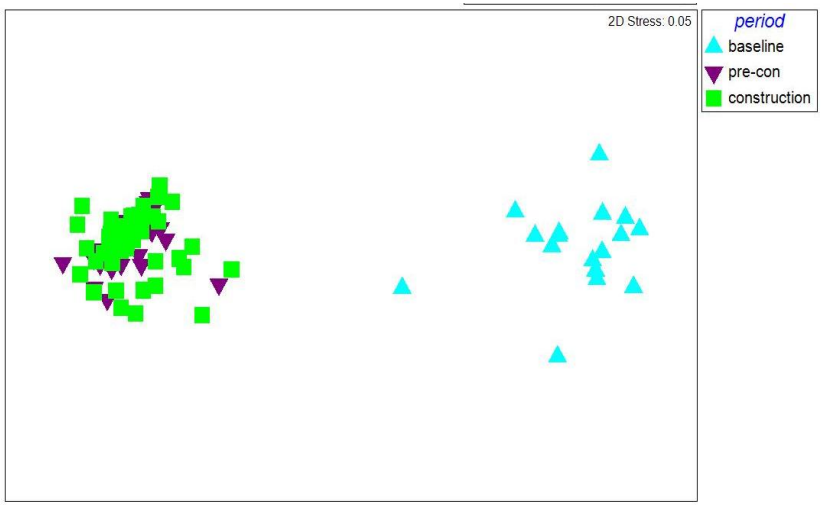


Benthic – Analysis:

- **Analysis of Biotope, Community structure & Sp Diversity**
- A total of 3590 individuals from 220 taxa identified; (baseline, pre-construction & construction)
- A variety of statistical tests were used to examine the data including: Bray Curtis similarity tests (illustrated by MDS plots) , Diversity tests, ANOVA, ANOSIM and PERMANOVA+.

Species		Number of individuals
Bathyporeia elegans	Sand digger shrimp	1002
Nephtys cirrosa	White cat worm	454
Scalibregma inflatum	Polychaete worm	258
Fabulina fabula	Bean-like tellin	165
Mysella bidentata	Bivalve mollusc	148
Pseudocuma longicorne	Acumacean	144
Magelona johnstoni	Bristleworm	139
Scolelepis mesnili	Bristleworm	107
Pomatoceros lamarcki	Keelworm	76
Bathyporeia nana	Sand digger shrimp	72
Nucula nitidosa	Bivalve mollusc	69
Abra alba	White furrow shell	54
Nephtys cirrosa	Cat worm	50
Gastrosaccus spinifer	Mysid shrimp	50
Nephtys caeca	Cat worm	49
Echinocardium cordatum	Sea potato	47
Bathyporeia elegans	Sand digger shrimp	36
Donax vittatus	Banded wedge shell	34
Ophelia borealis	Brittle worm	28
Bathyporeia sarsi	Sand digger shrimp	28





Nonmetric multi-dimensional scaling ordinations of benthic abundance data (untransformed) for each sampling period (baseline; pre-construction and during construction).

Benthic - Key Findings:

Ecological Group	Predictions from ES	Main conclusions: Pre-construction-construction analysis
Benthic	• The only biotope present within the wind farm site was *SS.SSa.IFiSA.NcirBat*, characterised by *Nephytis cirrosa* and *Bathyporeia* species in infralittoral sand. • Habitat loss for the above species as a result of the Robin Rigg was predicted to be 0.4%. • **No significant long-term impacts on benthos were predicted.**	• The benthic environment at the Robin Rigg wind farm site is dynamic. • changes in community structure & diversity over time are expected at any given sampling location. • Species diversity and community structure varied significantly among years. • Community structure did not vary between the control, cable-route and site areas. • **No evidence that changes in species diversity and/or community structure are attributable to construction of the Robin Rigg wind farm.**

Operational Year 1 Preliminary Analysis:

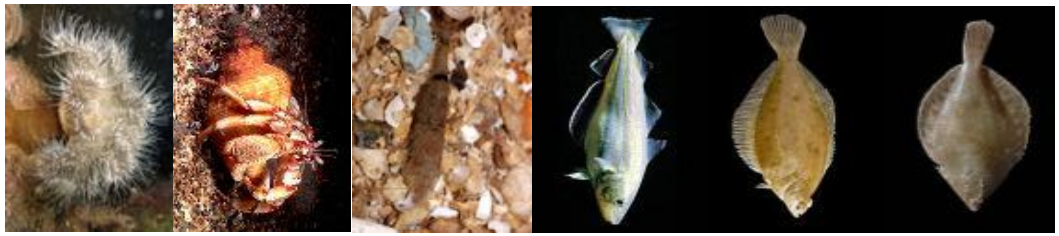
- *Biotype classification:*
  - *Predominant biotype remained same since baseline (EIA) data period.*
- *Variation in community structure:*
  - *No significant difference in benthic community types during the four survey periods;*
- *Ops Yr1 confirmed only changes in benthic community between baseline & pre-construction*
- *A dip in the numbers of fish & invertebrates captured during construction (although Non-significant)*
- *Species diversity:*
  - *Diversity low during all periods, as expected for the Solway Firth*

MEMP: Non-migratory & electro-sensitive fish

Non-migratory & electro-sensitive fish monitoring:

Fish	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001										NM Fish	NM Fish	NM Fish
2002		NM Fish	NM Fish	NM Fish	NM Fish	NM Fish	NM Fish	NM Fish	NM Fish			
2003												
2004												
2005												
2006												
2007								ES Fish			ES Fish	
2008		NM Fish	Fish (ES & NM)	NM Fish		ES Fish	NM Fish		ES Fish		NM Fish	
2009		Fish (ES & NM)				NM Fish		NM Fish				NM Fish
2010		NM Fish		Fish (ES & NM)			Fish (ES & NM)					
2011			Fish (ES & NM)									

EIA	Pre-construction	Construction	Operation



e·on | Climate & Renewables

natural power

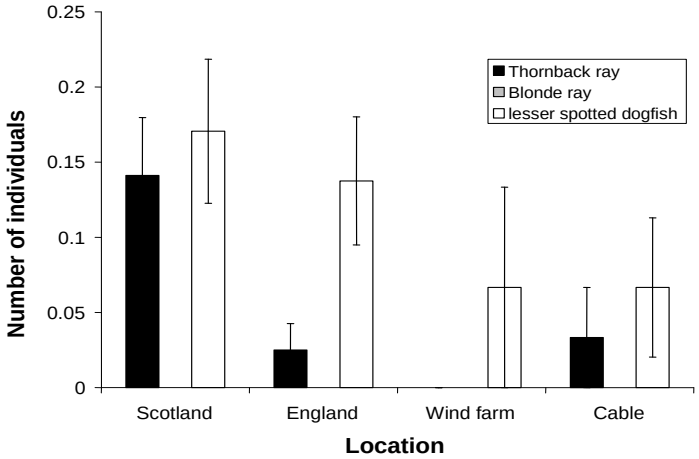
Electro-sensitive fish:

- Turbines connected (4 loops 33kV AC submarine cables, Linked to shore via 2 submarine HV 132 kV AC cables.
- Focal species: *elasmobranchs* (sharks, rays and skates) (COWRIE/FEPA guidance)
- 8 surveys along cable route for EMF fish & fish caught from non-migratory fish sampling.
- 3 species found in vicinity of Robin Rigg (figures in brackets represent number found):

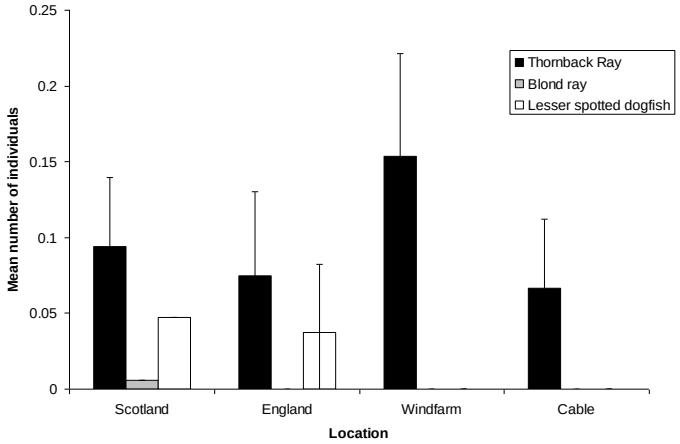
Thornback ray (57)

lesser spotted dogfish (56)

blond ray (1)



Distribution of elasmobranches during baseline surveys (2001-2002: left)



Construction phase surveys (2008-2009: right)
(Mean per location)

e·on Climate & Renewables

natural power

NM Fish & ESF - Key Findings:

Ecological Group	Predictions from ES	Main conclusions: Pre-construction-construction analysis: (Yr1, below table)
Non-migratory Fish	• Negligible impacts on commercially important flatfish (plaice/sole). • Short-term displacement of demersal species (e.g. whiting). • **Impacts on migratory and non-migratory fish expected to be low.**	• Significant change in community structure of fish and epifauna among years. • Community structure did not vary between the control, cable-route and site areas. • Evidence for a general decrease in species richness of both fish and epifaunal species through time, potentially due to re-positioning of channels. • **No evidence that observed changes in species richness and/or community structure is attributable to construction of the Robin Rigg wind farm.**
Electro-sensitive fish	• Focal electro-sensitive fish found in proximity to the Robin Rigg wind farm were thornback ray, lesser spotted dogfish and Blond ray. These were observed in small numbers.	• Electro-sensitive species found within the vicinity of the Robin Rigg wind farm will be able to detect EMF from cabling. • During baseline/pre-construction the majority of electro-sensitive fish species were found on Scottish Solway coast, away from the cable route suggesting this area is not as important for these species. • **Potential effects of EMF from the electrified cable on electro-/magneto-sensitive fish are likely to remain negligible/minimal significance.**

Abundance:

- *Number of fish decreased during construction period but increased to almost pre-construction values in Ops Yr1;*
- *Similar trend for invertebrates with double the number recorded during Ops Yr1 compared to baseline;*

Variation in community structure:

- *Wind farm area - Very little change in community structure between study periods for fish & epifauna.*
- *Cable route – Some evidence of a change in fish structure between periods. No change for epifauna.*

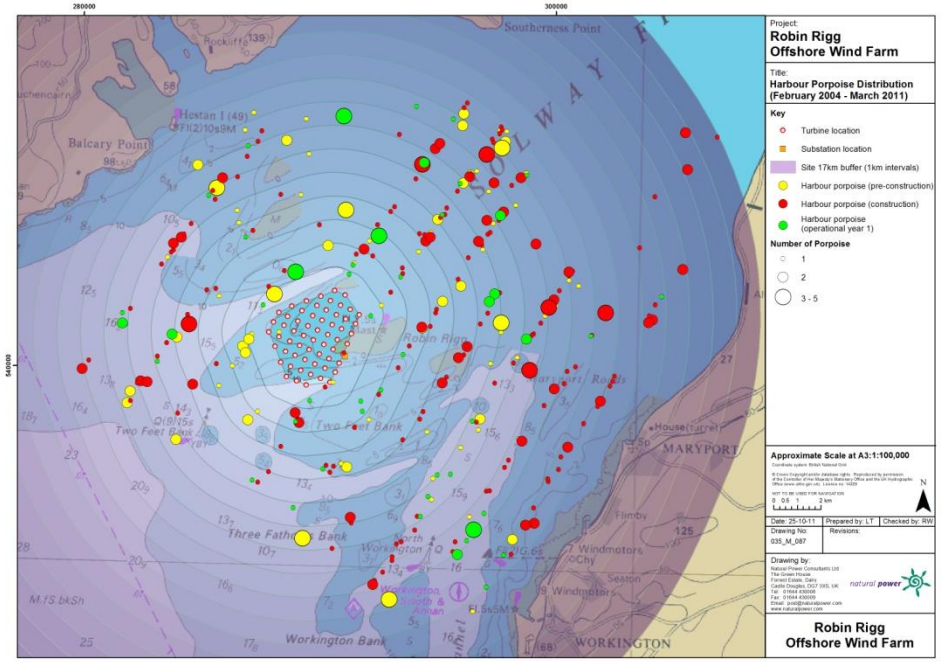
Species diversity:

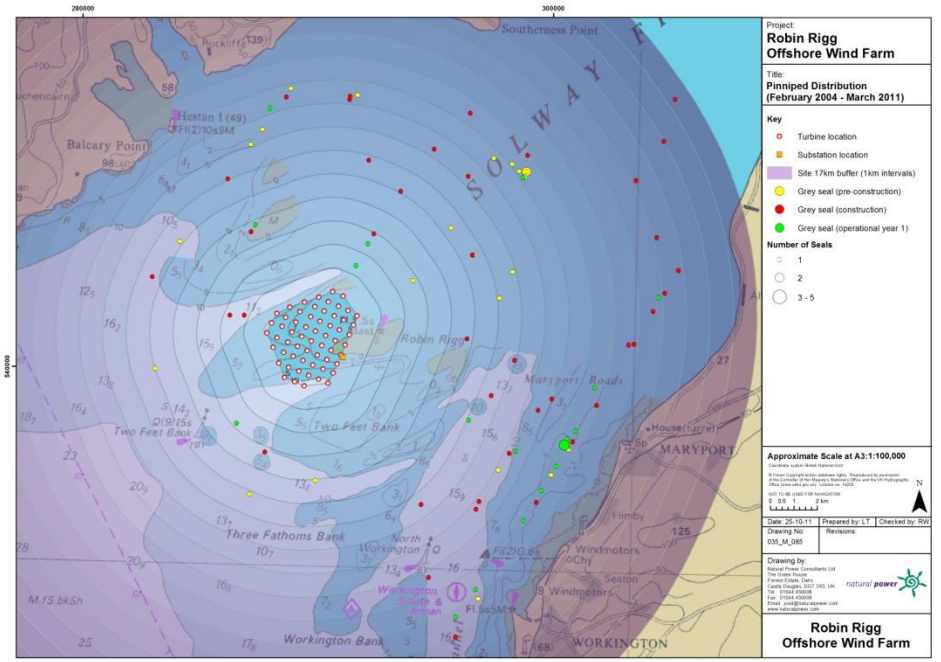
- *Some evidence of a difference in diversity between study periods for both the wind farm area (pre-cons vs. Ops Yr1) & cable route (Ops Yr1 1 vs. pre-construction/cons).*

MEMP: Marine Mammals

Marine mammal summary:

1. Boat-based observations (pre-COWRIE), single observer
2. Segment transects by distance to produce replicate sampling blocks of equal effort
3. For each phase, fit General Additive Models (GAMs) to data including covariates





Key Findings: marine mammals

Species	Predictions from ES	Main conclusions from construction analysis
Harbour porpoise 	• 120 individuals recorded pre-construction (not adjusted for survey effort circa 6 mths). • Short-term avoidance of local area of construction works expected. • Mitigation should be used to avoid startle/alarm responses in response to the onset of piling activities. • Impact on small cetacean species expected to be low.	• 271 individuals recorded during construction (not adjusted for survey effort circa 25 mths). • **Harbour porpoise observations across the study area decreased between the pre- and during construction periods, but this could not be directly attributed to construction activities.** • **Numbers of harbour porpoises observed increased significantly with days since the last piling and/or construction activity suggesting short-term displacement associated with these activities.** • **Evidence from other studies would indicate that noise effects cause displacement effects to marine mammals such as harbour porpoise at Robin Rigg.**
Grey seal 	• 73 individuals recorded pre-construction (not adjusted for survey effort circa 6 mths). • Short-term changes in behaviour of seals close to the site at the start of construction. • Low risk of physiological risks to seals due to piling. • Seals expected to habituate to construction activities. • Impact on seals considered to be moderate.	• 184 individuals recorded during construction (not adjusted for survey effort circa 25 mths). • **Low numbers of grey seal observations (95 observations when hauled out individuals are excluded) greatly reduce the likelihood of detecting any response to construction activities.** • **Grey seals were not observed within 3km of the wind farm area during pre-construction surveys or within 1.5km of the wind farm during construction.** • **Grey seal observations across the study area decreased between the pre- and during construction periods, but this could not be attributed to construction activities.** • **No evidence was found for impacts of piling on grey seal but this is likely to be due to the very low number of grey seals observed during the construction period (57 observations when hauled out individuals are excluded).**

MEMP: Ornithology

Bird & Marine Mammal Surveys:

marinescotland

Scottish Natural Heritage
All of nature for all of Scotland

- Boat-based visual surveys collected on monthly basis
- One survey per month pre-construction & operation (alternating high/low tide)
- Two surveys conducted per month during construction phase, (1 = high tide & 1 = low tide per mth)
- 10 boat transects, each about 18 km long, 2 km apart
- Pre-COWRIE guidelines for baseline works.
  (Primary vessel used 16 m long with viewing height of 4 m above sea level).

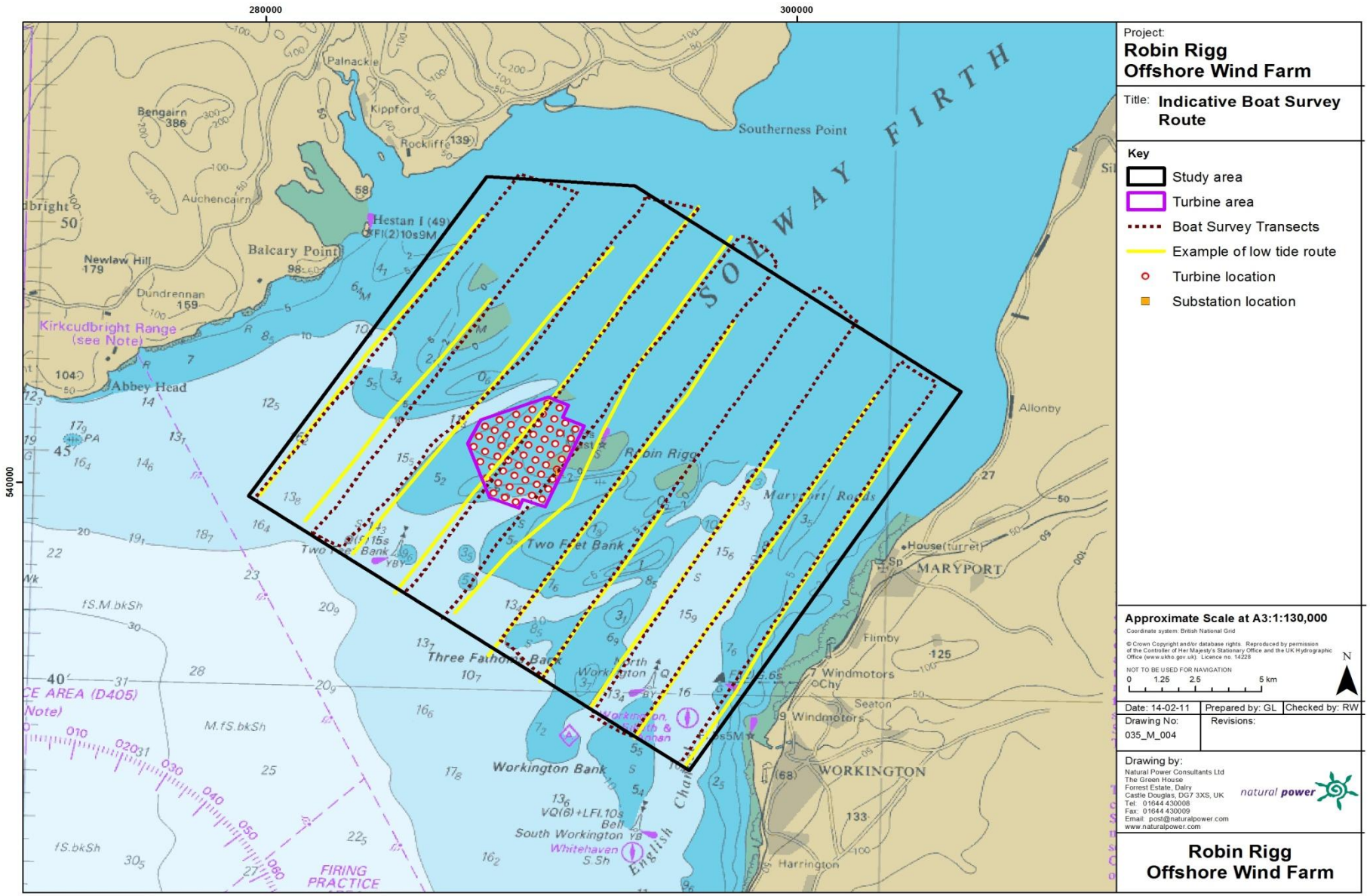
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001					Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2002	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2003				Birds	Birds							
2004	Birds	B & MM	B & MM		B & MM		MM	B & MM	B & MM	MM	MM	MM
2005	MM											
2006												
2007							B & MM					
2008	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM
2009	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM		B & MM
2010	Birds	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM
2011	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM			

EIA	Pre-construction	Construction	Operation

e·on Climate & Renewables

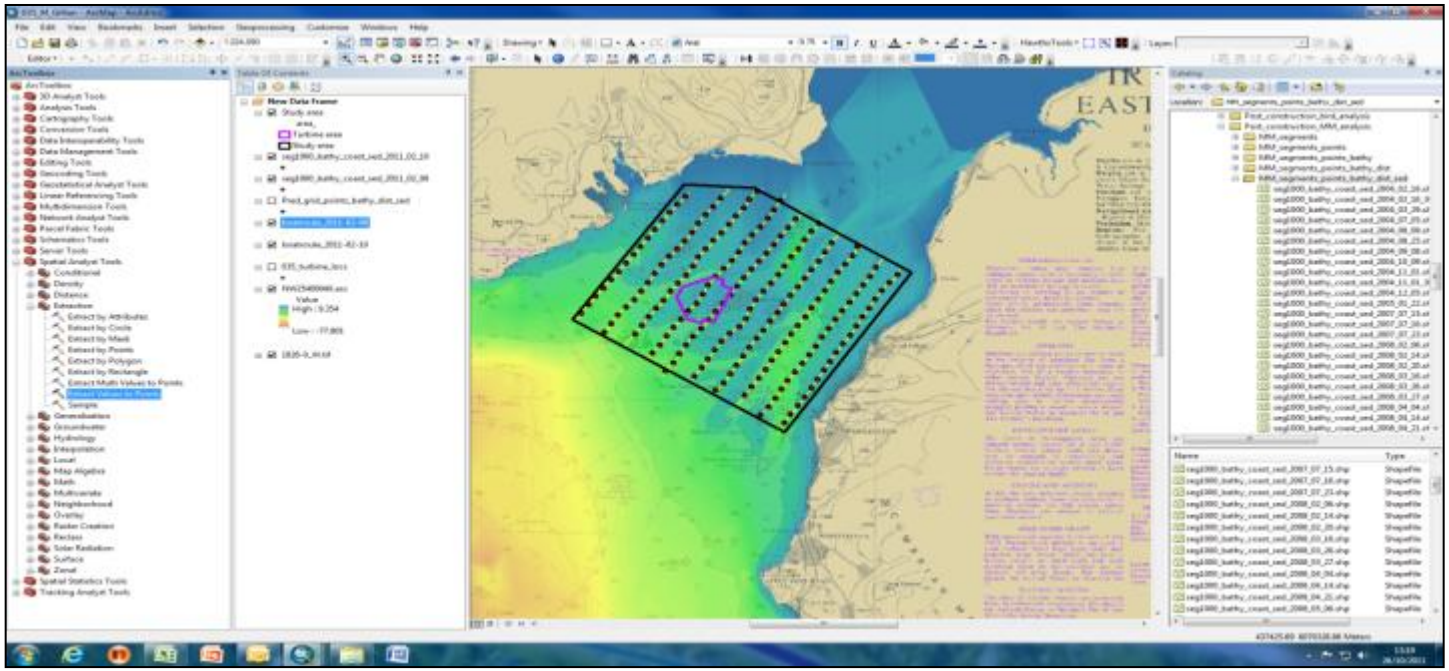
natural power

Boat-based Survey Area (study area):



Data collation, processing & GIS:

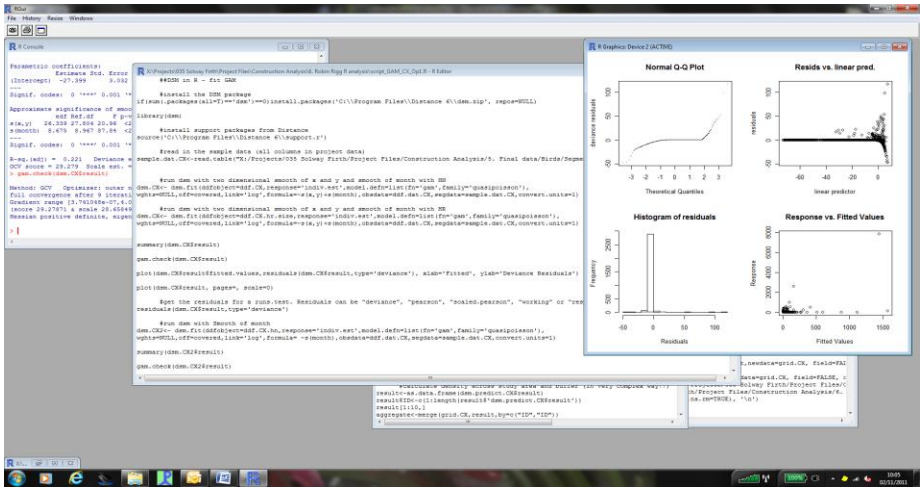
- Boat data divided into equal sized sampling units: Birds = 600 m2; Mammals = 1 km2
- Linked each sampling unit with underlying sea depth & geology data
- Calculate sampling unit mid point and distance to coast
- Link sightings recorded per day with corresponding sampling units of individual survey section for same day



Birds Statistical Analysis:

- Use distance sampling analysis to account for birds not seen by observers during surveys
- Segment transects by distance (600m) to produce replicate sampling blocks of equal effort
- For each phase, fit General Additive Models (GAMs) to data including covariates:

  (sea state, sea depth, sediment type, x, y & month)
- Use the model to estimate bird abundance and predict bird distribution across the survey area (R *version 13.1)*
- This approach produces the modelled density surfaces shown in the following figures of phases.
- Test for significant differences in bird number & distribution among the phases.



