

# **Digital Aerial Seabird and Cetacean Surveys Off the East Coast of Scotland**

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## **Digital Aerial Seabird and Cetacean Surveys Off the East Coast of Scotland**

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Marine Scotland is the directorate of the Scottish Government responsible for the integrated management of Scotland's seas. Marine Scotland Science (formerly Fisheries Research Services) provides expert scientific and technical advice on marine and fisheries issues. Scottish Marine and Freshwater Science is a series of reports that publishes results of research and monitoring carried out by Marine Scotland Science. It also publishes the results of marine and freshwater scientific work that has been carried out for Marine Scotland under external commission. These reports are not subjected to formal external peer-review.

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## Executive summary

APEM were commissioned by the Scottish Government to provide digital aerial surveys of the East Coast of Scotland, from February 2020 until January 2021. The main objective of the work was to deliver survey data and report on the outcome of the digital aerial surveys in regard to seabirds and cetaceans within the defined target area. This is the final report describing the methodology and results of the survey programme.

APEM's camera system was fitted into a twin-engine aircraft the aerial digital surveys captured images along ten transects spaced in a sawtooth pattern to achieve full coverage across the East Coast targeted area (hereafter known as Survey Area).

Data collected approximately two-centimetre (cm) ground sample distance (GSD) digital still images. The transect swathe was 960 meters (m), images were collected continuously (abutting digital still imagery) along the ten transects. At least 194 kilometres squared (km<sup>2</sup>) of sea surface area was collected, representing 1.5% coverage of the wider survey area.

Survey	Total Raw count		
	Birds	Mammals	Other marine megafauna
Survey 1	10,282	96	0
Survey 2	9,606	22	0
Survey 3	18,141	517	1
Survey 4	14,284	660	0
Survey 5	64,034	58	1
Survey 6	19,551	84	1
Survey 7	14,525	20	0
Survey 8	12,901	59	0

## **1. Introduction**

The Scottish Ministers acting through Marine Scotland brings together four parts of the Scottish Government, Marine Science, Compliance, Policy and Planning and Aquaculture & Wild Fisheries (known as Marine Scotland). Marine Scotland is a directorate of the Scottish Government, with the purpose to manage Scotland's seas for prosperity and environmental sustainability.

APEM were commissioned by the Scottish Government to provide digital aerial surveys of the East Coast of Scotland, from February 2020 until March 2021. The main objective of the work was to deliver survey data and report on the outcome of the digital aerial surveys in regard to seabirds and cetaceans within the defined target area. The information collected throughout the survey program on the abundance and distribution of seabirds at sea is required to help inform in the management of internationally protected seabird populations, assessing sensitivity to oil spills<sup>1</sup>, developing sectoral plans and associated Strategic Environmental Assessments. This study was required for this area as the existing data for seabirds at sea for the East of Scotland was dated<sup>2</sup>, therefore the need for more recent seabird distribution and abundance data was identified as a priority.

To meet the objectives of this program APEM completed eight digital aerial surveys, equating to two surveys per season (autumn: August to October, winter: November to January, spring: February to March and summer: April to July), off the East Coast of Scotland. This is the final report describing the methodology and results of the survey program.

## **2. Survey and analysis methodologies**

### **2.1. Survey planning**

APEM's camera system was fitted into a twin-engine aircraft (Ravenair) and custom flight planning software allowed each flight line to be accurately mapped out before take-off. The use of global positioning system (GPS) linked to a bespoke flight management system ensured the survey tracks were flown with a high degree of accuracy. The aerial digital surveys captured images along ten transects spaced in a

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<sup>1</sup> Oil Sensitivity Index- <http://jncc.defra.gov.uk/page-7373>

<sup>2</sup> European Seabirds At Sea <http://seamap.env.duke.edu/dataset/427>

sawtooth pattern to achieve full coverage across the wider East Coast targeted area (hereafter known as Survey Area; Figure 1).

Data collection was on average better than two-centimetre (cm) ground sample distance (GSD) digital still images. The transect swathe was 960 meters (m), images were collected continuously (abutting digital still imagery) along the ten transects. At least 194 kilometres (km<sup>2</sup>) of sea surface area was collected representing 1.5% coverage of the wider survey area (Figure 1).

## **2.2. Image review – marking and species identification**

The data collected from the Survey Area were processed to ensure the imagery was at the optimum clarity for screening purposes. Trained APEM analysts examined each image manually, using a systematic method. Images were split into those that contain targets (such as birds, marine mammals, sharks, fish and vessels) and those that were “blank” (no targets present). Via a user interface, targets were measured (cm) and identified. Analysts were aided by an in-house Image Archive Library, which provided images of avian and marine megafauna overhead, this was used alongside bird reference lengths to allow for accurate identification. For instance, when identifying sitting birds, the relationship between pixel size and length was known, this was compared to known reference lengths from multiple sources to aid identification. For flying birds, the wingspan measurements recorded were a minimum (as the wings may not be fully stretched), however this was still useful in eliminating confusion between species. Using these tools, targets were identified to the lowest taxonomic level possible. Once identified, each target was “snagged”, which provided the following data for each target:

- Unique identification and cropped (low resolution) image;
- Time and date at which individual image was collected;
- GPS coordinate for each individual recorded, at an accuracy of +/- 1 to 5 m;
- Unique identifying numbers for each individual recorded, image number, and individual camera that captured that image;
- Details of avian target age, gender, and molt status wherever possible;
- Behavioural information observed for avian records to provide data on whether a bird was sitting on the water, flying, or diving (further information on whether an individual was part of a group or carrying food were also recorded);
- Behaviour for marine mammals were recorded for whether an individual was submerged or surfacing or nursing a juvenile;

- The orientation of birds in flight; and
- Body length (cm) of all avian and marine megafauna, wingspan (cm) of flying birds.

### **2.3. Quality control procedure**

Once each target was located and identified in the imagery, the data was exported in Excel format. Following positive identification of targets, a review process was undertaken. The review was undertaken by internal quality control (QC) managers, experienced in the identification of the target taxa. During the QC process 100% of identified species were checked for accuracy.

A random audit of 10% of images recorded as “blank” was undertaken to quantify detection success. If detection success was  $\leq 95\%$ , all data was reprocessed. This was repeated until detection success reaches  $>95\%$  to address any consistent errors and issues.

### **2.4. Species distribution maps**

Bird observations comprised individual points for each recorded individual, geo-referenced to the actual spatial location at the time of survey. Species-specific survey distribution maps were produced for each survey using QGIS.

### **2.5. Summary of aerial digital surveys**

The survey was undertaken by an APEM camera technician, and a pilot (Ravenair), surveys were only undertaken when the weather was deemed appropriate by the survey crew (**Table 1**). As well as being continually monitored during the survey, following each survey, sample imagery was evaluated to make sure it was of suitable quality for analysis. Data were then backed up on more than one secure server after each survey and prepared for analysis.

**Table 1**

Minimum weather conditions to undertake digital aerial survey (Appendix II).

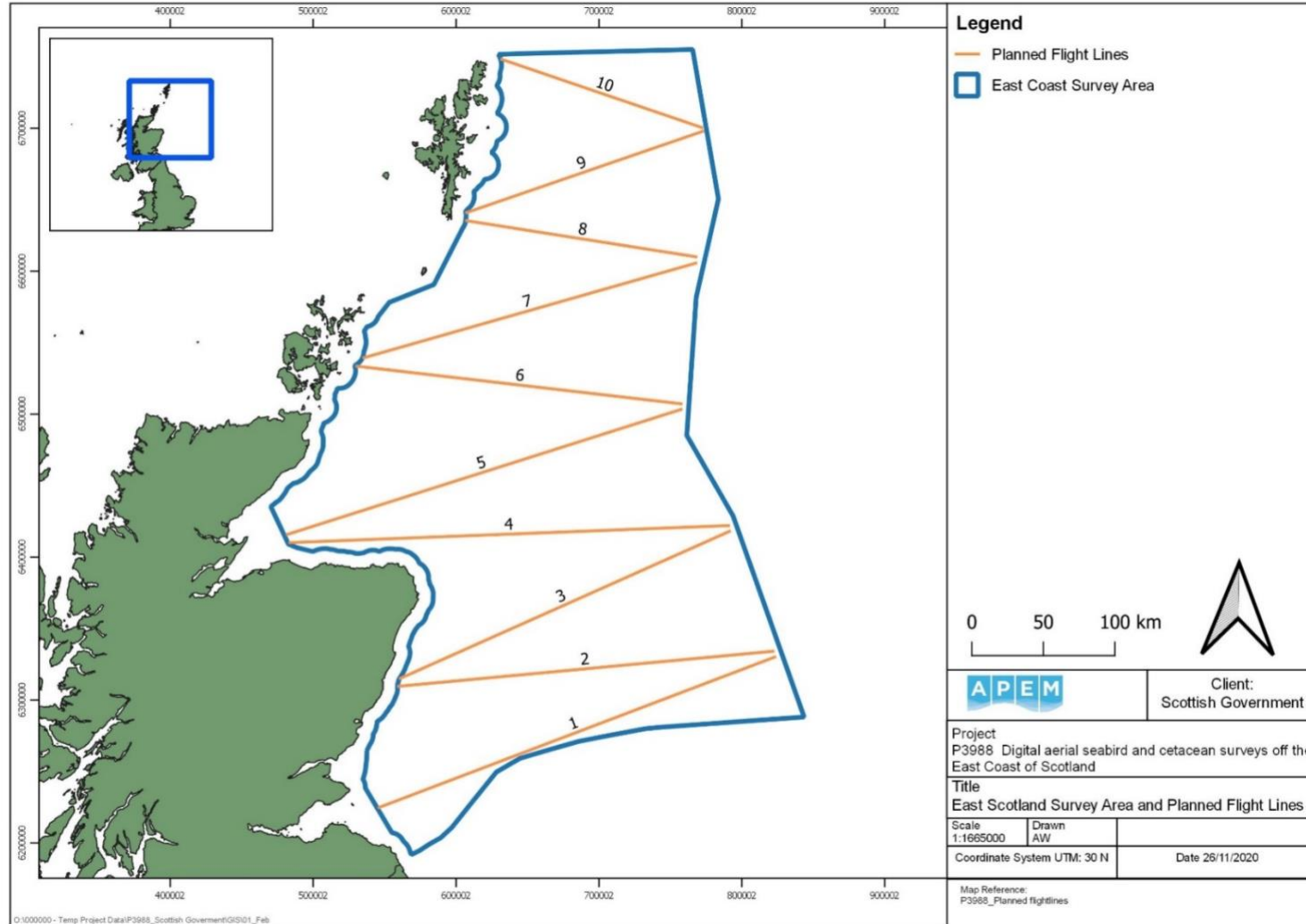
<b>Condition</b>	<b>Minimum Survey Requirement</b>
Visibility (kilometres)	>10
Cloud Cover (metres)	>549
Wind (knots)	<30
Sea State <sup>3</sup>	<4

A summary of the dates each of the eight surveys that were flown is provided in Table 2. Due to the size of the survey area, surveys were conducted over more than one day; wherever possible the transects were attempted to be flown over consecutive days and if this was not possible, e.g. due to poor weather, the survey was undertaken in the next available survey window (Figures 2-8). A summary of the weather conditions that were recorded are provided in Table 3.

No health and safety issues were reported during the surveys.

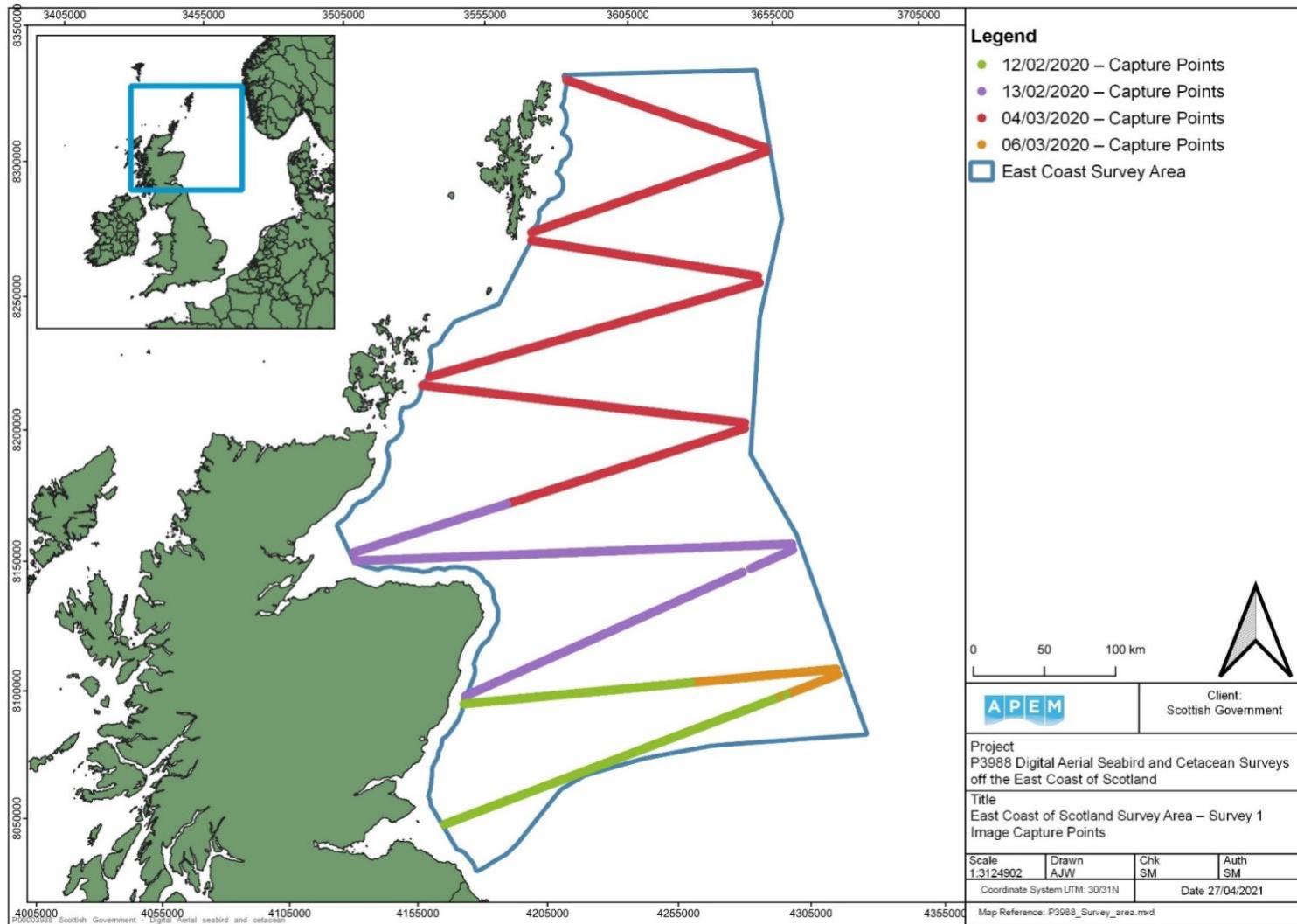
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<sup>3</sup> Beaufort Sea State – 0 = calm – flat, 1 = ripples, 2 = small wavelets, 3 = large wavelets, some white caps, 4= small waves (breaking), frequent whitecaps, 5= moderate waves of length, many whitecaps with spray.

