E.ON Climate & Renewables

Analysis of Marine Ecology Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland

(Operational Year 2)

Technical Report

Appendices

Report: 1012206

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Final Issue: 06/09/2013

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Checked	Dr Chris Pendlebury, Jane Lancaster, Dr. Sarah Canning	16/10/2012
Approved	Dr Jane Lancaster	18/10/2012

Classification COMMERCIAL IN CONFIDENCE

Distribution Sally Shenton, E.ON Climate & Renewables

Revision History

Issue	Date	Changes
A	18/10/2012	Draft Issue
B	17/01/2013	First Issue
Final	06/09/2013	Final Issue

Appendix 1: Benthic Ecology

Table A1.1: Total abundance of benthic infauna caught around the Robin Rigg Wind Farm, baseline – operational year two.

Species	Total numbers caught
Bathyporeia elegans	1123
Nephtys cirrosa	540
Scalibregma inflatum	265
Angulus fabula	169
Kurtiella bidentata	159
Magelona johnstoni	145
Pseudocuma longicornis	144
Scolelepis mesnili	107
Nucula nitidosa	91
Pomatoceros lamarcki	76
Bathyporeia nana	72
Abra alba	64
Gastrosaccus spinifer	60
Donax vittatus	55
Echinocardium cordatum	51
Nephtys caeca	49
Ophelia borealis	36
Bathyporeia sarsi	28
Nephtys hombergii	26
Glycera tridactyla	25
Pontocrates altamarinus	24
Pomatoceros	23
Tellimya ferruginosa	22
Mactra stultorum	22
Eteone flava/longa	20
Paraspio decorata	20
Spio martinensis	16
Nemertea indet.	15
Nemertea	14
Sigalion mathildae	14
Perioculodes longimanus	13
Lagis koreni	12
Exogone hebes	11
Pariambus typicus	10
Pontocrates arenarius	10
Nephtys assimilis	9
Pholoe inornata	9
Pholoe minuta	9
Spiophanes bombyx	9
Scoloplos armiger	8
Urothoe brevicornis	8
Nephtys juv. indet.	7
Polycirrus	7
Schistomysis spiritus	7
Tanaopsis graciloides	7
Liocarcinus marmoreus	6
Microphthalmus similis	6

Species	Total numbers caught
Onchidoris muricata	6
Pharus legumen	6
Bathyporeia indet.	5
Paraonis fulgens	5
Photis longicaudata	5
Sthenelais boa	5
Sthenelais limicola	5
Urothoe poseidonis	5
Chrysallida decussata	4
Gammarus indet.	4
Mytilus edulis (juv.)	4
Nephtys (juv.)	4
Ophiura albida	4
Phoronis sp.	4
Podarkeopsis capensis	4
Solenacea indet.	4
Cephalothricidae indet.	3
Cerebratulus sp.	3
Cerianthus lloydii	3
Dipolydora caeca (agg.)	3
Eumida sanguinea	3
Goniada maculata	3
Haustorius arenarius	3
Hydrobia ulvae	3
Mediomastus fragilis	3
Mytilus edulis	3
Owenia fusiformis	3
Spio armata	3
Actiniaria sp.	2
Ammodytes tobianus	2
Ampelisca spinipes	2
Conopeum reticulum	2
Dyopedos monacanthus	2
Echinocardium	2
Euspira pulchella	2
Magelona filiformis	2
Magelona mirabilis	2
Nephtys kersivalensis	2
Syllidia armata	2
Abra nitida	1
Achelia echinata	1
Alcyonium digitatum	1
Ampharete finmarchica	1
Amphiura filiformis	1
Angulus tenuis	1
Asterias rubens	1
Cerastoderma edule	1
Cliona	1
Crangon crangon	1
Echinocardium flavescens (?)	1

Species	Total numbers caught
Escharella immersa	1
Eteone foliosa	1
Eteone picta	1
Eulalia viridis	1
Eusyllis blomstrandi	1
Glycera convoluta	1
Golfingia elongata	1
Heteroclymene robusta	1
Hirudinea	1
Hydrozoa	1
Lagotia viridis	1
Lanice conchilega	1
Malmgreniella arenicolae (agg.)	1
Megaluropus agilis	1
Mya truncata	1
Mya truncata (juv.)	1
Ophiothrix fragilis	1
Phialella quadrata	1
Phyllodoce groenlandica	1
Pisces juv.	1
Pisidia longicornis	1
Pomatoceros triqueter	1
Pomatoschistus sp.	1
Sabellaria spinulosa	1
Schistomysis kervillei	1
Solen marginatus	1
Spisula (?)	1
Spisula subtruncata	1
Tritonia (juv.)	1
Verruca stroemia	1
Total abundance	3,796
Total no. of species	127

Table A1.2: SIMPER analysis results for operational year two.

Operational Year One					
Group A					
Average similarity: 86.07%					
Species	**Average Abundance**	**Average Similarity**	**Similarity/ Dissimilarity**	**Contribution %**	**Cumulative %**
Bathyporeia elegans	1.65	44.61	6.91	51.83	51.83
Nephtys cirrosa	1.64	41.47	11.02	48.17	100.00
Group B					
Average similarity: 49.99%					
Species	**Average Abundance**	**Average Similarity**	**Similarity/ Dissimilarity**	**Contribution %**	**Cumulative %**
Nephtys cirrosa	1.21	43.84	7.76	87.69	87.69
Ophelia borealis	0.50	6.16	0.41	12.31	100.00
Group C					
Average similarity: 45.63%					
Species	**Average Abundance**	**Average Similarity**	**Similarity/ Dissimilarity**	**Contribution %**	**Cumulative %**
Nephtys cirrosa	2.16	21.37	12.07	46.84	46.84
Bathyporeia elegans	1.75	12.42	4.06	27.22	74.06
Scalibregma inflatum	1.04	6.50	0.89	14.24	88.30
Pontocrates altamarinus	0.68	1.90	0.41	4.15	92.45

Appendix 2: Non-migratory Fish and Electrosensitive Fish

Table A2.1: Fish Species List from Non-migratory fish surveys 2001-2010

Common Name	Latin Name	Number of individuals
Plaice	*Pleuronectus platessa*	20961
Dab	*Limanda limanda*	19415
Whiting	*Merlangius merlangus*	10066
Lesser Weever	*Trachinus vipera*	4458
Solenette	*Buglossidium luteum*	2766
Pogge	*Agonus cataphractus*	2495
Sprat	*Sprattus sprattus*	1485
Sand Goby	*Pomatoschistus minitus*	1464
Sole	*Solea solea*	980
Scald Fish	*Arnoglossus laterna*	790
Greater Pipefish	*Syngnathus acus*	265
Bib	*Trisopterus luscus*	123
Dragonet	*Callionymus lyra*	122
Grey gurnard	*Eutrigla gurnardus*	106
Red gurnard	*Aspitriglia cuculus*	97
Sea Snail	*Liparis liparis*	75
Lesser spotted dogfish	*Scyliorhinus canicula*	62
Thornback Ray	*Raja clavata*	53
Five Bearded Rockling	*Ciliata mustela*	37
Cod	*Gadus morhua*	33
Tub Gurnard	*Trigla lucerna*	30
Flounder	*Platichthys flesus*	23
Greater Sand Eel	*Hyperoplus lanceolatus*	18
Brill	*Scophthalmus rhombus*	17
Three Bearded Rockling	*Gaidropsarus vulgaris*	7
Common Skate	*Raja batis*	6
Common Goby	*Pomatoschistus microps*	4
Turbot	*Scophthalmus maximus*	4
Transparent Goby	*Aphia minuta*	3
Butterfish	*Pholis gunnellus*	3
Bull Rout	*Myoxocephalus scorpius*	2
Long-spined Sea Scorpion	*Taurulus bubalis*	2
Blonde Ray	*Raja brachyura*	2
Shore Rockling	*Gaidropsarus mediterraneus*	1
Sea Stickleback	*Spinachia spinachia*	1
Lumpsucker	*Cyclopterus lumpus*	1

Table A2.2: Invertebrate Species List from Non-migratory fish surveys 2001-2010

Common Name	Latin Name	Number of Individuals
Brown shrimp	*Crangon crangon*	95442
Brittle star	*Ophiura ophiura*	23006
Hermit crab	*Pagurus bernhardus*	2186
Harbour crab	*Liocarcinus depurator*	1862
Common starfish	*Asterias rubens*	623
Baltic prawn	*Palaemon adspersus*	298
Plumose anemone	*Metridium senile*	278
Pink shrimp	*Pandalus montagui*	138
Small shrimps	*Philocheras trispinus*	125
Small decapod	*Eualus gaimardii*	98
Sea mouse	*Aphrodita aculeata*	94
Masked crab	*Corystes cassivelaunus*	79
Barnacle	*Semibalanus balanoides*	66
Strawberry crab	*Eurynome aspera*	65
Spotted crab	*Portumnus latipes*	63
Barnacle	*Eliminius modestus*	51
Squid	*Allotheuis subulata*	51
Brittle Star	*Ophiura albida*	50
Common whelk	*Buccinum undatum*	42
Cuttle fish	*Sepiola atlantica*	41
Shore crab	*Carcinus maenas*	37
Green sea urchin	*Psammechinus miliaris*	37
Hyroids on hermit crabs	*Podocoryne carnea*	36
Razor Clam	*Ensis ensis*	35
Isopod	*Idotea lineanis*	35
Rayed trough shell	*Mactra stultorum*	32
Hydroids on hermit crabs	*Hydractinia echinata*	30
Gammarid amphipod	*Chaetogammarus merinus*	28
Banded Wedge Shell	*Donax vittatus*	27
Spider Crab	*Macropodia rostrata*	16
Great Spider Crab	*Hyas araneus*	16
Top Shell	*Gibbula umbilicalis*	14
Sea Mat	*Membranipora membranacea*	14
Heart Urchin	*Echinocardium cordatum*	11
Hornedwrack	*Flustra foliacea*	11
Spider Crab	*Macropodia tenuirostris*	10
Queen Scallop	*Aequipecten opercularis*	9
Bivalve	*Mactridae sp.*	8
Alder's necklace Shell	*Polinices polionus*	7
Barnacle	*Balanus hameri*	6
Anemone	*Sagartia elegans*	6
Spider Crab	*Macropodia deflexa*	5
Barnacle	*Balanus balanus*	5
Velvet Swimming Crab	*Necora puber*	4
Mussel	*Mytilus edulis*	4
Blunt Gaper	*Mya truncata*	4
Sea squirt	*Tunicate sp.*	4

Common Name	Latin Name	Number of Individuals
Thin tellin	*Angulus tenuis*	3
Naken Sea Slug	*Phillene aperta*	3
Pea Crab	*Pinnorteres pisum*	2
White shrimp	*Pasiphaea sivado*	2
Baltic Tellin	*Macoma balthica*	2
Edible crab	*Cancer pagurus*	1
Sand Star	*Astropecten irregularis*	1
Dahlia anemone	*Urticina felina*	1
Dead man's fingers	*Alcyonium digitatum*	1
Sponge	*Hemimycale columella*	1
Ascidian	*Ascidiella scabra*	1

Table A2.3: Fish species from electrosensitive fish surveys 2007-2010

Common Name	Latin Name	Number of Individuals
Plaice	*Pleuronectes platessa*	558
Whiting	*Merlangius merlangus*	363
Dab	*Limanda limanda*	345
Lesser Weever	*Echiichthys vipera*	164
Solenette	*Buglossidium luteum*	99
Witch	*Pleuronectes cynoglossus*	79
Dover sole	*Solea solea*	56
Scaldfish	*Arnoglossus laterna*	54
Pogge	*Agonus cataphractus*	31
Sand Goby	*Pomatoschistus minutus*	28
Gurnard	*Aspitriglia cuculus*	25
Short spined sea scorpion	*Myoxocephalus scorpius*	24
Dragonet	*Callionymus lyra*	22
Brill	*Scopthalmus rhombus*	18
Poor cod	*Trisopterus minutus*	18
Thornback ray	*Raja clavata*	18
Lesser Spotted Dogfish	*Scyliorhinus canicula*	15
Bib	*Trisopterus luscus*	11
Sprat	*Sprattus sprattus*	9
Grey Gurnard	*Eutrigla gurnardus*	8
Four bearded rockling	*Enchelyopus cimbrius*	6
5 bearded rockling	*Ciliata mustela*	6
Flounder	*Pleuronectes flesus*	5
Gunnel	*Pholis gunnellus*	4
Tadpole fish	*Raniceps raninus*	2
Lemon Sole	*Microstomus kitt*	2
Sandeel	*Ammodytes tobianus*	2
Pipefish	*Sygnathus acus*	2
Turbot	*Scopthalmus maximus*	1
Tub gurnard	*Trigla lucerna*	1
Cod	*Gadhus morhua*	1
Ling	*Molva molva*	1

Table A2.4: Invertebrates species from electrosensitive fish surveys 2007-2010

Common Name	Latin Name	Number of Individuals
Brown Shrimp	*Crangon crangon*	1040
Starfish	*Asterias rubens*	474
Hermit crab	*Pagurus bernhardus*	215
Pink shrimp	*Pandalus montagui*	132
Swimming crab	*Liocarcinus holstatus*	43
Shore crab	*Carcinus maenas*	36
Harbour crab	*Liocarcinus depurator*	16
Whelk	*Buccinum undatum*	15
Spider crab	*Hyas araneus*	13
Brittlestar	*Ophiura ophiura*	13
Spider crab	*Macropodia deflexa*	9
Cuttlefish	*Sepiola atlantica*	3
Edible Crab	*Cancer pagurus*	2
Dead man's fingers	*Alcyonium digitatum*	2
Sea Mouse	*Aphrodita aculeata*	2
Squid	*Loligo forbesii*	1
Sea snail	*Liparis liparis*	1
Rayed trough shell	*Mactra stultorum*	1
Breadcrumb sponge	*Halichondria panicea*	1
Honeycomb worm	*Sabellaria alveolata*	1

Appendix 3: Birds

A3. ORTHNITHOLOGICAL MONITORING AT ROBIN RIGG

A3.1. Designated conservation areas for birds within the Solway Firth

The Solway Firth in an important area for a wide range of diverse bird species, with a number of areas being protected (Table A3.1. These protected areas fall into a number of designations/categories:

- Protected areas established under National Legislation, including Sites of Special Scientific Interest (SSSI) and National Nature Reserves.
- Protected areas established as a result of European Union Directives or other European initiatives, including the Natura 2000 network.
- Protected areas set up under Global Agreements, including Ramsar sites.
- Marine Protected Areas

Table A3.1: Areas of protection for birds within the Solway Firth.

Site Name	Designation	Approximate Distance from Site (km)	Qualifying Features
Upper Solway Flats and Marshes	RAMSAR	6.4	Bar-tailed godwit: non-breeding Svalbard barnacle goose: non-breeding Curlew: non-breeding Knot: non-breeding Oystercatcher: non-breeding Pink-footed goose: non-breeding Pintail: non-breeding Scaup: non-breeding
Upper Solway Flats and Marshes	SPA	6.4	Bar-tailed godwit: non-breeding Svalbard barnacle goose: non-breeding Cormorant: non-breeding Curlew: non-breeding Dunlin: non-breeding Golden plover: non-breeding Goldeneye: non-breeding Great-crested grebe: non-breeding Grey plover: non-breeding Knot: non-breeding Lapwing: non-breeding Mallard: non-breeding Oystercatcher: non-breeding Pink-footed goose: non-breeding Pintail: non-breeding Redshank: non-breeding Ringed plover: non-breeding & passage Scaup: non-breeding Shelduck: non-breeding Whooper swan: non-breeding
Upper Solway Flats and Marshes	SSSI	6.4	Bar-tailed godwit: non-breeding Barnacle goose: non-breeding Breeding bird assemblage Curlew: non-breeding

			Dunlin:– non-breeding Golden plover: non-breeding Goldeneye: non-breeding Grey plover: non-breeding Knot: non-breeding Oystercatcher: non-breeding Pintail: non-breeding Redshank: non-breeding Ringed plover: non-breeding Sanderling: non-breeding Scaup: non-breeding Shelduck: non-breeding
Abbey Burn Foot to Balcary Point	SSSI	8.5	Cormorant: breeding Fulmar: breeding Guillemot: breeding Kittiwake: breeding Razorbill: breeding
Borgue Coast	SSSI	22	Common gull: breeding Greater black-backed gull: breeding
St Bees Head	SSSI	23	Guillemot: breeding Fulmar: breeding Kittiwake: breeding Razorbill: breeding Puffin: breeding Shag: breeding Herring gull: breeding Black guillemot: breeding
Cree Estuary	SSSI	40	Pink-footed goose: non-breeding
Scare Rocks	SSSI	62	Gannet: breeding Guillemot: breeding Shag: breeding
Loch of Inch and Torrs Warren	RAMSAR	69	Greenland white-fronted goose: non-breeding
Loch of Inch and Torrs Warren	SPA	69	Greenland white-fronted goose: non-breeding Hen harrier: non-breeding
Torrs Warren to Luce Sands	SSSI	69	Hen harrier: non-breeding
Mull of Galloway	SSSI	73	Fulmar: breeding Kittiwake: breeding Razorbill: breeding
Ailsa Craig* *Although not within the Solway, is there nearest breeding site for gannets.	SPA	100	Gannet: breeding Lesser black-backed gull: breeding Guillemot: breeding Kittiwake: breeding Herring gull: breeding

A3.2. Data collection methods

The survey vessel used for most of the boat surveys was a Fisheries Protection Vessel (16 m length, 18 tonne displacement). This vessel provided an excellent viewing platform and had the combination of speed (to be able to survey across the range of tidal conditions) and the ability to operate in relatively shallow water. Its viewing platform gives a 4 m viewing height above the sea surface. Although this is below the JNCC recommended 5 m, it gave a very suitable viewing platform, especially when taking into account the site constraints on a larger boat which would not have been able to navigate the sandbanks that run through much of the study area. The maximum wind force for observations was reduced from force 5 to force 4 (see Table A3.2 for full definition of sea states) to further ensure that viewing conditions were optimal and were not compromised by the slightly lower viewing height.

Table A3 2: Definition of sea states used in the collection of environmental data.

Sea State	Definition
0	Mirror calm
1	Slight ripples, no foam crests
2	Small wavelets, glassy crests but no whitecaps
3	Large wavelets, crests begin to break, few whitecaps
4	Longer waves, many whitecaps
5	Moderate waves of longer form, some spray

The survey route was designed to provide a 2 km interval between transects; a total of ten transects were surveyed, each of about 18 km length (see Figure A3.1). This separation distance was chosen to ensure that a good sample of the study area was covered for all species, whilst minimising the likelihood that birds may be displaced from one transect to the adjacent one and double-counted.

The same route was used for all the surveys, though restricted hours of daylight, weather and tidal conditions meant that it was not always possible to cover the whole survey area in a single day. Where complete surveys were not possible the second survey each month was designed to ensure that the whole study area was covered at least once per month and that the potential wind farm area twice per month whenever possible. A GPS record of the precise route was taken on each trip, so that the location at all times was known.

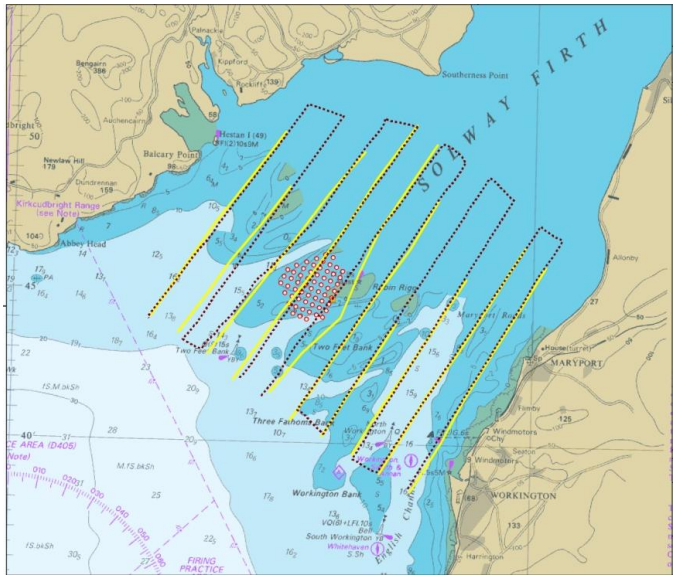


Figure A3.1: Illustration showing the 10 transect lines followed during the bird and marine mammal surveys. The yellow lines represent the area that could be covered at low tide. Red circles represent turbine locations.

Two surveys were completed each month from May 2001 to April 2002, with the exception of May and October 2001, when only one survey was completed. Alternate surveys covered the high tide and the low tide periods. Monthly surveys were conducted in April/May 2003 and between January and September 2004 with an addition survey performed in July 2007, just prior to construction commencing. Construction phase surveys began in January 2008 and continued on a bi-monthly basis until the end of the phase in February 2010. Surveys were completed in all months of the construction phase except November 2009.

All birds encountered, their behaviour, flight height and approximate distance from the boat were recorded.

Two observers worked simultaneously, each observing a 90° angle ahead and to the side of the vessel. Following the JNCC Seabirds at Sea recommendations, birds were recorded into five distance bands (0-50 m, 50-100 m, 100-200 m, 200-300 m and 300+ m). Birds were recorded continuously, at a steady speed of approximately 12 knots, with the precise time of each observation recorded where possible to give as accurate a position as possible (linking to the GPS position information being recorded simultaneously). A range-finder was used to estimate distances of the birds from the ship. All records of birds observed flying as well as those on the sea was recorded.

A3.3. Bird species recorded during boat-based surveys between 2001 and 2012.

Table A3.3: Summary of the raw count data collected to the end of March 2012 during boat-based bird surveys at the Robin Rigg offshore wind farm.