Bird & marine mammal summary:

- Raw count data for the **Whole Study Area** – which includes **RR WF site** (average count per survey month):

Key species	No sightings per month effort			No individuals per month effort		
	Pre Construction	Construction	Operation Yr 1	Pre Construction	Construction	Operation Yr 1
Birds						
Common scoter	24	74	48	2719	3419	1727
Cormorant	10	38	38	16	127	106
Gannet	12	25	10	18	33	13
Guillemot	87	163	110	147	226	158
Kittiwake	20	35	19	31	70	28
Manx shearwater	6	12	9	53	71	17
Razorbill	23	48	22	69	117	52
Red-throated diver	7	15	18	17	22	46
Sandwich tern	2	9	4	4	22	7
Scaup	0	0	1	23	25	262
Marine Mammals						
Harbour porpoise	8	9	5	11	13	7
Grey seal	2	2	2	3	2	2

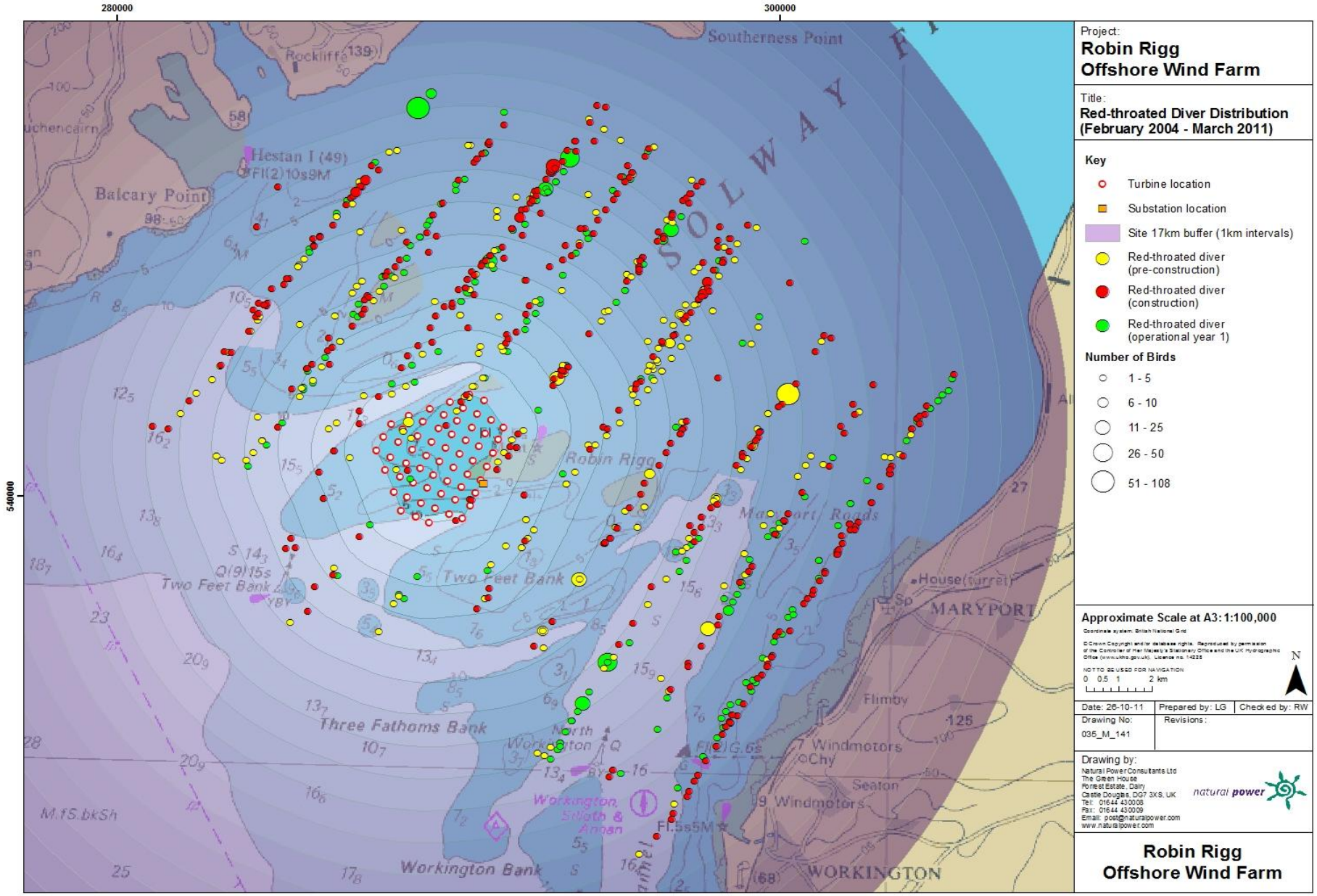
Birds (on water) analysis:

- **Estimated abundances based on the Model** developed using R (Density Surface Model):

Species	Study area			Site			% of total within site		
	Preconstruction	Construction	Operation	Preconstruction	Construction	Operation			
Common scoter	20784 (269)	13298 (747)	61123 (205)	3	6	1	0.01	0.04	0.00
Red-throated diver	123 (153)	89 (173)	164 (205)	1	1	0	0.94	1.17	0.17
Manx shearwater	** (16)	34 (86)	1098 (27)	**	1	1	**	2.99	0.11
Gannet	72 (60)	48 (97)	** (11)	1	0	**	1.81	0.92	**
Cormorant	97 (110)	68 (222)	189 (102)	5	16	9	5.07	23.14	4.69
Kittiwake	350 (145)	111 (323)	166 (56)	15	8	9	4.32	6.85	5.21
Herring gull	274 (63)	78 (126)	23 (25)	7	2	10	2.45	2.40	43.28
Great black-backed gull	23 (36)	15 (112)	393 (50)	1	0	0	6.32	2.42	0.00
Guillemot	1221 (1942)	1109 (3461)	1455 (954)	69	47	58	5.68	4.23	3.96
Razorbill	1894 (484)	484 (1059)	2108 (218)	182	16	148	9.63	3.23	7.01
Auk species	2962 (2506)	1482 (4689)	5881 (1242)	199	54	277	6.72	3.64	4.71

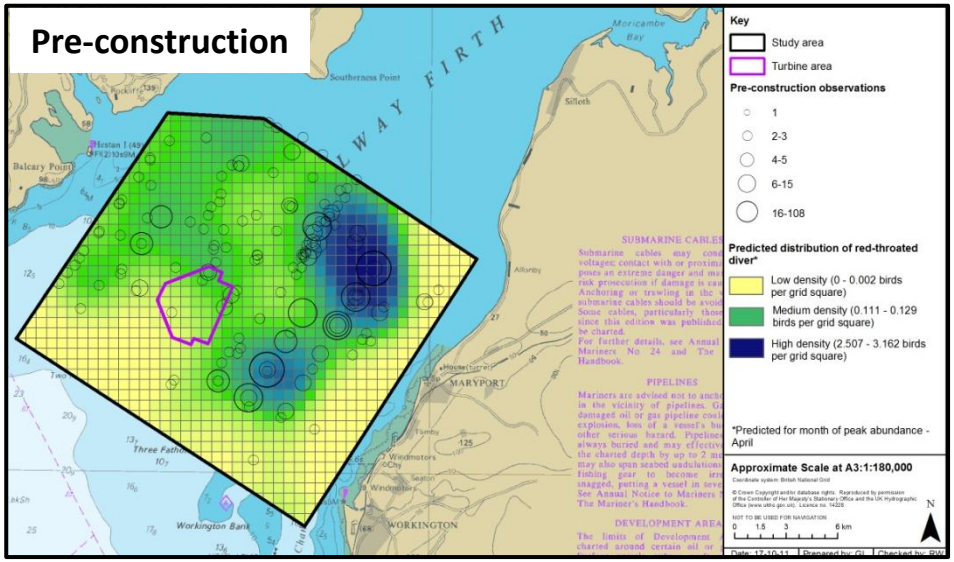
** = too few data to analyse
Number in brackets = number of observations used in analysis
Survey effort: Pre-construction = September 2001-July 2007; 24 surveys: Construction = January 2008-March 2010; 47 surveys: Operation year 1 = April 2010-March 2011: 12 surveys.

Red-throated Diver Distribution (Raw observations): (on the water)

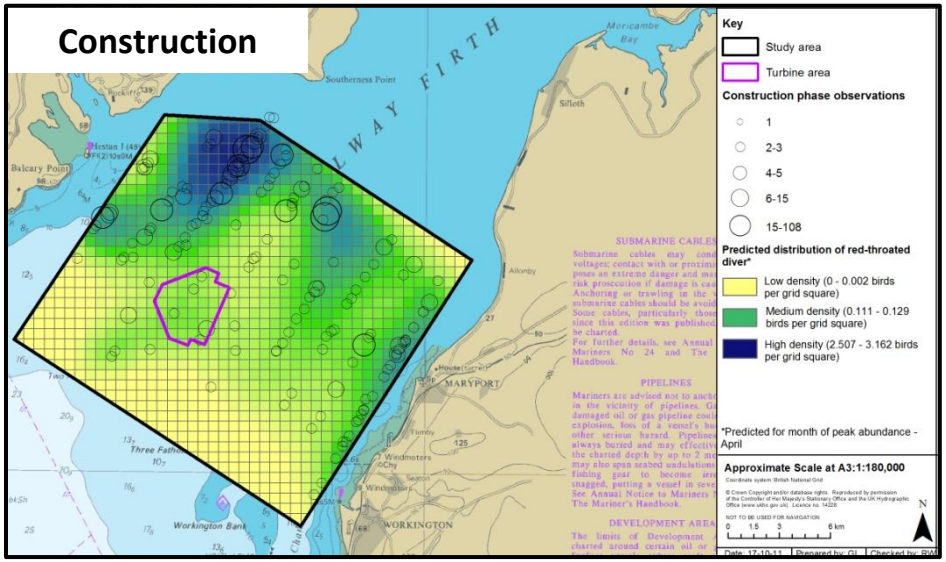


Red-throated Diver - Density Surfaces – 3 Phases: (on the water)