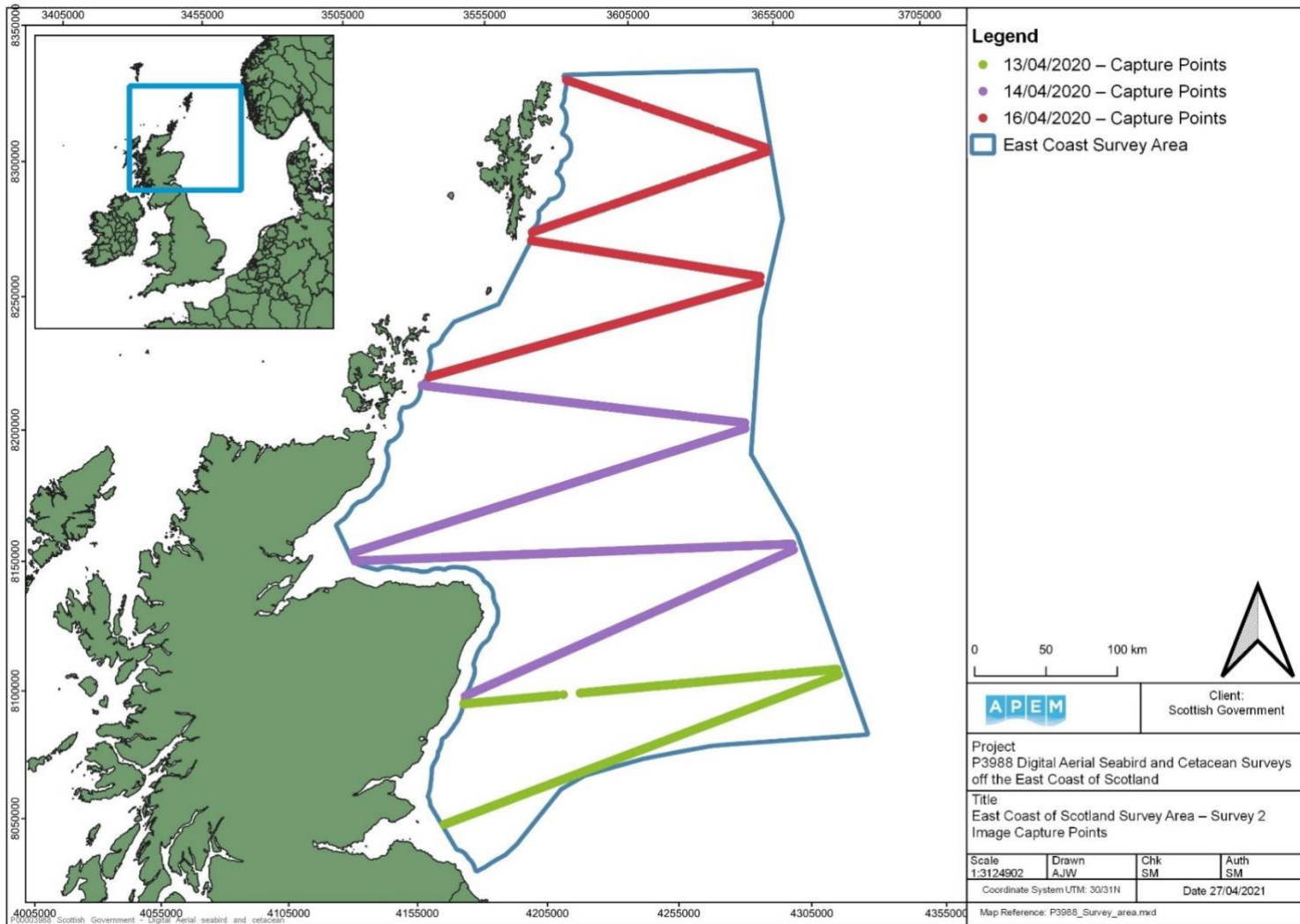


**Figure 1:** East Coast Scotland survey area with planned flight lines.

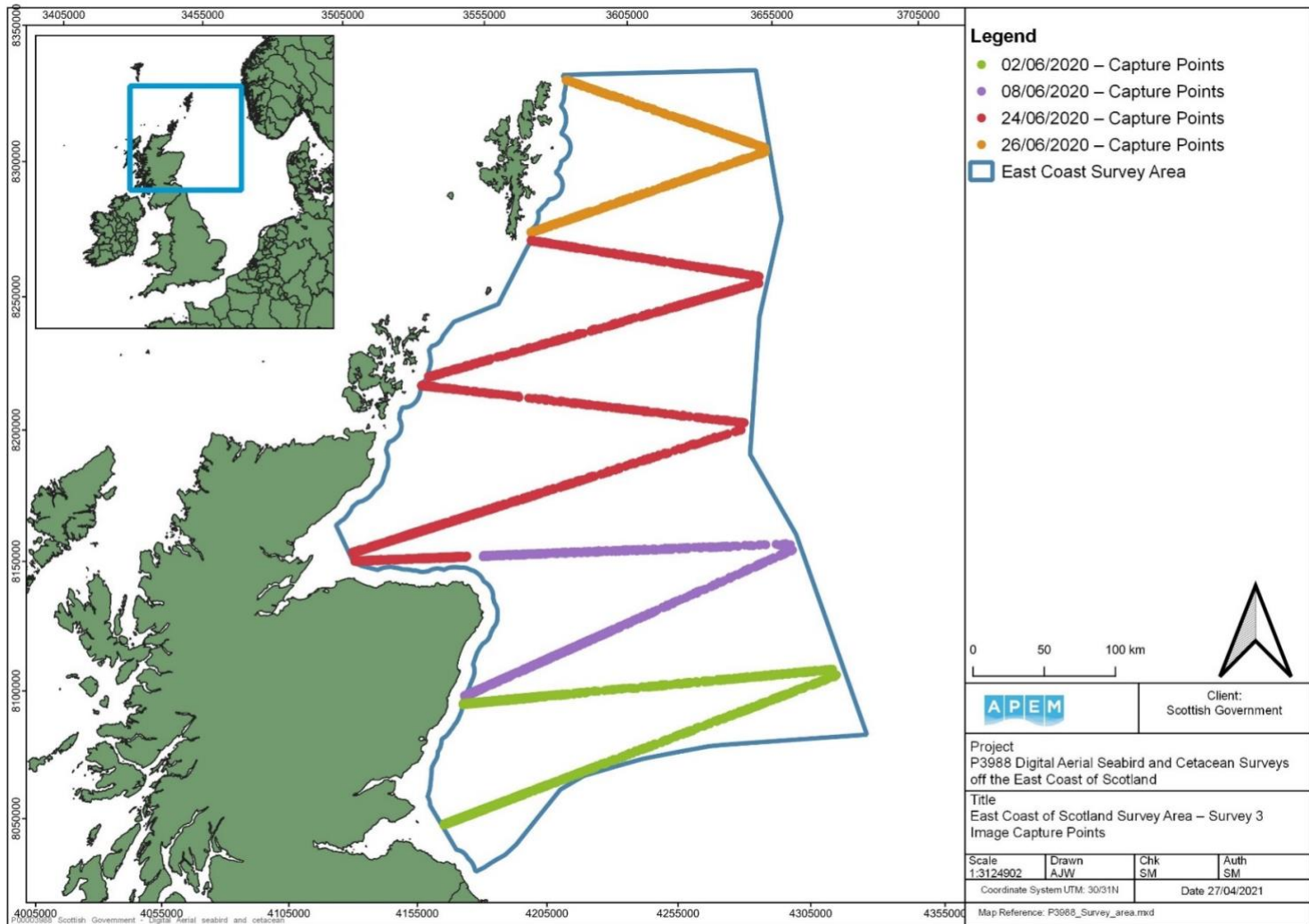




**Figure 2:** Survey 1 capture points.

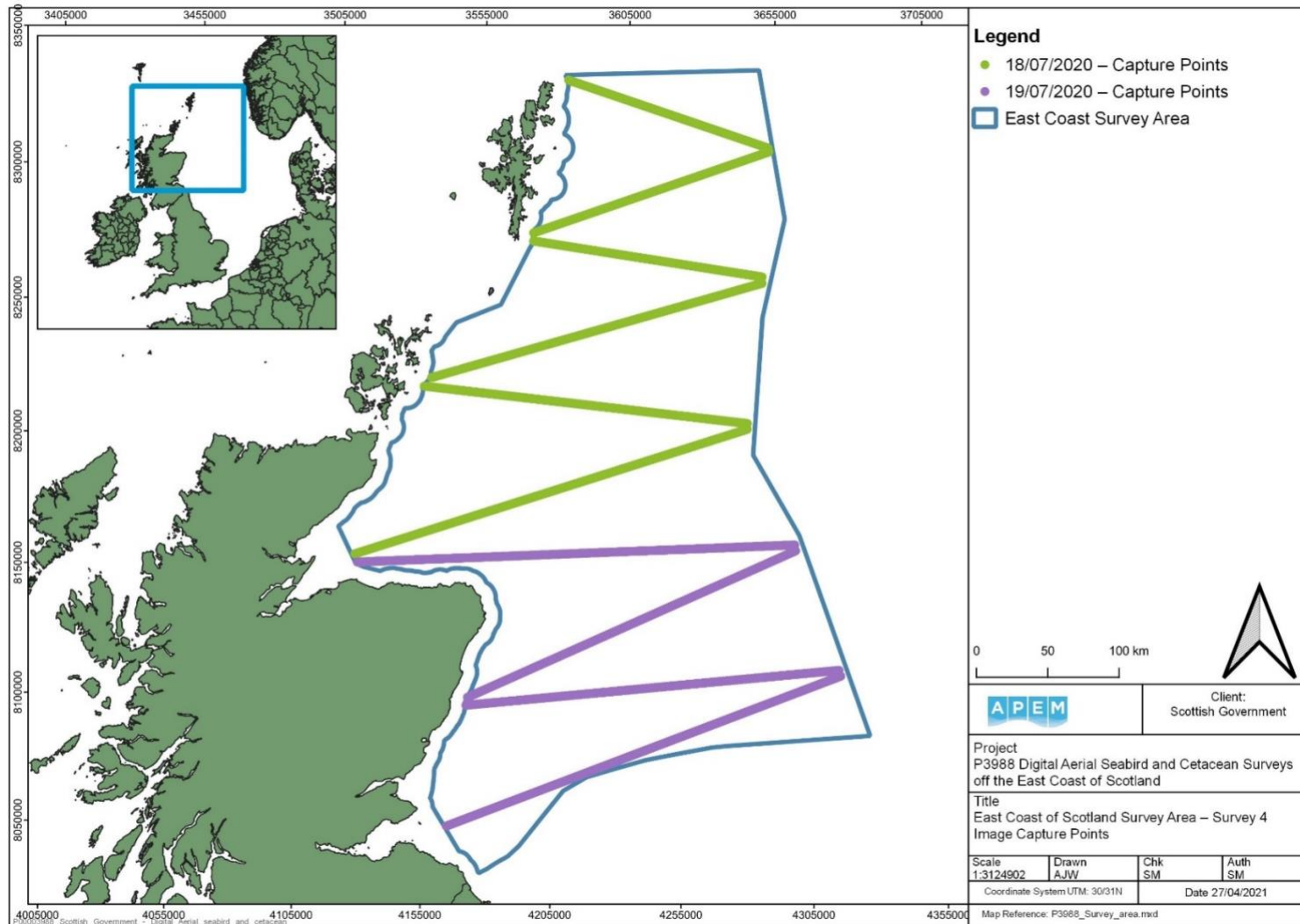


**Figure 3:** Survey 2 capture points.



**Figure 4:** Survey 3 capture points.

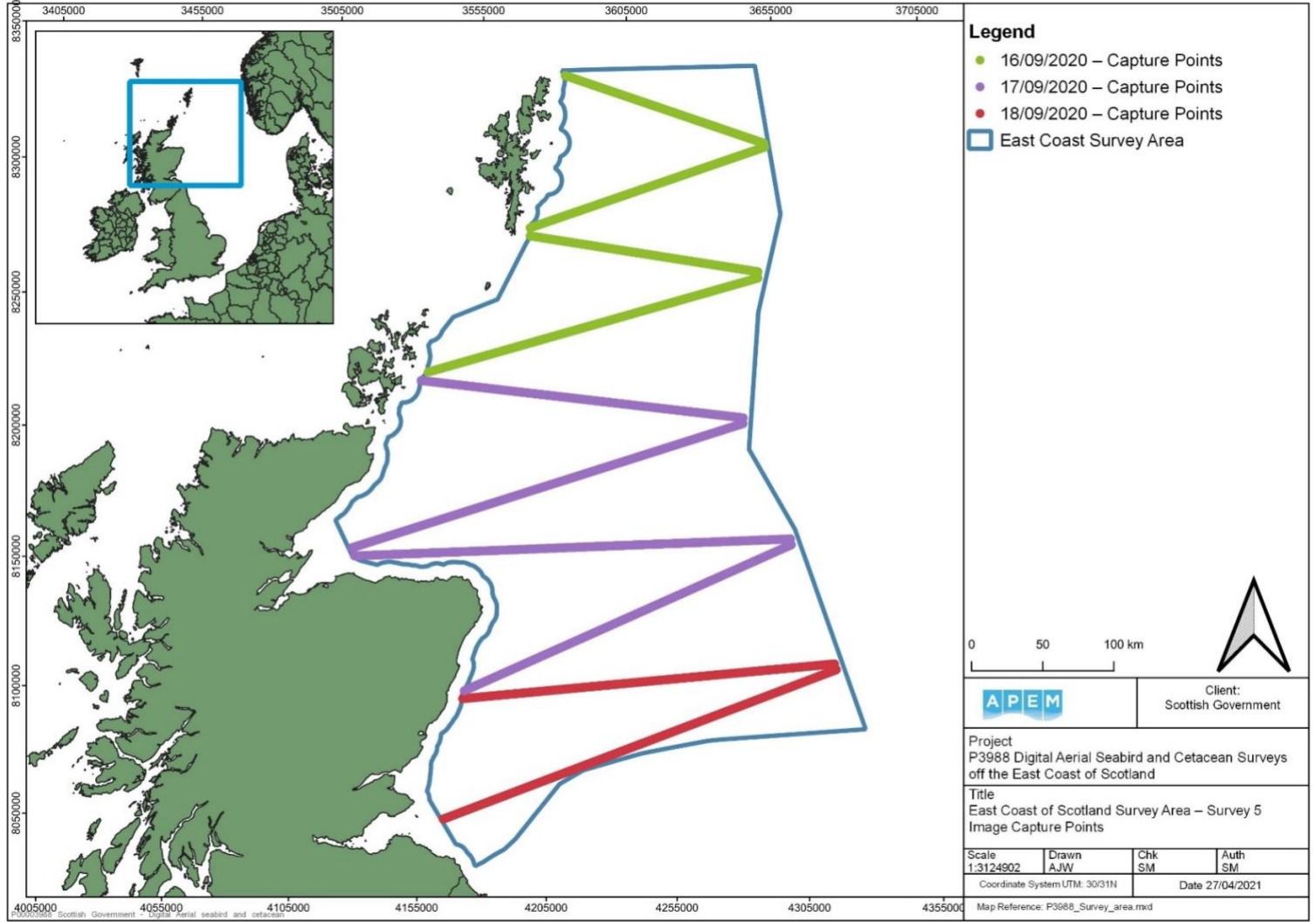
Alt text: Map showing the capture points along the East Coast of Scotland Survey Area for Survey 3.