	Baseline			Construction			Operation		
	Sea	Flight	Total	Sea	Flight	Total	Sea	Flight	Total
Arctic Skua	2	10	12	10	48	58	1	7	8
Arctic Tern				2	73	75	6	3	9
Auk species	224	358	582	719	379	1098	160	373	533
Auk species (large)							20	60	80
Bar-tailed Godwit					2	2		4	4
Black Guillemot	1		1	3	1	4	1		1
Black-headed Gull	53	322	375	503	1443	1946	89	158	247
Black-tailed Godwit					1	1			
Black-throated Diver				5		5			
Black-throated Diver(?)	3	3	6		1	1			
Buzzard					1	1			
Canada Goose					4	4			
Carrion Crow					1	1			
Collared Dove				1		1			
Commic Tern	21	99	120	19	48	67	7	50	57
Common Gull	443	826	1269	2102	5029	7131	1323	1497	2820
Common Scoter	25820	12261	38081	36274	19054	55328	19757	4204	23961
Common Tern		5	5	2	22	24		27	27
Common Tern(?)								2	2
Cormorant	161	192	353	702	1576	2278	487	1182	1669
Cormorant/Shag	1	1	2						
Curlew		11	11		16	16			
Curlew/Whimbrel								2	2
Diver species	212	244	456	378	903	1281	73	254	327
Duck species								1	1
Dunlin		90	90		43	43			
Dunlin(?)					3	3			
Eider				2	3	5			
Feral Pigeon		1	1						
Finch species		5	5		1	1			
Fulmar	13	104	117	10	65	75	2	12	14
Gannet	106	352	458	139	602	741	60	294	354
Golden Plover		2	2					51	51
Goldeneye		1	1						

	Baseline			Construction			Operation		
	Sea	Flight	Total	Sea	Flight	Total	Sea	Flight	Total
Goosander				12		12	227	71	298
Goose species				1	4	5		20	20
Great Black-backed Gull	58	142	200	202	276	478	172	240	412
Great Crested Grebe	45	25	70	18	1	19	10	3	13
Great Northern Diver	5	6	11	17	8	25			
Great Northern Diver(?)	4	3	7						
Great Skua		3	3		4	4		2	2
Grey Goose								1	1
Grey Heron		1	1						
Grey Plover					4	4			
Grey Plover(?)		3	3						
Greylag Goose								1	1
Guillemot	3530	355	3885	4693	725	5418	3132	419	3551
Gull species	4	111	115	86	1249	1335	1	139	140
Gull species (large)							30	76	106
Gull species (small)							1	24	25
Gull species(large)	18	333	351	5	156	161		94	94
Gull species(mixed)	120		120						
Gull species(small)	20	2	22	22	285	307	1	13	14
Hen Harrier					1	1			
Herring Gull	379	910	1289	529	1218	1747	201	427	628
Herring/Lesser Black-backed Gull		10	10						
Hirundine								8	8
Hirundine species					7	7			
House Martin					1	1		2	2
Kestrel		1	1						
Kittiwake	393	479	872	612	955	1567	407	527	934
Knot(?)		15	15		1	1			
Lapwing								1	1
Lesser Black-backed Gull	108	196	304	347	424	771	36	126	162
Lesser Redpoll(?)								1	1
Little Auk					1	1			
Little Gull	1	13	14	3	9	12	1	6	7
Little Tern		17	17						
Long-tailed Duck					2	2			

	Baseline			Construction			Operation		
	Sea	Flight	Total	Sea	Flight	Total	Sea	Flight	Total
Long-tailed Duck (?)								1	1
Mallard				2		2		2	2
Manx Shearwater	97	1467	1564	660	664	1324	267	249	516
Meadow Pipit		29	29		169	169		61	61
Merlin		1	1						
Oystercatcher		20	20		13	13		7	7
Passerine species		9	9		73	73			
Peregrine		1	1		1	1		2	2
Pied Wagtail		1	1		2	2			
Pink-footed Goose				3	693	696	1	1106	1107
Pink-footed Goose(?)					6	6			
Pipit species		37	37		29	29		21	21
Pomarine Skua		3	3		1	1		1	1
Puffin	2	2	4	1	7	8	8	7	15
Purple Sandpiper								3	3
Raptor (Buzzard?)								1	1
Razorbill	1274	921	2195	2493	284	2777	1292	380	1672
Red throated Diver								1	1
Red-breasted Merganser	19	5	24	8	12	20	6	19	25
Red-breasted Merganser(?)		4	4						
Redshank					15	15			
Red-throated Diver	363	170	533	256	243	499	247	437	684
Redwing								1	1
Ringed Plover		20	20		9	9			
Ringed Plover(?)		1	1						
Sand Martin		26	26		11	11		7	7
Sanderling					3	3		33	33
Sandwich Tern	5	115	120	49	463	512	3	166	169
Sandwich Tern(?)		1	1						
Scaup		318	318	351	40	391	1301	160	1461
Shag(?)							1		1
Shelduck		2	2	2	8	10		7	7
Skua species					2	2		1	1
Skylark		14	14		13	13			
Song Thrush/Redwing					1	1			
Sparrowhawk		1	1		1	1			

	Baseline			Construction			Operation		
	Sea	Flight	Total	Sea	Flight	Total	Sea	Flight	Total
Starling					6	6		15	15
Storm Petrel		20	20	3	16	19			
Swallow		25	25		112	112		98	98
Swan species		3	3						
Swift		4	4		9	9			
Teal		1	1	3		3		1	1
Tern species		35	35	6	130	136	1	63	64
Turnstone		4	4		2	2			
Velvet Scoter	23	2	25	1	2	3		1	1
Wader (large)					1	1			
Wader (small)		6	6		28	28			
Wader species		2	2		3	3			
White/Pied Wagtail		2	2		3	3			
Whooper Swan		14	14		7	7	34	2	36
Wigeon								11	11
Yellowhammer(?)		1	1						
Grand Total	**33528**	**20799**	**54327**	**51256**	**37732**	**88988**	**29366**	**13246**	**42612**

A3.4. Data exploration

A3.4.1. Relationship between variables

Is there even coverage between months?

Table A3.4: Number of segments for each month during each phase of the development. There should be an even distribution of effort between months and phases.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre	380	495	522	377	332	254	368	393	394	350	525	602
During	436	391	162	271	256	237	266	561	446	548	247	443
Post	453	601	547	616	531	565	550	614	485	421	532	529

Spatial distribution of effort

There should be an even distribution across the site between phases (Figure A3.2).

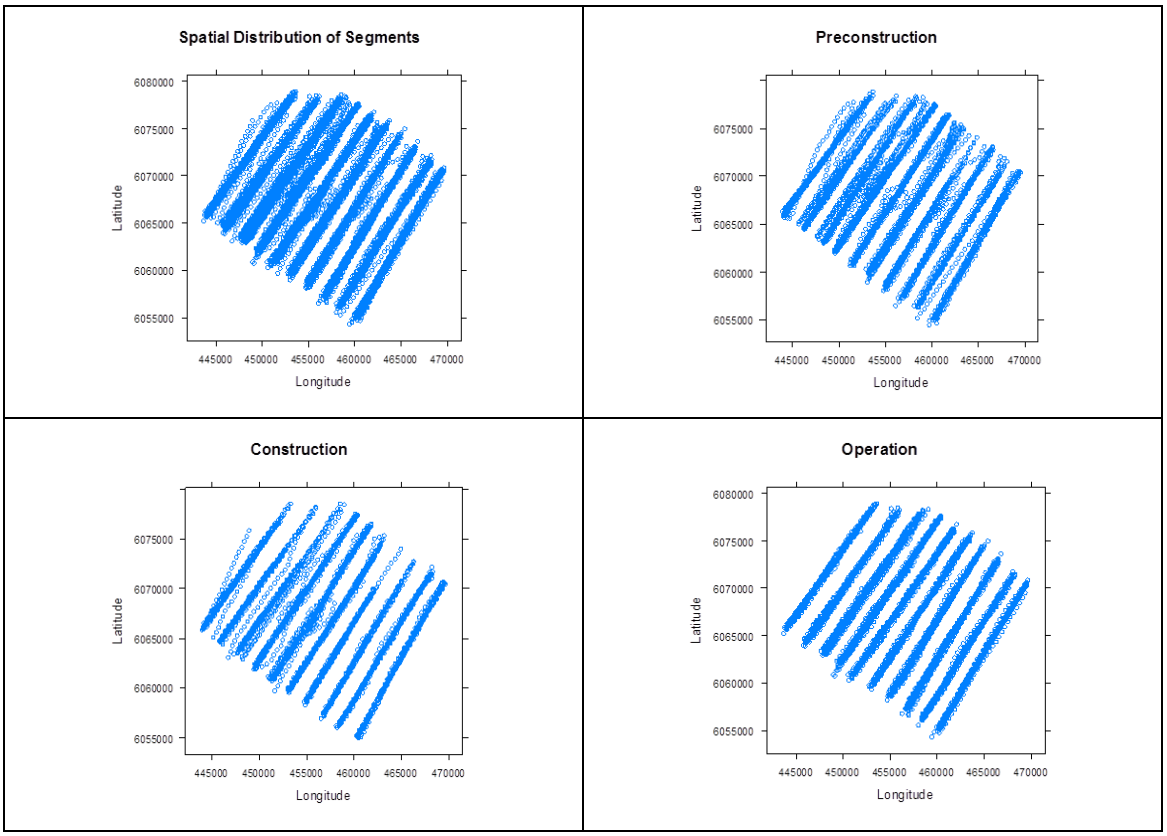


Figure A3.2: Visual representation of the survey segments by effort.

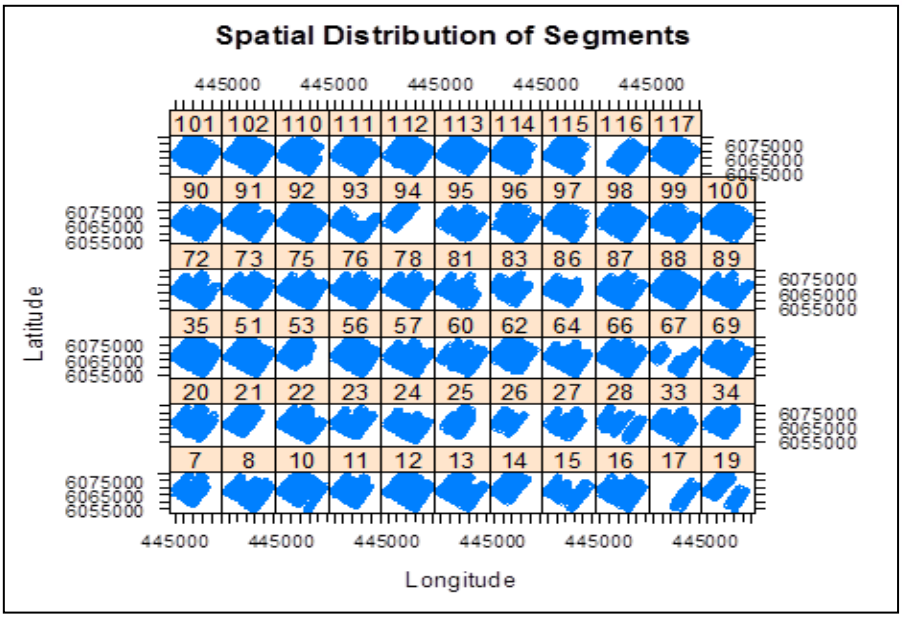


Figure A3.3: Visual representation of the survey segments by effort for each individual survey.

Check variables for outliers and even coverage

Response variables were allocated to each survey segment. Each variable was checked for even coverage (Figure A3.4; Table A3.5). As can be seen, sea state is not available for a large proportion of the pre-construction data and therefore will not be used in analysis.

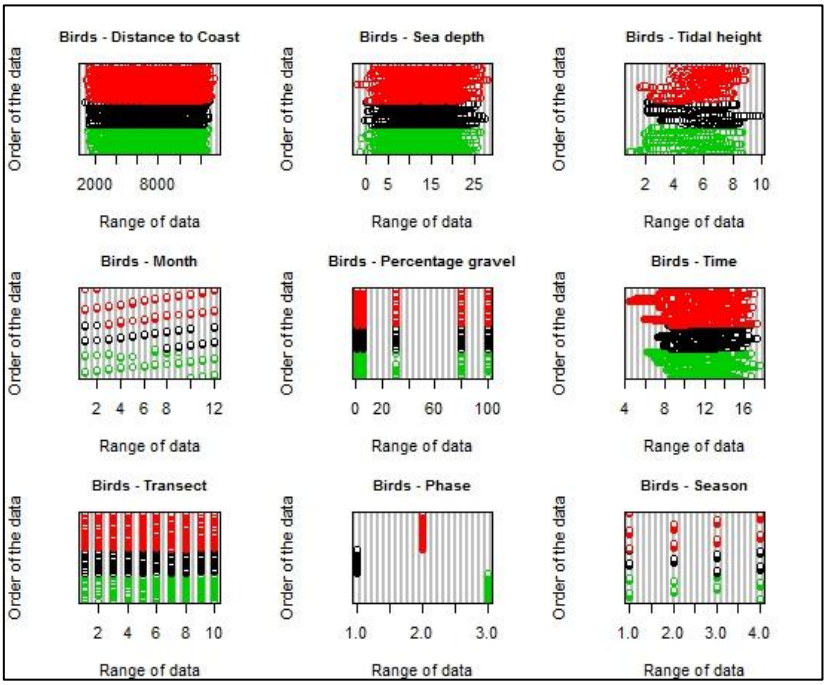


Figure A3.4: Figures visually representing the coverage of each of the response variable

Table A3.5: The number of segments collected at each different sea state during each of the three phases.

Sea state	0	1	2	3	4	5	NA
Pre	59	108	259	496	130	12	3928
During	212	270	1157	667	1515	262	0
Post	427	558	2150	911	1610	486	0

Pearson's coefficient looks for linear relationships, the larger the number the stronger the relationship. Generally, if they have a value of greater than 0.8, there is a strong relationship. For large datasets it is advisable to bear in mind any relationships with a coefficient of greater than 0.5. The output below (Figure A3.5) suggests relationships between depth and lat/long and between distance and gravel need further investigation.

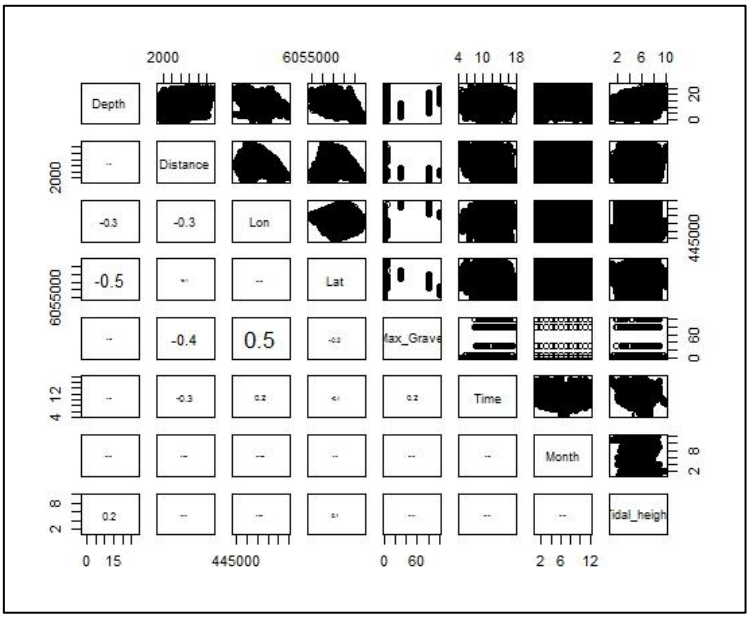
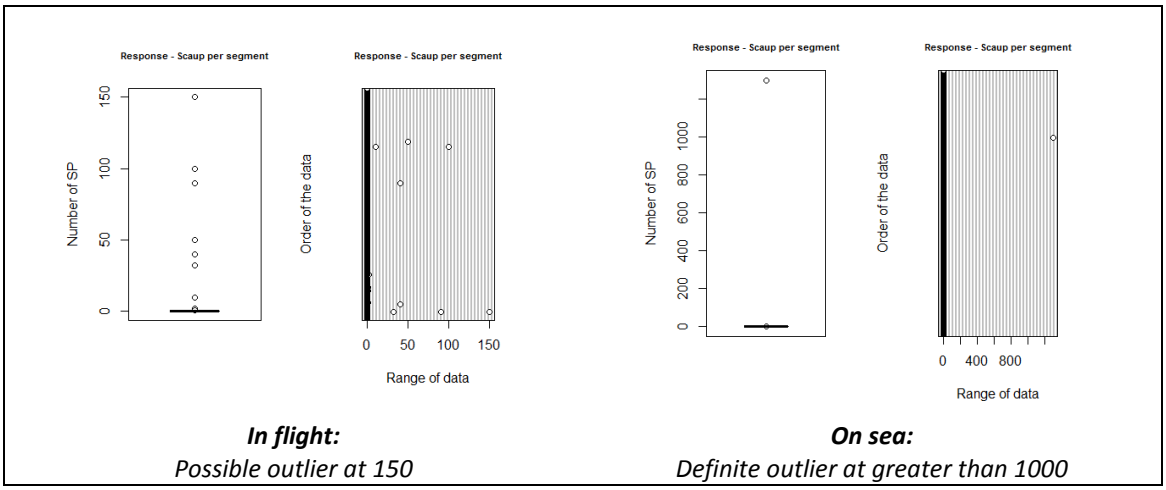


Figure A3.5: Collinearity among continuous variables.

A3.5. Response Variables

A3.5.1. Scaup (SP)

Check response variable for outliers



In flight:
Possible outlier at 150

On sea:
Definite outlier at greater than 1000

Figure A3.6: Response variable for scaup data

Check for zero inflation

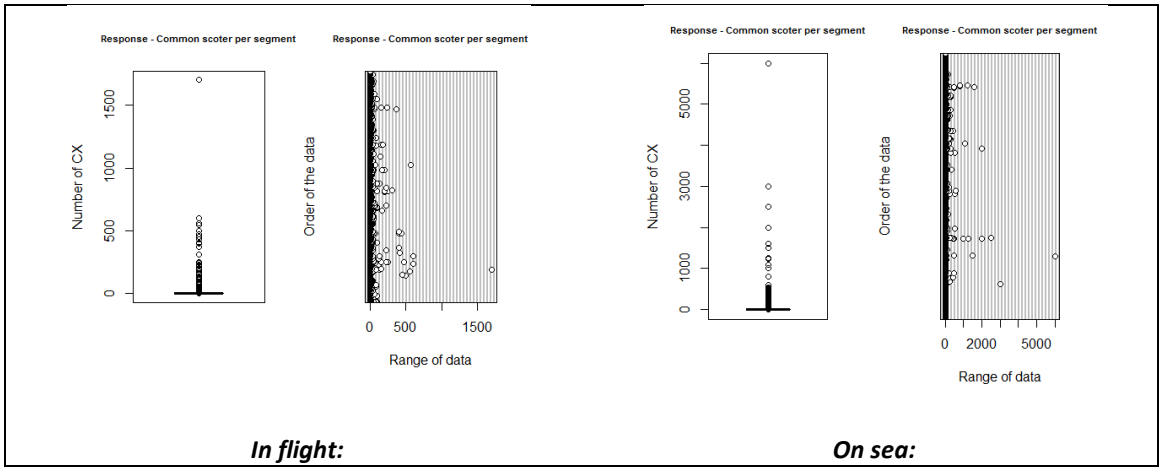
Too few non-zero sightings to perform analysis (Table A3.6)

Table A3.6: Percentage zero sightings

	% zeros	No. observations	No. non-zero's
In flight	99.9	1570	13
On sea	99.9	15700	3

A3.5.2. Common scoter (CX)

Check response variable for outliers



In flight: ***On sea:***

Possible outlier at 1600	Definite outlier at greater than 5000

Figure A3.7: *Response variable for scaup data*.

Check for zero inflation

High proportion of zero observations.

Table A3.7: Percentage zero sightings

	% zeros	No. observations	No. non-zero's
In flight	94.9	15700	801
On sea	95.5	15700	700

Check for relationships with variables

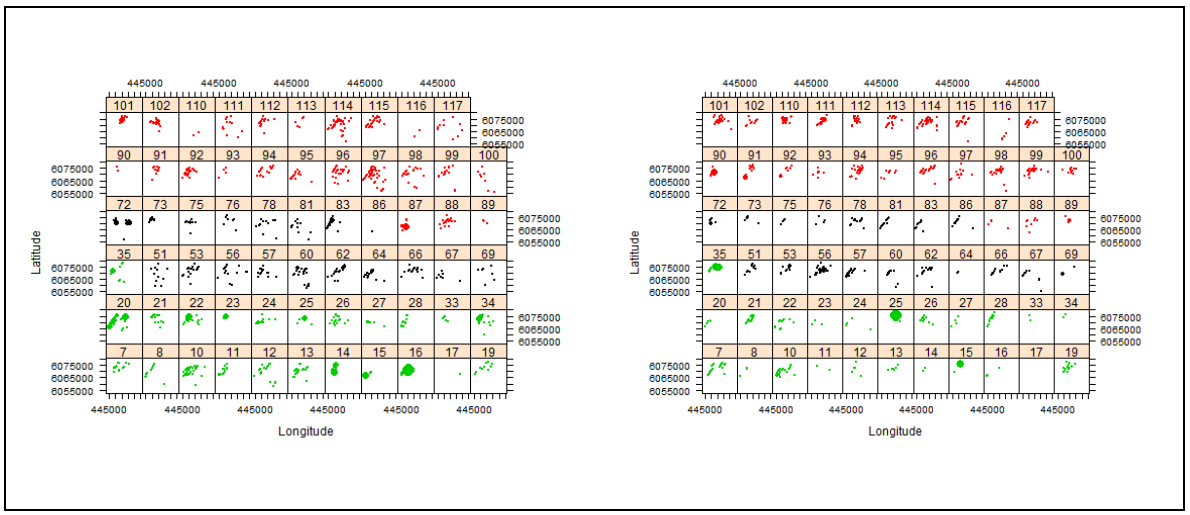


Figure A3.8: Spatial distribution by survey (left = in flight, right = on sea)

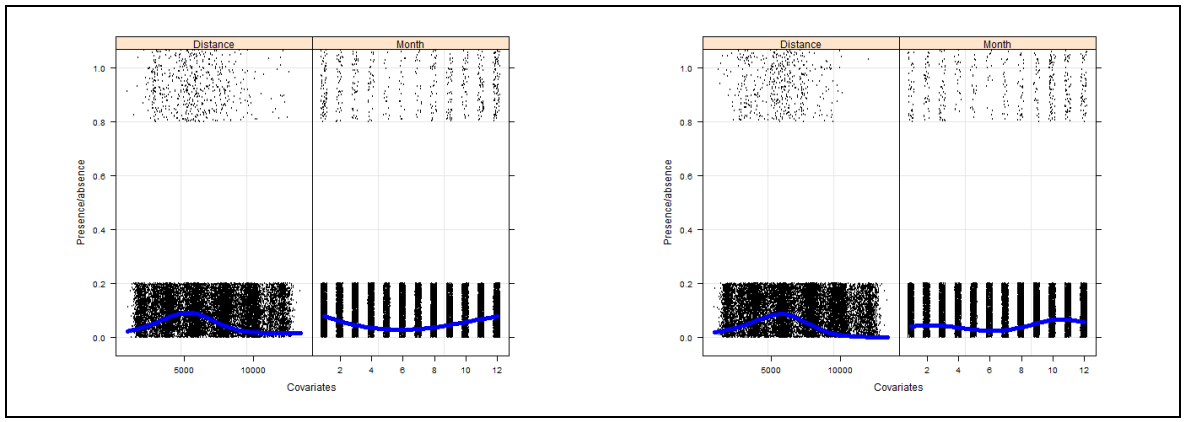


Figure A3.9: Binary response (left = in flight, right = on sea)