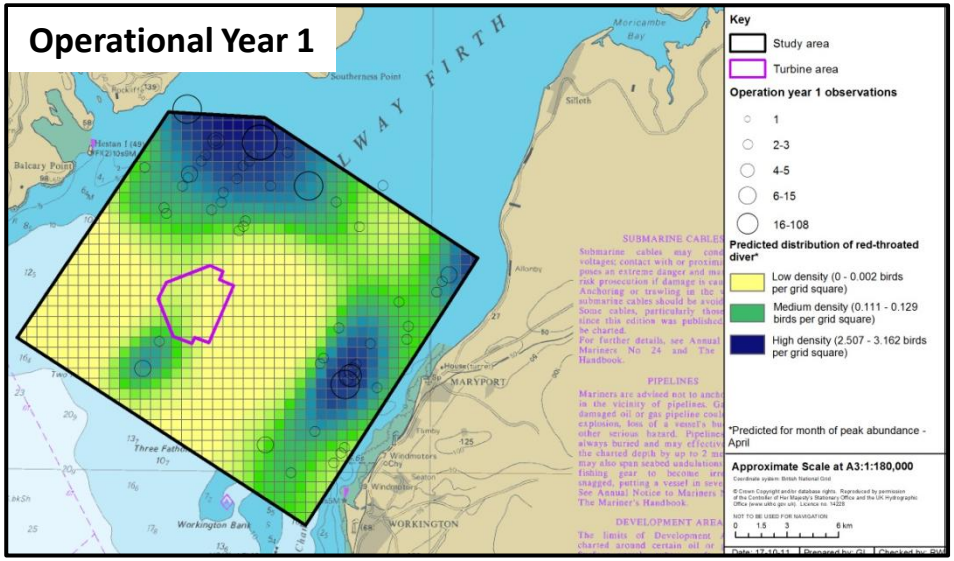
Pre-construction



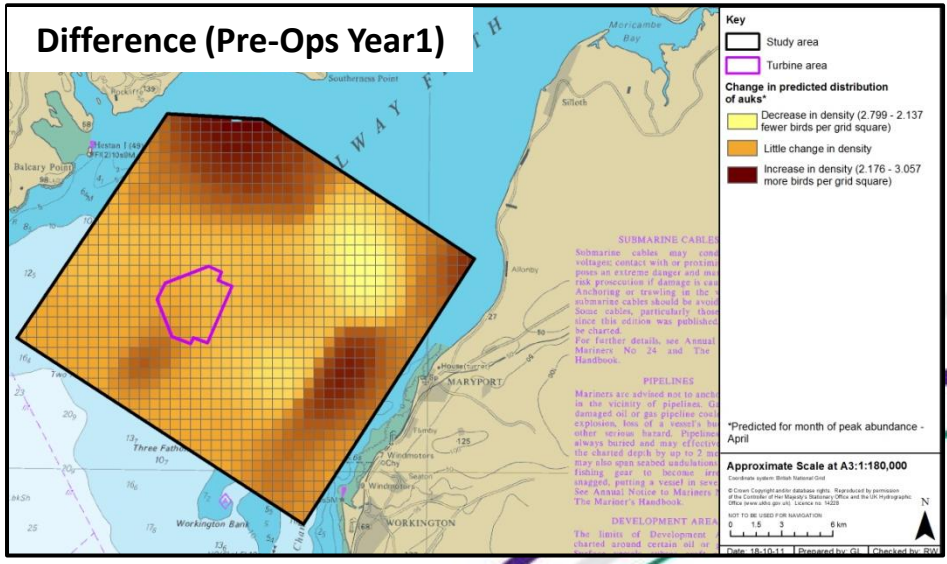
Construction



Operational Year 1



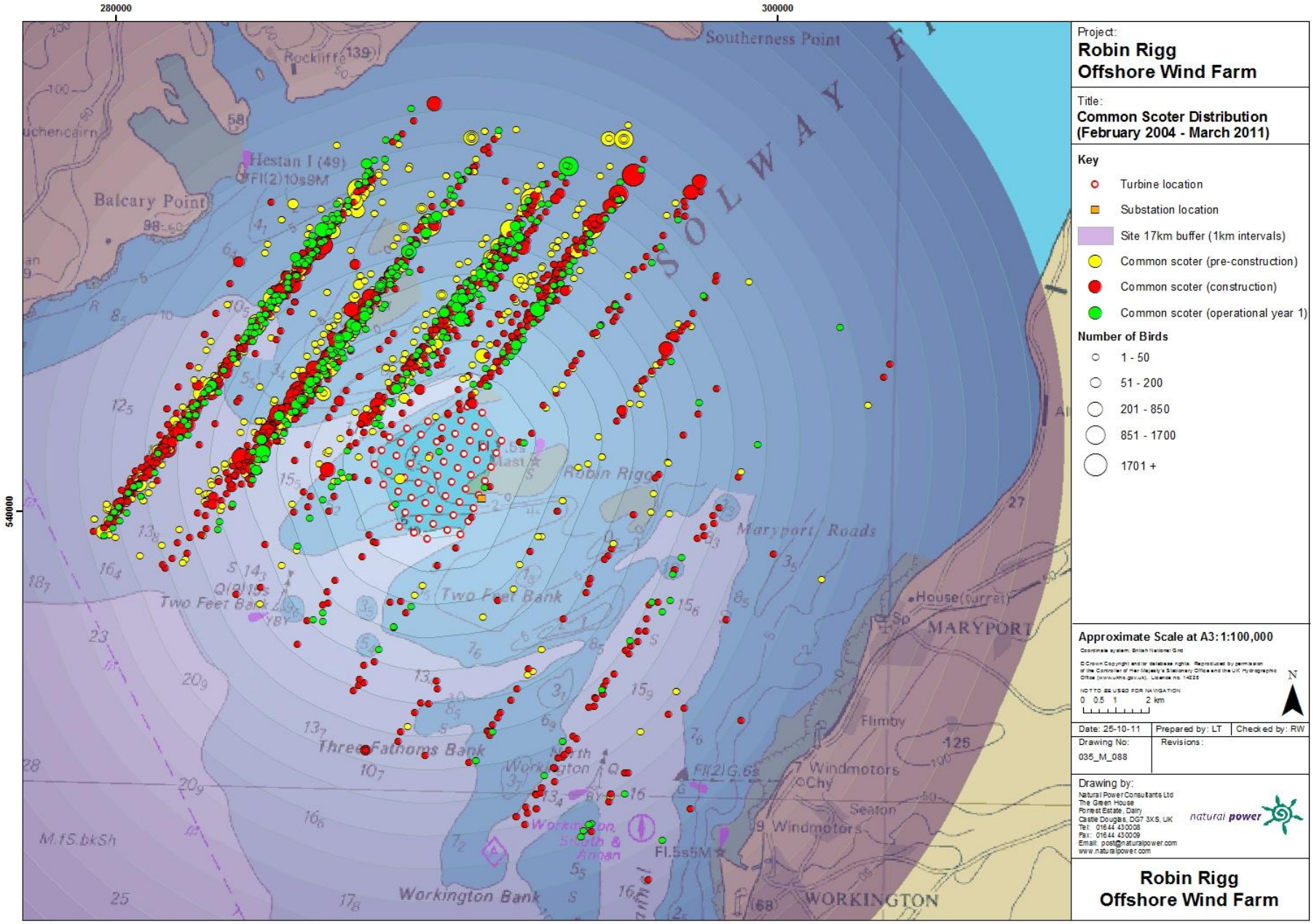
Difference (Pre-Ops Year1)



e·on | Climate & Renewables

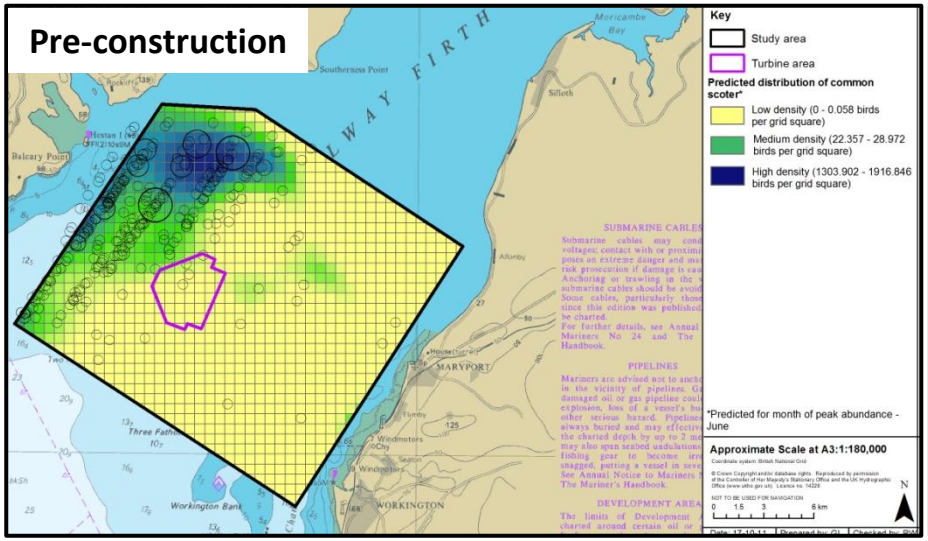
natural power

Common Scoter Distribution (Raw observations): (on the water)

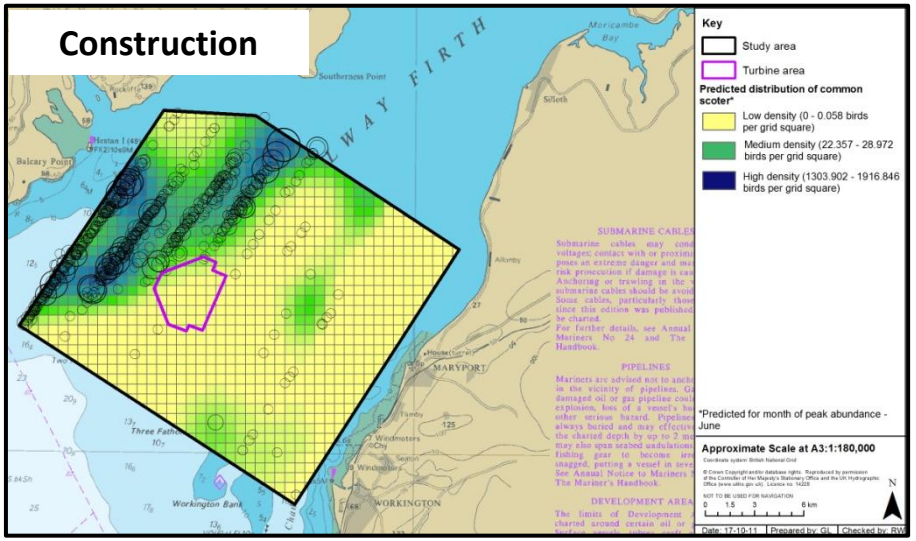


Common Scoter - Density Surfaces – 3 Phases: (on the water)