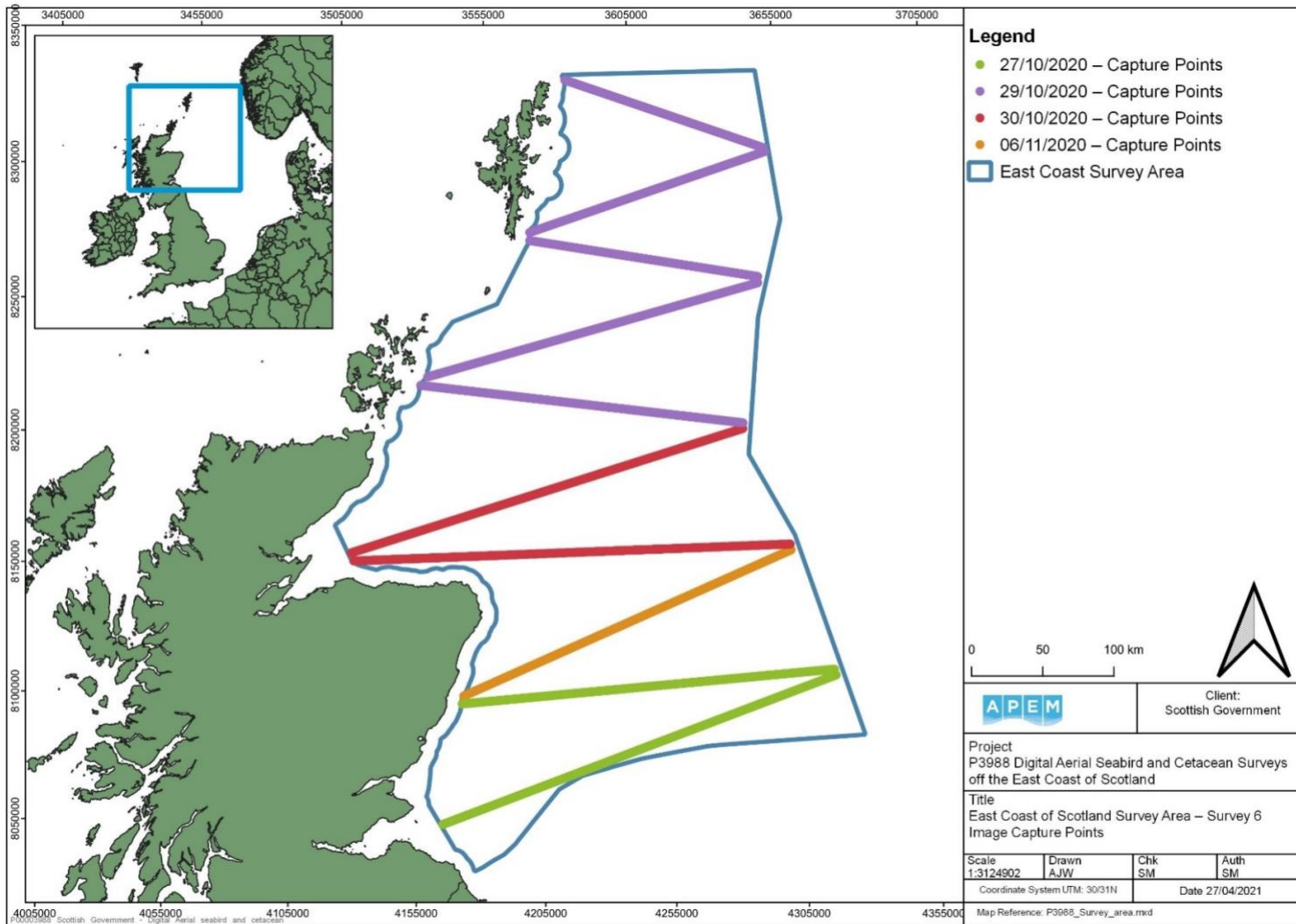
**Figure 5:** Survey 4 capture points.

Alt text: Map showing the capture points along the East Coast of Scotland Survey Area for Survey 4.

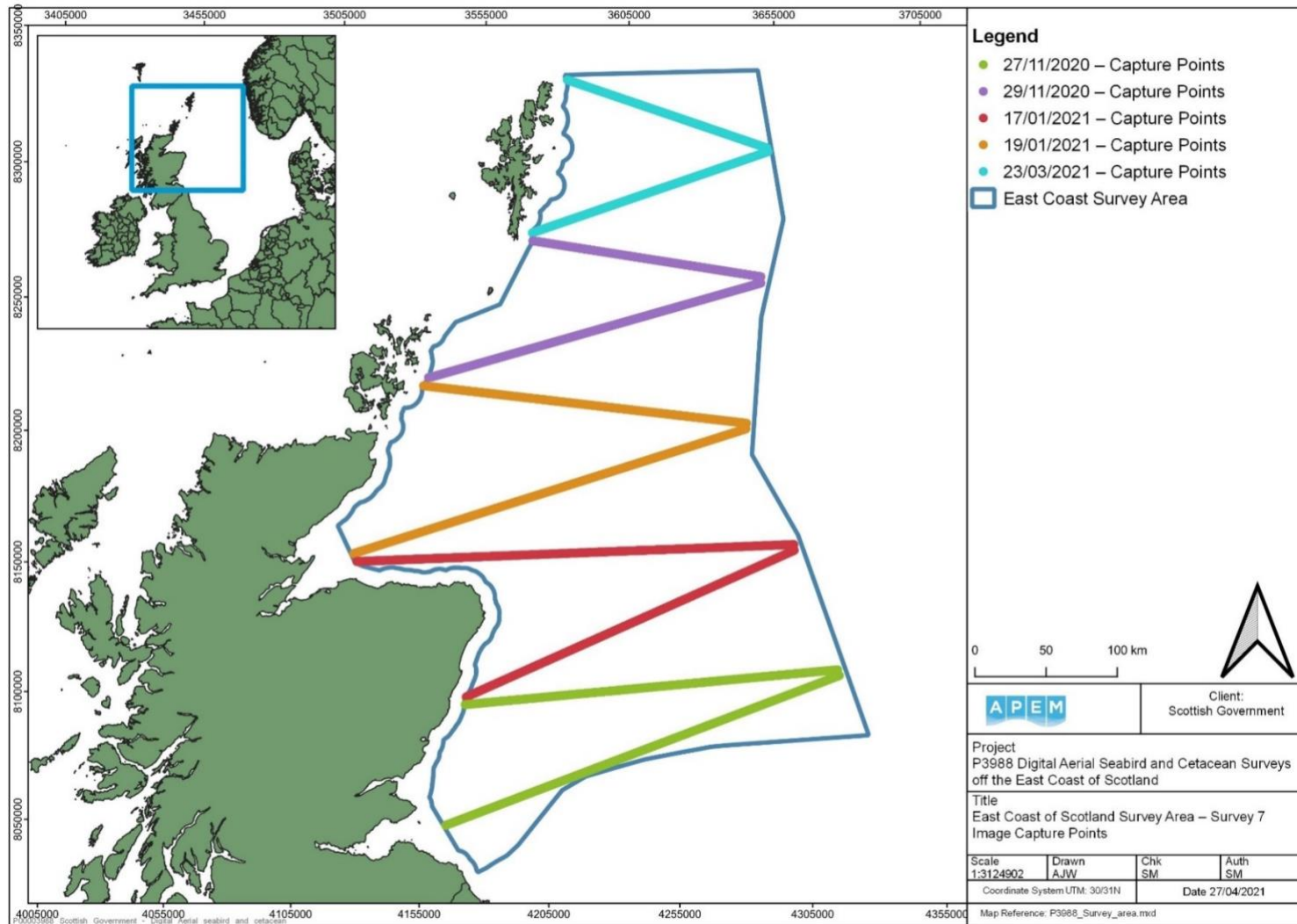




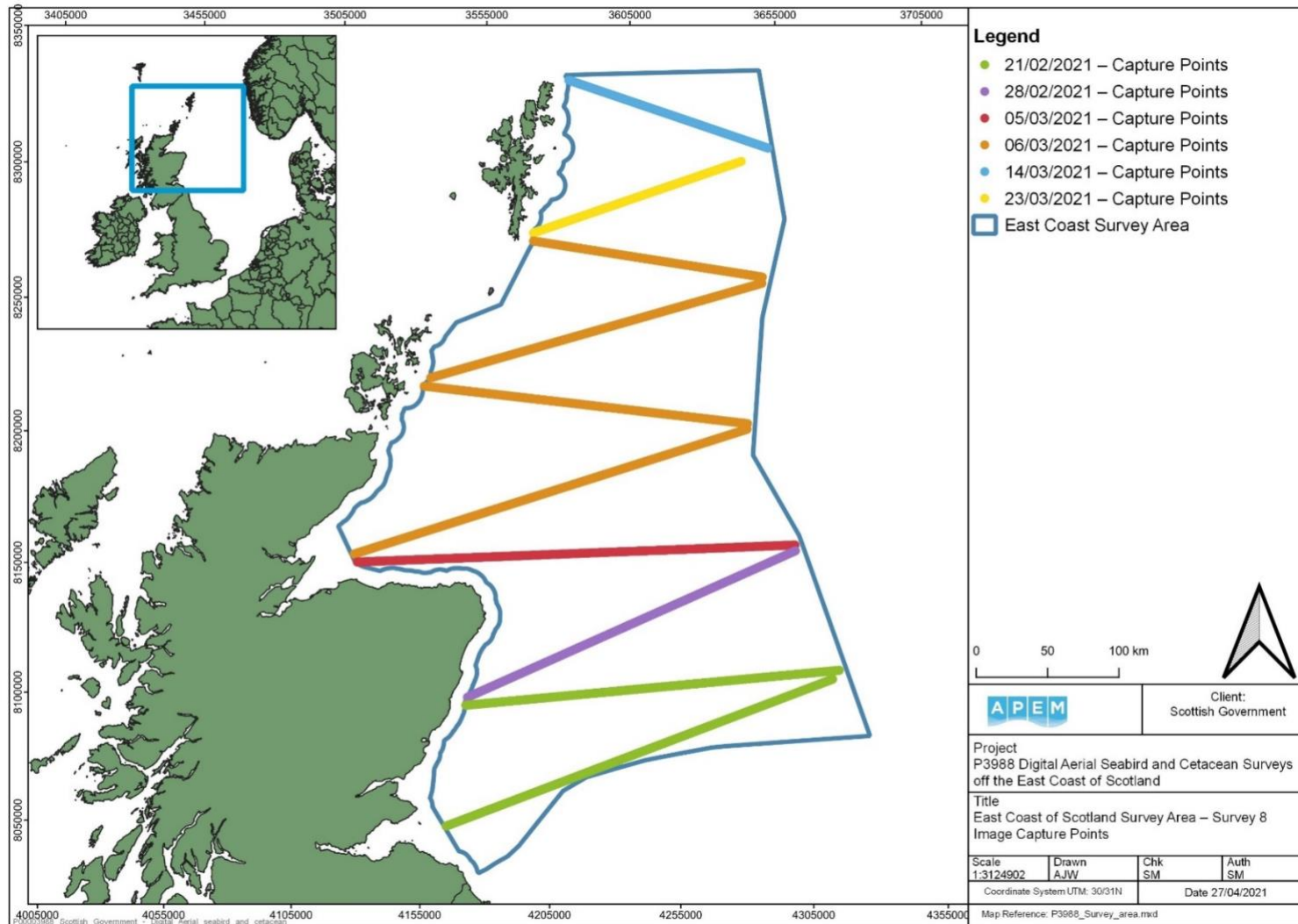
**Figure 6:** Survey 5 capture points.



**Figure 7:** Survey 6 capture points.



**Figure 8:** Survey 7 capture points.



**Figure 9:** Survey 8 capture points.



**Table 2**

Date, start and end time (Coordinated Universal Time) for each survey.

Survey	Date	UTC Start Time (HH:MM)	UTC End Time (HH:MM)
Survey 1	12/02/2020	12:57	15:34
	13/02/2020	10:40	16:10
	04/03/2020	09:37	14:53
	06/03/2020	16:58	17:38
Survey 2	13/04/2020	15:00	17:32
	14/04/2020	09:15	17:05
	16/04/2020	09:09	14:12
Survey 3	02/06/2020	08:19	10:56
	08/06/2020	14:25	16:31
	24/06/2020	08:19	13:31
	25/06/2020	10:03	11:32
Survey 4	18/07/2020	07:50	11:13
	18/07/2020	14:34	16:58
	19/07/2020	08:55	11:32
	19/07/2020	13:50	16:23
Survey 5	16/09/2020	08:10	09:58
	16/09/2020	13:15	14:40
	17/09/2020	08:37	11:01
	17/09/2020	13:31	16:06
	18/09/2020	08:21	10:54
Survey 6	27/10/2020	11:54	14:12
	29/10/2020	08:58	12:23
	29/10/2020	14:45	15:57
	30/10/2020	09:48	12:45
Survey 7	27/11/2020	10:06	12:32
	29/11/2020	11:02	12:59
	17/01/2021	12:36	15:12
	19/01/2021	12:33	15:02
	23/03/2021	10:39	11:39
	23/03/2021	15:43	16:22
Survey 8	21/02/2021	11:01	14:04
	28/02/2021	15:38	16:42
	05/03/2021	11:27	12:50
	06/03/2021	10:40	13:01
	06/03/2021	15:14	17:11
	14/03/2021	12:01	12:37
	23/03/2021	16:24	17:06

**Table 3**

Summary of weather conditions recorded for each flight.