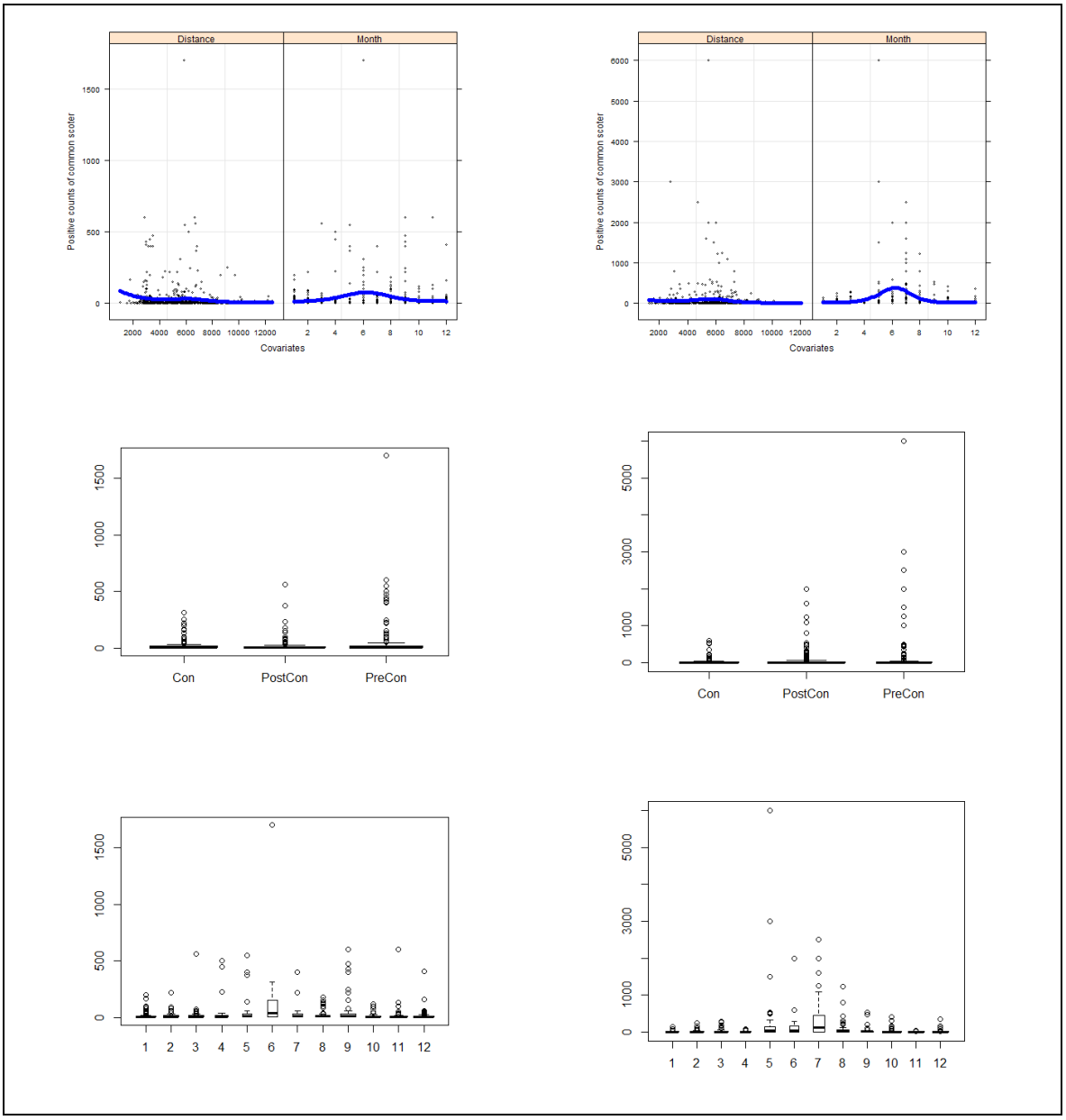
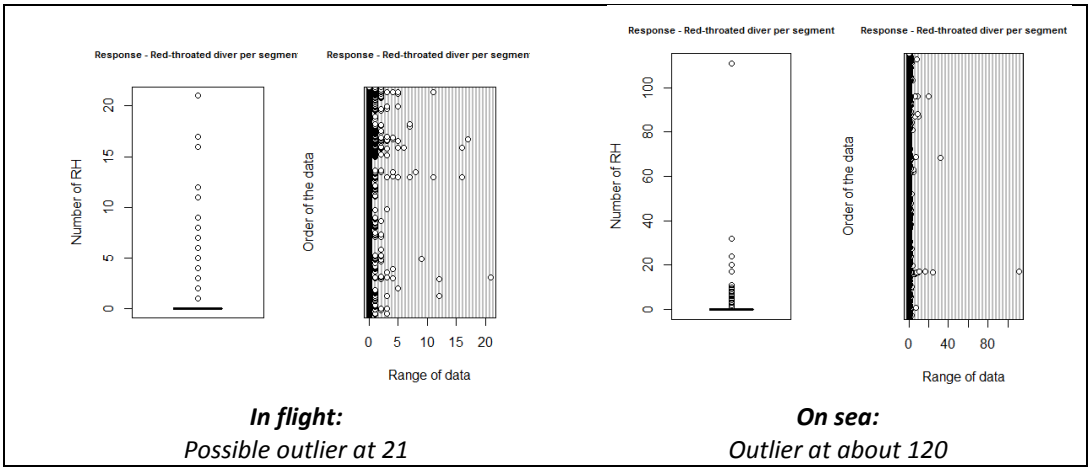


Figure A3.10: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.3. Red-throated diver (RH)

Check response variable for outliers



In flight:
Possible outlier at 21

On sea:
Outlier at about 120

Figure A3.11: Response variable for red throated diver data.

Check for zero inflation

High proportion of zero observations.

Table A3.8: Percentage zero sightings

	% Zero's	No. observations	No. non-zero's
In flight	97.8	15700	341
On sea	98.2	15700	275

Check for relationships with variables

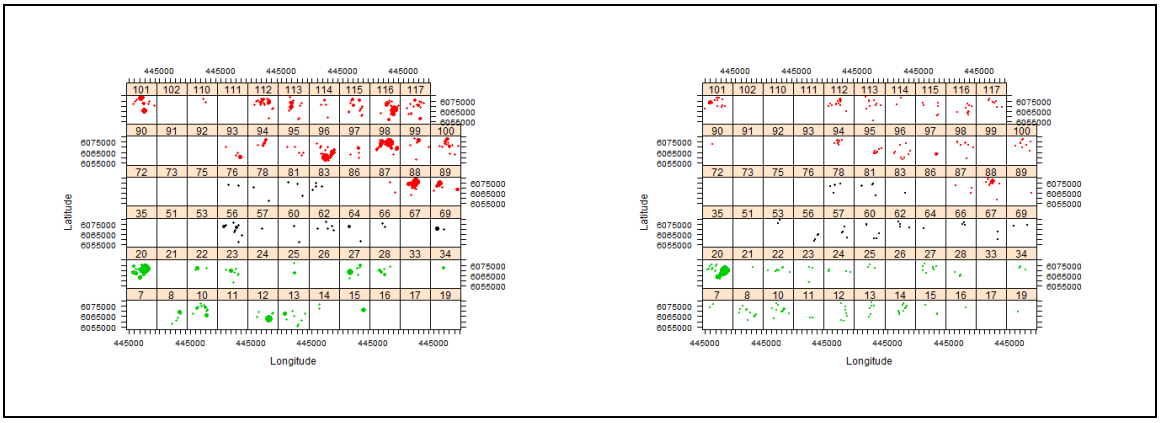


Figure A3.12: Spatial distribution by survey (left = in flight, right = on sea)

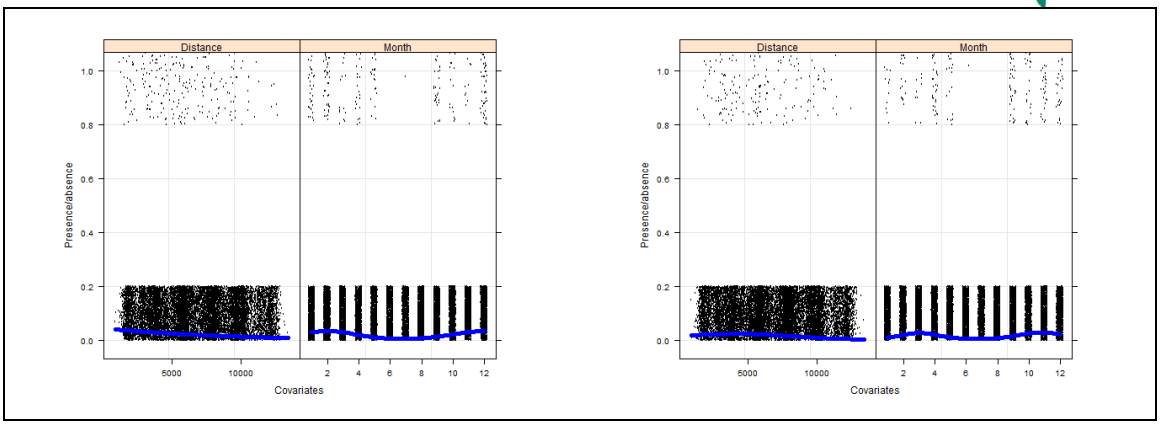
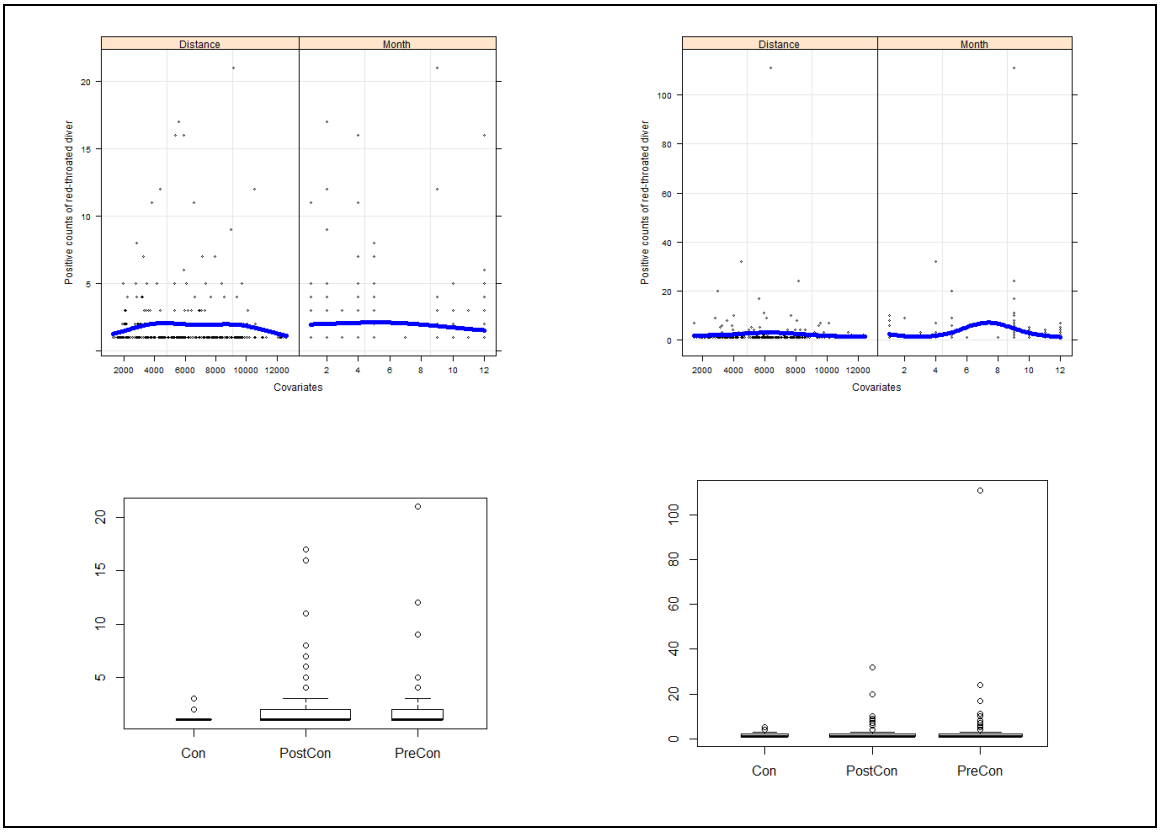


Figure A3.13: Binary response (left = in flight, right = on sea)



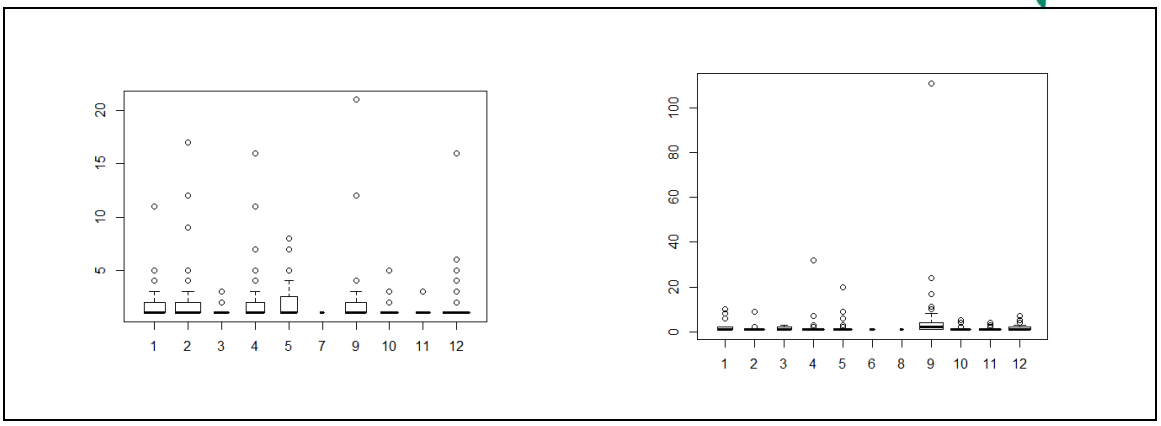
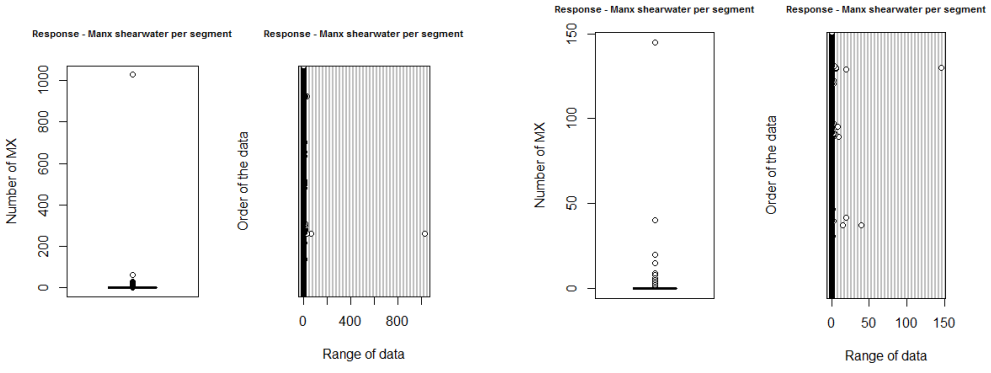


Figure A3.14: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.4. Manx shearwater

Check response variable for outliers



In flight:
Outlier at just over 1000

On sea:
Outlier at 150

Figure A3.15: Response variable for manx shearwater data.

Check for zero inflation

High proportion of zero observations.

Table A3.9: Percentage zero sightings

	% zero's	No. observations	No. non-zero's
In flight	98.7	15700	208
On sea	99.6	15700	64

Check for relationships with variables

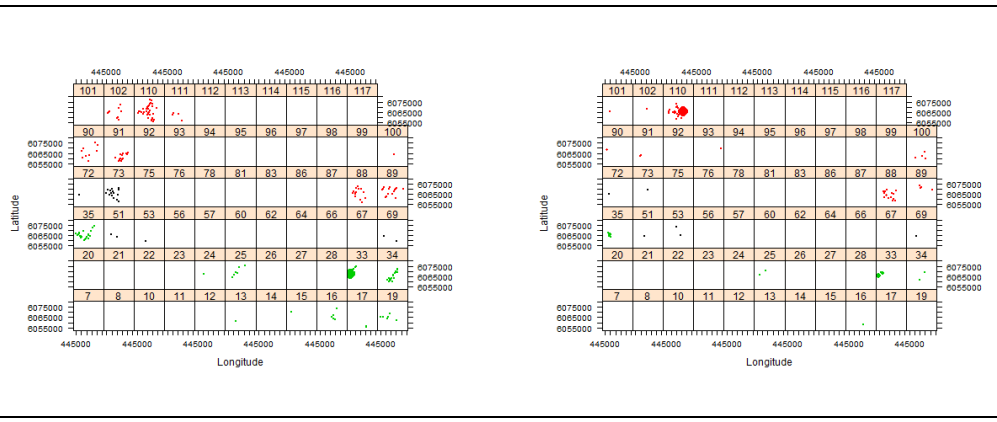


Figure A3.16: Spatial distribution by survey (left = in flight, right = on sea)

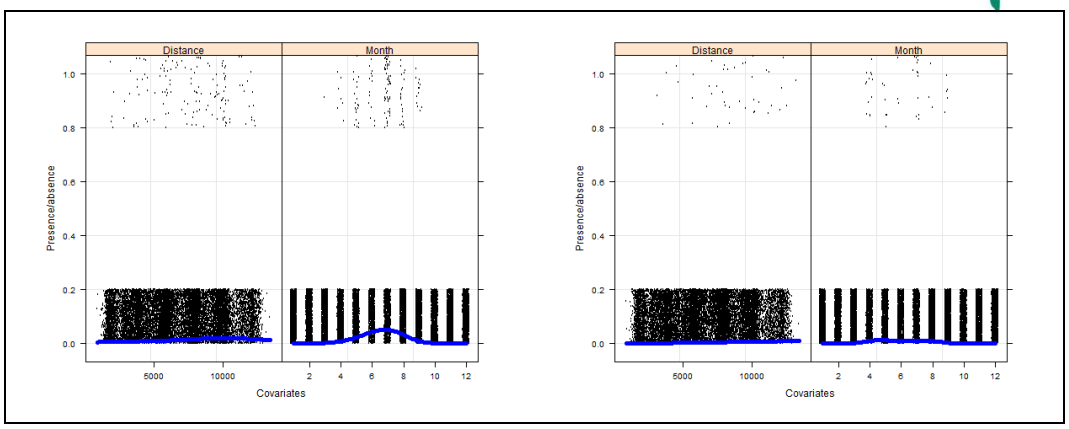
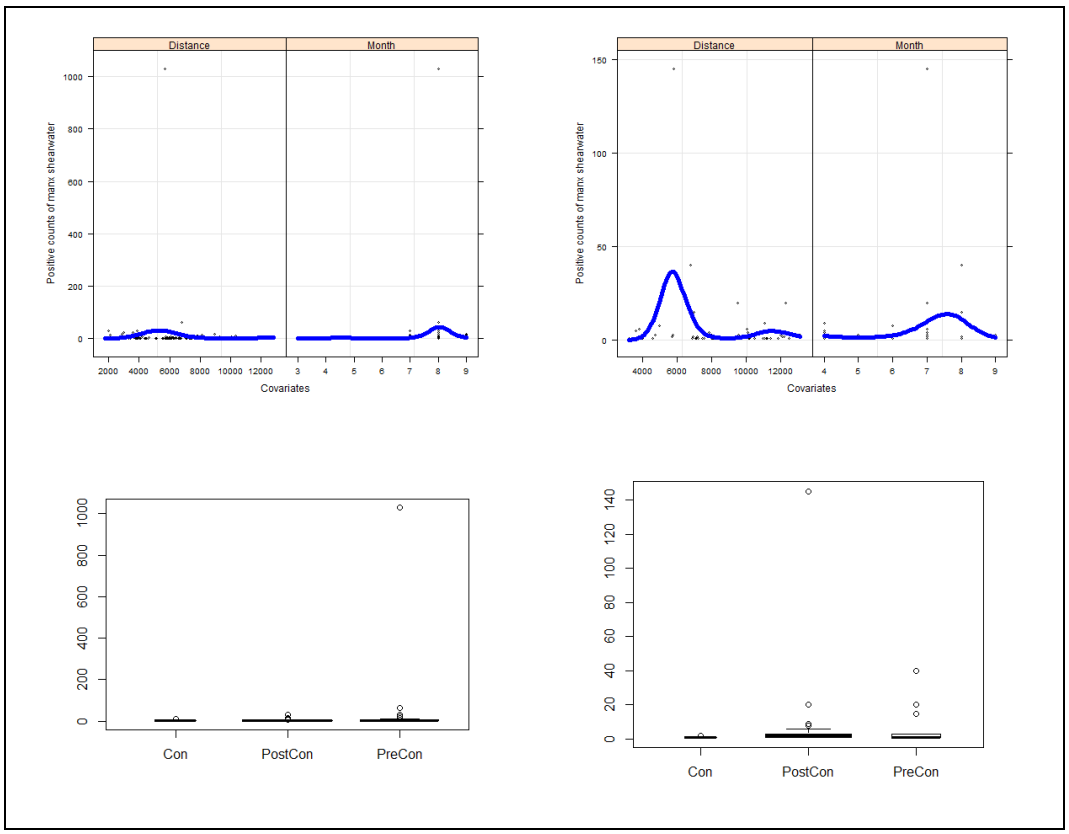


Figure A3.17: Binary response (left = in flight, right = on sea)



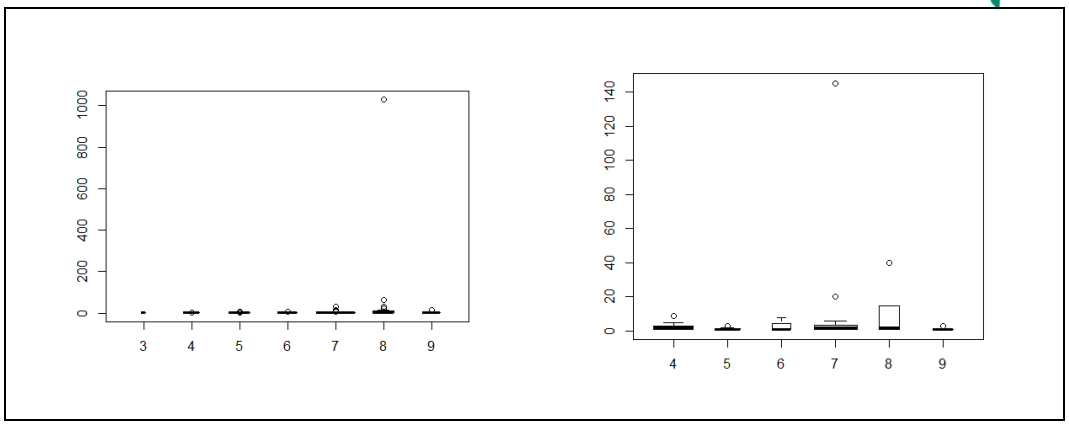
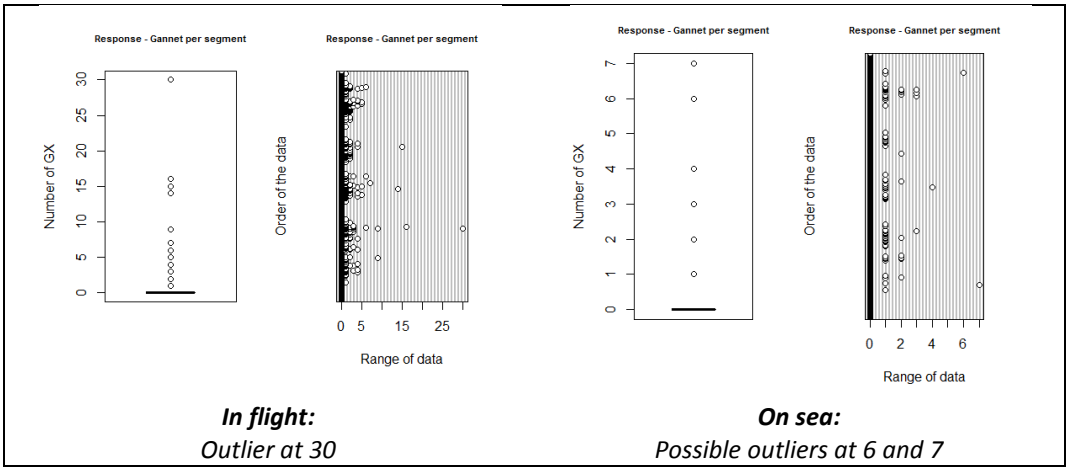


Figure A3.18: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.5. Gannet

Check response variable for outliers



In flight:
Outlier at 30

On sea:
Possible outliers at 6 and 7

Figure A3.19: Response variable for gannet data.