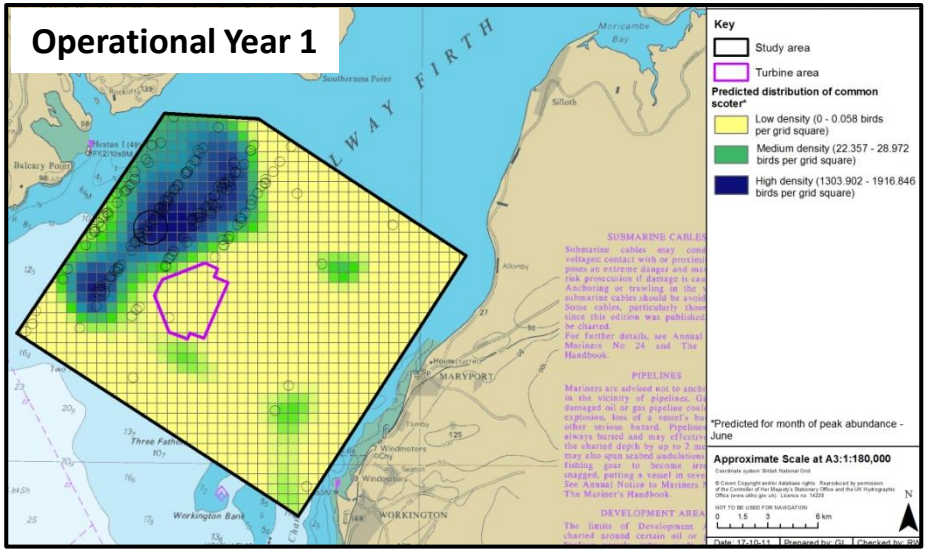
Pre-construction



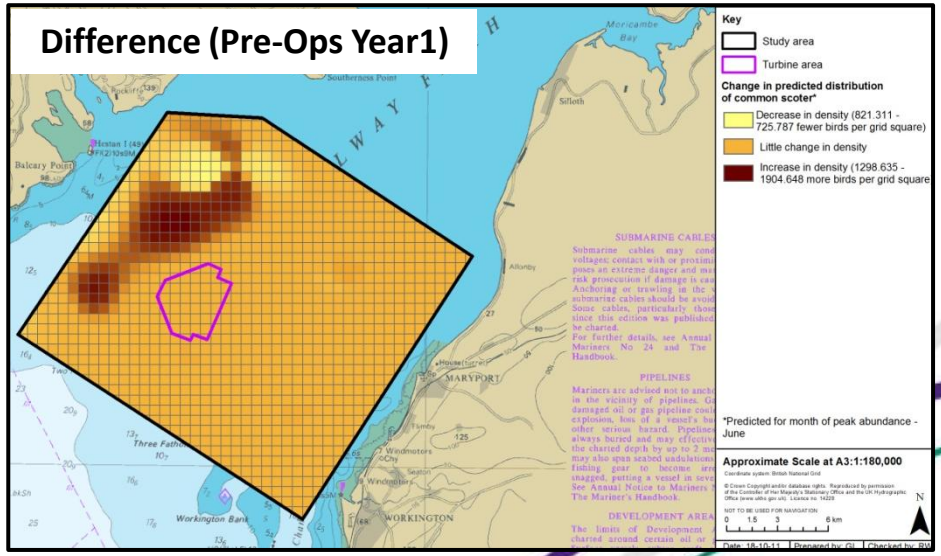
Construction



Operational Year 1



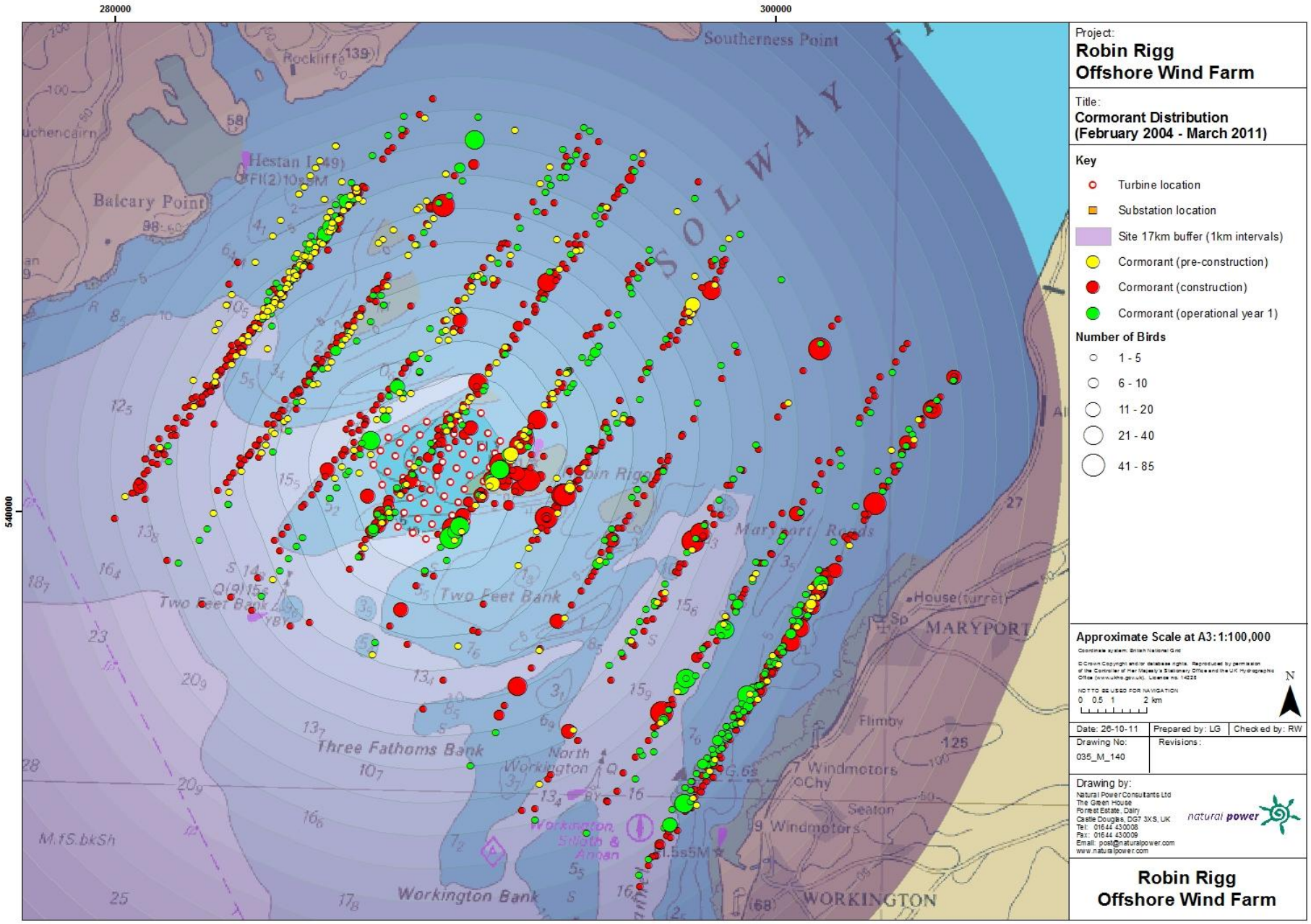
Difference (Pre-Ops Year1)



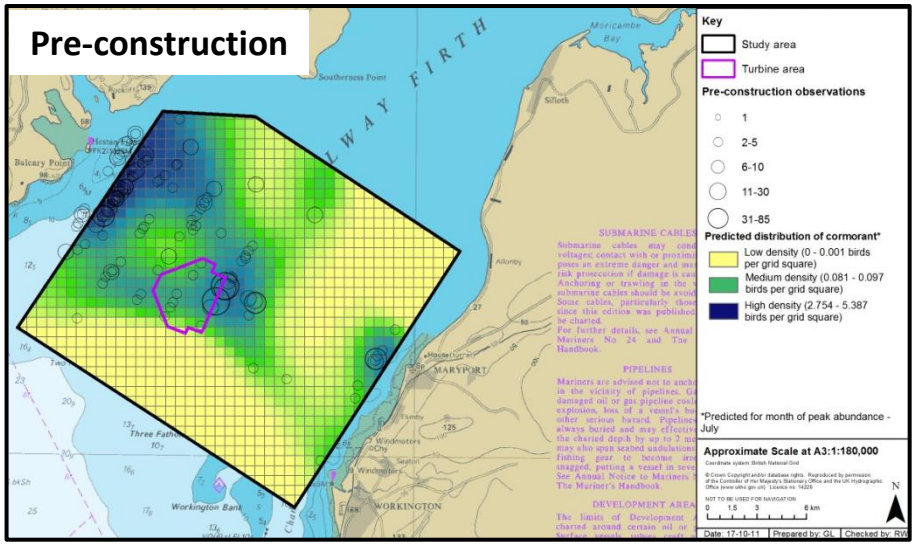
e·on Climate & Renewables

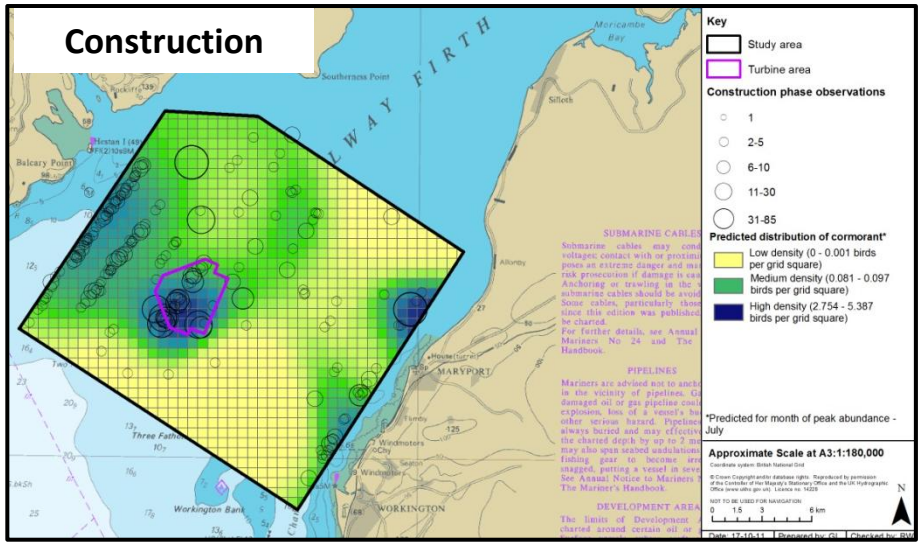
natural power

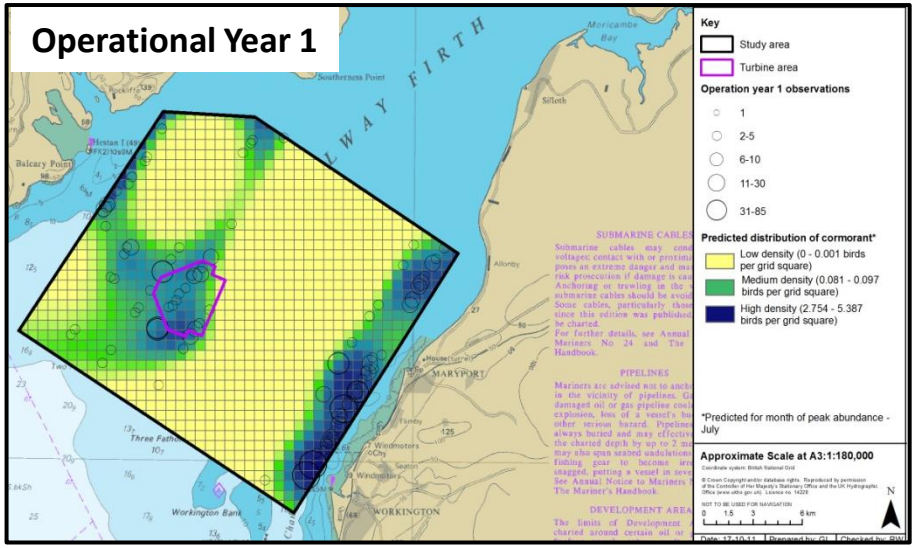
Cormorant Raw Observations: (on the water)

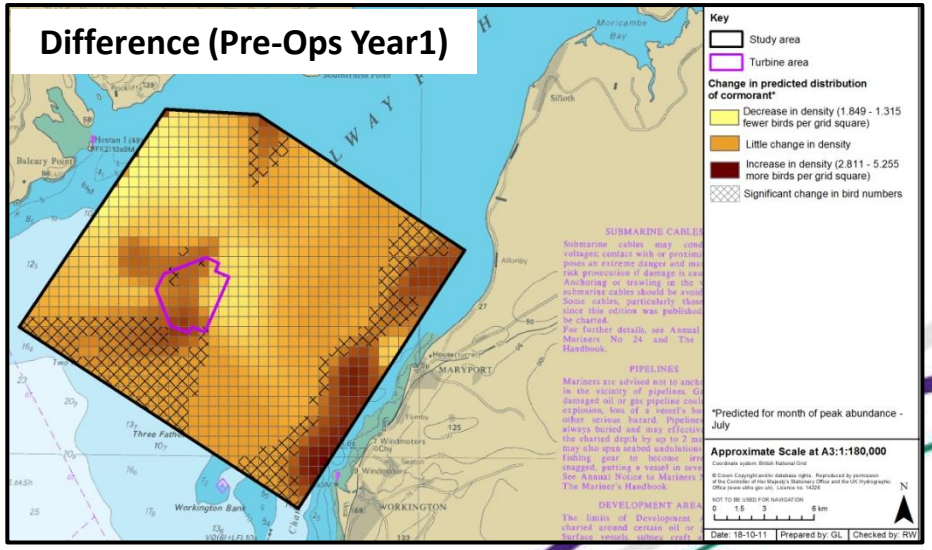


Cormorant – Density Surfaces – 3 Phases: (on the water)