Survey	Date	Visibility (km)	Sea State	Turbidity	Cloud Cover (%)	Air Temp (°C)	Wind Speed (knots) / Direction
Survey 1	12/02/2020	10+	4	1	73	-7 to -6	37.5 – 40 / W
	13/02/2020	10+	1	0	10	-6	10 – 15
	04/03/2020	10+	1	1	50	-6	<10
	06/03/2020	10+	1	0	50	-6	16 / W
Survey 2	13/04/2020	10+	1	0	50	0	10 / E
	14/04/2020	10+	1 – 2	0	50	1 – 4	5 – 20 / E
	16/04/2020	10+	1	0	50	4	20 / E – 10 / W
Survey 3	02/06/2020	10+	0 – 1	0	10	13 – 15	5 / E – 10 / NW
	08/06/2020	10+	0 – 1	0	10	5	9 / NW
	24/06/2020	10+	1	1	10 – 95	15 – 16	15 / SW – 30 / SE
	25/06/2020	10+	1	0	50	18	30 / SE
Survey 4	18/07/2020	10+	1 – 3	1	0	8	20 / SW
	18/07/2020	10+	2	1	0	10	24 / W
	19/07/2020	10+	2	1	0	8	20 / W
	19/07/2020	10+	1	1	0	8	10 / W
Survey 5	16/09/2020	10+	3	0	90 – 100	8	10 / E
	16/09/2020	10+	2	0	0 – 100	4	7 / W
	17/09/2020	10+	3	0	90 – 100	12	10 / W
	17/09/2020	10+	3	0	100	18	15 / W
	18/09/2020	10+	1	0	0	15	7 / W
Survey 6	27/10/2020	10+	1	2	70	7	10 / SW
	29/10/2020	10+	1	2	10 – 40	10	10 / SW
	29/10/2020	10+	1	2	50	10	17 – 20 / E
	30/10/2020	10+	2	2	30 – 40	9	10 / S

Survey	Date	Visibility (km)	Sea State	Turbidity	Cloud Cover (%)	Air Temp (°C)	Wind Speed (knots) / Direction
Survey 7	27/11/2020	10+	1	1	50 – 60	5	12 / W
	29/11/2020	10+	2	1	70 – 80	8	15 / SW
	17/01/2021	10+	3	1	50 – 70	4	15 / W
	19/01/2021	10+	2	1	50	2	15 / W
	23/03/2021	10+	3	0	100	3	35 / SW
	23/03/2021	10+	3	0	100	3	35 / SW
Survey 8	21/02/2021	10+	2	1	50 – 60	6	30 / S
	28/02/2021	10+	0	1	60	3	10 / W
	05/03/2021	10+	1 – 2	2	10	4	15 / NW
	06/03/2021	10+	1 – 2	2	70 – 100	3	20 / W
	06/03/2021	10+	1 – 2	2	60	5	18 / W
	14/03/2021	10+	2	1	100	1	28 / N
23/03/2021	10+	3	0	100	3	30 / SW	

\***Beaufort Sea State** – 0 = calm – flat, 1 = ripples, 2 = small wavelets, 3 = large wavelets, some white caps, 4= small waves (breaking), frequent whitecaps, 5= moderate waves of length, many whitecaps with spray

\*\***Turbidity** - 0 - Clear, 1 - Slightly Turbid, 2 - Moderately Turbid, 3 - Highly Turbid.

\*\*\* **Cloud Cover** - 0% - Clear, 1- 10% Few, 11- 50% Scattered, 51- 95% Broken Clear, 96-100% Overcast.

**Table 4**

Image number and coverage for each survey.

<b>Survey</b>	<b>Images</b>	<b>Km<sup>2</sup></b>	<b>Coverage (%)</b>
Survey 1	32,049	2,181	1.94
Survey 2	23,625	1,607	1.43
Survey 3	32,036	2,180	1.94
Survey 4	32,208	2,192	2.00
Survey 5	32,064	2,185	1.94
Survey 6	31,940	2,176	1.93
Survey 7	32,278	2,196	1.95
Survey 8	31,704	2,157	1.92

### 3. Distribution

Survey accounts have been provided below, which includes survey collection summary, raw count tables of avian species, raw count tables of other marine megafauna, summary of anthropological targets and distribution maps of all targets found during the survey. For more detail on species groupings see Appendix I.

#### 3.1. Survey 1 – Winter 2019/2020

Survey 1 was conducted in winter 2019/2020 over three days, transects one and two were collected over 12 February and 6 March, transects three and four on 13 February, transects five over 13 February and 4 March, and data for all remaining transects (six, seven, eight, nine and 10) were collected on 4 March (Figure 2). The total coverage collected for this survey represented 1.94% of the wider survey area.

A total of 10,282 birds were recorded in the survey area during Survey 1 (**Table 5**). The most abundant species recorded was guillemot/razorbill (n=5,720), followed by fulmar (n=1,838), kittiwake (n=794), large gull species (n=411), auk species (n=393), gannet (n=377), herring gull (n=271), small gull species (n=245), great black-backed gull (n=184), puffin (n=29), common gull (n=13), lesser black-backed gull (n=3), black-backed gull species (n=2), gull species (n=1) and razorbill (n=1).

A total of 2,123 birds (21%) were recorded in flight during this survey, these consisted of fulmar (n=967), kittiwake (n=633), gannet (n=183), guillemot/razorbill (n=127), herring gull (n=100), great black-backed gull (n=66), large gull species (n=22), common gull (n=13), small gull species (n=6), auk species (n=4), gull species (n=1), lesser black-backed gull (n=1). There were 8,154 birds (79%) recorded as sitting. There were 4 birds (<1%) recorded as diving.

**Table 5**

Raw counts of avian species recorded in Survey 1.

Species	Flying	Sitting	Diving	Total
Kittiwake	634	160	-	794
Common Gull	13	-	-	13
Small Gull sp. – unidentified	6	239	-	245
Great Black-backed Gull	66	118	-	184
Herring Gull	100	171	-	271
Lesser Black-backed Gull	1	2	-	3
Black-backed Gull sp. – unidentified	-	2	-	2
Large Gull sp. – unidentified	22	389	-	411
Gull sp. - unidentified	1	-	-	1
Razorbill	-	1	-	1
Guillemot / Razorbill	127	5,589	4	5,720
Puffin	-	29	-	29
Auk sp. – unidentified	4	389	-	393
Fulmar	967	871	-	1,838
Gannet	183	194	-	377
<b>Total</b>	<b>2,124</b>	<b>8,154</b>	<b>4</b>	<b>10,282</b>

A total of 96 marine mammals were recorded in the survey area during Survey 1 (**Table 6**), these were recorded as dolphin/porpoise (n=51), dolphin species (n=27), grey seal (n=6), common dolphin (n=5), phocids (n=3), white-beaked dolphin (n=3) and common minke whale (n=1).

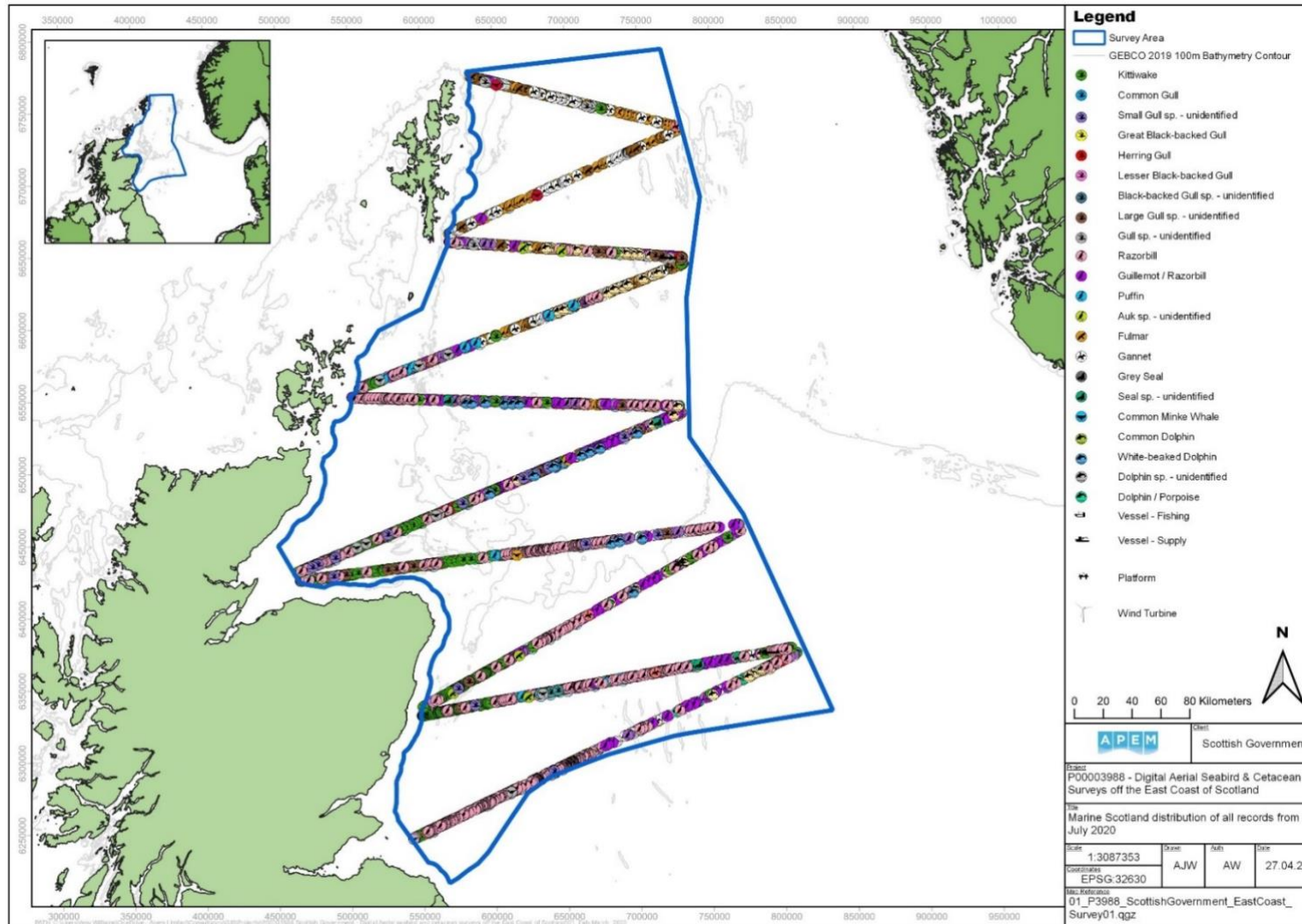
**Table 6**

Raw counts of marine megafauna species recorded in Survey 1.

Species	Submerged	Surfacing	Total
Grey Seal	2	4	6
Seal sp. – unidentified	1	2	3
Common Minke Whale	1	-	1
Common Dolphin	4	1	5
White-beaked Dolphin	1	2	3
Dolphin sp. – unidentified	22	5	27
Dolphin / Porpoise	35	16	51
<b>Total marine mammals</b>	<b>66</b>	<b>30</b>	<b>96</b>

A total of eight anthropogenic objects were recorded in the survey area during Survey 1, these were recorded as platform (n=4), fishing vessel (n=2), supply vessel (n=1) and wind turbine (n=1).

shows the location of all birds and marine megafauna recorded throughout the survey area during Winter 2019 / 2020 (Survey 1).



**Figure Note:** Individuals may appear to overlap if they are in close proximity to each other.  
**Figure 10:** Distribution of avian fauna, marine megafauna and human artefacts recorded in Survey 1.



### 3.2. Survey 2 – Spring 2020

Survey 2 was conducted over three days and all flight lines were successfully completed. Data for transects one and two were collected on 13 April, transects three, four, five and six on 14 April, and transects seven, eight, nine and ten on 16 April (Figure 3). The total coverage collected for this survey represented 1.43% of the wider survey area, this lower than expected due to a camera malfunction.

A total of 9,606 birds were recorded in the survey area during Survey 2 (**Table 7**). The most abundant species recorded was guillemot / razorbill (n=4,230), followed by kittiwake (n=1,356), fulmar (n=1,300), razorbill (n=1,043), gannet (n=720), guillemot (n=701), auk species (n=87), puffin (n=74), small gull species (n=31), great black-backed gull (n=21), large gull species (n=21), herring gull (n=14), common gull (n=2), gull species (n=2), black guillemot (n=1), great northern diver (n=1), great skua (n=1) and lesser black-backed gull (n=1).

A total of 2,720 birds (28%) were recorded in flight during this survey, these consisted of kittiwake (n=1,068), fulmar (n=996), gannet (n=505), guillemot (n=67), guillemot / razorbill (n=60), small gull species (n=7), auk species (n=5), great black-backed gull (n=3), common gull (n=2), herring gull (n=2), large gull species (n=2), great skua (n=1), gull species (n=1) and razorbill (n=1). There were 6,886 birds (72%) recorded as sitting.

**Table 7**

Raw counts of avian species recorded in Survey 2.

<b>Species</b>	<b>Flying</b>	<b>Sitting</b>	<b>Total</b>
Kittiwake	1,068	288	1,356
Common Gull	2	-	2
Small Gull sp. – unidentified	7	24	31
Great Black-backed Gull	3	18	21
Herring Gull	2	12	14
Lesser Black-backed Gull	-	1	1
Large Gull sp. – unidentified	2	19	21
Gull sp. – unidentified	1	1	2
Great Skua	1	-	1
Guillemot	67	634	701
Razorbill	1	1,042	1,043
Guillemot / Razorbill	60	4,170	4,230
Black Guillemot	-	1	1
Puffin	-	74	74
Auk sp. – unidentified	5	82	87
Great Northern Diver	-	1	1
Fulmar	996	304	1,300
Gannet	505	215	720
<b>Total</b>	<b>2,720</b>	<b>6,886</b>	<b>9,606</b>

A total of 22 marine mammals were recorded in the survey area during Survey 2 (**Table 8**), these were recorded as dolphin / porpoise (n=13), common minke whale (n=3), phocids (n=3), dolphin species (n=2) and grey seal (n=1).