Check for zero inflation

High proportion of zero observations

Table A3.10: Percentage zero sightings

	% Zero's	No. observations	No. non-zero's
In flight	97.1	15700	448
On sea	99.3	15700	108

Check for relationships with variables

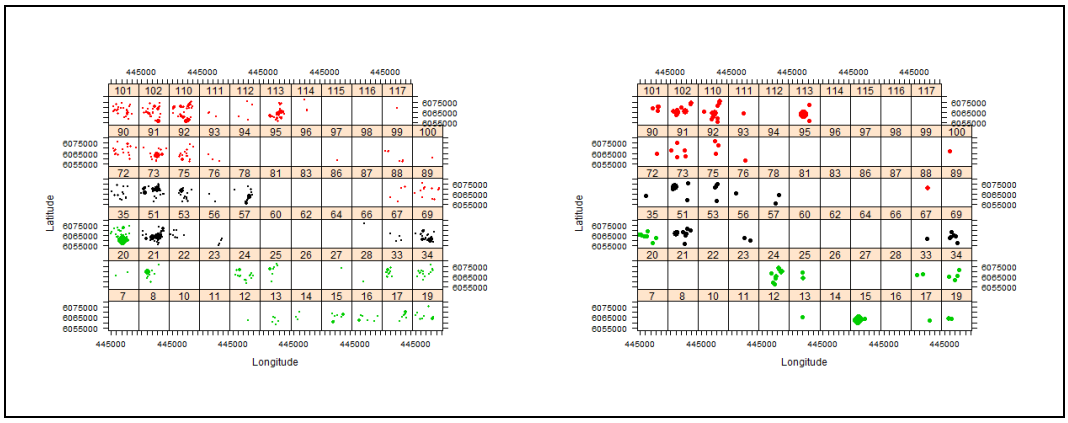


Figure A3.20: Spatial distribution by survey (left = in flight, right = on sea)

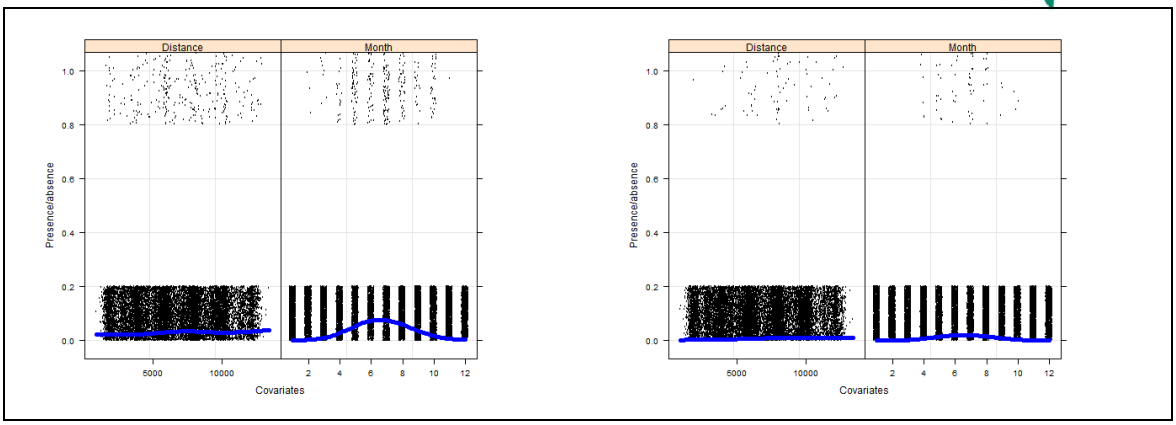
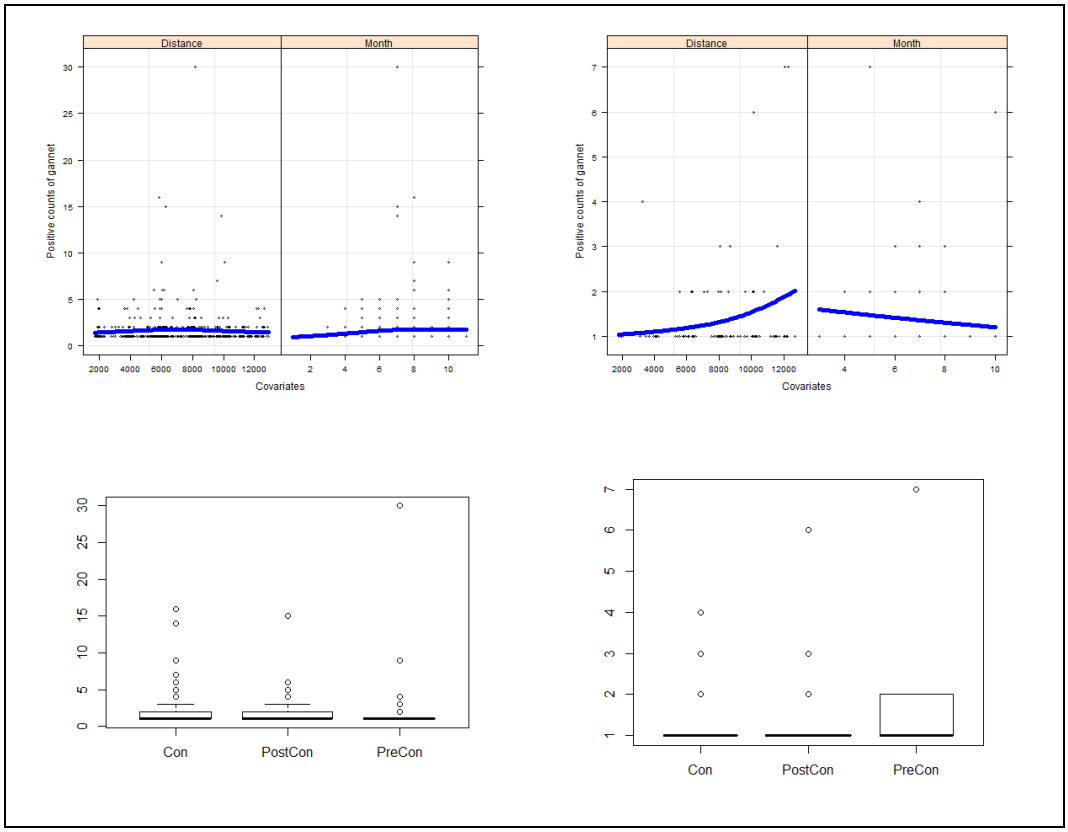


Figure A3.21: Binary response (left = in flight, right = on sea)



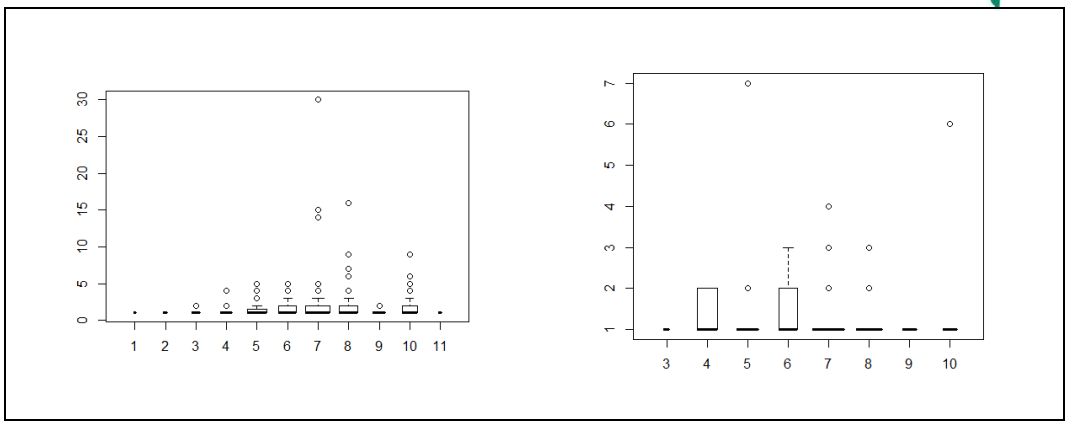
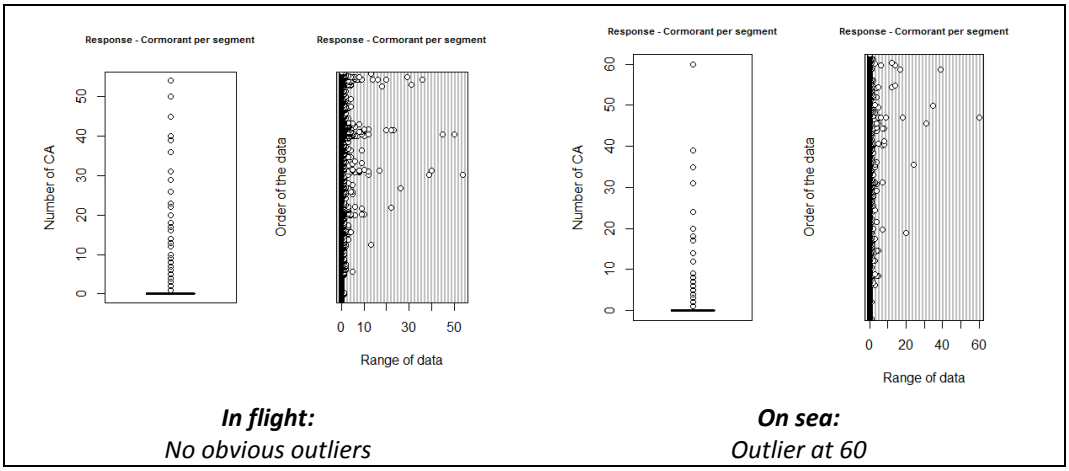


Figure A3.22: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.6. Cormorant

Check response variable for outliers



In flight:
No obvious outliers

On sea:
Outlier at 60

Figure A3.23: Response variable for cormorant data

Check for zero inflation

High proportion of zero observations.

Table A3.11: Percentage zero sightings

	% Zero's	No. observations	No. non-zero's
In flight	95.7	15700	675
On sea	98.4	15700	259

Check for relationships with variables

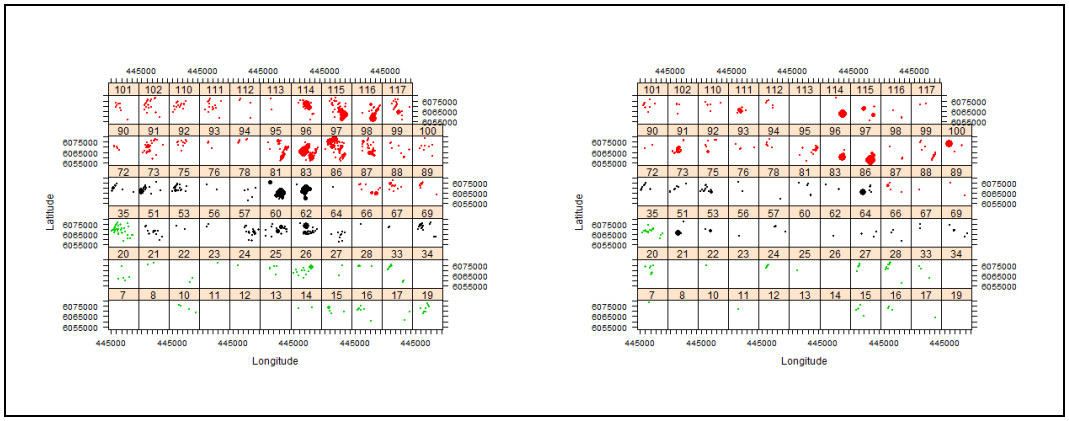


Figure A3.24: Spatial distribution by survey (left = in flight, right = on sea)

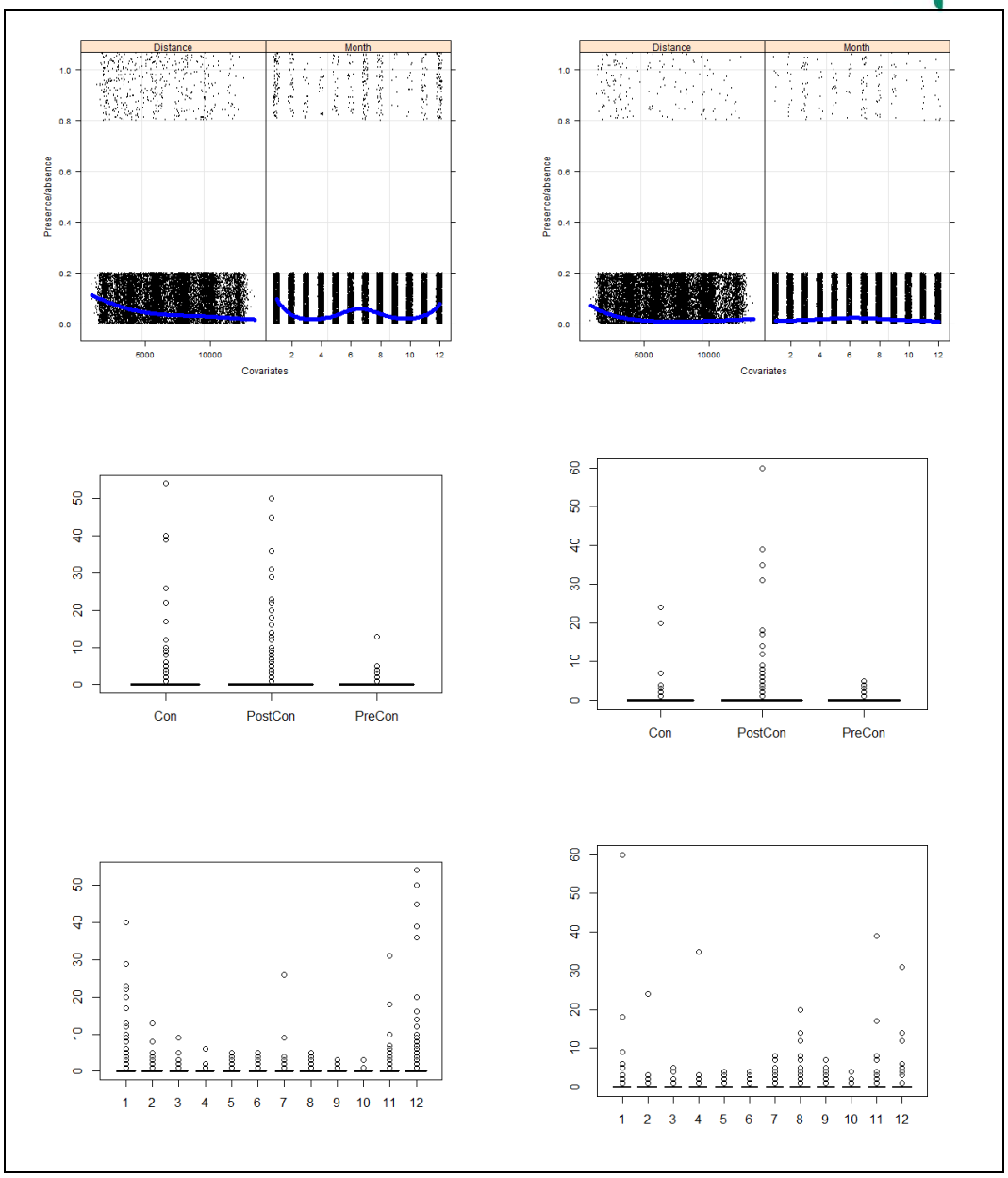


Figure A3.25: Binary response (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

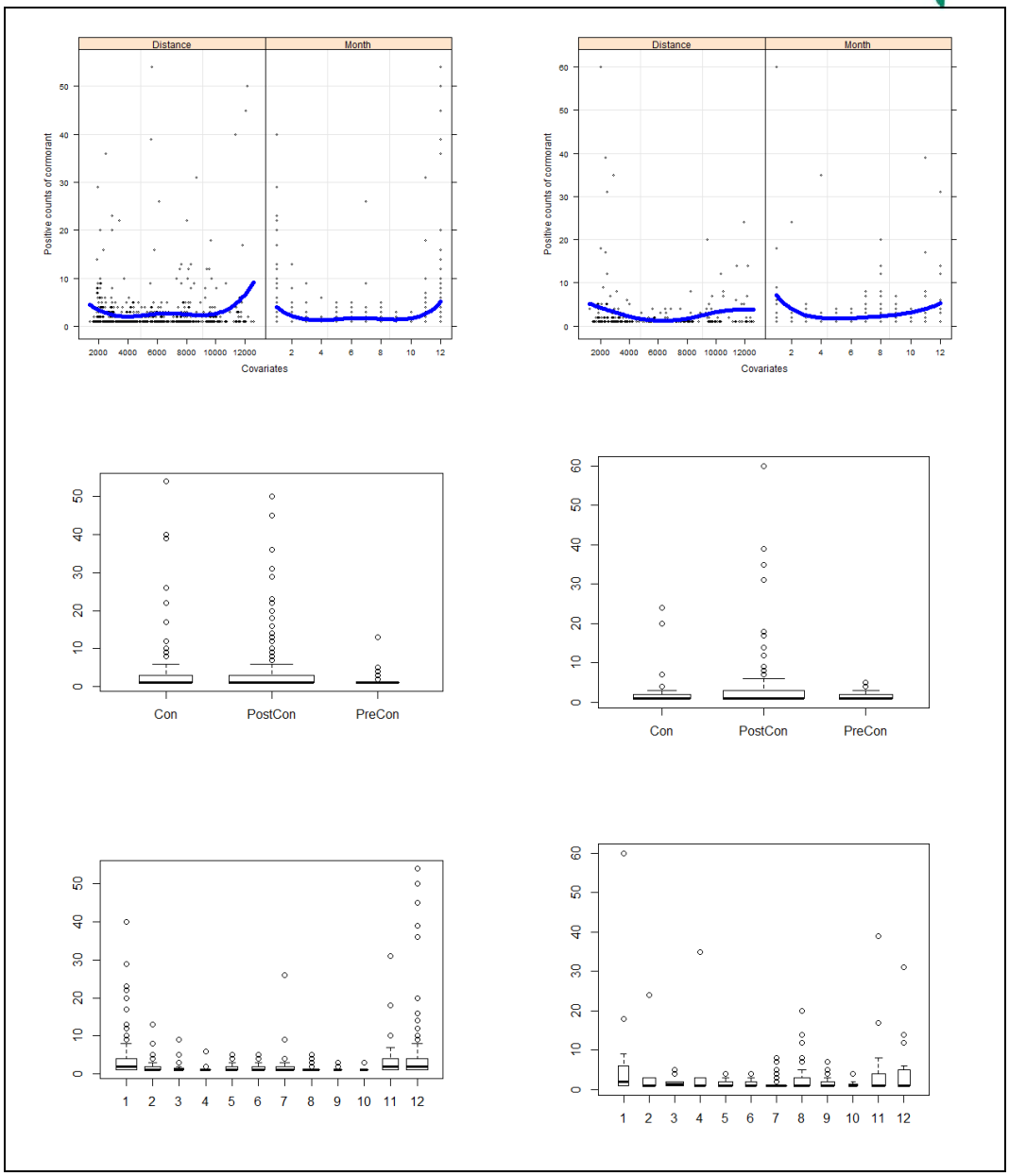
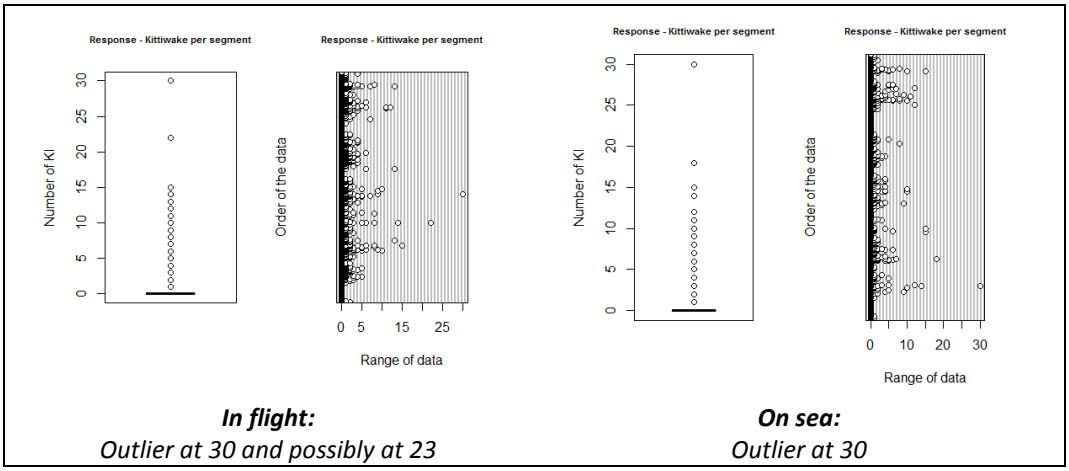


Figure A3.26: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.7. Kittiwake

Check response variable for outliers



In flight:
Outlier at 30 and possibly at 23

On sea:
Outlier at 30

Figure A3.27: Response variable for kittiwake data.

Check for zero inflation

High proportion of zero observations.