e·on | Climate & Renewables

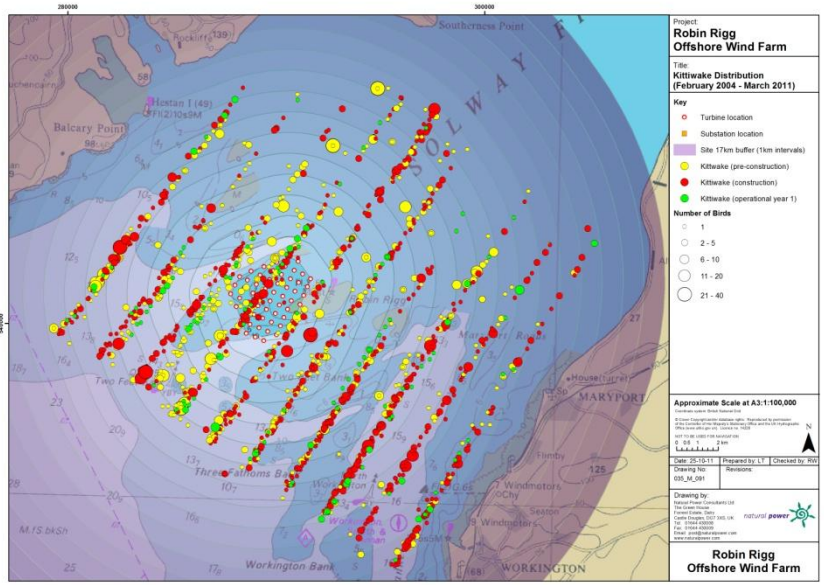
natural power

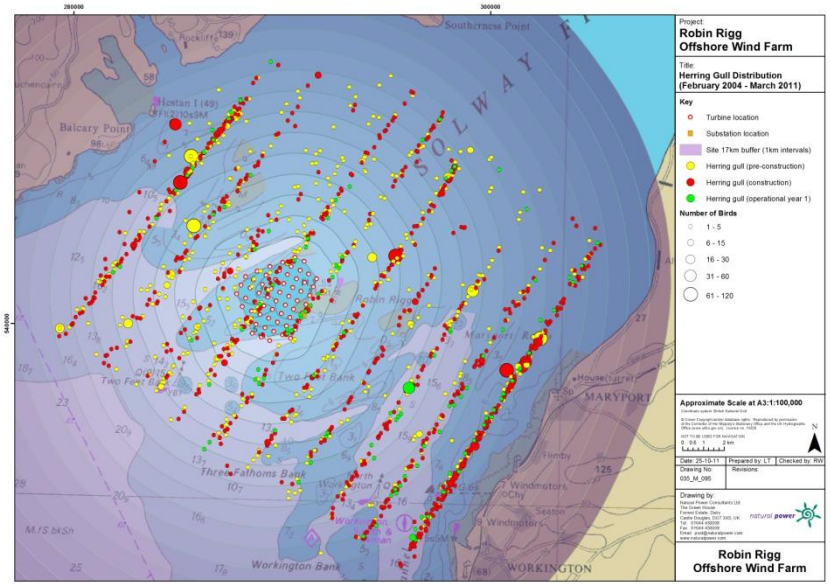
Cormorant:

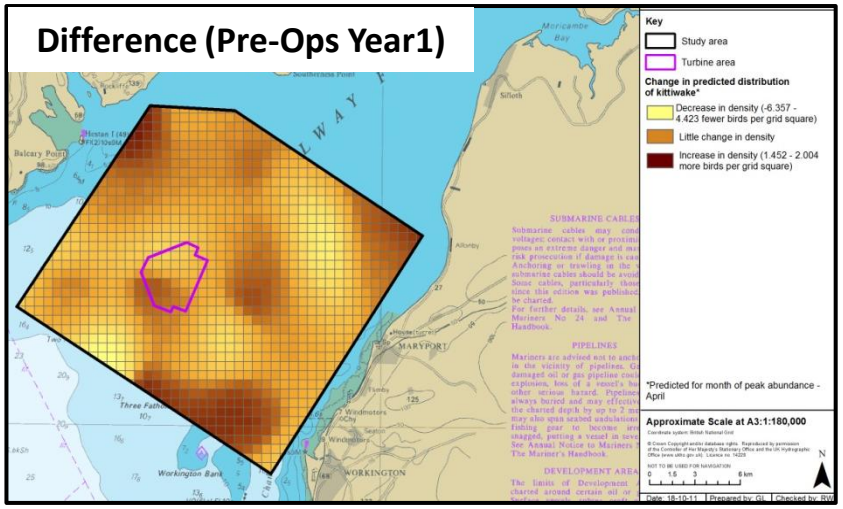
Climate & Renewables

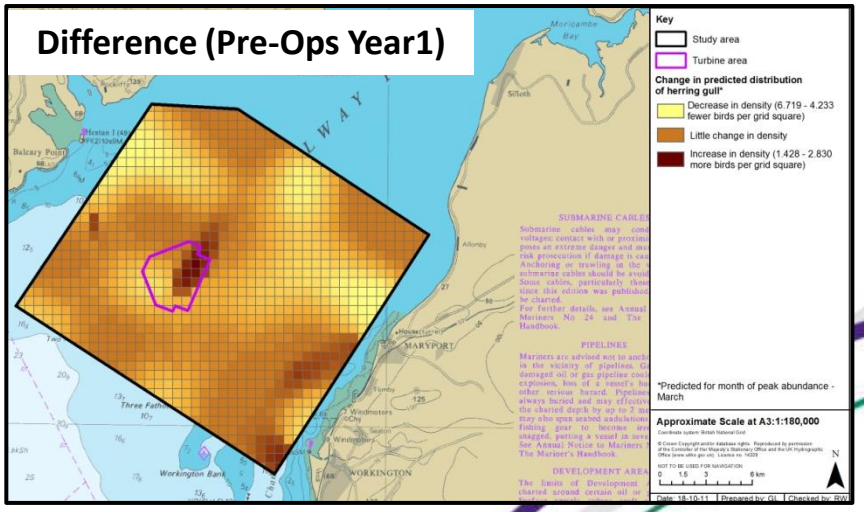
natural power

Kittiwake & Herring gull Observations & Density Surfaces:





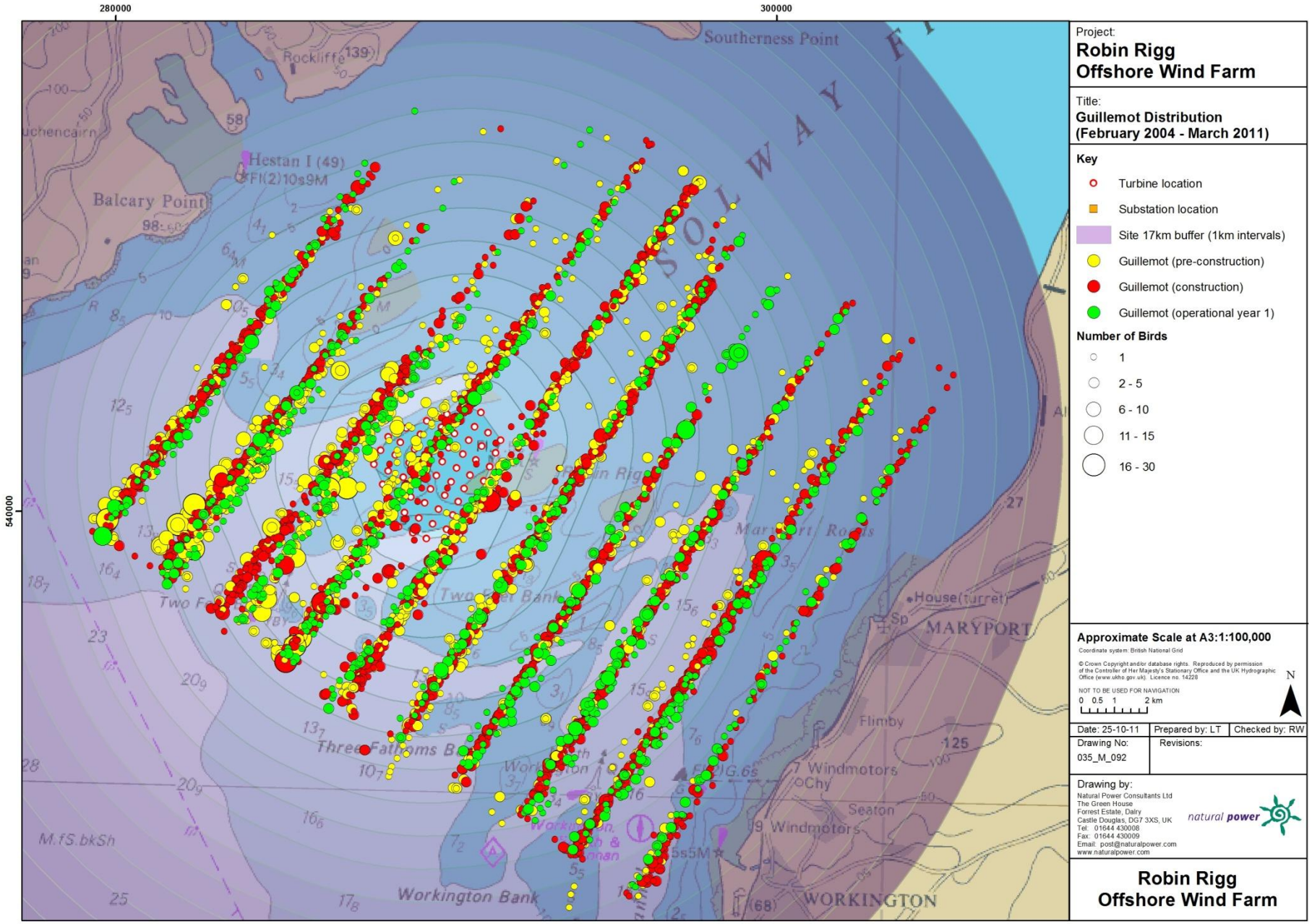




e·on | Climate & Renewables

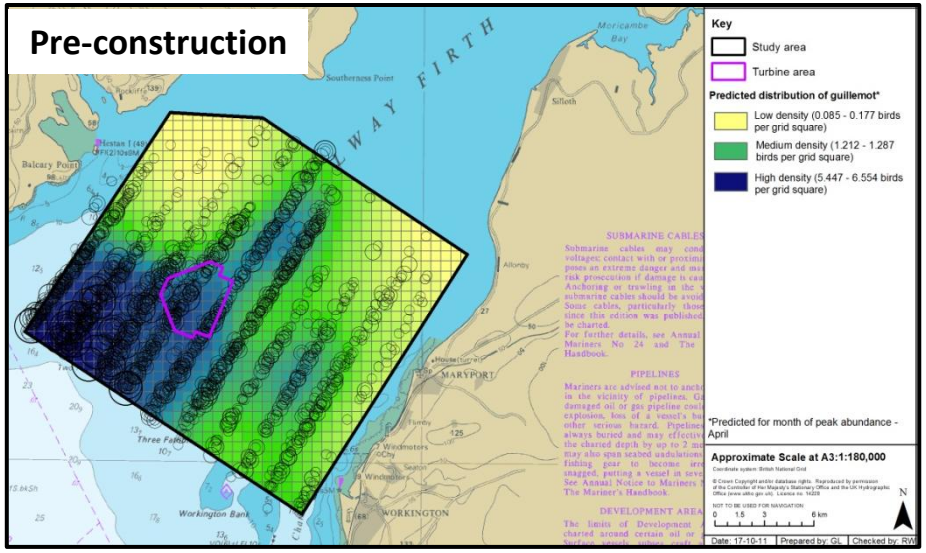
natural power

Guillemot Raw Observations: (on the water)

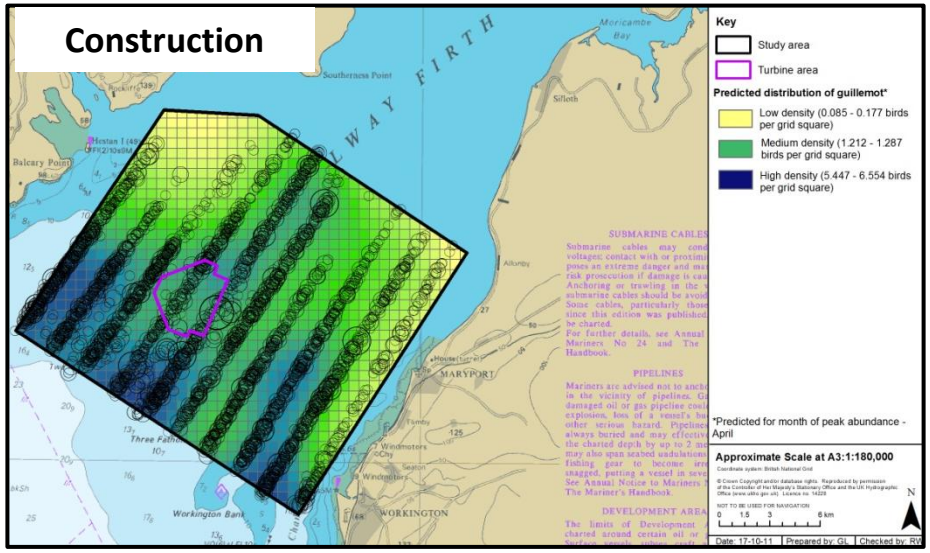


Guillemot – Density Surfaces – 3 Phases: (on the water)