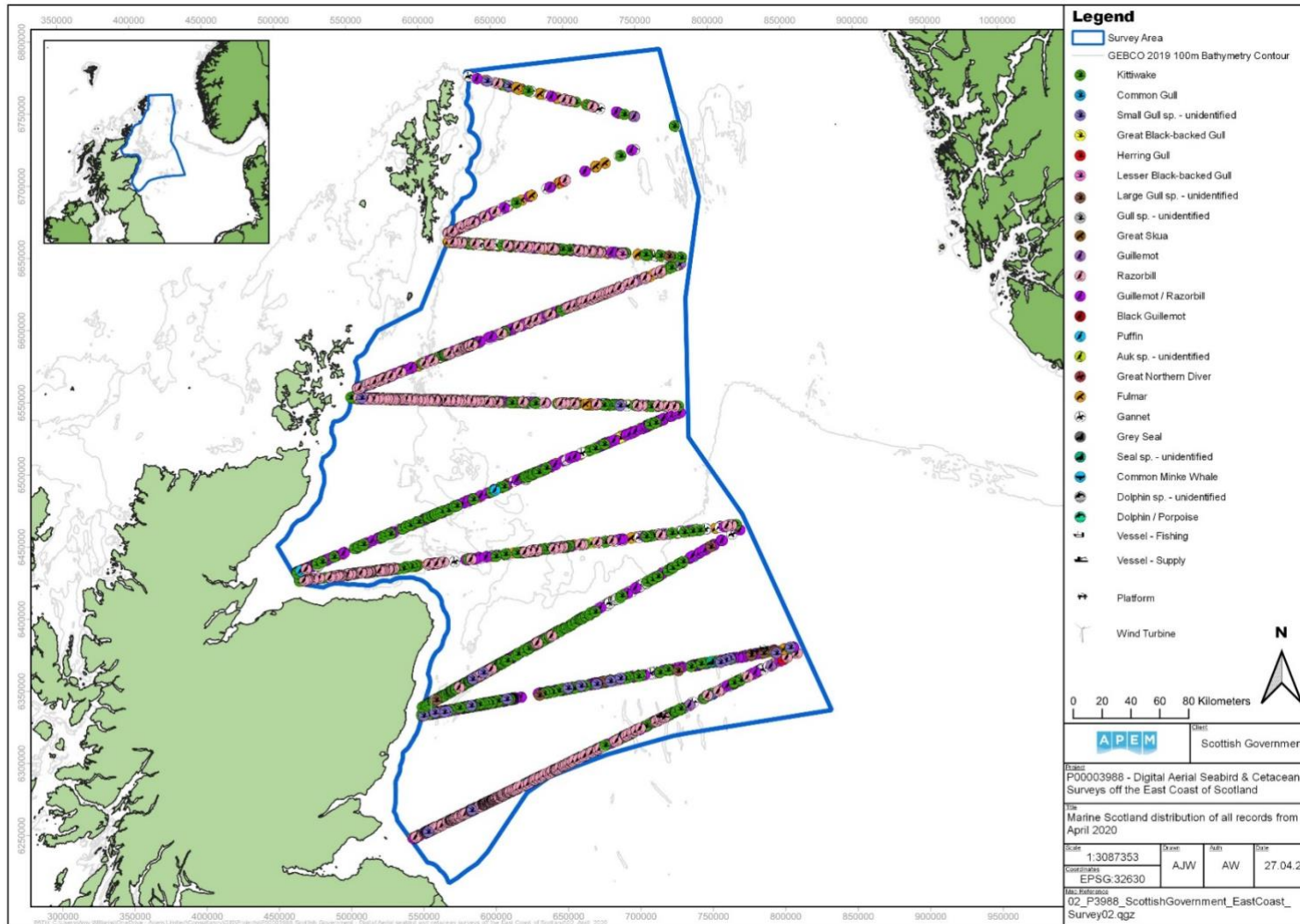
**Table 8**

Raw counts of marine megafauna species recorded in Survey 2.

<b>Species</b>	<b>Submerged</b>	<b>Surfacing</b>	<b>Total</b>
Grey Seal	1	-	1
Seal sp. – unidentified	2	1	3
Common Minke Whale	3	-	3
Dolphin sp. – unidentified	2	-	2
Dolphin / Porpoise	7	6	13
<b>Total marine mammals</b>	<b>15</b>	<b>7</b>	<b>22</b>

A total of five anthropogenic objects were recorded in the survey area during Survey 2, these were recorded as platform (n=2), fishing vessel (n=1), supply vessel (n=1) and wind turbine (n=1).

Figure 11 shows the location of all birds and marine megafauna recorded throughout the survey area during Spring 2020 (Survey 2).



**Figure 11:** Distribution of avian fauna, marine megafauna and human artefacts recorded in Survey 2.

**Figure Note:** Individuals may appear to overlap if they are in close proximity to each other.

### 3.3. Survey 3 – Summer I 2020

Survey 3 was conducted over four days and all flight lines were successfully completed. Data for transects one and two were collected on 2 June, transect three on 8 June, transect four over 8 June and 24 June, transect five, six, seven and eight on 24 June, and transects nine and ten on 26 June (Figure 4). The total coverage collected for this survey represented 1.94% of the wider survey area.

A total of 18,141 birds were recorded in the survey area during Survey 3 (**Table 9**). The most abundant species recorded was guillemot (n=4,371), followed by kittiwake (n=3,718), razorbill (n=2,843), guillemot / razorbill (n=2,370), fulmar (n=2,056), gannet (n=1,773), herring gull (n=301), auk species (n=254), puffin (n=251), small gull species (n=59), large gull species (n=44), great skua (n=28), lesser black-backed gull (n=17), 'commic' tern (n=13), gull species (n=7), black guillemot (n=6), curlew (n=5), great black-backed gull (n=4), storm petrel (n=4), Arctic skua (n=3), Manx shearwater (n=3), black-backed gull species (n=2), common tern (n=2), tern species (n=2), cormorant / shag (n=1), great northern diver (n=1), red-throated diver (n=1), skua species (n=1) and unidentified bird species (n=1).

A total of 4,720 birds (26%) were recorded in flight during this survey, these consisted of kittiwake (n=2,067), fulmar (n=909), gannet (n=909), guillemot (n=406), herring gull (n=174), razorbill (n=106), guillemot / razorbill (n=65), great skua (n=26), auk species (n=16), 'commic' tern (n=13), puffin (n=6), curlew (n=5), lesser black-backed gull (n=4), Arctic skua (n=3), large gull species (n=3), Manx shearwater (n=3), common tern (n=2), tern species (n=2) and great black-backed gull (n=1). There were 13,417 birds (74%) recorded as sitting. There were three birds (<1%) recorded as diving, and one bird (<1%) recorded as perched.

**Table 9**

Raw counts of avian species recorded in Survey 3.

Species	Flying	Sitting	Diving	Perched	Total
Curlew	5	-	-	-	5
Kittiwake	2,067	1,651	-	-	3,718
Small Gull sp. – unidentified	-	59	-	-	59
Great Black-backed Gull	1	3	-	-	4
Herring Gull	174	127	-	-	301
Lesser Black-backed Gull	4	13	-	-	17
Black-backed Gull sp. – unidentified	-	2	-	-	2
Large Gull sp. – unidentified	3	40	-	1	44
Gull sp. – unidentified	-	7	-	-	7
Common Tern	2	-	-	-	2
'Commic' Tern	13	-	-	-	13
Tern sp. – unidentified	2	-	-	-	2
Great Skua	26	2	-	-	28
Arctic Skua	3	-	-	-	3
Skua sp. – unidentified	-	1	-	-	1
Guillemot	406	3,964	1	-	4,371
Razorbill	106	2,737	-	-	2,843
Guillemot / Razorbill	65	2,304	1	-	2,370
Black Guillemot	-	6	-	-	6
Puffin	6	245	-	-	251
Auk sp. – unidentified	16	238	-	-	254
Red-throated Diver	-	1	-	-	1
Great Northern Diver	-	1	-	-	1
Storm Petrel sp. – unidentified	-	4	-	-	4
Fulmar	909	1,147	-	-	2,056
Manx Shearwater	3	-	-	-	3
Gannet	909	863	1	-	1,773
Cormorant / Shag	-	1	-	-	1
Bird sp. – unidentified	-	1	-	-	1
<b>Total</b>	<b>4,720</b>	<b>13,417</b>	<b>3</b>	<b>1</b>	<b>18,141</b>

A total of 517 marine mammals were recorded in the survey area during Survey 3 (**Table 10**), these were recorded as dolphin/porpoise (n=249), harbour porpoise (n=128), marine mammal species (n=29), phocids (n=29), dolphin species (n=24), common dolphin (n=22), common minke whale (n=12), grey seal (n=11), white-beaked dolphin (n=10) and whale species (n=3).

A total of one other marine species was recorded in the survey area during Survey 3 (**Table 10**), this was recorded as shark species (n=1).

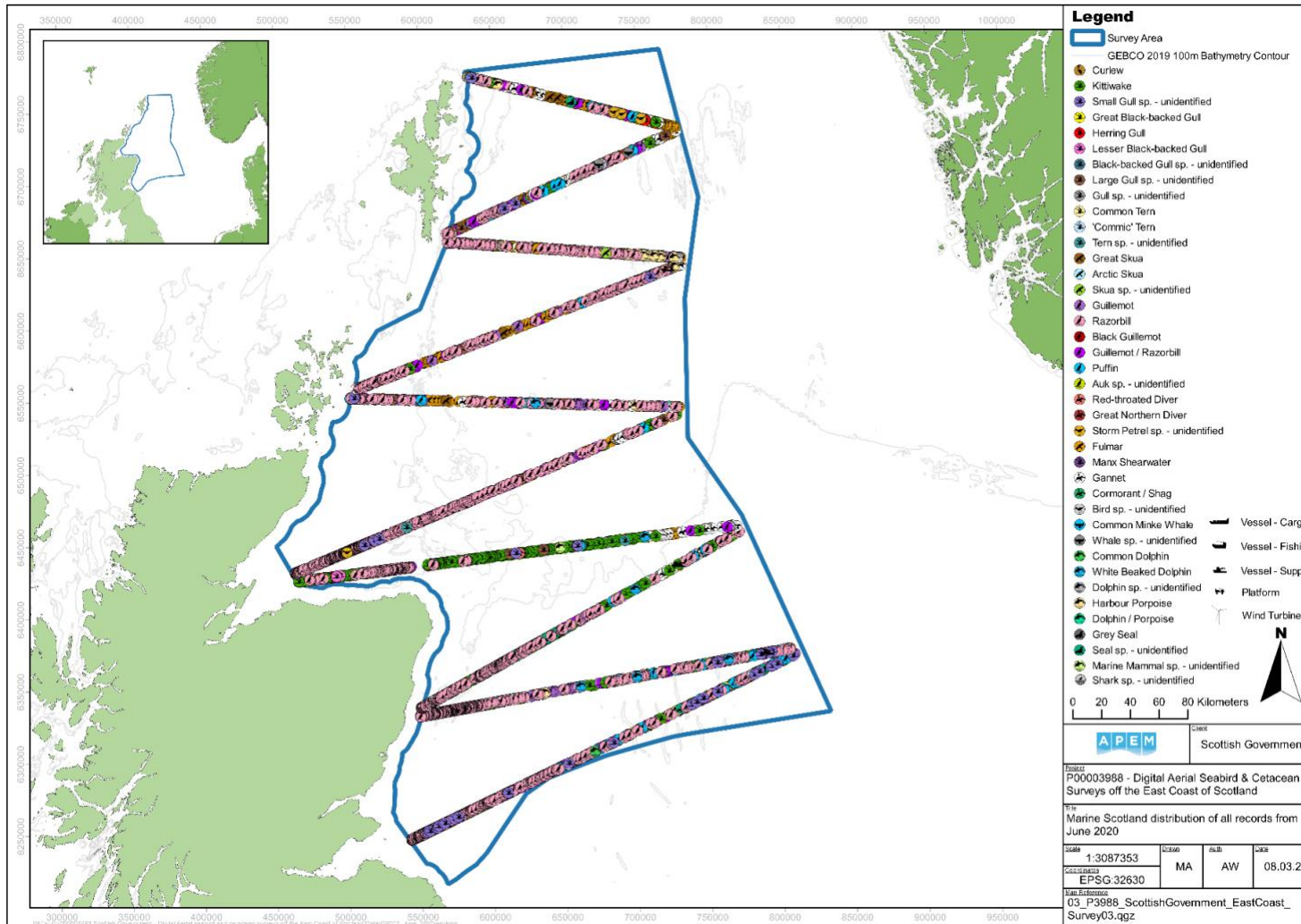
**Table 10**

Raw counts of marine megafauna species recorded in Survey 3.

<b>Species</b>	<b>Submerged</b>	<b>Surfacing</b>	<b>Total</b>
Grey Seal	10	1	11
Seal sp. – unidentified	25	4	29
Common Minke Whale	11	1	12
Whale sp. – unidentified	3	-	3
White-beaked Dolphin	8	2	10
Common Dolphin	20	2	22
Dolphin sp. – unidentified	19	5	24
Dolphin / Porpoise	228	21	249
Harbour Porpoise	108	20	128
Marine Mammal sp. – unidentified	28	1	29
<b>Total marine mammals</b>	<b>460</b>	<b>57</b>	<b>517</b>
Shark sp. – unidentified	1	-	1
<b>Total other marine megafauna</b>	<b>1</b>	<b>-</b>	<b>1</b>

A total of 18 anthropogenic objects were recorded in the survey area during Survey 3, these were recorded as fishing vessel (n=7), platform (n=5), supply vessel (n=3), cargo ship (n=2) and wind turbine (n=1).

Figure 12 shows the location of all birds and marine megafauna recorded throughout the survey area during Summer survey I (Survey 3).



**Figure 12:** Distribution of avian fauna, marine megafauna and human artefacts recorded in Survey 3.  
**Figure Note:** Individuals may appear to overlap if they are in close proximity to each other.

### 3.4. Survey 4 – Summer II 2020

Survey 4 was conducted over two days and all flight lines were successfully completed. Data for transects five, six, seven, eight nine and 10 were collected on 18 July and transects one, two, three and four on 19 July (Figure 5). The total coverage collected for this survey represented 2% of the wider survey area.