Table A3.12: Percentage zero sightings

	% zero's	No. observations	No. non-zero's
In flight	95.7	15700	669
On sea	97.6	15700	380

Check for relationships with variables

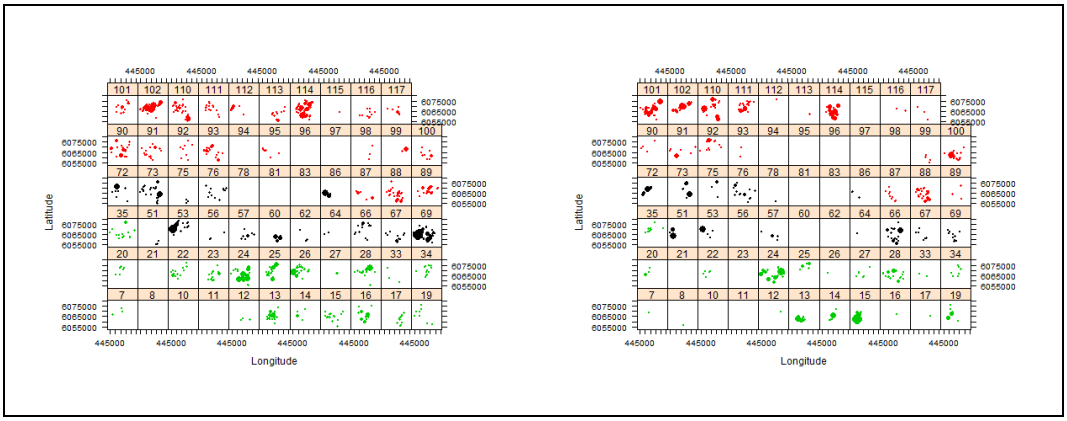


Figure A3.28: Spatial distribution by survey (left = in flight, right = on sea)

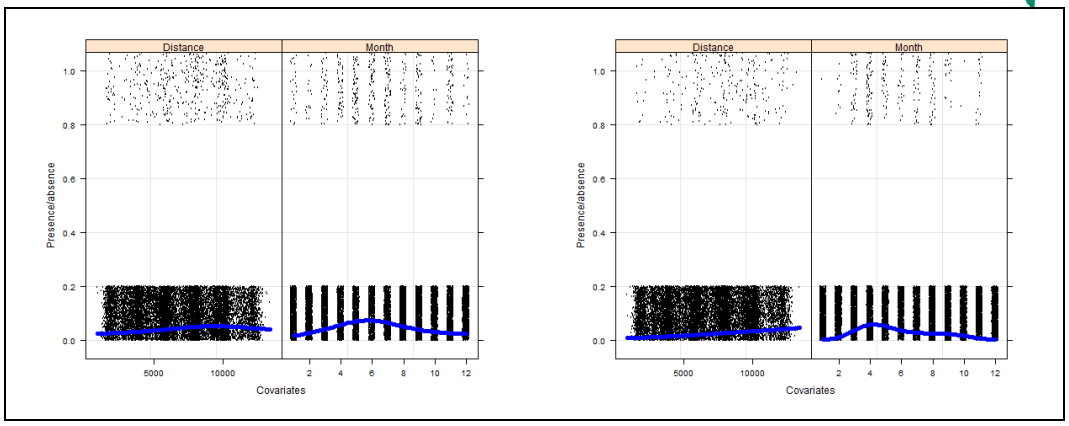
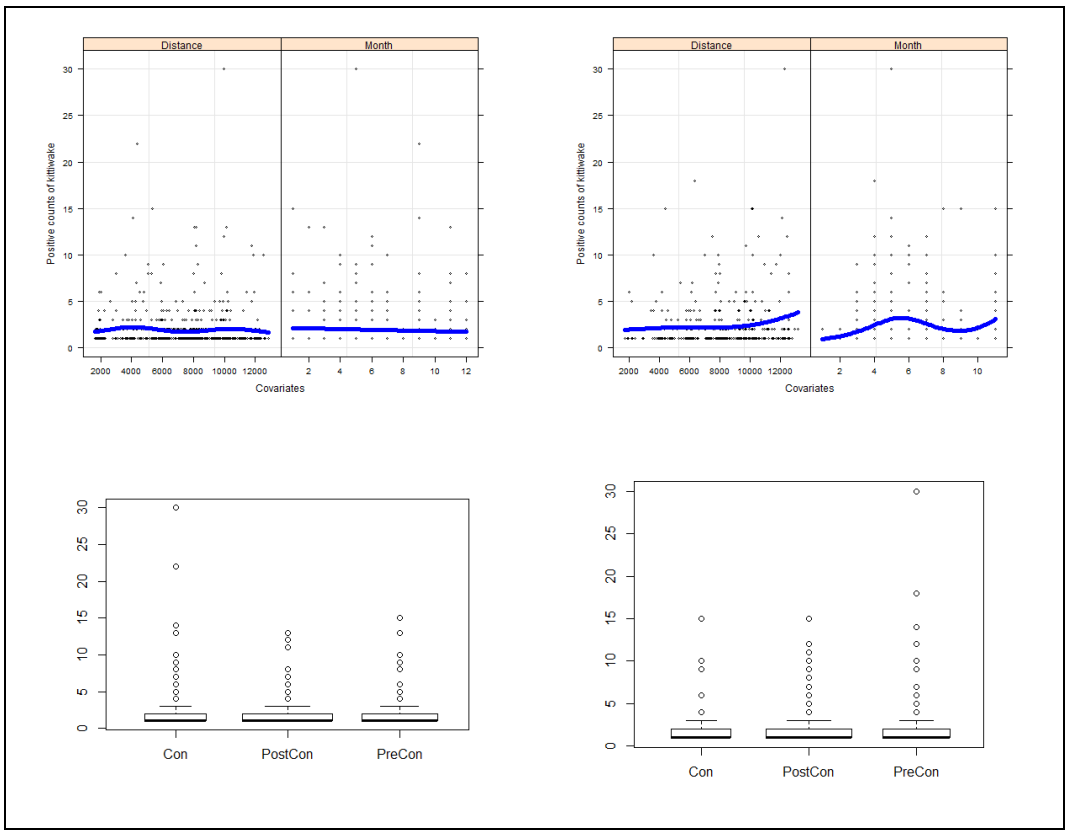


Figure A3.29: Binary response (left = in flight, right = on sea)



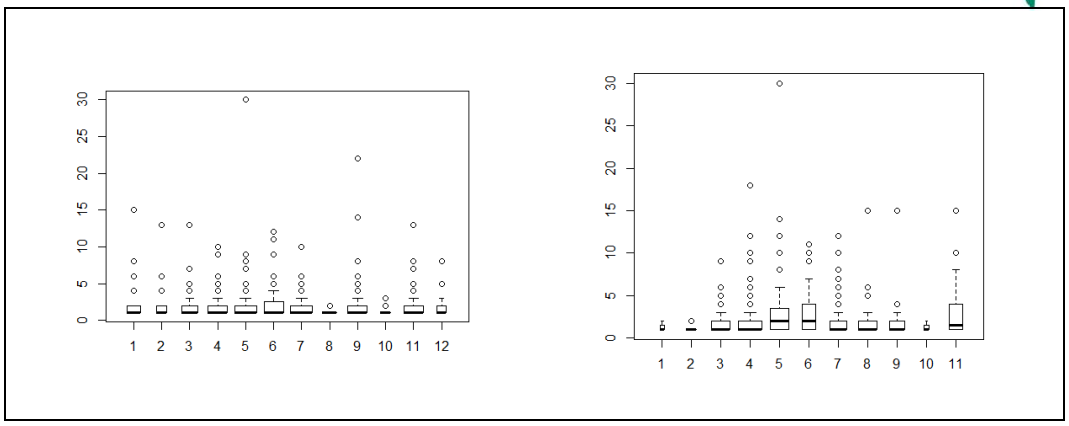
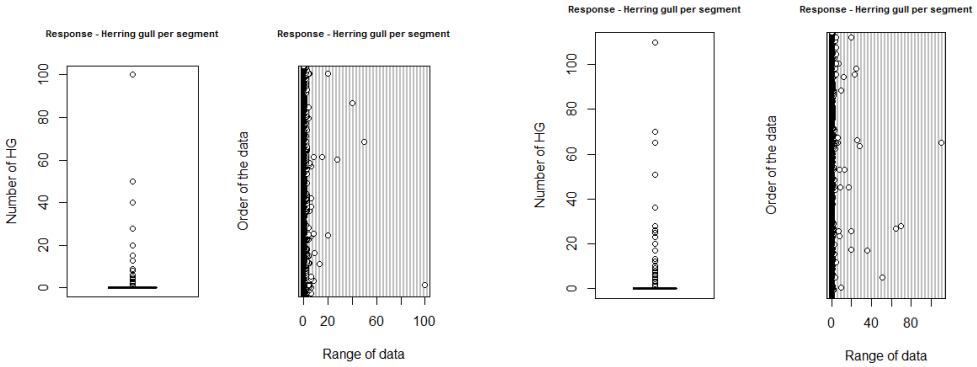


Figure A3.30: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.8. Herring gull

Check response variable for outliers



In flight:
Outlier at 100

On sea:
Outlier at about 120

Figure A3.31: Response variable for herring gull data.

Check for zero inflation

High proportion of zero observations.

Table A3.13: Percentage zero sightings

	% Zero's	No. observations	No. non-zero's
In flight	95.0	15700	787
On sea	98.0	15700	169

Check for relationships with variables

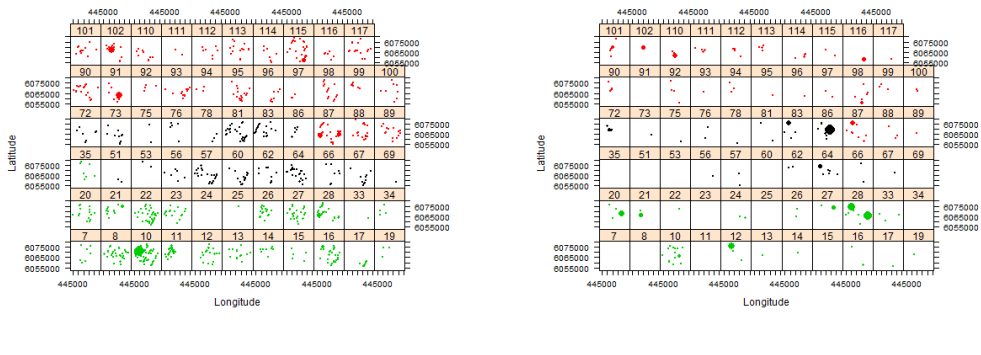


Figure A3.32: Spatial distribution by survey (left = in flight, right = on sea)

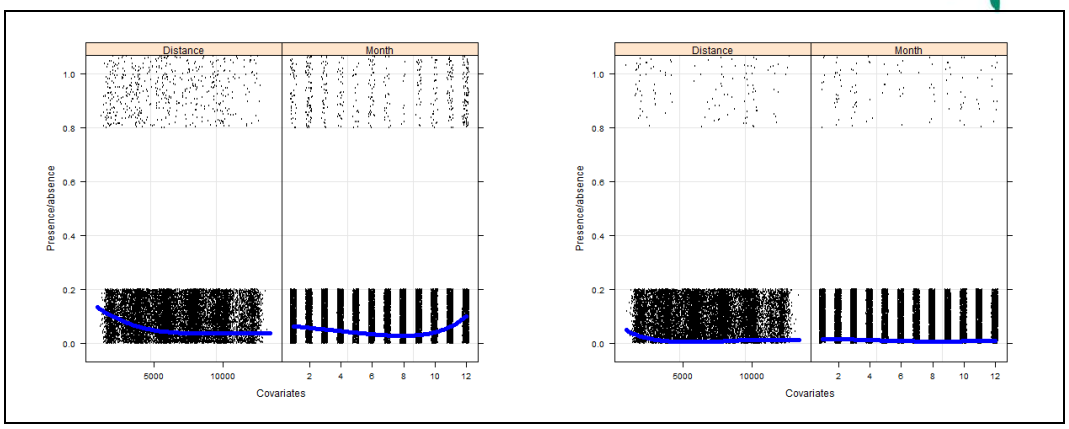
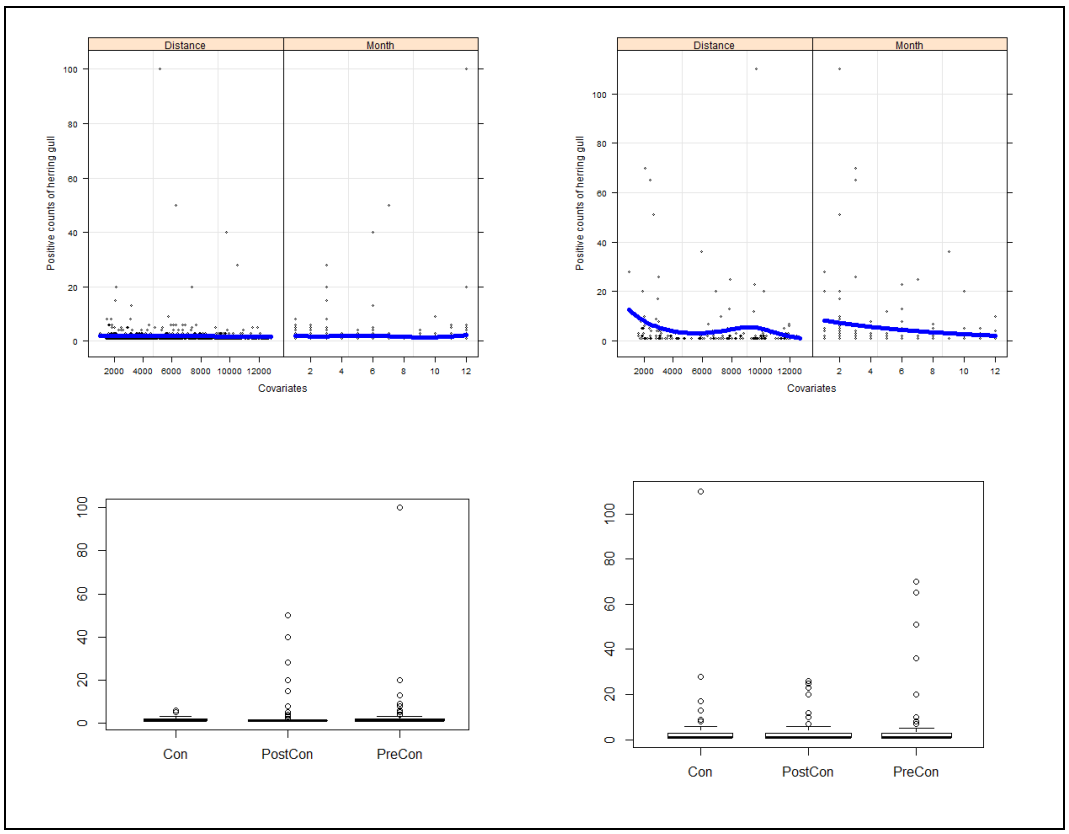


Figure A3.33: Binary response (left = in flight, right = on sea)



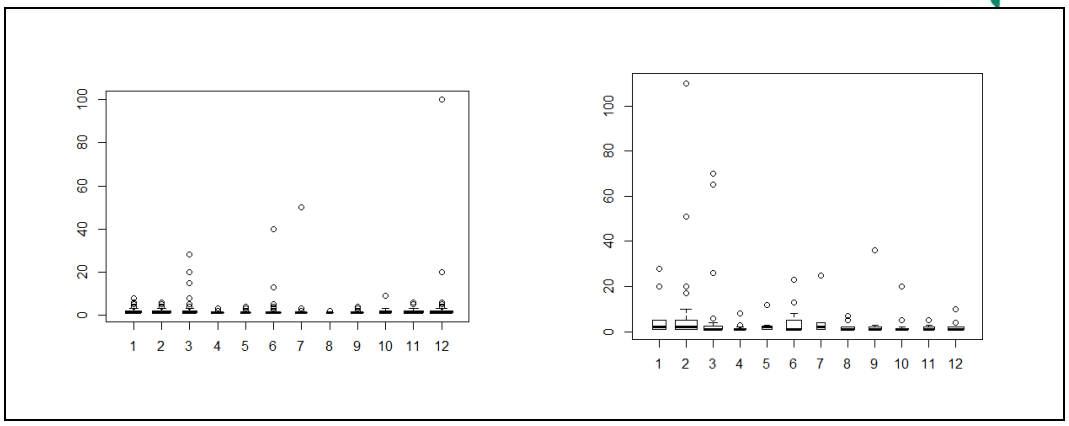
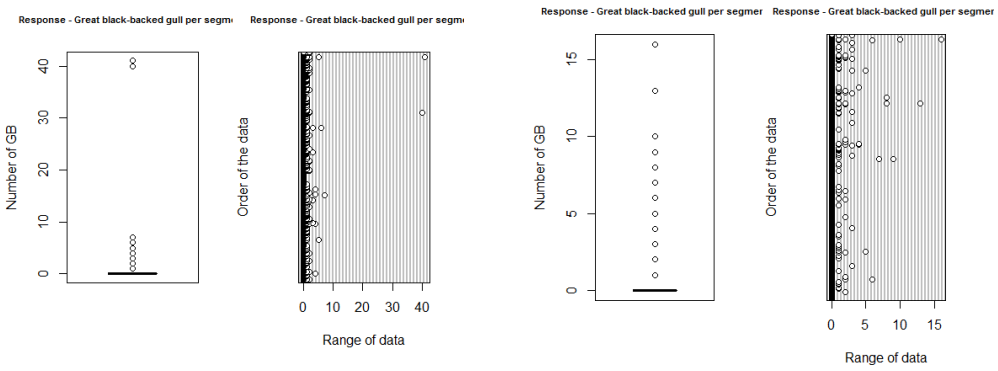


Figure A3.34: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.9. Great black-backed gull

Check response variable for outliers



In flight:
Two outliers at about 40

On sea:
Two possible outliers at about 13 and 16

Figure A3.35 Response variable for great black-backed gull data

Check for zero inflation

High proportion of zero observations.

Table A3.14: Percentage zero sightings

	% Zero's	No. observations	No. non-zero's
In flight	98.2	15700	288
On sea	99.0	15700	152

Check for relationships with variables

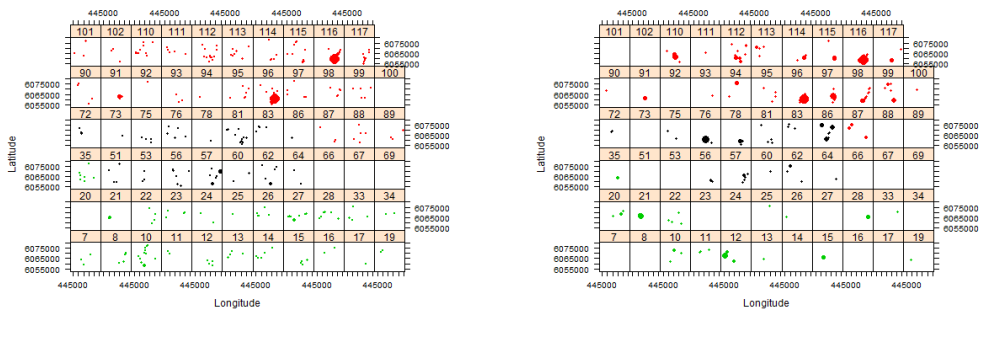


Figure A3.36: Spatial distribution by survey (left = in flight, right = on sea)

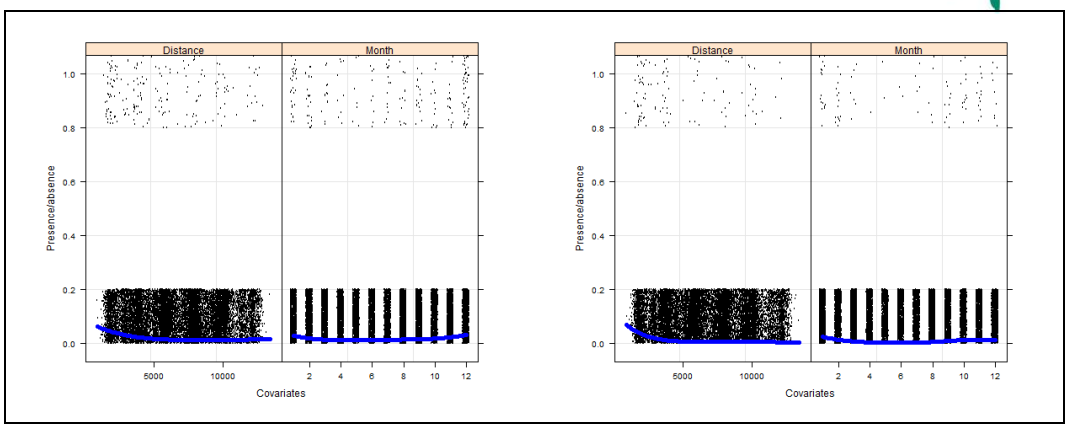
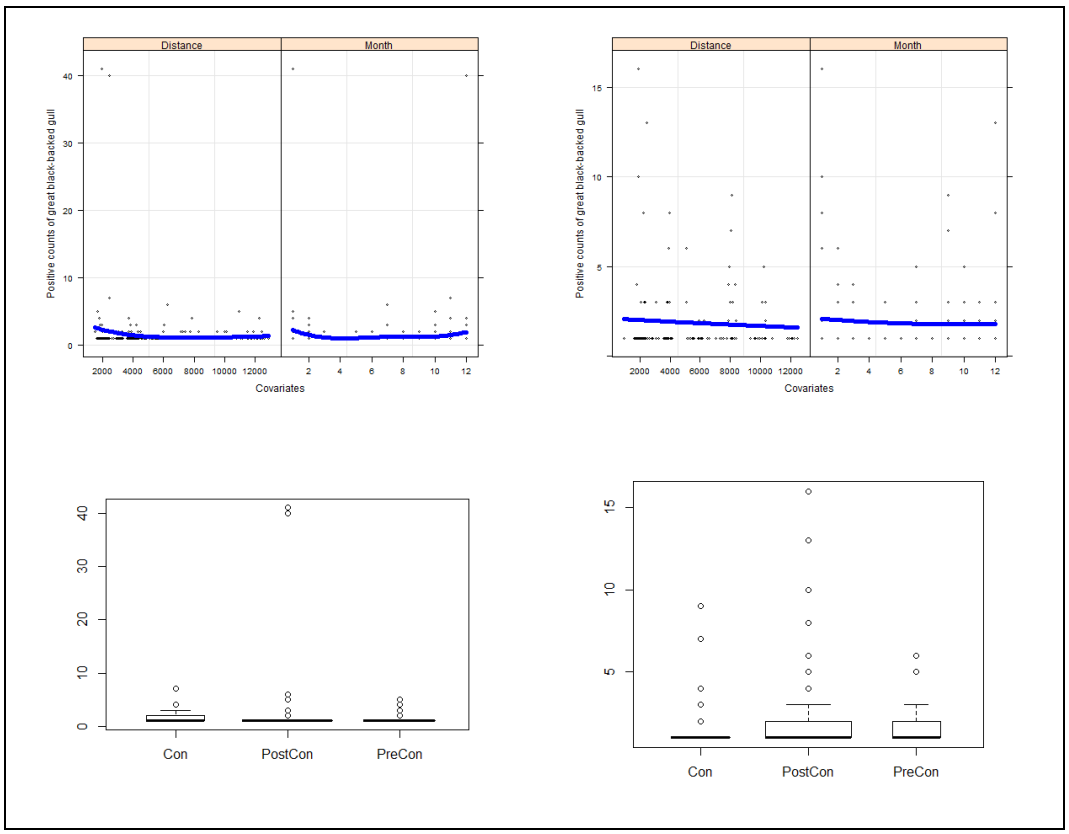


Figure A3.37: Binary response (left = in flight, right = on sea)



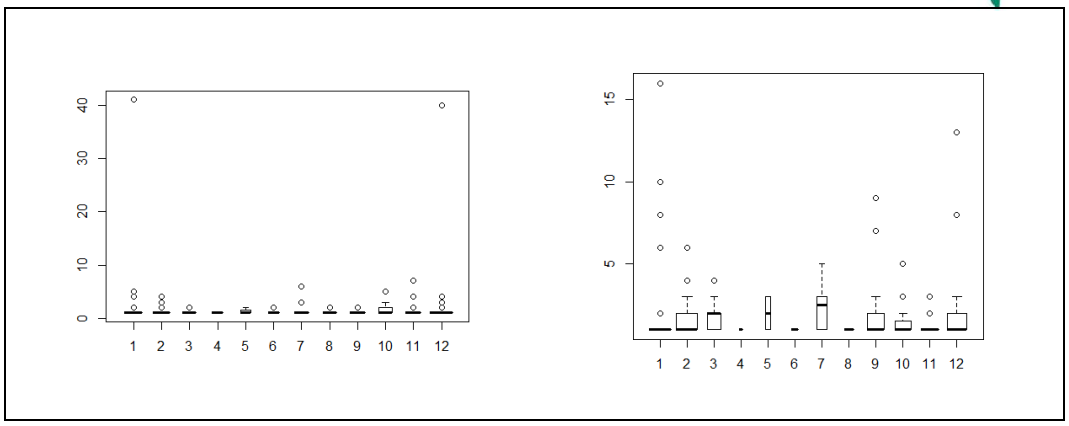
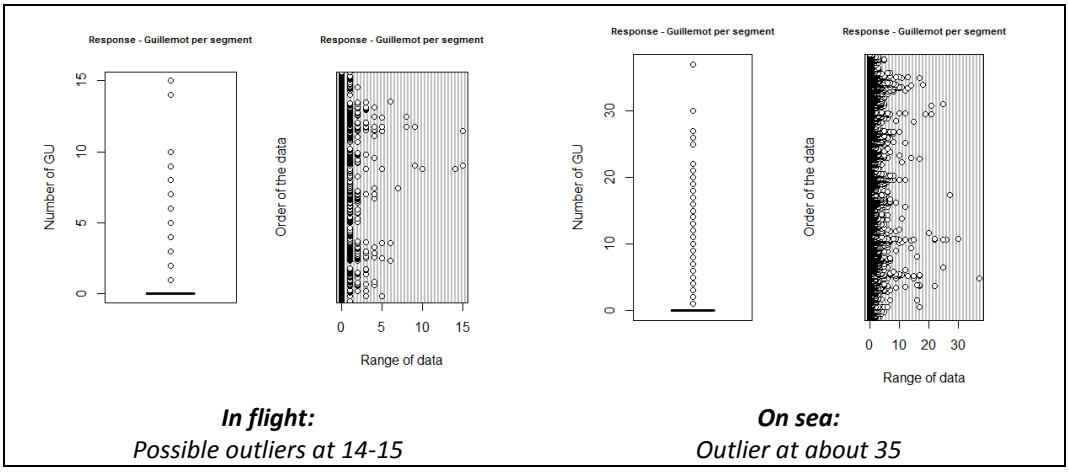


Figure A3.38: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.10. Guillemot

Check response variable for outliers



In flight:
Possible outliers at 14-15

On sea:
Outlier at about 35

Figure A3.39: Response variable for guillemot data

Check for zero inflation

High proportion of zero observations.