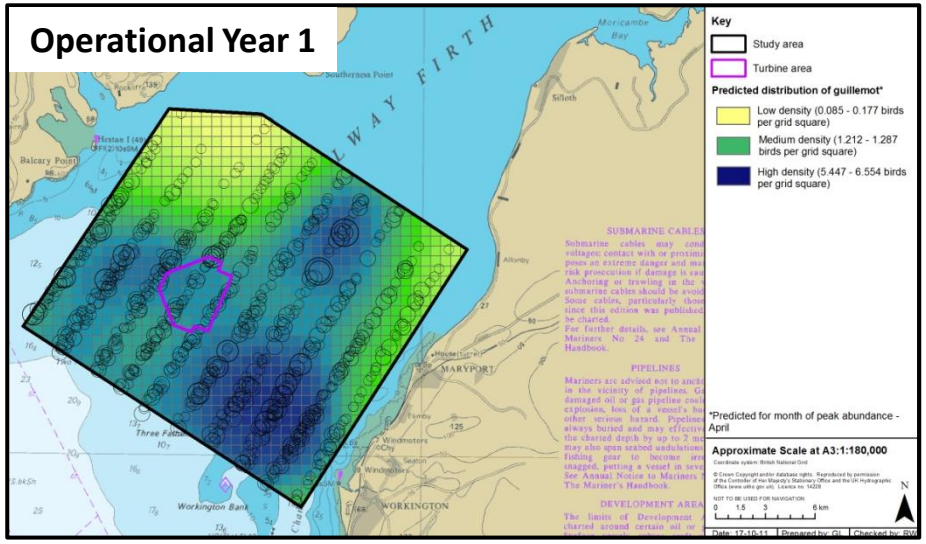
Pre-construction



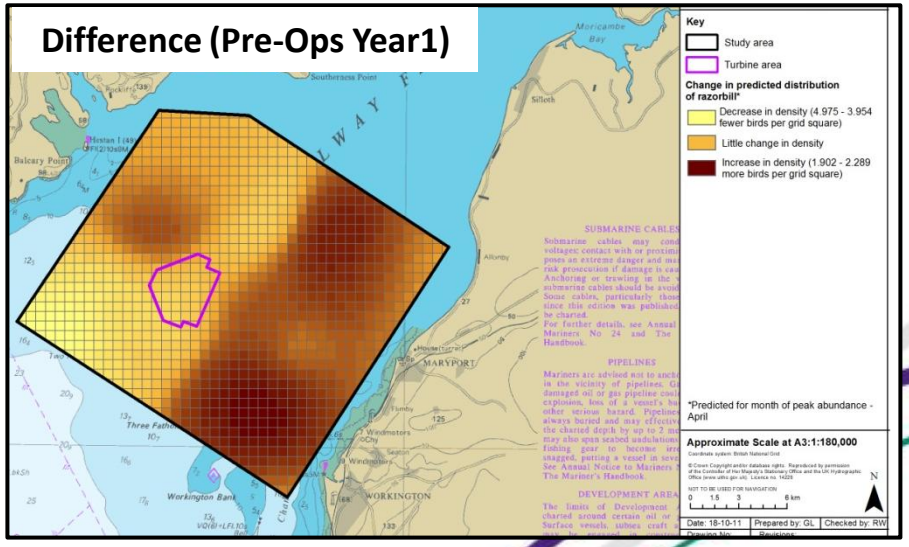
Construction



Operational Year 1



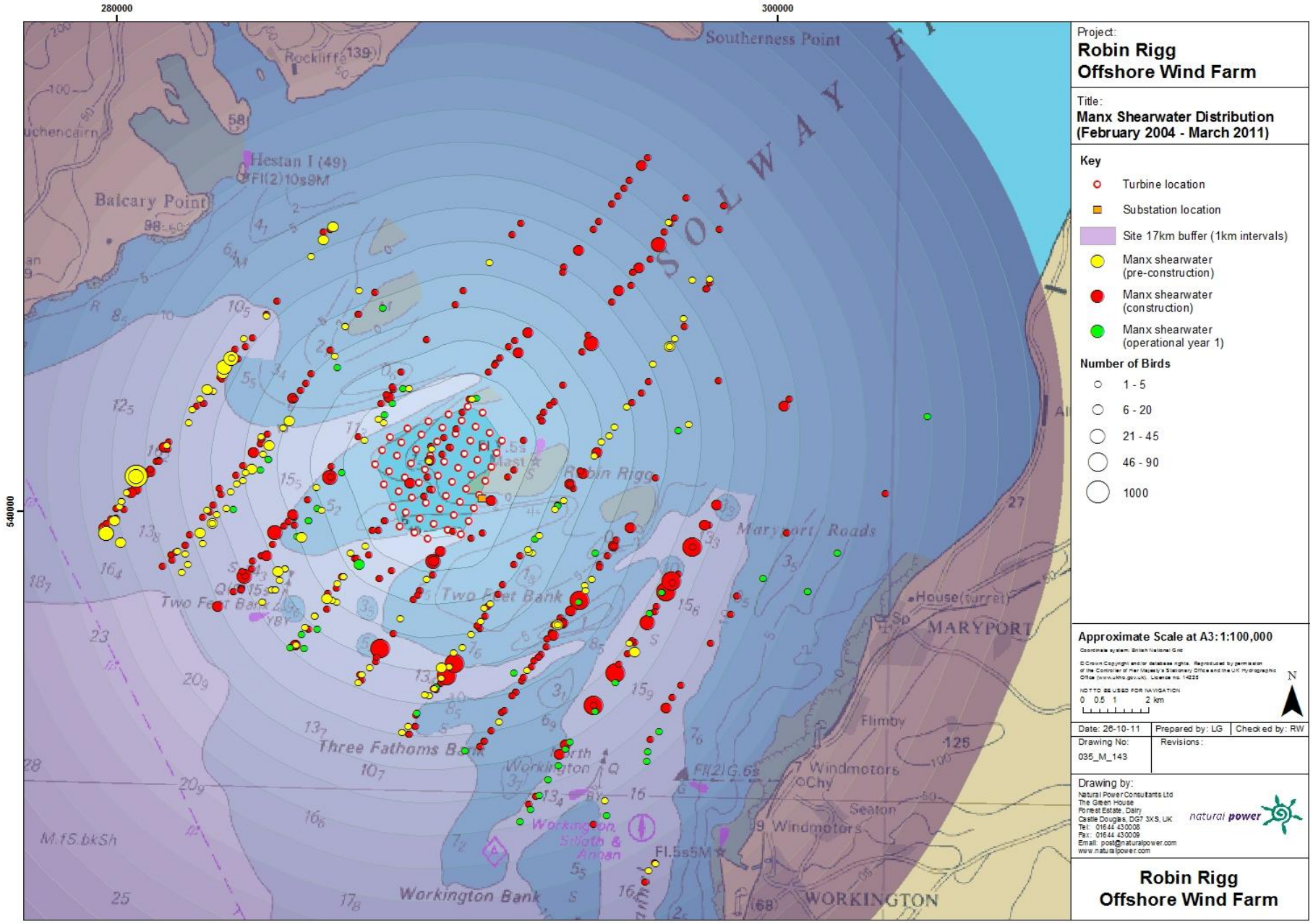
Difference (Pre-Ops Year1)



e·on Climate & Renewables

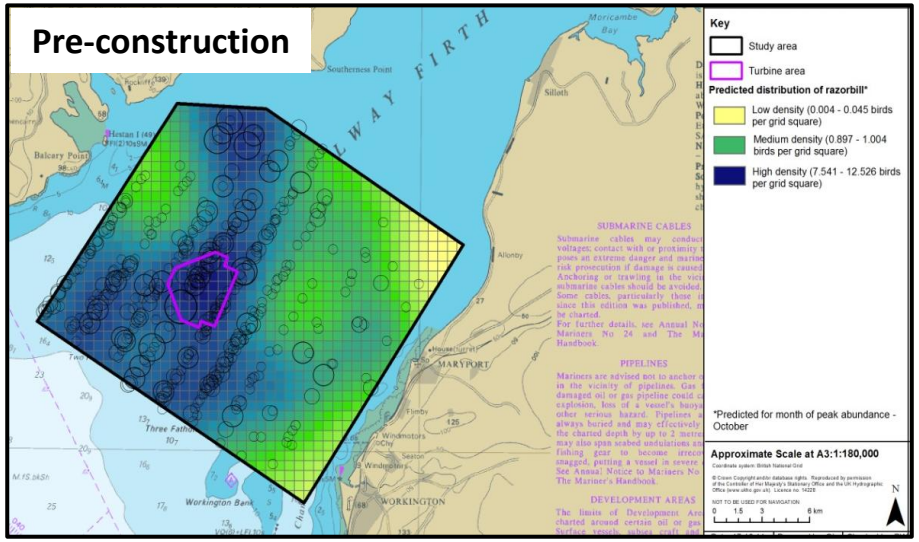
natural power

Razorbill Raw Observations: (on the water)

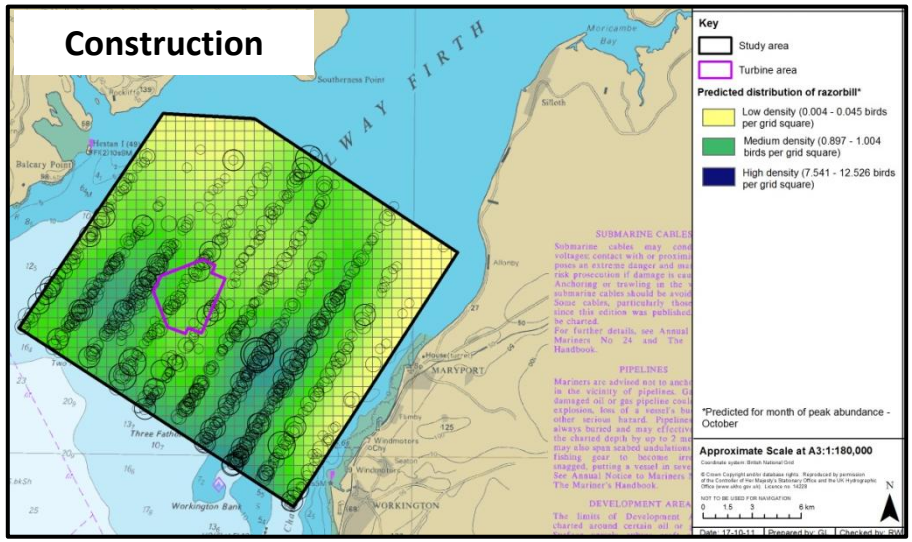


Razorbill - Density Surfaces – 3 Phases: (on the water)