A total of 14,284 birds were recorded in the survey area during Survey 4 (**Table 11**). The most abundant species recorded was fulmar (n=2,906), followed by kittiwake (n=2,802), guillemot (n=2,713), guillemot / razorbill (n=1,694), gannet (n=1,582), razorbill (n=1,397), 'commic' tern (n=384), auk species (n=243), herring gull (n=148), wader species (n=87), large gull species (n=67), puffin (n=65), small gull species (n=40), great skua (n=33), tern species (n=31), redshank (n=28), gull species (n=17), great black-backed gull (n=11), lesser black-backed gull (n=10), Manx shearwater (n=9), skua species (n=5), common gull (n=3), red-throated diver (n=3), diver species (n=2), storm petrel species (n=2), Arctic skua (n=1) and black-backed gull species (n=1).

A total of 4,584 birds (32%) were recorded in flight during this survey, these consisted of fulmar (n=1,841), kittiwake (n=1,159), gannet (n=973), 'commic' tern (n=255), wader species (n=87), guillemot (n=57), herring gull (n=54), great skua (n=31), redshank (n=28), razorbill (n=25), guillemot / razorbill (n=21), auk species (n=9), Manx shearwater (n=9), great black-backed gull (n=7), lesser black-backed gull (n=7), small gull species (n=6), puffin (n=5), large gull species (n=4), common gull (n=3), Arctic skua (n=1), gull species (n=1) and skua species (n=1). There were 9,696 birds (68%) recorded as sitting. There were four birds (<1%) recorded as diving.



**Table 11**

Raw counts of avian species recorded in Survey 4.

<b>Species</b>	<b>Flying</b>	<b>Sitting</b>	<b>Diving</b>	<b>Total</b>
Redshank	28	-	-	28
Wader sp. – unidentified	87	-	-	87
Kittiwake	1,159	1,643	-	2,802
Common Gull	3	-	-	3
Small Gull sp. – unidentified	6	34	-	40
Great Black-backed Gull	7	4	-	11
Herring Gull	54	94	-	148
Lesser Black-backed Gull	7	30	-	10
Black-backed Gull sp. – unidentified	-	1	-	1
Large Gull sp. – unidentified	4	63	-	67
Gull sp. – unidentified	1	16	-	17
'Commic' Tern	255	129	-	384
Tern sp. – unidentified	-	31	-	31
Great Skua	31	2	-	33
Arctic Skua	1	-	-	1
Skua sp. – unidentified	1	4	-	5
Guillemot	57	2,656	-	2,713
Razorbill	25	1,371	1	1,397
Guillemot / Razorbill	21	1,673	-	1,694
Puffin	5	60	-	65
Auk sp. – unidentified	9	233	1	243
Red-throated Diver	-	3	-	3
Diver sp. – unidentified	-	2	-	2
Storm Petrel sp. – unidentified	-	2	-	2
Fulmar	1,841	1,065	-	2,906
Manx Shearwater	9	-	-	9
Gannet	973	607	2	1,582
<b>Total</b>	<b>4,584</b>	<b>9,696</b>	<b>4</b>	<b>14,284</b>

A total of 660 marine mammals were recorded in the survey area during Survey 4 (**Table 12**), these were recorded as dolphin / porpoise (n=293), harbour porpoise (n=250), white-beaked dolphin (n=71), dolphin species (n=17), seal species (n=16), grey seal (n=7), common minke whale (n=3) and marine mammal species (n=3).

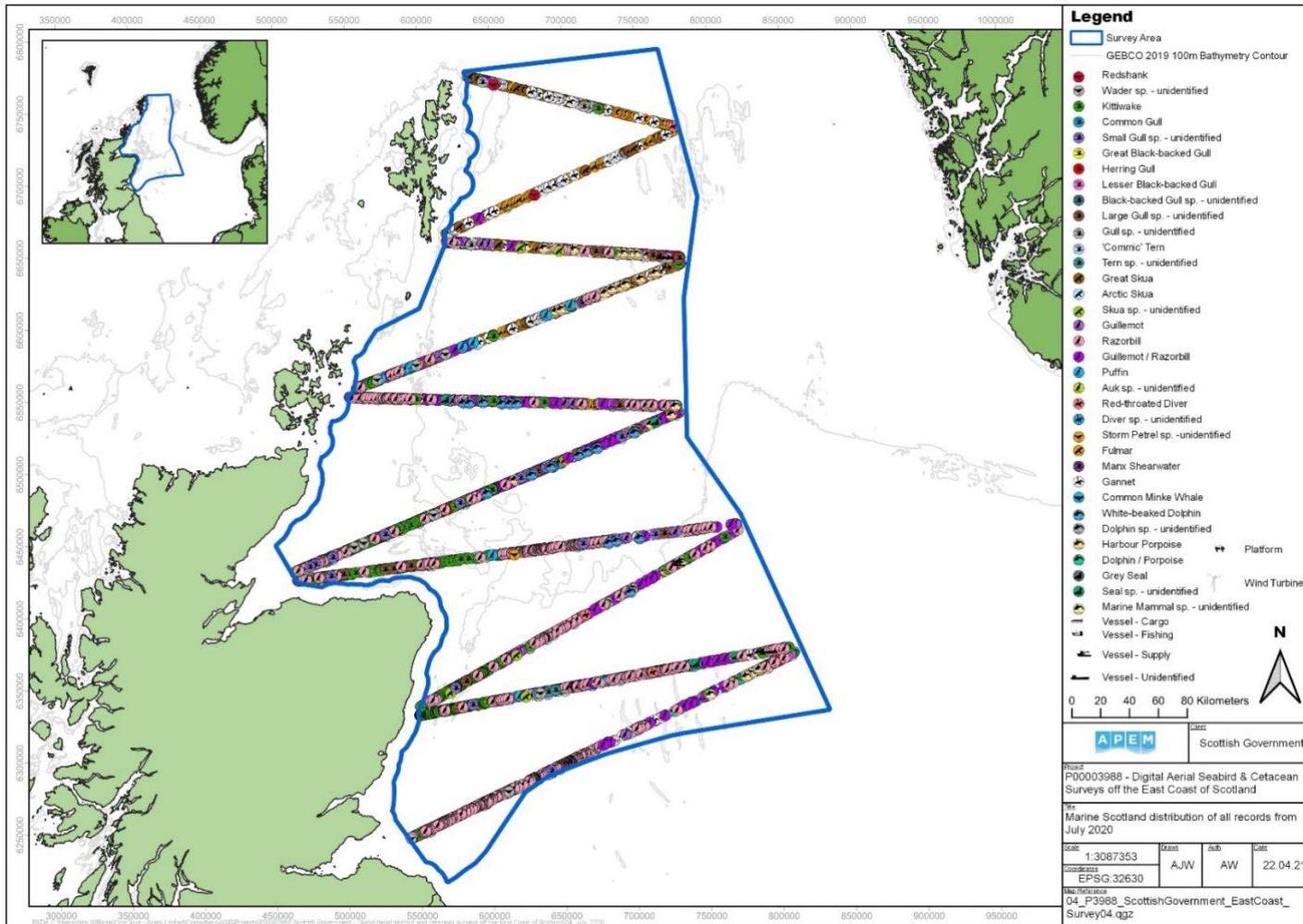
**Table 12**

Raw counts of marine megafauna species recorded in Survey 4.

<b>Species</b>	<b>Submerged</b>	<b>Surfacing</b>	<b>Total</b>
Grey Seal	5	2	7
Seal sp. – unidentified	11	5	16
Common Minke Whale	1	2	3
White-beaked Dolphin	60	11	71
Dolphin sp. – unidentified	15	2	17
Harbour Porpoise	223	27	250
Dolphin / Porpoise	265	28	293
Marine Mammal sp. - unidentified	3	-	3
<b>Total marine mammals</b>	<b>583</b>	<b>77</b>	<b>660</b>

A total of 13 anthropogenic objects were recorded in the survey area during Survey 4, these were recorded as platform (n=4), fishing vessel (n=3), supply vessel (n=2), unidentified vessel (n=2), cargo ship (n=1) and wind turbine (n=1).

Figure 13 shows the location of all birds and marine megafauna recorded throughout the survey area during Summer survey II (Survey 4).



**Figure 13:** Distribution of avian fauna, marine megafauna and human artefacts recorded in Survey 4.  
**Figure Note:** Individuals may appear to overlap if they are in close proximity to each other.

### 3.5. Survey 5 – Autumn I 2020

Survey 5 was conducted over three days and all flight lines were successfully completed. Data for transects seven, eight, nine and ten were collected on 16 September, transects three, four, five and six on 17 September, and transects one and two on 18 September (Figure 6). The total coverage collected for this survey represented 1.94% of the wider survey area.

A total of 64,034 birds were recorded in the survey area during Survey 5 (**Table 13**). The most abundant species recorded was guillemot/razorbill (n=38,482), followed by kittiwake (n=9,178), fulmar (n=8,003), guillemot (n=3,311), gannet (n=3,012), razorbill (n=996), auk species (n=365), great black-backed gull (n=223), large gull species (n=170), small gull species (n=119), black-backed gull species (n=31), great skua (n=31), Manx shearwater (n=22), herring gull (n=20), gull species (n=18), puffin (n=12), red-throated diver (n=11), common gull (n=8), diver species (n=7), skua species (n=7), 'commic' tern (n=3), Arctic skua (n=2), common eider (n=1), great northern diver (n=1) and shearwater species (n=1).

A total of 7,947 birds (12%) were recorded in flight during this survey, these consisted of kittiwake (n=3,883), fulmar (n=2,186), gannet (n=1,518), guillemot/razorbill (n=131), great black-backed gull (n=69), large gull species (n=40), great skua (n=31), Manx shearwater (n=22), black-backed gull species (n=19), herring gull (n=16), common gull (n=6), razorbill (n=6), small gull species (n=3), 'commic' tern (n=3), guillemot (n=3), auk species (n=3), Arctic skua (n=2), puffin (n=2), skua species (n=2), red-throated diver (n=1) and diver species (n=1). There were 56,063 birds (88%) recorded as sitting and 24 birds recorded as diving.

**Table 13**

Raw counts of avian species recorded in Survey 5.

Species	Flying	Sitting	Diving	Total
Common Eider	-	1	-	1
Kittiwake	3,883	5,295	-	9,178
Common Gull	6	2	-	8
Small Gull sp. - unidentified	3	116	-	119
Great Black-backed Gull	69	154	-	223
Herring Gull	16	4	-	20
Black-backed Gull sp. - unidentified	19	12	-	31
Large Gull sp. - unidentified	40	130	-	170
Gull sp. - unidentified	-	18	-	18
'Commic' Tern	3	-	-	3
Great Skua	31	-	-	31
Arctic Skua	2	-	-	2
Skua sp. - unidentified	2	5	-	7
Guillemot	3	3,308	-	3,311
Razorbill	6	990	-	996
Guillemot / Razorbill	131	38,350	1	38,482
Puffin	2	10	-	12
Auk sp. - unidentified	3	362	-	365
Red-throated Diver	1	10	-	11
Great Northern Diver	-	1	-	1
Diver sp. - unidentified	1	6	-	7
Fulmar	2,186	5,817	-	8,003
Manx Shearwater	22	-	-	22
Shearwater sp. - unidentified	-	1	-	1
Gannet	1,518	1,471	23	3,012
<b>Total</b>	<b>7,947</b>	<b>56,063</b>	<b>24</b>	<b>64,034</b>

A total of 58 marine mammals were recorded in the survey area during Survey 5 (**Table 14**), these were recorded as dolphin/porpoise (n=18), white-beaked dolphin (n=12), common minke whale (n=8), harbour porpoise (n=8), dolphin species (n=5), seal species (n=4), grey seal (n=2) and marine mammal species (n=1).

A total of one other marine megafauna species was recorded in the survey area during Survey 5, this was recorded as basking shark (n=1).

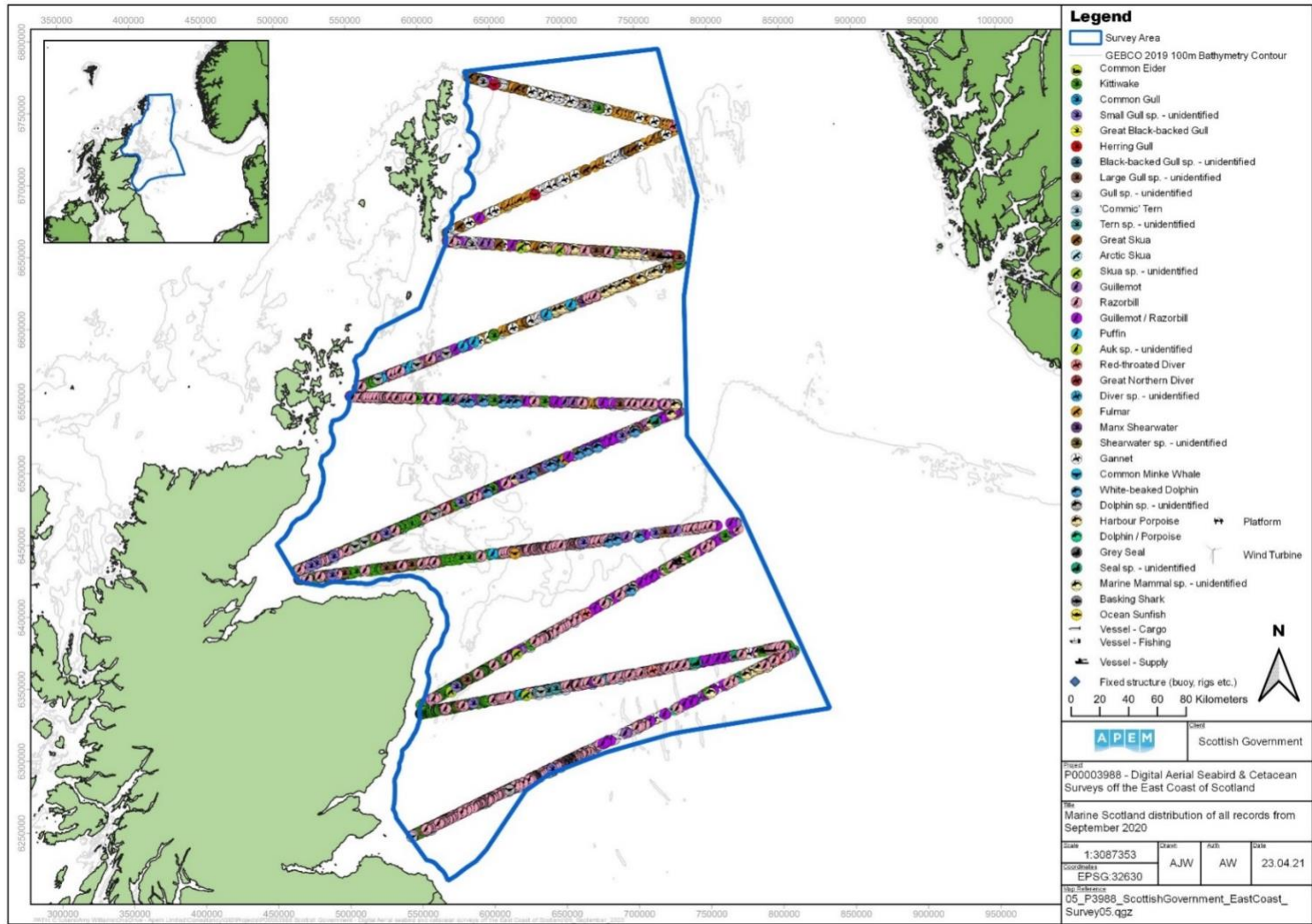
**Table 14**

Raw counts of marine megafauna species recorded in Survey 5.