Table A3.15: Percentage zero sighting

	% Zero's	No. observations	No. non-zero's
In flight	96.0	15700	631
On sea	78.4	15700	3385

Check for relationships with variables

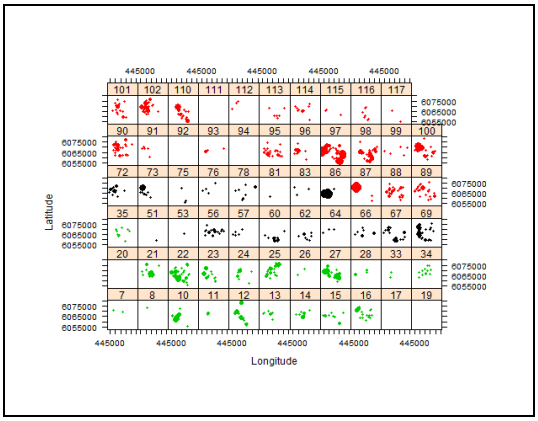


Figure A3.40: Spatial distribution by survey

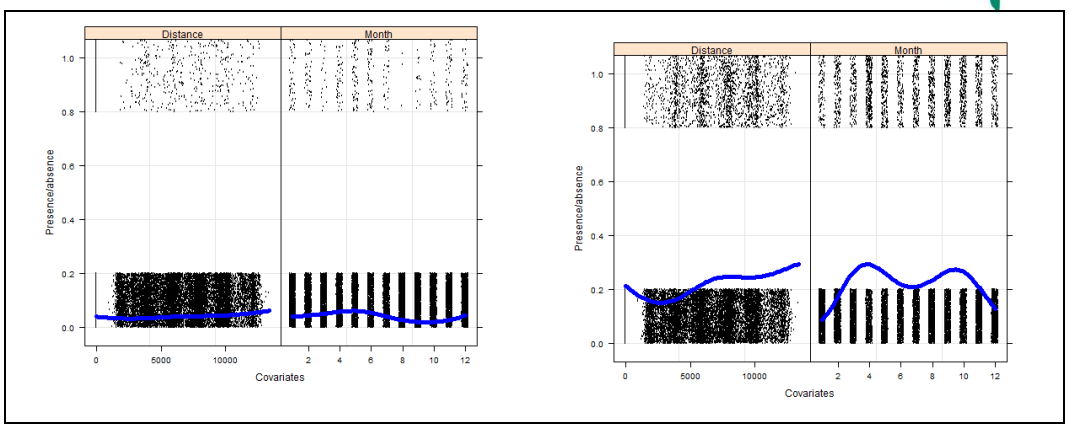
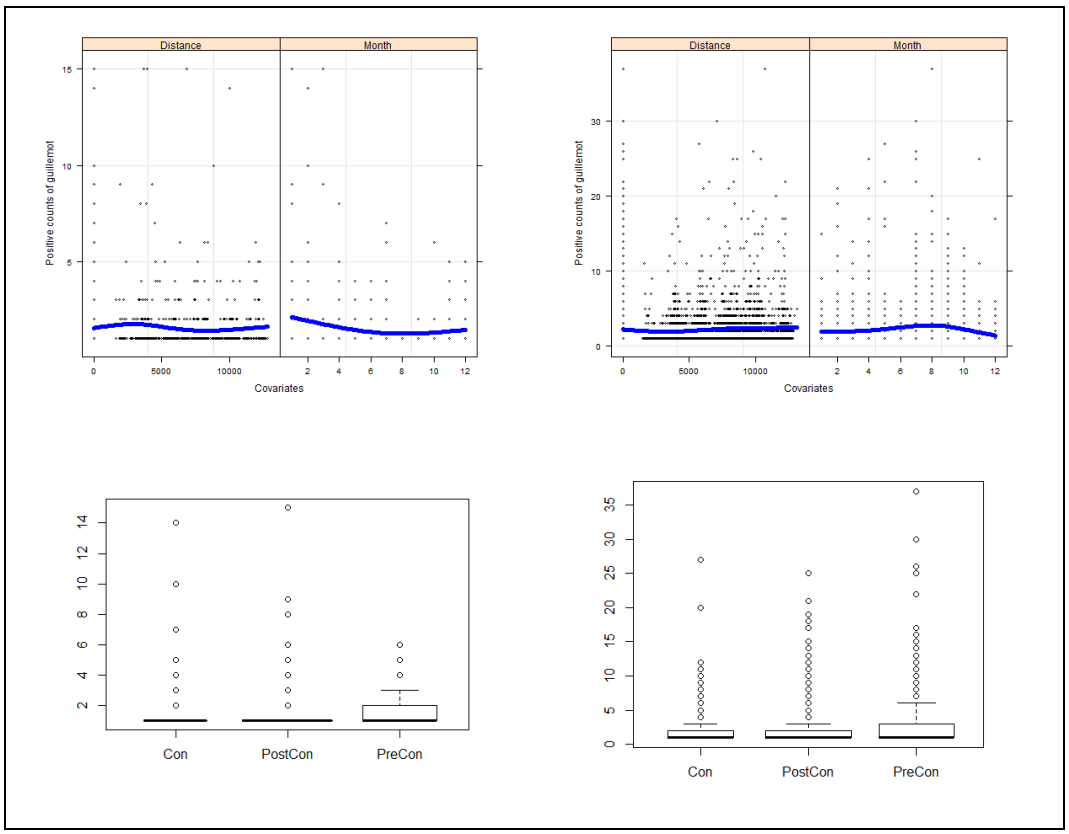


Figure A3.41: Binary response (left = in flight, right = on sea)



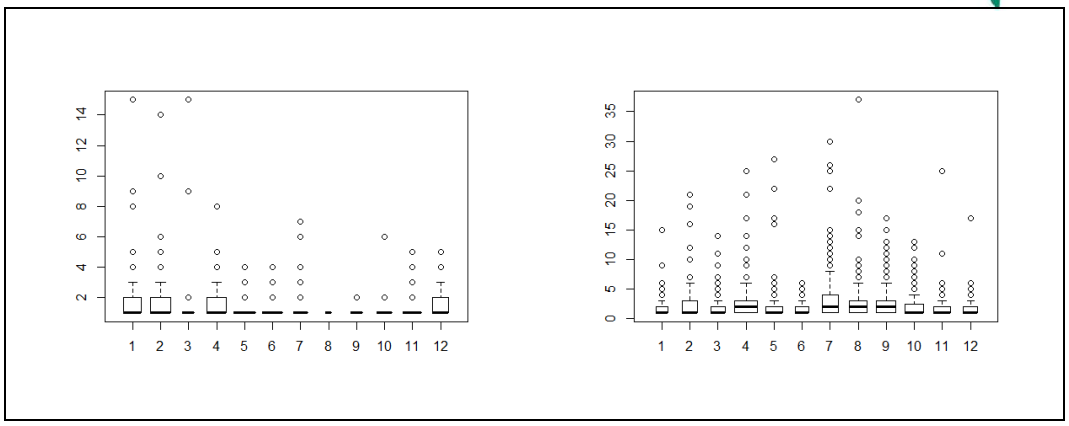
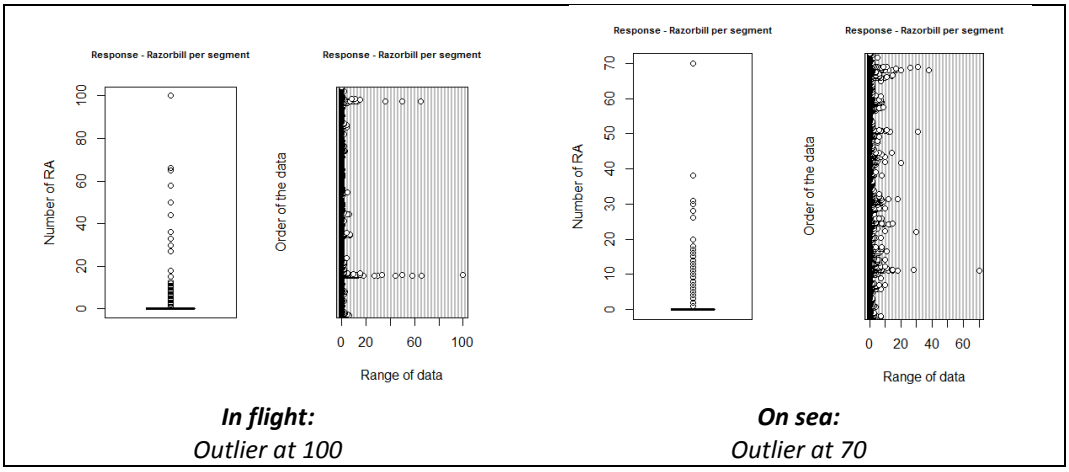


Figure A3.42: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.5.11. Razorbill

Check response variable for outliers



In flight:
Outlier at 100

On sea:
Outlier at 70

Figure A3.43: Response variable for razorbill data.

Check for zero inflation

High proportion of zero observations.

Table A3.16: Percentage zero sightings

	% Zero's	No. observations	No. non-zero's
In flight	98.2	15700	284
On sea	93.6	15700	1058

Check for relationships with variables

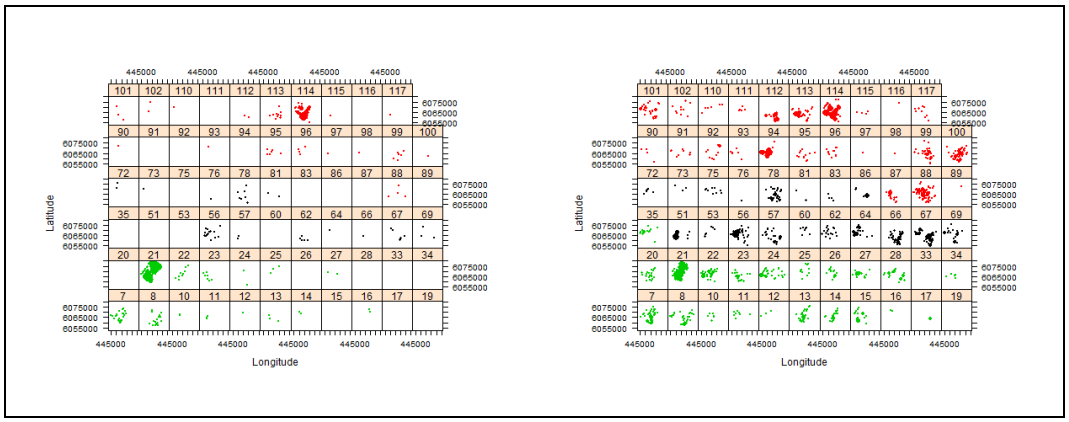


Figure A3.44: Spatial distribution by survey (left = in flight, right = on sea)

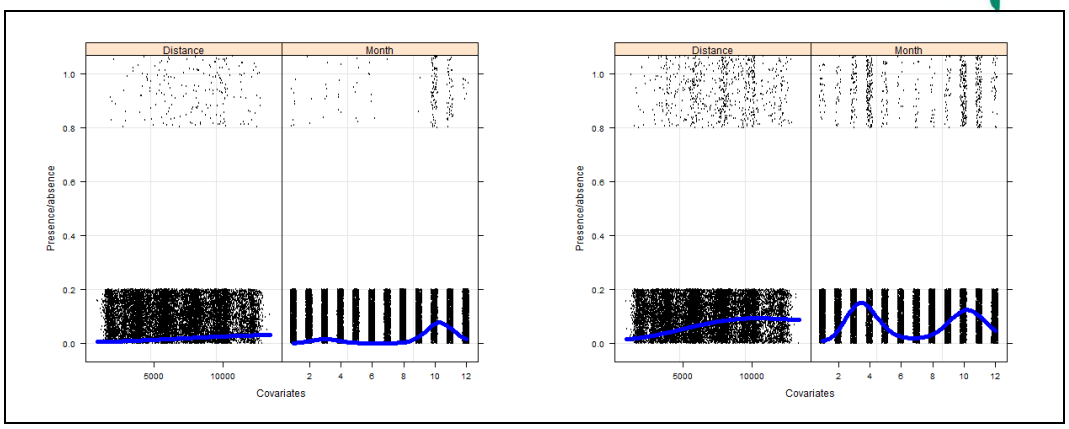
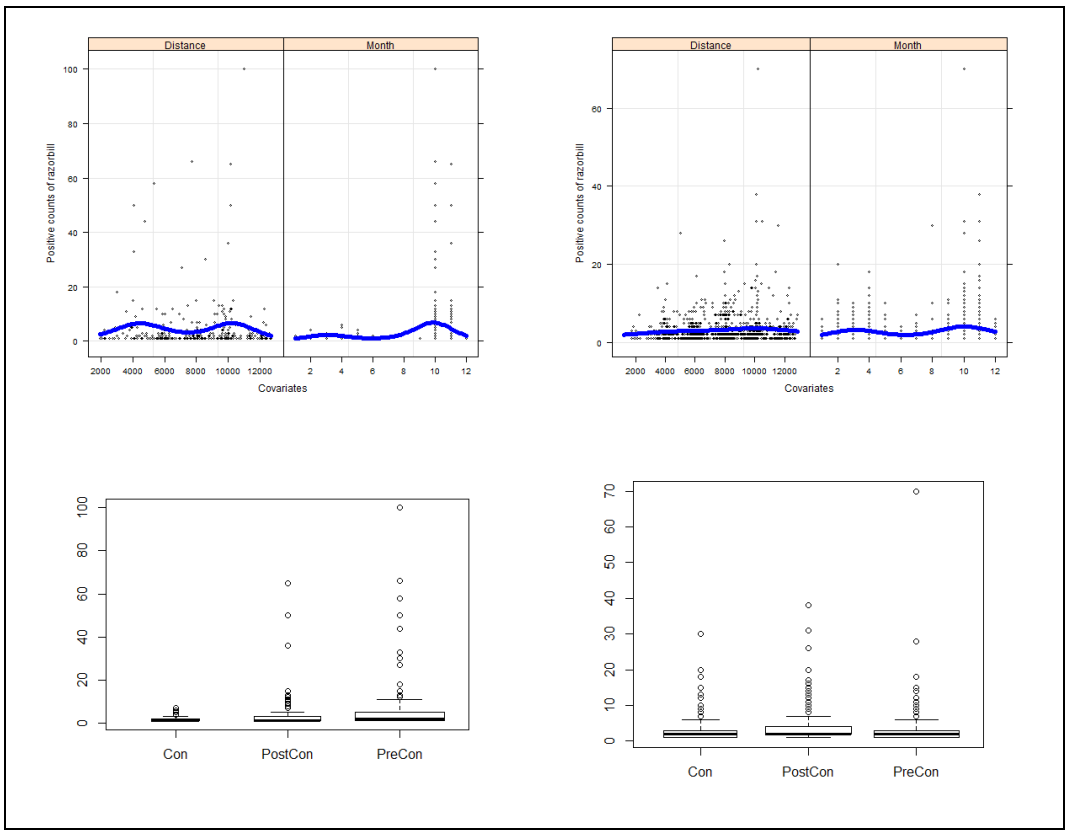


Figure A3.45: Binary response (left = in flight, right = on sea)



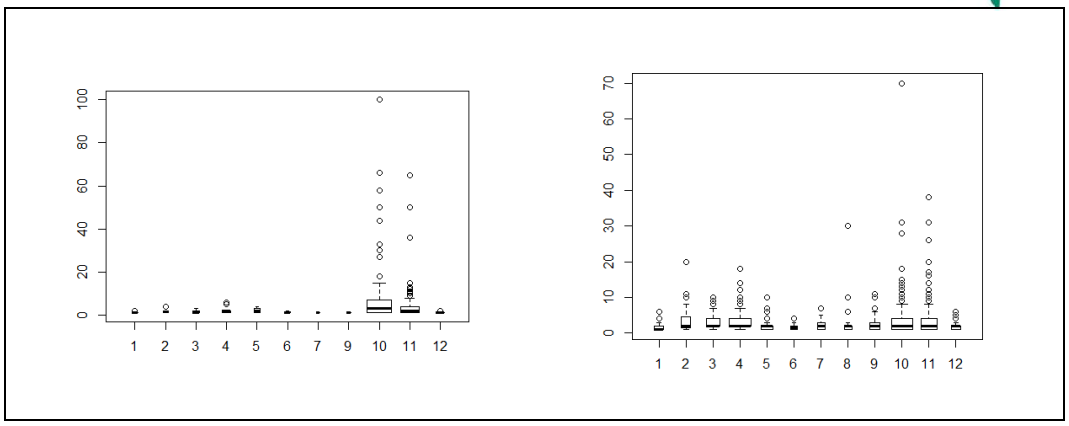


Figure A3.46: Visualization of non-zero data (left = in flight, right = on sea). Top figures show possible relationships with continuous covariates, middle figures show possible relationship with factor period and bottom figures show possible relationship with factor month.

A3.6. Distribution maps of raw sightings data

Distribution maps illustrating the raw sightings data are presented below.

Species
Scaup
Red-throated diver
Manx shearwater
Gannet
Cormorant
Kittiwake
Herring gull
Great black-backed gull
Guillemot
Razorbill

Appendix 4: Marine Mammals

A4. MARINE MAMMAL MONITORING AT ROBIN RIGG

A4.1. Robin Rigg offshore wind farm Marine Environment Monitoring Programme (MEMP)

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 the 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.

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 is 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.

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 wind farm. However, it must also recognise that 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.

Summary of direct and indirect impacts identified in the Environmental Statement

Direct and indirect potential impacts on the physical environment and biological receivers identified within the Environmental Statement (ES) and the requirements of the conditions contained in the consents and licenses guide the scope and detail of the monitoring programme.

However, it is possible the issues may arise or evolve that require changes to be made, in which case such changes will be discussed with the RRMG and agreed with the licensing authorities.

Full details of the protected species and habitats are contained within the ES.

Proposed outline monitoring programme

The following section gives an outline of the monitoring regime proposed by the Developer for the environmental monitoring of the Robin Rigg wind farm. It also identifies additional base line surveys that may be required where considered necessary to complement the original baseline surveys carried out for the ES, in order to give a sufficiently robust picture of the baseline environment for later comparison with monitoring data.

[1] In this context the marine environment includes the birdlife in the vicinity of the wind farm

Depending upon the detailed arrangements for monitoring or results obtained it may be appropriate to amend the monitoring arrangements from time to time in order to ensure that the methods are effective or appropriately focussed. Such amendments would be subject to consultation as appropriate between the Developer and the RRMG and agreement with the relevant licensing authorities as appropriate.

The developer is actively involved in COWRIE and will keep track of the research carried out and associated conclusions. COWRIE conclusions available at the time will be taken into account in the specification for the design and construction of the Robin Rigg wind farm. However, once firm contract commitments have been made by the developer, it will not always be possible to apply new research findings retrospectively, otherwise it will be impossible to finalise major design and construction methodologies.

Ecological monitoring for marine mammals

Table A4.1: Distribution and abundance.

Pre-construction	
Reason	To establish addition background data of abundance and distribution of mammals in region of wind farm in order to establish/confirm measures to be adopted during construction.
Suggested survey type	Boat-based surveys to coincide with pre-construction boat-based surveys using formal survey procedure and dedicated spotter. Leases with WDCS and MCS to agree training and survey methods for construction and post-construction monitoring. Continue to liaise with SSW on data exchange and collation.
Timing and frequency	As for boat-based bird surveys
During construction	
Reason	To comply with Section 36 and Condition 26 of the FEPA licence
Suggested survey type	As for pre-construction
Timing and frequency	As for boat-based bird surveys
Pre-construction	
Reason	To comply with Section 36 and Condition 26 of the FEPA licence
Suggested survey type	As for pre-construction
Timing and frequency	As for boat-based bird surveys for a period of 2 years.

Mitigation measures

The RRMG has advised that mitigation measures to be developed in light of results of the monitoring programme where appropriate.

Where monitoring results reveal unexpected results, it may be appropriate to carry out further, possibly more detailed or focussed monitoring in order to investigate further. In this respect mitigation measures are considered to include additional monitoring.

Where the need for mitigation is demonstrated by the results from the monitoring programme, such measures will be agreed by the Developer with the relevant licensing authorities and subject to appropriate consultation with the RRMG.

A4.2. FEPA Licence 2236 - Licence authorising deposits in the sea in connection with the construction of an offshore wind farm: monitoring conditions

17. The licensee shall submit the details and specifications of all studies and surveys to the licensing authority for their information and approval as necessary.

18. The licensee shall undertake monitoring at 6 monthly intervals during the licensed construction period and then annually for a further two years following the completion of all construction works in order to assess changes in the sea bed conditions in and around the wind farm site. The monitoring should specifically address the following: scour, sedimentary, erosion, hydrological processes and their impacts on marine benthos and ecosystem function. The licensee shall produce a report of their findings including the need for scour protection within one month of completion of each monitoring study.

19. The licensee shall produce proposals for pre-construction baseline and post-construction surveys of fish species (both migratory and non-migratory) in the area of the wind farm. The licensee shall, in drafting these proposals, canvas the views of local fisheries interests (both freshwater and marine).

20. The licensee shall undertake such ornithological monitoring as Scottish Executive experts advise.

21. The licensee shall make provision during the construction phase of the wind farm to monitor subsea noise and vibration during the construction work and for the first year of the operational phase of the wind farm.

22. The licensee shall, prior to construction of the wind farm, provide the licensing authority with a report on “best practice” relating to the attenuation of field strengths of cables by shielding or burial designed to minimise effects on electro-sensitive species. Such “best practice” guidance as is identified shall be incorporated into the Working Method Statement of the Robin Rigg development.

23. The licensee shall arrange to have no more than five composite sediment samples collected from the area of the wind farm for the purpose of measuring representative values of radioactivity in the finer particle material (clay etc.) excavated from the site. The samples should be analysed by an independent party on behalf of the licensee.

24. The licensee shall ensure that during the construction phase all reasonable steps should be taken to minimise any disturbance to cetaceans. This should include temporary suspension of piling operations if cetaceans are sighted in close proximity to the works. Such “best practice” guidance and mitigation measures as is identified in any appropriate report and/or study shall be incorporated into the Working Method Statement as directed by the licensing authority.

25. The licensee shall submit the reports, studies and surveys described in paragraphs 18-24 to the licensing authority at the appropriate time in order to allow the licensing authority to consider what, if any, action may be required as a consequence.

26. The licensee shall detail in a plan the working arrangements to be put into place during the construction period to minimise interference with other legitimate users of the sea. The plan must provide details on issuing Notices to Mariners, appointing onshore and offshore liaison officers and alerting fisheries interests.

A4.3. DEROG 068A/2007: Licence to allow the disturbance of cetaceans: harbour porpoise.

This licence is granted under regulation 44(2)(e) of the Conservation (Natural Habitats &c) Regulations 1994 by Scottish Ministers who, after consultation with, and having been advised as to the circumstances in which they should grant such licenses, by SNH, are satisfied as regards the purpose for which the licence is granted (namely, for an imperative reason of overriding public interest including that of social and economic nature and of beneficial consequences of primary importance for the environment); and that (a) there is no satisfactory alternative and (b) that the action will not be detrimental to the maintenance of the population of the species concerned at a favourable conservation status in their natural range; and is valid unless previously revoked and authorises:

E.On UK Solway Offshore Ltd and E.On UK offshore Energy resources Ltd (the "companies")

Or any persons authorised by the "companies"

To disturb European Protected Species of Cetacean – the harbour porpoise (*Phocoena phocoena*) during the laying of foundations for the Robin Rigg offshore wind farm in the Solway Firth.