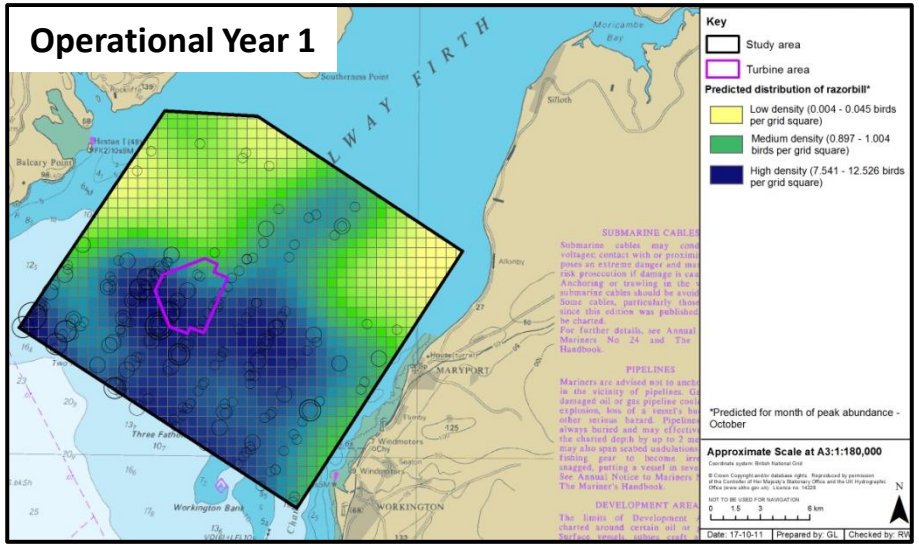
Pre-construction



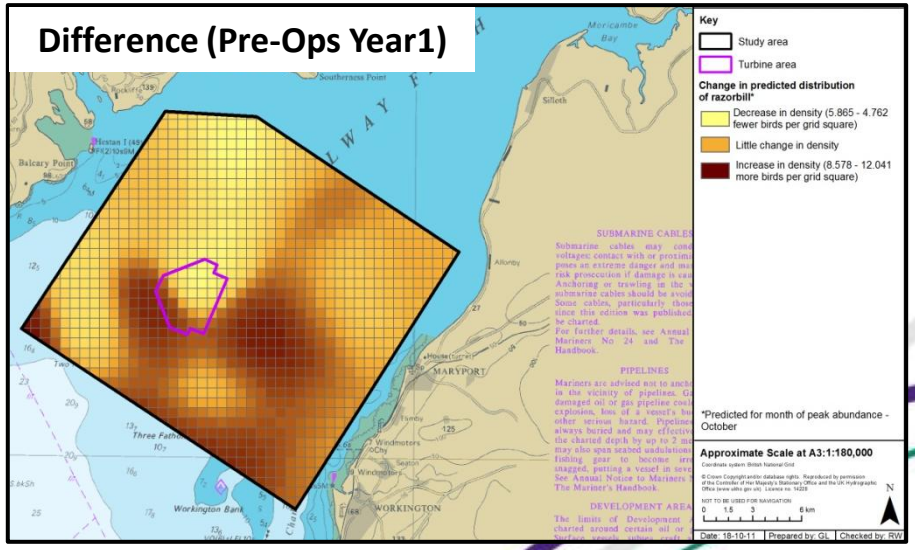
Construction



Operational Year 1



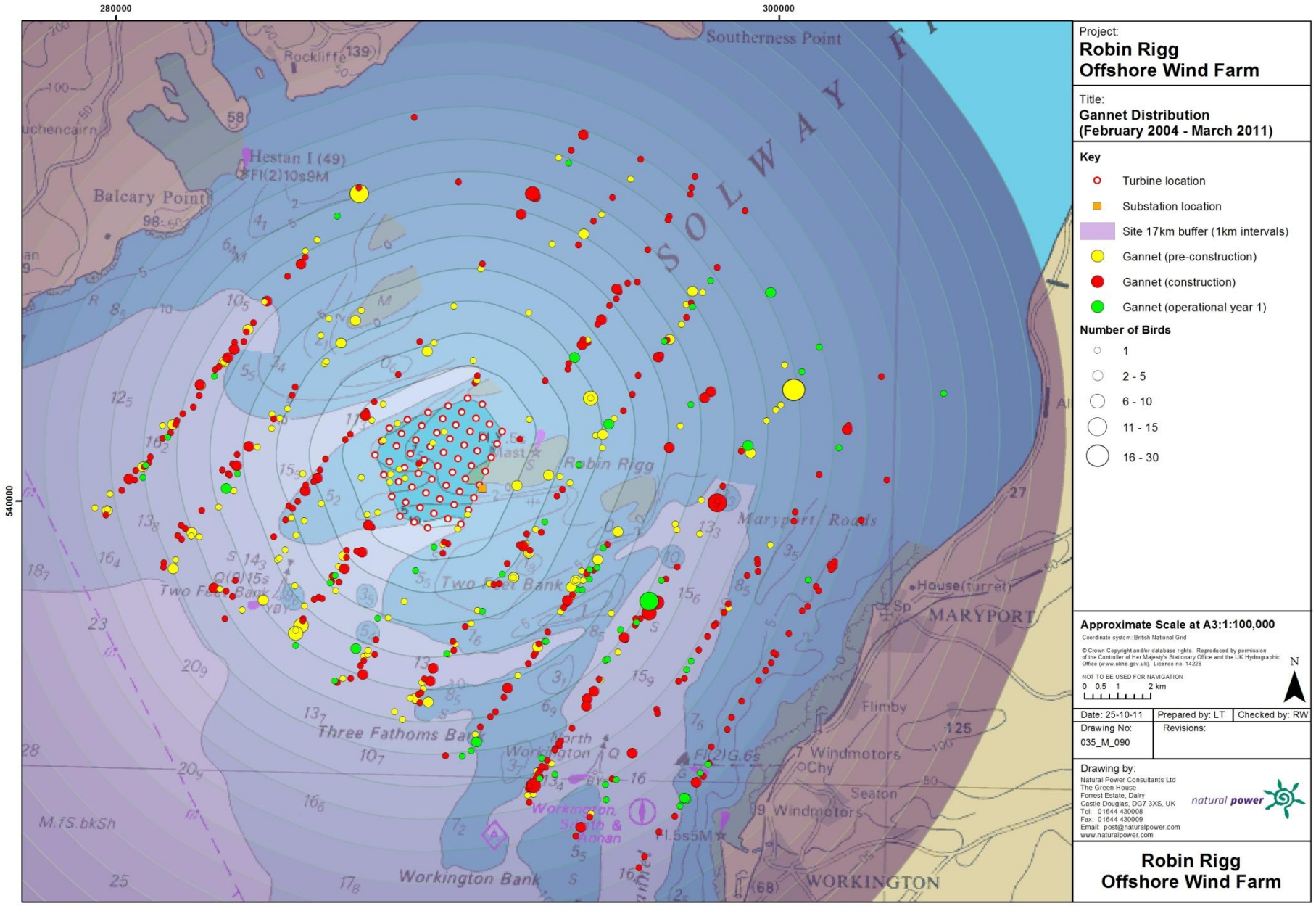
Difference (Pre-Ops Year1)



e·on | Climate & Renewables

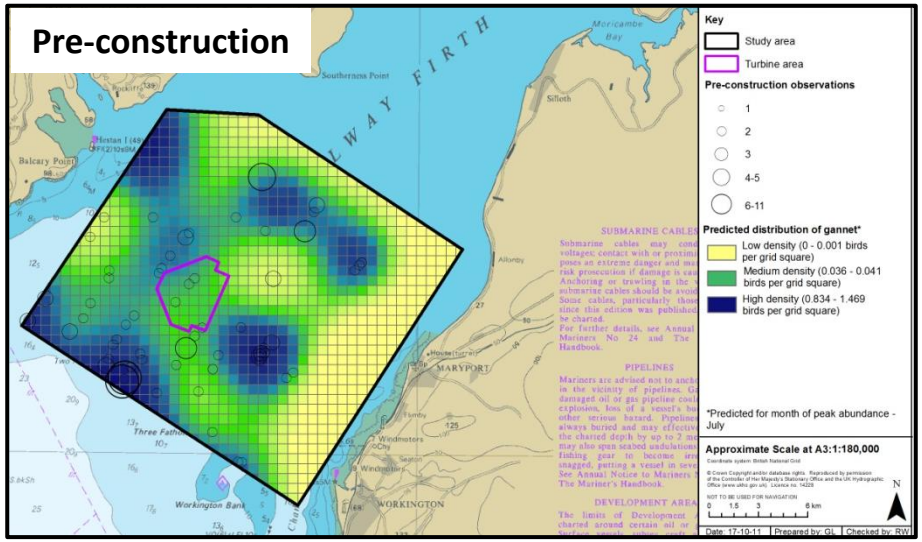
natural power

Gannet Raw Observations: (on the water)

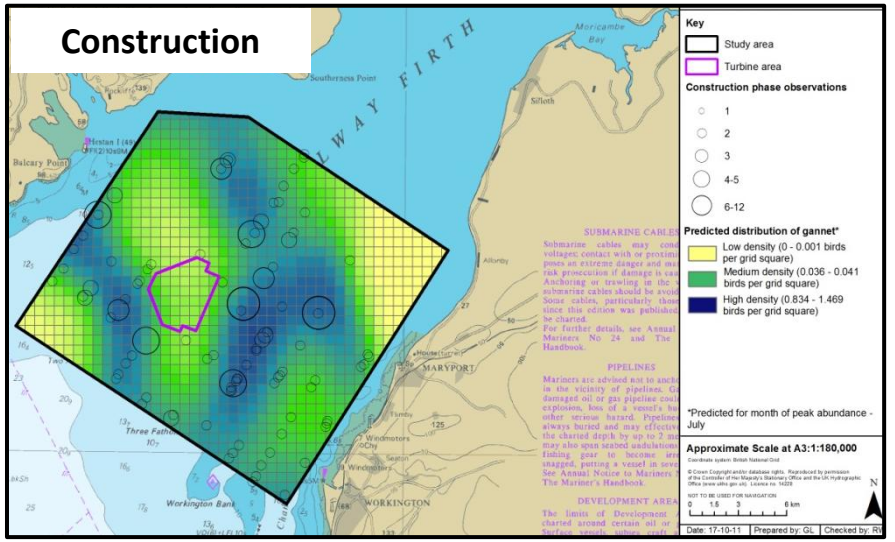


Gannet - Density Surface – 3 Phases: (on the water)

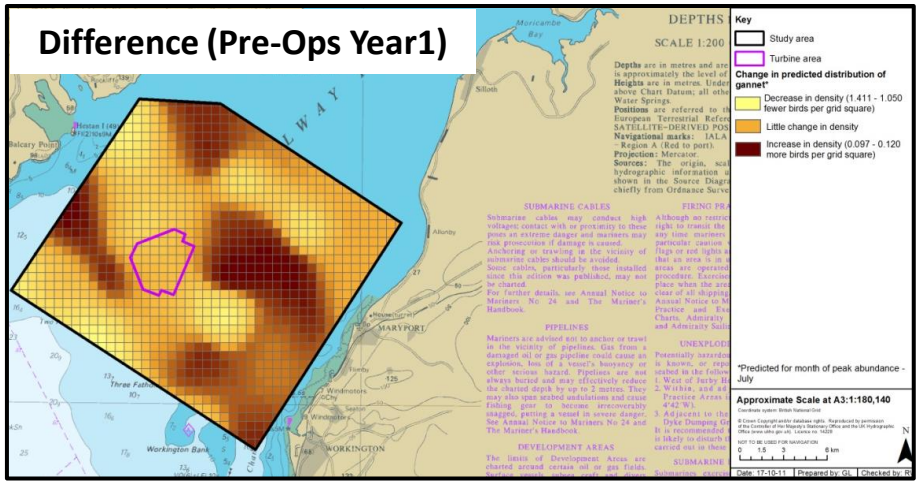
Pre-construction



Construction



Difference (Pre-Ops Year1)



e·on | Climate & Renewables

natural power

Birds Analysis Summary at this stage:

(Birds on the water):

Applying Caution at an early stage:

1. **Little indication of an effect** on:
   - Common scoter, Red-throated diver & Scaup as predicted by ES
2. **Increase in Cormorant** during construction phase & into Ops Yr1+
3. **No obvious displacement of gull species** (GBB, HG & KI)
4. **Indication from Ops Yr1 of a displacement rates** of *circa 30% for Auk species (between pre-construction & Ops Yr1) from the modelled densities for Site .v. Study area*
5. **Indication from Ops Yr1 of a displacement rates** of *circa 50% for Gannet (between pre-construction & Ops Yr1) from the modelled densities for Site .v. Study area*
   More post-construction data being collected for analysis)
7. Fulmar, LBB, Manx shearwater, & Tern sp – too little or infrequent data to model
8. Unable to model birds in flight due to no snapshot data, simple analysis alternative

Summary of MEMP:

1. Next steps will to be the finalisation of Ops Yr1 & Ops Yr2 data
2. Confirmation of preliminary findings
3. Dissemination of key ecological findings from the MEMP
4. RRMG meetings will plan the next steps & lessons learned from the process

Acknowledgements:

- *Robin Rigg Management Group (RRMG)* – MS, SNH, NE, RSPB, GFT, SEPA, EA, s36 ECU, EON
- Dr Gillian Lye – *Natural Power*
- Dr Sarah Canning – *Natural Power*
- Dr Jane Lancaster – *Natural Power*
- Dr Chris Pendlebury – *Natural Power*
- Peter Ullrich, Clive Hartley, Dave Shackleton, Dave Piercy, Steve Percival
- Eric Rexsted & Monique MacKenzie, *CREEM, The University of St Andrews*
- AMEC (formerly ENTEC)
- Galloway Fisheries Trust (GFT)

For Information contact:

richardw@naturalpower.com
Sally.Shenton@eon.com