<b>Species</b>	<b>Submerged</b>	<b>Surfacing</b>	<b>Total</b>
Common Minke Whale	5	3	8
White-beaked Dolphin	10	2	12
Dolphin sp. - unidentified	3	2	5
Harbour Porpoise	6	2	8
Dolphin / Porpoise	12	6	18
Grey Seal	1	1	2
Seal sp. - unidentified	-	4	4
Marine Mammal sp. - unidentified	-	1	1
<b><i>Total marine mammals</i></b>	<b>37</b>	<b>21</b>	<b>58</b>
Basking Shark	1	-	1
<b><i>Total other marine megafauna</i></b>	<b>1</b>	<b>-</b>	<b>1</b>

A total of 13 anthropogenic objects were recorded in the survey area during Survey 5, these were recorded as fishing vessel (n=4), platform (n=3), cargo ship (n=2), supply vessel (n=2), wind turbine (n=1) and fixed structure (buoy, rigs etc.; n=1).

Figure 14 shows the location of all birds and marine megafauna recorded throughout the survey area during Autumn survey I (Survey 5).



**Figure 14:** Distribution of avian fauna, marine megafauna and human artefacts recorded in Survey 5.  
**Figure Note:** Individuals may appear to overlap if they are in close proximity to each other.

### 3.6. Survey 6 – Autumn II 2020

Survey 6 was conducted over four days and all flight lines were successfully completed. Data for transects one and two were collected on 27 October, transects six, seven, eight, nine, and ten on 29 October, transects four and five on 30 September, and transects three on 6 November (Figure 7). The total coverage collected for this survey represented 1.94% of the wider survey area.

A total of 19,551 birds were recorded during Survey 6 (**Table 15**). The most abundant species recorded was guillemot/razorbill (n=8,434), followed by fulmar (n=5,384), gannet (n=2,146), kittiwake (n=903), great black-backed gull (n=532), guillemot (n=469), large gull species (n=449), razorbill (n=455), herring gull (n=378), gull species (n=168), small gull species (n=81), auk species (n=65), common gull (n=35), black-backed gull species (n=25), wader species (n=7), puffin (=6), great skua (n=5), skua species (n=2), red-throated diver (n=2), diver species (n=2), black-headed gull (n=1), great northern diver (n=1) and shag (n=1).

A total of 4,720 birds (24%) were recorded in flight during this survey, these consisted of fulmar (n=2,609), gannet (n=855), kittiwake (n=642), herring gull (n=214), great black-backed gull (n=143), guillemot / razorbill (n=107), large gull species (n=48), common gull (n=35), guillemot (n=28), auk species (n=10), wader species (n=7), gull species (n=5), great skua (n=5), black-backed gull species (n=4), razorbill (n=3), small gull species (n=2), black-headed gull (n=1), diver species (n=1) and shag (n=1). There were 14,813 birds (76%) recorded as sitting, 17 birds recorded as perched (<1%) and one bird recorded as diving (<1%)



**Table 15**

Raw counts of avian species recorded in Survey 6.

<b>Species</b>	<b>Flying</b>	<b>Sitting</b>	<b>Diving</b>	<b>Perched</b>	<b>Total</b>
Wader sp. – unidentified	7	-	-	-	7
Kittiwake	642	261	-	-	903
Black-headed Gull	1	-	-	-	1
Common Gull	35	-	-	-	35
Small Gull sp. – unidentified	2	79	-	-	81
Great Black-backed Gull	143	372	-	17	532
Herring Gull	214	164	-	-	378
Black-backed Gull sp. – unidentified	4	21	-	-	25
Large Gull sp. – unidentified	48	401	-	-	449
Gull sp. – unidentified	5	163	-	-	168
Great Skua	5	-	-	-	5
Skua sp. – unidentified	-	2	-	-	2
Guillemot	28	441	-	-	469
Razorbill	3	452	-	-	455
Guillemot / Razorbill	107	8,327	-	-	8,434
Puffin	-	6	-	-	6
Auk sp. – unidentified	10	54	1	-	65
Red-throated Diver	-	2	-	-	2
Great Northern Diver	-	1	-	-	1
Diver sp. – unidentified	1	1	-	-	2
Fulmar	2,609	2,775	-	-	5,384
Gannet	855	1,291	-	-	2,146
Shag	1	-	-	-	1
<b>Total birds</b>	<b>4,720</b>	<b>14,813</b>	<b>1</b>	<b>17</b>	<b>19,551</b>

A total of 84 marine mammals were recorded in the survey area during Survey 6 (**Table 16**), these were recorded as harbour porpoise (n=34), white-beaked dolphin (n=20), dolphin/porpoise (n=18), seal species (n=4), common minke whale (n=4), marine mammal species (n=3) and whale species (n=1).

A total of one other marine megafauna species was recorded in the survey area during Survey 6, this was recorded as ocean sunfish (n=1).

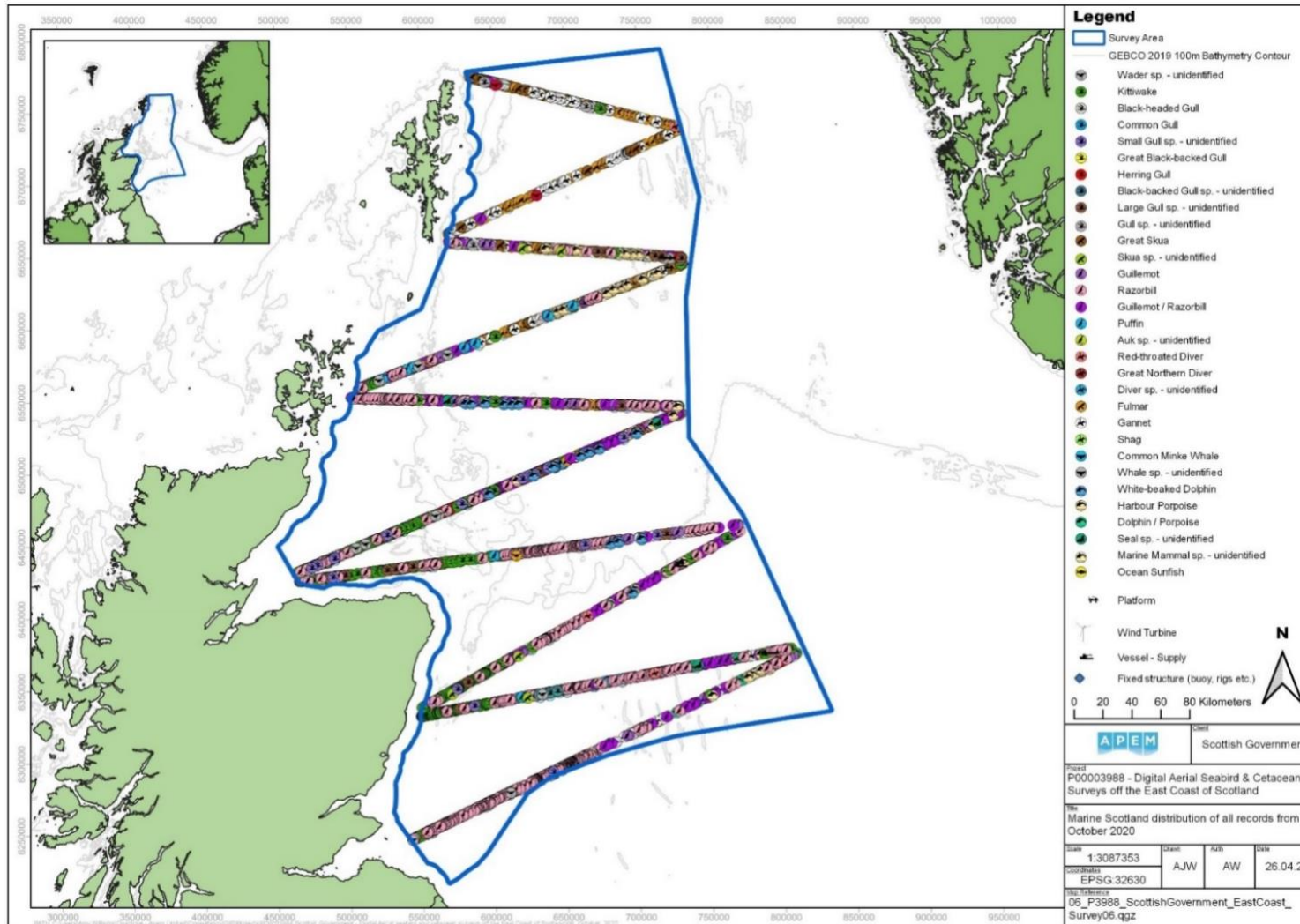
**Table 16**

Raw counts of marine megafauna species recorded in Survey 6.

<b>Species</b>	<b>Submerged</b>	<b>Surfacing</b>	<b>Total</b>
Seal sp. – unidentified	4	-	4
Common Minke Whale	2	2	4
Whale sp. – unidentified	1	-	1
White-beaked Dolphin	18	2	20
Harbour Porpoise	33	1	34
Dolphin / Porpoise	14	4	18
Marine Mammal sp. – unidentified	3	-	3
<b><i>Total marine mammals</i></b>	<b>75</b>	<b>9</b>	<b>84</b>
Ocean Sunfish	1	-	1
<b><i>Total other marine megafauna</i></b>	<b>1</b>	<b>-</b>	<b>1</b>

A total of 12 anthropogenic objects were recorded in the survey area during Survey 6, these were recorded as supply vessel (n=6), platform (n=4), fixed structure (buoy, rigs etc.; n=1) and wind turbine (n=1).

Figure 15 shows the location of all birds and marine megafauna recorded throughout the survey area during Autumn II (Survey 6).



**Figure 15:** Distribution of avian fauna, marine megafauna and human artefacts recorded in the Survey 6.

**Figure Note:** Individuals may appear to overlap if they are in close proximity to each other.

### 3.7. Survey 7 – Winter 2020 / 2021

Survey 7 was conducted over five days and all flight lines were successfully completed. Data for transects one and two were collected on 27 November, transects seven and eight on 29 November, transects three and four on 17 January, transects five and six on 19 January, and transects nine and ten on 23 March (Figure 8). The total coverage collected for this survey represented 1.67% of the wider survey area.

A total of 14,525 birds were recorded during Survey 7 (**Table 17, Table 15**). The most abundant species recorded was guillemot/razorbill (n=7,246), followed by fulmar (n=3,284), gannet (n=1,088), kittiwake (n=982), herring gull (n=705), great black-backed gull (n=483), guillemot (n=246), large gull species (n=224), auk species (n=142), small gull species (n=35), common gull (n=29), black-backed gull species (n=27), gull species (n=11), knot (n=5), diver species (n=3), long-tailed duck (n=3), glaucous gull (n=2), great skua (n=2), lesser black-backed gull (n=2), black guillemot (n=1), grebe species (n=1), Iceland gull (n=1), red-breasted merganser (n=1), red-throated diver (n=1) and velvet scoter (n=1).

A total of 3,881 birds (26%) were recorded in flight during this survey, these consisted of fulmar (n=2,171), kittiwake (n=770), gannet (n=366), herring gull (n=240), great black-backed gull (n=157), guillemot / razorbill (n=51), large gull species (n=43), common gull (n=29), guillemot (n=19), auk species (n=7), small gull species (n=6), gull species (n=5), knot (n=5), black-backed gull species (n=3), long-tailed duck (n=3), great skua (n=2), glaucous gull (n=1), lesser black-backed gull (n=1), red-breasted merganser (n=1) and velvet scoter (n=1). There were 10,631 birds (73%) recorded as sitting, 12 birds recorded as perched (<1%) and one bird recorded as deceased (<1%)

**Table 17**

Raw counts of avian species recorded in Survey 7.

<b>Species</b>	<b>Flying</b>	<b>Sitting</b>	<b>Perched</b>	<b>Deceased</b>	<b>Total</b>
Velvet Scoter	1	-	-	-	1
Long-tailed Duck	3	-	-	-	3
Red-breasted Merganser	1	-	-	-	1
Grebe sp. – unidentified	-	1	-	-	1
Knot	5	-	-	-	5
Kittiwake	770	212	-	-	982
Common Gull	29	-	-	-	29
Small Gull sp. – unidentified	6	29	-	-	35
Great Black-backed Gull	157	314	12	-	483
Glaucous Gull	1	1	-	-	2
Iceland Gull	-	1	-	-	1
Herring Gull	240	465	-	-	705
Lesser Black-backed Gull	1	1	-	-	2
Black-backed Gull sp. – unidentified	3	24	-	-	27
Large Gull sp. – unidentified	43	181	-	-	224
Gull sp. – unidentified	5	6	-	-	11
Great Skua	2	-	-	-	2
Guillemot	19	227	-	-	246
Guillemot / Razorbill	51	7,195	-	-	7,246
Black Guillemot	-	1	-	-	1
Auk sp. – unidentified	7	135	-	-	142
Red-throated Diver	-	1	-	-	1
Diver sp. – unidentified	-	3	-	-	3
Fulmar	2,171	1,113	-	-	3,284
Gannet	366	721	-	1	1,088
<b>Total birds</b>	<b>3,881</b>	<b>10,631</b>	<b>12</b>	<b>1</b>	<b>14,525</b>

A total of 20 marine mammals were recorded in the survey area during Survey 7 (**Table 18**), these were recorded as dolphin / porpoise (n=9), Risso's dolphin (n=5), white-beaked dolphin (n=2), marine mammal species (n=2), whale species (n=1) and dolphin species (n=1).