Purpose and circumstance in which action is required

The construction of the Robin Rigg offshore wind farm will require the driving in, by impact piling, 62 monopile foundations. The noise generated by this has the potential to disturb cetaceans. The effects of this could be two-fold. In the short range, it is possible that the noise could physiologically damage cetaceans. In the longer range, the noise may deter cetaceans from using the area, with an attendant risk of trapping cetaceans within parts of the Solway Firth during low tide. The developer has mitigated against short range damage to cetaceans by the use of acoustic deterrents that will be sounded prior to the commencement of piling, in order to ensure that cetaceans are deterred from the immediate area of piling. A further mitigation against physical damage to cetaceans in that the piling operation will commence at only 20% of full energy and will be slowly ramped up 90% in accordance with this licence – giving time for cetaceans to vacate the area.

However, it is difficult to completely mitigate against long range disturbance to cetaceans during the laying of foundations for the Robin Rigg offshore wind farm. The following conditions seek to minimise potential disturbance to cetaceans in the course of the works and ensure adequate monitoring of the effects of the piling operation on cetaceans. This licence is intended to compliment FEPA licence 2236, in providing for protection of the environment during the construction of the Robin Rigg offshore wind farm.

Conditions of licence

1. Nothing in this licence conveys any right of entry upon land.
2. Nothing in this licence invalidates anything in FEPA licence 2236.
3. The "companies" are responsible for ensuring that the conditions of this licence are met, and that any person carrying out work under this licence is fully aware of the conditions of this licence and of their responsibilities with regard to meeting those conditions.
4. During the piling period, the piling contractor will ensure that the correct "soft start" procedure is followed to allow marine mammals to move away from the area should they wish to do so; ensure the AHD is deployed according to the correct procedures; and ensure that there is no piling activity apart from that necessary for the normal operations or "soft start".
5. The following details will be recorded for each pile installation: date and location of installation; status of installation and details of pile energy (where possible); a record of the details of the pre-installation watch and the duration of the soft-start; details of any problems encountered during marine mammal detection procedures, or during the survey; marine mammal sightings; reports from any observers on board.
6. The MMO on board the installation vessel shall ensure that their efforts are concentrated on keeping watch prior to the soft start. Any MMO shall manage their time to ensure that they are available to undertake the tasks required when carrying out a watch during the 30 minutes before commencement of piling.

7. Beginning at least 30 minutes before commencement of piling the MMO will carefully make a visual check from a suitable high observation platform to see if there are any marine mammals within 500 meters of the pile location.
8. If marine mammals are seen within 500 meters of the pile location, the start of piling will be delayed until they have moved away, allowing adequate time after the last sighting for the animals to move away (at least 30 minutes).
9. The hydraulic hammer will be commenced with an energy level of 20% or less of the maximum rated energy. The installation at low energy levels will be carried out over at least 20 minutes (the "soft start" period) to give adequate time for marine mammals to leave the vicinity.
10. Following the soft start period, the power will be increased to maximum power (or just below maximum power) over at least 60 seconds. There will be a soft start every time the piling commences, even if no marine mammals have been observed.
11. The soft start procedure shall be followed at all times prior to the commencement of piling.
12. If, for any reason, the piling has stopped and not re-started for at least 15 minutes, a full 20 minute soft start will be carried out which will include a visual check for marine mammals within 500 meters of the pile location. If a marine mammal is present than recommencement of piling should be delayed as per conditions above which deal with the commencement of piling.
13. The MMO will have undertaken suitable training in marine mammal observation as well as suitable instruction and training (if required) on implementing and reporting on these procedures.
14. The MMO will be located onboard the installation vessel.
15. Acoustic Harassment Devices (AHDs) will be correctly employed in association with pile driving activities in order to cause sea mammals to vacate the vicinity of the construction activity.
16. The AHD proposed will be of the type manufactured by Lofitech which has the following nominal operating characteristics: a frequency range of 13-15 kHz, sound pressure 189 dB re 1µPa @ 1 m, and the operational range that is referred to in the Subacoustic Report 773R0102. If for any reason this particular device cannot be used, a device having similar characteristics shall be used.
17. The AHD will be deployed from the main installation vessel for a period of 30 minutes prior to the commencement of the soft start.
18. Additional boat-based monitoring will be employed during the first 4 daylight piling activities. The purpose of the enhanced monitoring is to determine the behaviour of any cetaceans that may be disturbed by the piling activities and to ensure, if necessary, that a suitable mitigation is applied (e.g. pause piling during a period either prior to or during low water).
19. In addition to the enhanced boat-based monitoring, noise measurements will be made during the installation of the first few piles in order to gain a greater understanding of site specific noise propagation.
20. Reasonable care shall be taken at all times to avoid and prevent injury or death of any cetaceans in the course of the works.
21. The Scottish Government shall be informed of any death or injury to cetaceans resulting from these activities.
22. The licence holder shall, no later than one month after the expiry date of this licence, submit to the Scottish Government Rural Directorate, Landscapes and Habitats Division, a written report detailing all actions taken place and certifying that these have been carried out in accordance with the specified terms and conditions of this licence.

A4.4. Data Collection Methods

The survey vessel used for most of the boat surveys was a Fisheries Protection Vessel (16 m length, 18 tonne displacement). This vessel provided an excellent viewing platform and had the combination of speed (to be able to survey across the range of tidal conditions) and the ability to operate in relatively shallow water. Its viewing platform gives a 4 m viewing height above the sea surface. Although this is below the JNCC recommended 5 m, it gave a very suitable viewing platform, especially when taking into account the site constraints on a larger boat which would not have been able to navigate the sandbanks that run through much of the study area. The maximum wind force for observations was reduced from force 5 to force 4 (see Table A4.2 for full definition of sea states) to further ensure that viewing conditions were optimal and were not compromised by the slightly lower viewing height.

Table A4.2: Definition of sea states used in the collection of environmental data.

Sea State	Definition
0	Mirror calm
1	Slight ripples, no foam crests
2	Small wavelets, glassy crests but no whitecaps
3	Large wavelets, crests begin to break, few whitecaps
4	Longer waves, many whitecaps
5	Moderate waves of longer form, some spray

All surveys were done in conjunction with ornithological surveys (see Appendix 5 for bird methodology). The survey route was designed to provide a 2 km interval between transects; a total of ten transects were surveyed, each of about 18 km length (see Figure A4.1). This separation distance was chosen to ensure that a good sample of the study area was covered for all species, whilst minimising the likelihood that birds may be displaced from one transect to the adjacent one and double-counted.

The same route was used for all the surveys, though restricted hours of daylight, weather and tidal conditions meant that it was not always possible to cover the whole survey area in a single day. Where complete surveys were not possible the second survey each month was designed to ensure that the whole study area was covered at least once per month and that the potential wind farm area twice per month whenever possible. A GPS record of the precise route was taken on each trip, so that the location at all times was known.

Two surveys were completed each month from May 2001 to April 2002, with the exception of May and October 2001, when only one survey was completed. Alternate surveys covered the high tide and the low tide periods. Monthly surveys were conducted in April/May 2003 and between January and September 2004 with an addition survey performed in July 2007, just prior to construction commencing. Construction phase surveys began in January 2008 and continued on a bi-monthly basis until the end of the phase in February 2010. Surveys were completed in all months of the construction phase except November 2009.

No marine mammal surveys were carried out during the EIA process. Baseline surveys were conducted on a monthly basis between February 2004 and January 2005 with an addition survey performed in July 2007, just prior to construction commencing. Construction phase surveys began in January 2008 and continued on a bi-monthly basis until the end of the phase in February 2010. Surveys were completed in all months of the construction phase except November 2009.

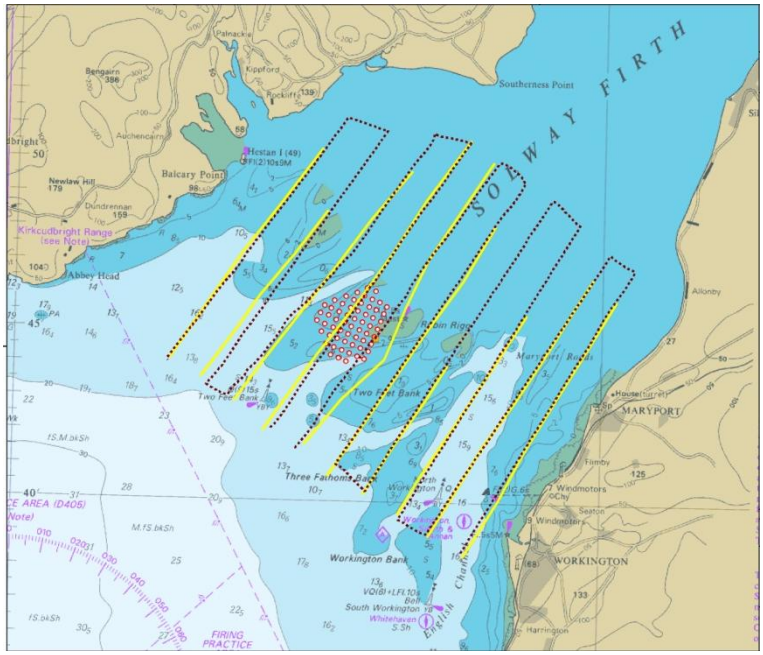


Figure A4.1: Illustration showing the 10 transect lines followed during the bird and marine mammal surveys. The yellow lines represent the area that could be covered at low tide. Red circles represent turbine locations.

Data was collected following Sea Watch Foundation guidelines. A single observer scanned a 180° area ahead and to either side of the vessel looking for marine mammals. When a mammal was observed, the species id, number of animals, distance from the boat and direction relative to the direction of travel were recorded along with any behavioural information. In addition to this, environmental data such as sea state, swell height and water depth were recorded every 15 minutes.

A4.5. Data exploration

Data exploration on final data set i.e. extensions removed and sea states combined:

A4.5.1. Relationship between variables

Is there even coverage between months?

Table A4.3: Number of segments for each month during each phase of the development. There should be an even distribution of effort between months and phases. Note that that the effort for April and June has been removed from all phases as there was no data for these months pre-construction.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre	142	100	130		136		322	137	98	159	150	69
During	151	230	95		153		157	244	266	325	146	263
Post	338	358	324		315		326	366	287	250	313	312

Spatial distribution of effort

There should be an even distribution across the site between phases (Figure A4.2).

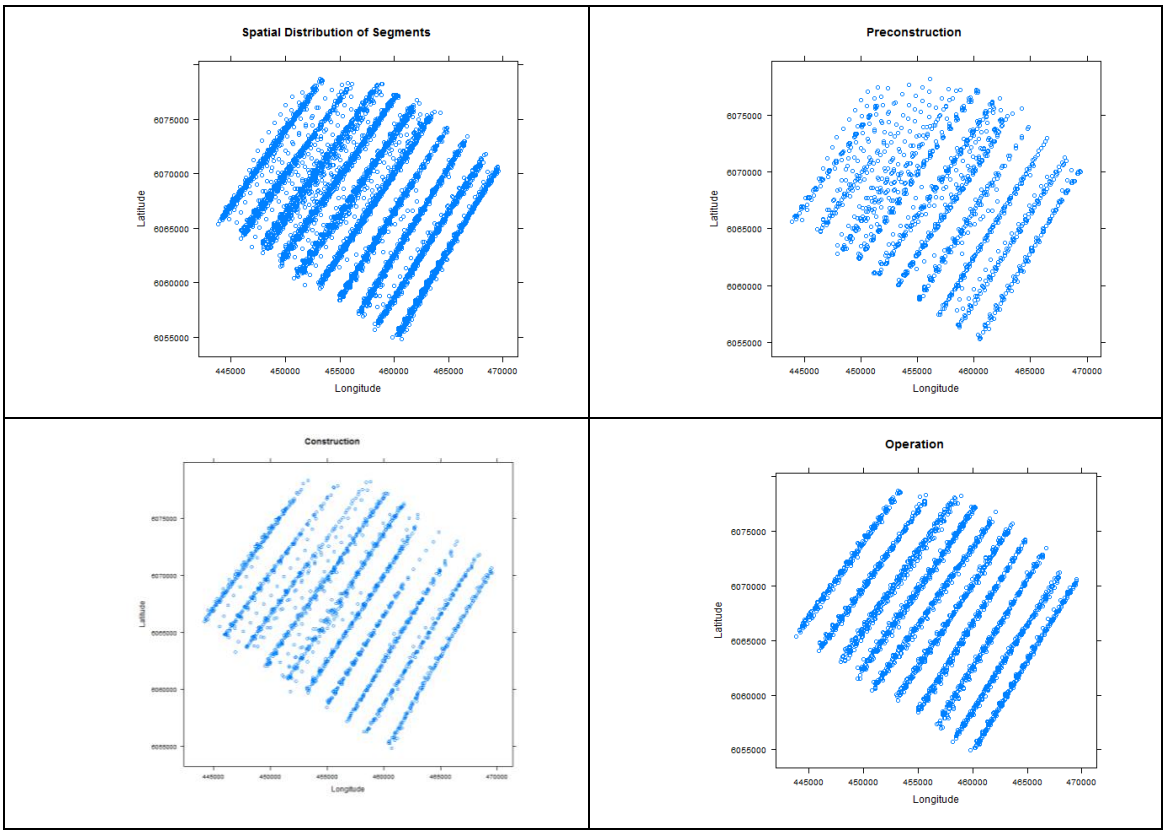


Figure A4.2: Visual representation of the survey segments by effort.

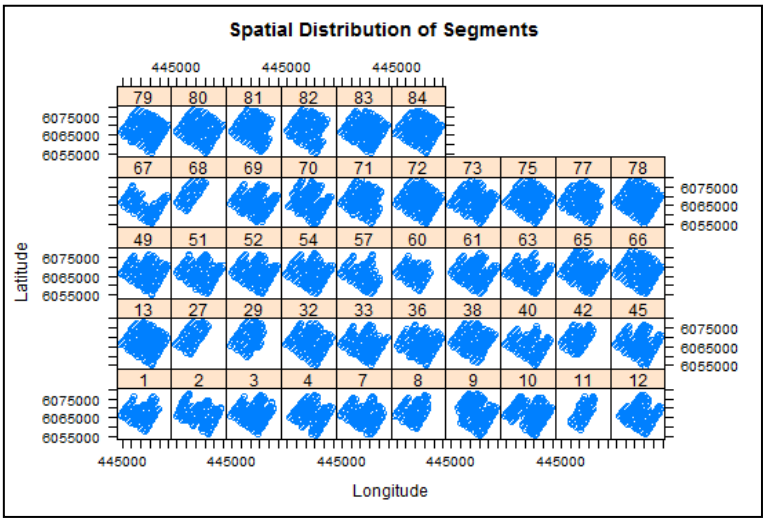


Figure A4.3: Visual representation of the survey segments by. effort for each individual survey.

Check variables for outliers and even coverage

Response variables were allocated to each survey segment. Each variable was checked to ensure even coverage (figure A4.4; table A4.4). In order to reduce the number of levels within the models, the original values have been combined. 1 – sea state 0-1; 2 = sea state 2-3; and 3 = sea state 4-5.

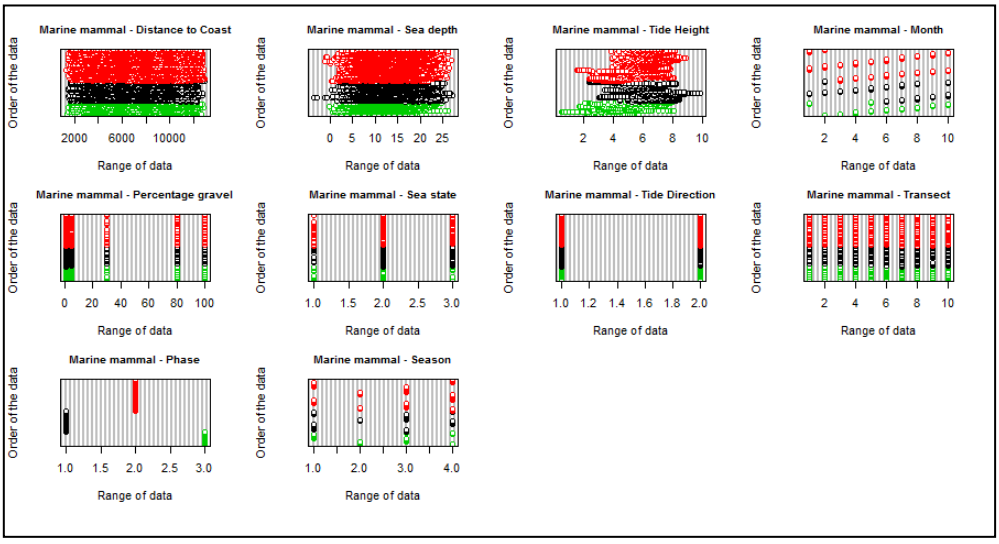


Figure A4.4: Figures visually representing the coverage of each of the response variable

Table A4.4: The number of segments collected at each different sea state during each of the three phases with the original values combined. 1 – sea state 0-1; 2 = sea state 2-3; and 3 = sea state 4-5.

Sea state	1	2	3	NA
Pre	377	883	183	0
During	193	951	886	0
Post	578	1535	1076	0

The values in the bottom left are Pearson's coefficients. The higher the value, the stronger the relationship between the variables. A value of 0.8 or above indicates a strong linear relationship.When dealing with large data sets (as here), variables with a value of 0.4-0.5 or above should be investigated further as this may be an indication on non-linear relationships.

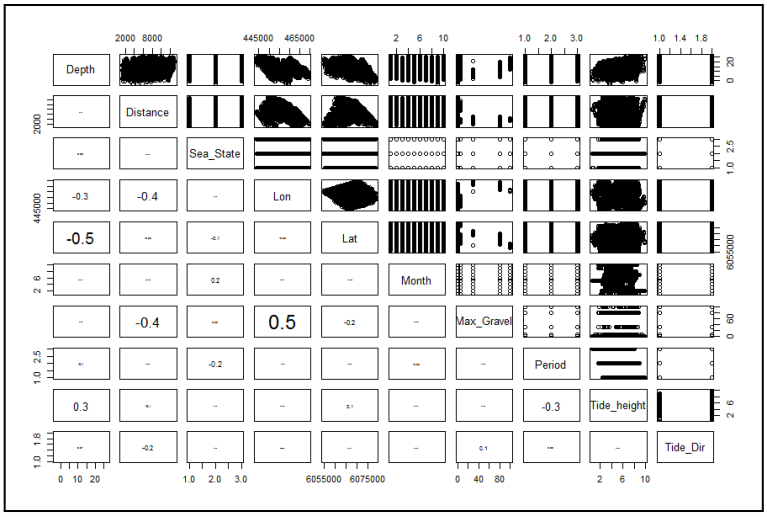


Figure A4.5: Collinearity among continuous variables.

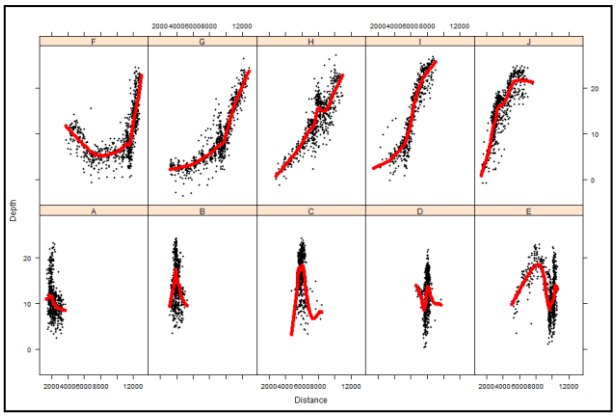


Figure A4.6: Further investigation of variables found non-linear relationships with distance and depth nested in transect.

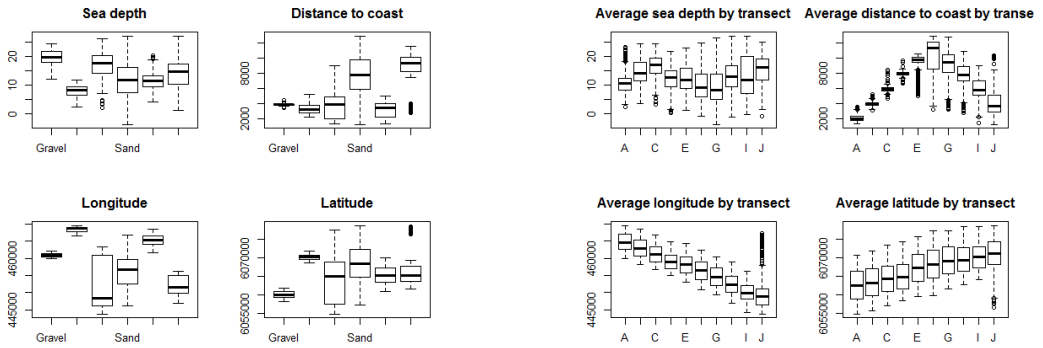


Figure A4.7: Collinearity between factors and covariates

A4.5.2. Relationships with response variables

Check response variable for outliers

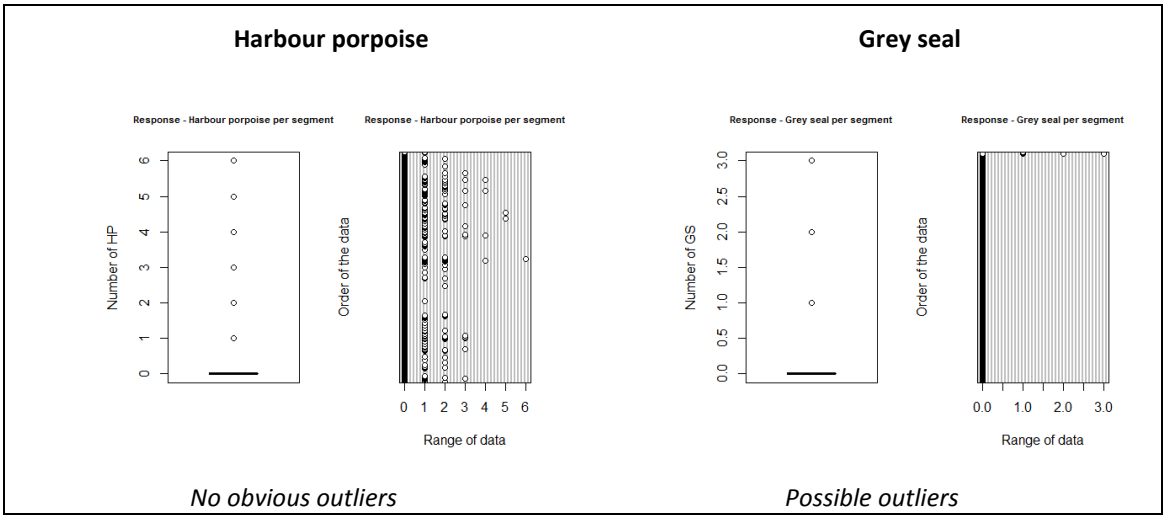


Figure A4.8: *Response variable for harbour porpoise and grey seal data*

Check for zero inflation

High proportion of zero observations.

Table A4.5: Percentage zero sightings - There are too few non-zero data points to allow further analysis of grey seal data.

	% zeros	No observations	No non-zero's
Harbour porpoise	95.8	6662	281
Grey seal	99.4	6662	38

Harbour porpoise

Check for relationships with variables

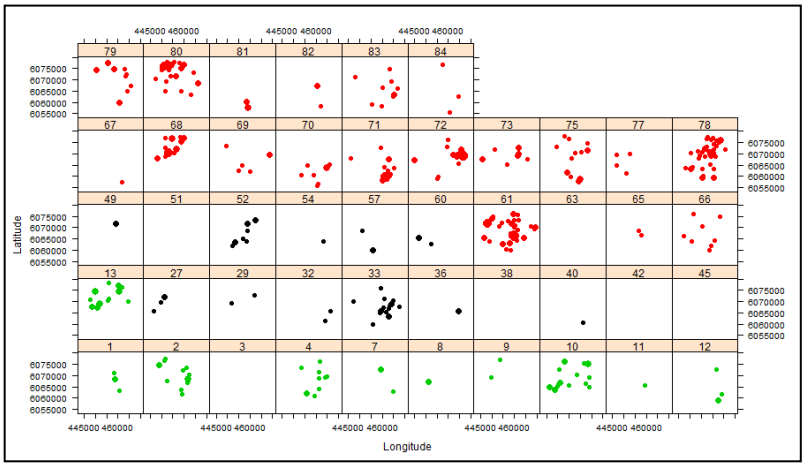


Figure A4.9: Spatial distribution by survey

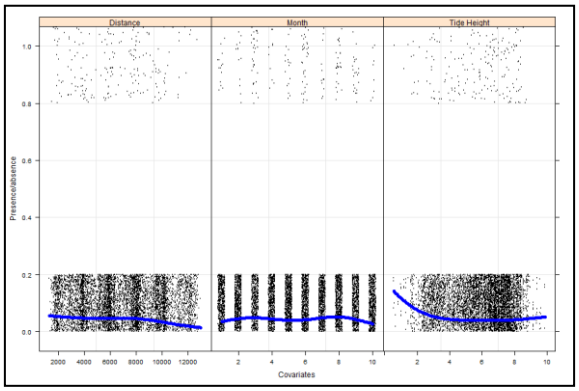


Figure *A4.10: Visualization of relationship between response and variables (binary response)*

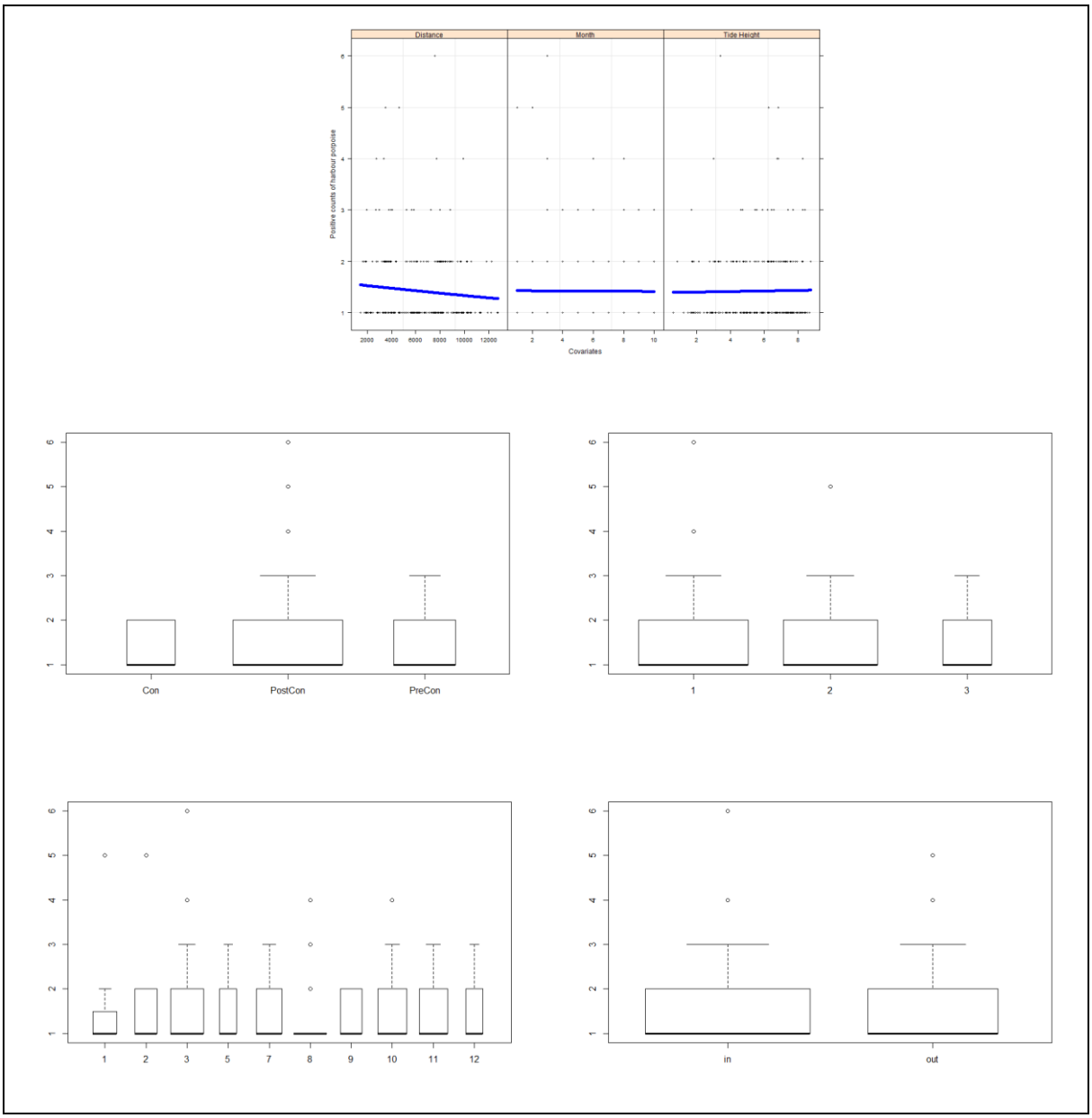


Figure A4.11: Visualization of relationship between response and variables (non-zero data). Figures from top left to bottom right: relationship with continous covariates, relationship with wind farm phase, relationship with sea state, relationship with month and relationship with direction of the tide.

A4.6. Model outputs

The table below contains the Information Criteria (IC) for each variation of the model containing sea state in the binary part. The lower the value the better the model explains the data. Colour coding ranges from dark green (lowest) to red (highest). Models M3. 17, 18 and 19 appear to be the best. The models below will be repeated, this time including a random effect in the binary part of the model (in addition to sea state) and the outputs compared.

Table A4.6: Information Criteria (IC) for each variation of the model containing sea state in the binary part.

Model	DIC	AIC	BIC	Min AIC	Min BIC	Posterior Mean AIC	Posterior mean BIC
M1: intercept only	2434.82	2282.20	2315.75	2268	2302	2363.52	2397.06
M2: distance	2411.31	2248.36	2288.62	2238	2278	2335.83	2376.08
M3: period + distance	2396.20	2243.56	2297.23	2220	2273	2327.87	2381.54
M4: season	2436.77	2282.57	2329.53	2256	2303	2366.66	2413.63
M5: period + season	2418.28	2274.93	2335.31	2247	2307	2355.59	2415.98
M6: period	2416.12	2274.47	2321.44	2245	2292	2352.30	2399.27
M7: distance + season	2413.73	2250.13	2303.80	2225	2279	2339.93	2393.60
M8: distance*season	2412.98	2246.51	2313.60	2247	2314	2339.74	2406.83
M9: period*season	2415.59	2295.86	2383.08	2273	2360	2368.72	2455.94
M10: period*distance	2397.22	2250.38	2317.47	2230	2297	2333.81	2400.90
M11: period + distance + seastate	2397.70	2242.08	2309.17	2225	2292	2329.90	2396.99
M12: season + distance*period	2398.39	2248.11	2328.62	2235	2316	2335.24	2415.76
M13: period + distance*season	2263.06	2374.05	2454.56	2227	2308	2330.55	2411.06
M14: distance*period + season*period	2198.51	2463.79	2571.13	2245	2352	2347.15	2454.50
M15: distance*period + distance*season + season*peric	2397.44	2259.59	2380.36	2236	2356	2346.53	2467.30
M16: tide_height	2432.18	2275.90	2316.16	2260	2300	2360.05	2400.30
M17: tide_height + distance	2406.14	2238.91	2285.88	2219	2266	2329.53	2376.50
M18: tide_height*distance	2404.81	2237.28	2290.96	2233	2287	2329.06	2382.73
M19: tide_height*distance + period	2386.37	2239.72	2306.81	2216	2283	2323.05	2390.14

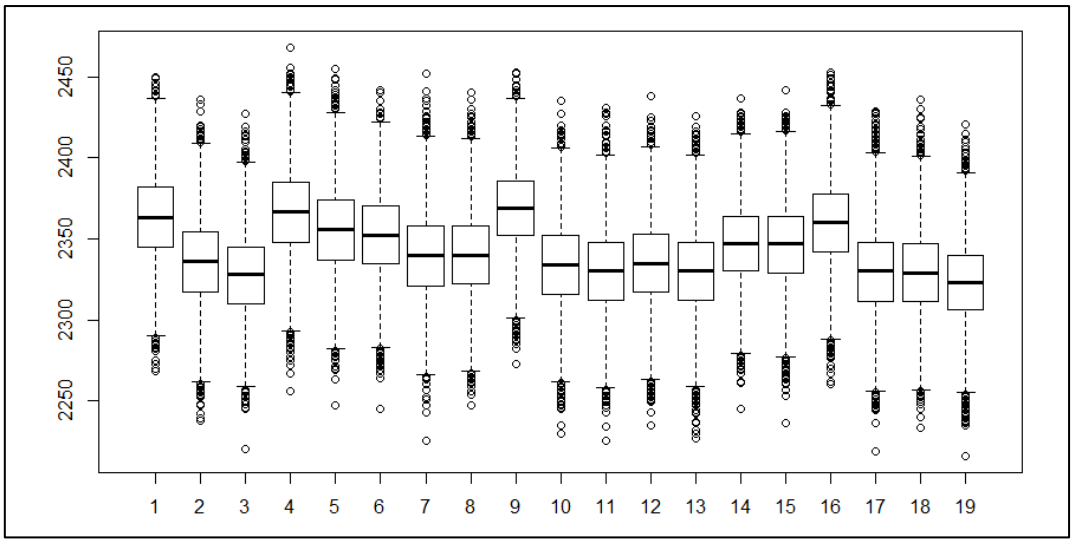


Figure A4.12: visual representation of the AICs calculated for the above listed models.

Table A4.7: Parameter estimates, 95% Credible Intervals (CI) and significances for each individual model. A parameter is considered significant if the 95% CIs do not bound zero.

Model 1					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.56	0.57	0.16	0.92	Yes
Sea state 2 v Sea state 1	1.75	1.75	1.39	2.12	Yes
Sea state 3 v Sea state 1	2.54	2.54	2.06	3.05	Yes
Poisson intercept	-0.98	-0.98	-1.38	-0.60	Yes
Random effect (transect: survey)	0.71	0.71	0.46	0.97	Yes
Model 2					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.38	0.39	-0.06	0.76	No
Sea state 2 v Sea state 1	1.81	1.81	1.43	2.20	Yes
Sea state 3 v Sea state 1	2.63	2.63	2.15	3.16	Yes
Poisson intercept	-1.16	-1.16	-1.58	-0.77	Yes
Distance	-0.37	-0.36	-0.53	-0.21	Yes
Random effect (transect: survey)	0.75	0.74	-.50	1.01	Yes
Model 3					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.34	0.35	-0.09	0.71	No
Sea state 2 v Sea state 1	1.76	1.76	1.39	2.16	Yes
Sea state 3 v Sea state 1	2.58	2.58	2.08	3.12	Yes
Poisson intercept	-1.9	-1.90	-2.49	-1.37	Yes
Distance	-0.34	-0.33	-0.50	-0.18	Yes
Post con V Con	1.00	1.00	0.56	1.46	Yes
Pre con v Con	0.65	0.65	0.14	1.16	Yes
Random effect (transect: survey)	0.71	0.71	0.47	0.97	Yes
Model 4					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.55	0.56	0.16	0.91	Yes
Sea state 2 v Sea state 1	1.75	1.75	1.39	2.11	Yes
Sea state 3 v Sea state 1	2.53	2.52	2.04	3.05	Yes
Poisson intercept	-0.96	-0.96	-1.44	-0.51	Yes
Summer v Autumn	0.12	-0.12	-0.53	0.28	No
Winter v Autumn	0.02	0.02	-0.39	0.43	No
Random effect (transect: survey)	0.72	0.72	0.47	0.98	Yes
Model 5					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.52	0.53	0.13	-.88	Yes
Sea state 2 v Sea state 1	1.68	1.68	1.32	2.05	Yes
Sea state 3 v Sea state 1	2.46	2.46	1.98	2.98	Yes
Poisson intercept	-1.70	-1.69	-2.32	-1.10	Yes
Post con v Con	1.07	1.07	0.63	1.55	Yes
Pre con v Co	0.69	0.68	0.19	1.21	Yes
Summer v Autumn	-0.17	-0.17	-0.57	0.22	No
Winter v Autumn	-0.13	-0.13	-0.53	0.28	No
Random effect (transect: survey)	0.69	0.68	0.43	0.96	Yes
Model 6					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.52	0.53	0.14	0.87	Yes
Sea state 2 v Sea state 1	1.69	1.69	1.33	2.05	Yes
Sea state 3 v Sea state 1	2.47	2.46	1.99	2.99	Yes

Poisson intercept	-1.76	-1.75	-2.33	-1.23	Yes
Post con v Con	1.04	1.04	0.61	1.50	Yes
Pre con v Co	0.66	0.66	0.18	1.78	Yes
Random effect (transect: survey)	0.67	0.67	0.43	0.94	Yes
Model 7					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.38	0.38	-0.04	0.76	Yes
Sea state 2 v Sea state 1	1.81	1.81	1.43	2.20	Yes
Sea state 3 v Sea state 1	2.63	2.62	2.13	3.15	Yes
Poisson intercept	-1.19	-1.18	-1.68	-0.73	Yes
Distance	-0.37	-0.37	-0.53	-0.21	Yes
Summer v Autumn	-0.01	-0.01	-0.42	0.40	No
Winter v Autumn	0.06	0.07	-0.34	0.46	No
Random effect (transect: survey)	0.75	0.75	0.51	1.02	Yes
Model 8					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.36	0.36	-0.08	-.75	No
Sea state 2 v Sea state 1	1.80	1.80	1.42	2.19	Yes
Sea state 3 v Sea state 1	2.60	2.60	2.09	3.13	Yes
Poisson intercept	-1.24	-1.23	-1.75	-0.78	Yes
Distance	-0.42	-0.42	-0.71	-0.14	Yes
Summer v Autumn	0.01	0.01	-0.39	0.43	No
Winter v Autumn	0.04	0.04	-0.39	0.48	No
Distance * Summer	0.22	0.22	-0.15	0.60	No
Distance * Winter	-0.12	-0.12	-0.52	0.28	No
Random effect (transect: survey)	0.77	0.77	0.53	1.03	Yes
Model 9					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.53	0.53	0.14	0.88	Yes
Sea state 2 v Sea state 1	1.74	1.73	1.38	2.10	Yes
Sea state 3 v Sea state 1	2.55	2.55	2.05	3.05	Yes
Poisson intercept	-1.26	-1.25	-1.95	-0.64	Yes
Post con v Con	0.74	0.73	0.09	1.40	Yes
Pre con v Con	-0.10	-0.11	-0.92	0.70	No
Summer v Autumn	-0.30	-0.30	-1.11	0.54	No
Winter v Autumn	-1.76	-1.74	-3.03	-0.62	Yes
Post con * Summer	-0.09	-0.08	-1.05	0.87	No
Pre con *Summer	-.74	0.74	-0.38	1.86	No
Post con * Winter	1.72	1.70	0.48	3.06	Yes
Pre con * Winter	2.27	2.26	0.84	3.78	Yes
Random effect (transect: survey)	0.61	0.61	0.36	0.88	Yes
Model 10					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.32	0.33	-0.13	0.72	Yes
Sea state 2 v Sea state 1	1.79	1.79	1.39	2.19	Yes
Sea state 3 v Sea state 1	2.59	2.59	2.09	3.13	Yes
Poisson intercept	-1.89	-1.88	-2.46	-1.35	Yes
Distance	-0.07	-0.06	-0.44	0.32	No
Post con v Con	0.97	0.97	0.55	1.42	Yes
Pre con v Con	0.64	0.64	0.13	1.14	Yes
Pre con * Distance	-0.36	-0.37	-0.79	0.06	No
Post con * Distance	-0.23	-0.23	-0.72	0.26	No

Random effect (transect: survey)	0.69	0.69	0.44	0.96	Yes
Model 11					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.34	0.35	-0.08	0.72	No
Sea state 2 v Sea state 1	1.75	1.74	1.36	2.14	Yes
Sea state 3 v Sea state 1	2.58	2.57	2.06	3.13	Yes
Poisson intercept	-1.88	-1.88	-2.51	-1.30	Yes
Distance	-0.34	-0.34	-0.50	-0.18	Yes
Post con v Con	1.02	1.02	0.57	1.49	Yes
Pre con v Con	0.66	0.65	-.14	1.18	Yes
Summer v Autumn	-0.07	-0.07	-0.49	0.35	No
Winter v Autumn	-0.09	-0.09	-0.51	0.32	No
Random effect (transect: survey)	0.73	0.73	0.49	1.00	Yes
Model 12					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.32	0.33	-0.09	0.71	No
Sea state 2 v Sea state 1	1.77	1.77	1.38	2.16	Yes
Sea state 3 v Sea state 1	2.60	2.60	2.09	3.14	Yes
Poisson intercept	-1.86	-1.85	-2.46	-1.30	Yes
Distance	-0.06	-0.06	-0.45	0.31	No
Post con v Con	1.00	0.99	0.56	1.48	Yes
Pre con v Con	0.65	0.65	0.15	1.17	Yes
Summer v Autumn	-0.09	-0.09	-0.49	0.31	No
Winter v Autumn	-0.11	-0.10	-0.52	0.29	No
Post con * Distance	-0.36	-0.37	-0.78	0.06	No
Pre con * Distance	-0.24	-0.24	-0.74	0.25	No
Random effect (transect: survey)	0.72	0.72	0.47	0.98	Yes
Model 13					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.34	0.35	-0.05	0.71	No
Sea state 2 v Sea state 1	1.72	1.72	1.34	2.11	Yes
Sea state 3 v Sea state 1	2.52	2.52	2.00	3.05	Yes
Poisson intercept	-1.94	-1.94	-2.56	-1.35	Yes
Distance	-0.42	-0.42	-0.71	-0.14	No
Post con v Con	1.03	1.03	0.58	1.50	Yes
Pre con v Con	0.68	0.68	0.17	1.22	Yes
Summer v Autumn	-0.05	-0.05	-0.46	0.37	No
Winter v Autumn	-0.09	-0.09	-0.53	0.34	No
Distance * Summer	0.26	0.26	-0.11	0.63	No
Distance * Winter	-0.07	-0.07	-0.47	0.33	No
Random effect (transect: survey)	0.74	-0.74	-0.50	1.01	Yes
Model 14					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.31	0.32	-0.12	0.70	No
Sea state 2 v Sea state 1	1.83	1.83	1.44	2.23	Yes
Sea state 3 v Sea state 1	2.67	2.67	2.15	3.20	Yes
Poisson intercept	-1.39	-1.38	-2.07	-0.70	Yes
Distance	0.05	0.05	-0.36	0.46	No
Post con v Con	0.57	0.57	-0.10	1.26	No
Pre con v Con	-0.17	-1.17	-1.00	0.65	No
Summer v Autumn	-0.37	-0.36	-1.23	0.48	No
Winter v Autumn	-1.84	-1.81	-3.21	-0.63	Yes

Post con * Distance	-0.47	-0.46	-0.92	-0.02	Yes
Pre con * Distance	-0.34	-0.33	-0.86	0.17	No
Post con * Summer	0.14	0.14	-0.84	1.15	No
Pre con * Summer	0.84	0.84	-0.30	1.99	No
Post con * Winter	1.84	1.82	0.54	3.28	Yes
Pre con * Winter	2.34	2.33	0.84	3.96	Yes
Random effect (transect: survey)	0.66	0.66	0.82	0.93	Yes
Model 15					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.30	0.31	-0.14	0.69	No
Sea state 2 v Sea state 1	1.80	1.80	1.40	2.21	Yes
Sea state 3 v Sea state 1	2.62	2.62	2.10	3.17	Yes
Poisson intercept	-1.46	-1.45	-2.19	-0.78	Yes
Distance	-0.06	-0.05	-0.50	0.39	No
Post con v Con	0.58	0.58	-0.11	1.28	No
Pre con v Con	-0.14	-0.14	-0.97	0.72	No
Summer v Autumn	-0.37	-0.37	-1.27	0.52	No
Winter v Autumn	-1.75	-1.71	-3.13	-0.57	Yes
Post con * Distance	-0.45	-0.45	-0.90	0.01	No
Pre con * Distance	-0.34	-0.34	-0.86	0.17	No
Distance * Summer	0.24	0.24	-0.13	0.63	No
Distance * Winter	0.00	0.00	-0.40	0.40	No
Post con * Summer	0.18	0.17	-0.85	1.23	No
Pre con * Summer	0.86	0.86	-0.30	2.04	No
Post con * Winter	1.76	1.74	0.49	3.25	Yes
Pre con * Winter	2.23	2.21	0.72	3.91	Yes
Random effect (transect: survey)	0.69	0.68	0.44	0.95	Yes
Model 16					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.54	0.55	0.15	0.9-	Yes
Sea state 2 v Sea state 1	1.74	1.74	1.38	2.11	Yes
Sea state 3 v Sea state 1	2.51	2.51	2.02	3.01	Yes
Poisson intercept	-1.03	-1.03	-1.45	-0.64	Yes
Tide height	-0.14	-0.14	-0.29	0.01	No
Random effect (transect: survey)	0.72	0.72	0.48	0.99	Yes
Model 17					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.35	0.35	-0.07	0.74	No
Sea state 2 v Sea state 1	1.80	1.80	1.42	2.19	Yes
Sea state 3 v Sea state 1	2.60	2.60	2.10	3.12	Yes
Poisson intercept	-1.23	-1.23	-1.65	-0.83	Yes
Tide height	-0.18	-0.18	-0.34	-0.03	Yes
Distance	-0.39	-0.38	-0.55	-0.23	Yes
Random effect (transect: survey)	0.76	0.76	0.52	1.02	Yes
Model 18					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.32	0.33	-0.11	0.71	No
Sea state 2 v Sea state 1	1.82	1.82	1.44	2.23	Yes
Sea state 3 v Sea state 1	2.62	2.62	2.12	3.17	Yes
Poisson intercept	-1.27	-1.27	-1.68	-0.87	Yes
Tide height	-0.22	-0.21	-0.38	-0.05	Yes
Distance	-0.43	-0.42	-0.60	-0.27	Yes

Tide height * Distance	-0.13	-0.13	-0.28	0.02	No
Random effect (transect: survey)	0.77	0.77	0.53	1.02	Yes
Model 19					
Parameter	**Mean**	**Median**	**2.5% C.I.**	**95.5% C.I.**	**Significant?**
Binary intercept	0.28	0.29	-0.14	0.67	No
Sea state 2 v Sea state 1	1.79	1.79	1.41	2.19	Yes
Sea state 3 v Sea state 1	2.59	2.59	2.08	3.13	Yes
Poisson intercept	-1.99	-1.98	-2.57	-1,46	Yes
Tide height	-0.29	-0.29	-0.45	-0.13	Yes
Distance	-0.41	-0.40	-0.57	-0.25	Yes
Tide height * Distance	-0.15	-0.15	-0.30	0.00	Yes
Post con v Con	1.07	1.07	0.64	1.52	Yes
Pre con v Con	0.47	0.46	-0.05	1.01	No
Random effect (transect: survey)	0.70	0.70	0.45	0.95	Yes

A4.7. Maps

A4.7.1. Raw data

The following maps represent the raw sightings data for the grey seal and harbour porpoise.

Species
Grey seal
Harbour porpoise

A4.7.2. Surveys associated with piling

The following maps illustrate the transects covered by the vessel on days when piling occurred, including the location of any marine mammal sightings that occurred.

Date of Survey
1st January 2008
24th June 2008
29th July 2008
28th August 2008
13th October 2008
6th November 2008
8th December 2008
5th January 2009