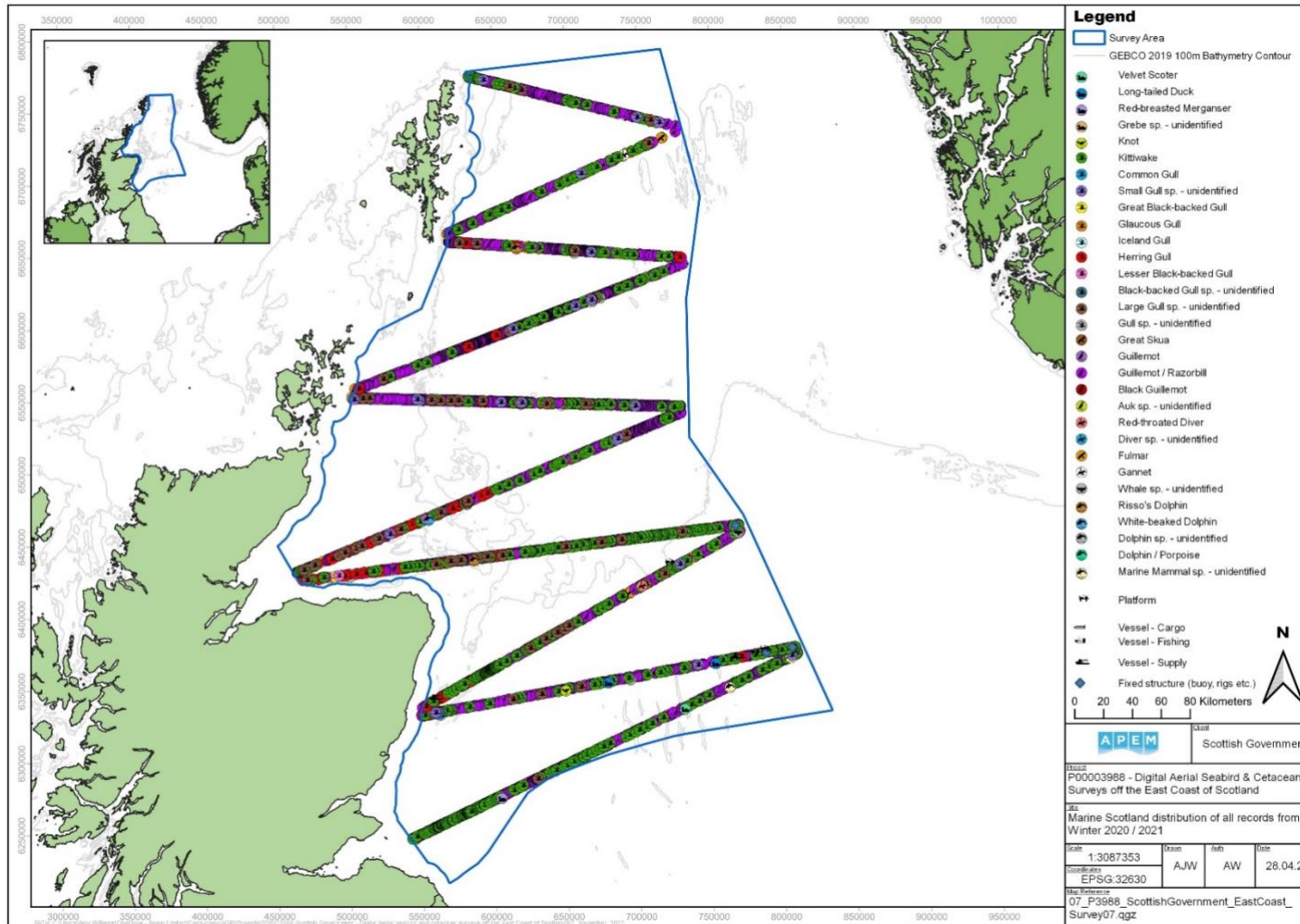
**Table 18**

Raw counts of marine megafauna species recorded in Survey 6.

<b>Species</b>	<b>Submerged</b>	<b>Surfacing</b>	<b>Total</b>
Whale sp. – unidentified	1	-	1
Risso's Dolphin	2	3	5
White-beaked Dolphin	2	-	2
Dolphin sp. – unidentified	1	-	1
Dolphin / Porpoise	7	2	9
Marine Mammal sp. – unidentified	2	-	2
<b>Total marine mammals</b>	<b>15</b>	<b>5</b>	<b>20</b>

A total of 13 anthropogenic objects were recorded in the survey area during Survey 7, these were recorded as platform (n=4), fishing vessel (n=3), fixed structure (buoy, rigs etc.; n=3), supply vessel (n=2) and cargo ship (n=1).

Figure 15 shows the location of all birds and marine megafauna recorded throughout the survey area during Winter 2020/2021 (Survey 7).



**Figure 16:** Distribution of avian fauna, marine megafauna and human artefacts recorded in the Survey 7.  
**Figure Note:** Individuals may appear to overlap if they are in close proximity to each other.

### 3.8. Survey 8 – Spring 2021

Survey 8 was conducted over six days and all flight lines were successfully completed. Data for transects one and two were collected on 21 of February, transect three on 28 February, transect four on 5 March, transects five, six, seven and eight on 6 March, transect ten on 14 March and transect nine on 23 March. The total coverage collected for this survey represented 1.92% of the wider survey area.

A total of 12,901 birds were recorded in the Survey Area during the survey 8 (**Table 19**). The most abundant species recorded was Guillemot/Razorbill (n= 6,922), followed by fulmar (n=2,440), kittiwake (n=1,203), gannet (n=826), guillemot (n=675), auk species (n=392), razorbill (n=131), great black-backed gull (n=92), large gull species (n=65), herring gull (n=57), small gull species (n=56), gull species (n=19), black-backed gull species (n=7), black guillemot (n=6), common gull (n=6), diver species (n=3) and red throated diver (n=1) .

A total of 3,132 birds (24 %) were recorded in flight during this survey, these consisted of fulmar (n=1,870), kittiwake (n=702), gannet (n=394), herring gull (n=42), great black-backed gull (n=39), guillemot / razorbill (n=36), large gull species (n=18), guillemot (n=7), common gull (n=6), small gull species (n=5), auk species (n=4), razorbill (n=4), gull species (n=3) and black-backed gull species (n=2). There were 9,769 birds (76 %) recorded as sitting.



**Table 19**

Raw counts of avian species recorded in Survey 8.

Species	Flying	Sitting	Total
Kittiwake	702	501	1,203
Common Gull	6	-	6
Great Black-backed Gull	39	53	92
Herring Gull	42	15	57
Black-backed Gull sp. – unidentified	2	5	7
Small Gull species	5	51	56
Large Gull species	18	47	65
Gull sp. – unidentified	3	16	19
Guillemot	7	668	675
Razorbill	4	127	131
Guillemot/Razorbill	36	6,886	6,922
Black Guillemot	-	6	6
Auk sp. – unidentified	4	388	392
Red-throated Diver	-	1	1
Diver sp. – unidentified	-	3	3
Fulmar	1,870	570	2,440
Gannet	394	432	826
<b>Total birds</b>	<b>3,132</b>	<b>9,769</b>	<b>12,901</b>

A total of 59 marine mammals were recorded in the Survey Area during survey 7 (**Table 20**), these were recorded as dolphin/porpoise (n=22), harbour porpoise (n=17), white-beaked dolphin (n=12), marine mammal species (n=6) and phocids (n=2).

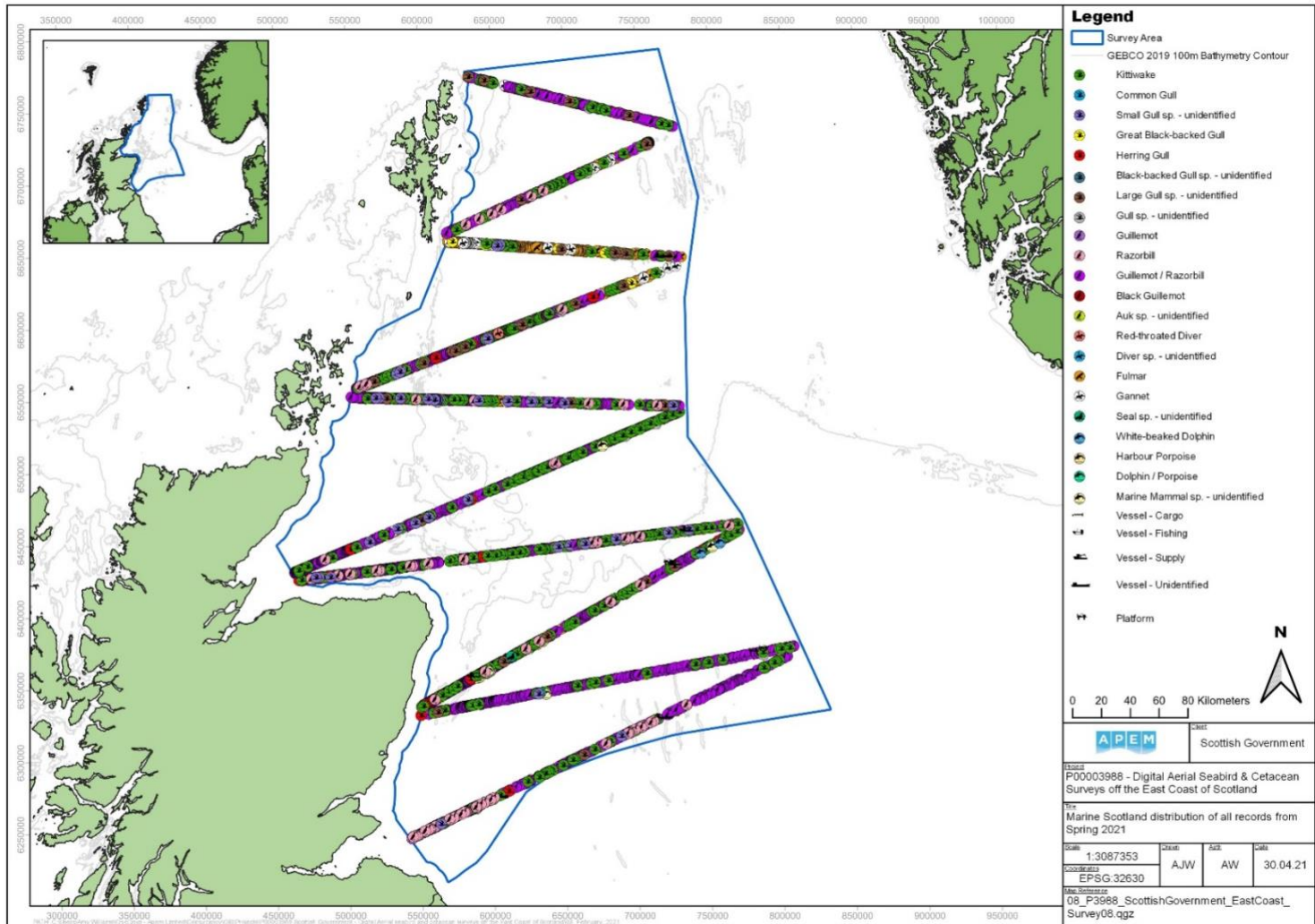
**Table 20**

Raw counts of marine megafauna species recorded in Survey 8.

Species	Submerged	Surfacing	Total
Phocids sp. – unidentified	1	1	2
White-beaked Dolphin	12	-	12
Harbour Porpoise	11	6	17
Dolphin / Porpoise	16	6	22
Marine Mammal sp. – unidentified	4	2	6
<b>Total marine mammals</b>	<b>44</b>	<b>15</b>	<b>59</b>

A total of 12 anthropogenic objects were recorded in the survey area during Survey 8, these were recorded as supply vessel (n=3), unidentified vessel (n=3), platform (n=3), fishing vessel (n=2), cargo ship (n=1) and fixed structure (buoy, rigs etc.; n=3).

Figure 17 shows the location of all birds and marine megafauna recorded throughout the survey area during Spring 2021 (Survey 8).



**Figure 17:** Distribution of avian fauna, marine megafauna and human artefacts recorded in the Survey 8.  
**Figure Note:** Individuals may appear to overlap if they are in close proximity to each other.

## 4. Discussion

### 4.1. Comparison of results to previous European Seabirds at Sea (ESAS) studies and other relevant literature

European Seabirds at Sea (ESAS) data have been used to inform the findings of the Marine Scotland (2020–2021) survey results presented in this report.

The ESAS database was established in 1991 as a collaboration between individuals and institutes who collected data on the distribution of seabirds and marine mammals in north-west European waters. The database, collated by the JNCC, contains over two million records collected over 25 years (Halpin *et al.* 2009, Dunn 2012). The data can be explored on an interactive map. The data were collected from boat-based surveys using standardised protocols. The data have been used to designate Special Protection Areas (SPAs) for birds and Special Areas of Conservation (SACs) for marine mammals.

The ESAS data was used to create “An atlas of seabird distribution in north-west European waters” (herein referred to as the Atlas) in the 1990s (Stone *et al.* 1995).

Here, we compare the bird species observations from this study with the densities (bird per km<sup>2</sup>) and abundances (bird per km) outlined in the Atlas for the relevant areas. Total numbers cannot be compared but patterns in observations have been compared, for example peak counts or densities in particular seasons. The area surveyed by this study covered sections of the areas defined in the atlas as Northern Isles, Western North Sea and Central and Northern North Sea.

#### **Wader species**

Wader species were not included in the Atlas but were observed during the summer surveys in 2020 and the winter 2020/2021. The wader species identified in the summer surveys included curlew (*Numenius arquata*) and redshank (*Tringa tetanus*) and, in the winter, knot (*Calidris canutus*) were identified.

#### **Kittiwake**

Kittiwake (*Rissa tridactyla*) were observed across the year in this study with high counts throughout the year. Peak counts of kittiwake were recorded in autumn with

high counts in the summer and lower counts in the winter. This corresponds to the observations in the Atlas, higher numbers in summer and peak numbers in autumn.

### **Gulls and terns**

The patterns of observations of gulls were the same for this study and the Atlas. Great black-backed gull (*Larus marinus*) had peak counts and densities in autumn with lows in the summer which corresponded between the studies. Lesser black-backed gull (*Larus fuscus*) had low numbers across the year in both studies. Herring gull (*Larus argentatus*) had high numbers in summer, autumn and winter, which was similar in the Atlas, although there were low densities recorded in summer.

The low numbers of common gulls corresponded between this study and the Atlas, although the Atlas had peak densities in winter and in this study the peak was in the autumn surveys.

In the Atlas, low numbers of Iceland and glaucous gulls were recorded, in this study only one Iceland gull (*Larus glaucoides*) and two glaucous gulls (*Larus hyperboreus*) was recorded in the winter of 2020/2021.

In this study, terns were only observed in the summer and autumn and this corresponds to the peak numbers in summer in the Atlas. Arctic (*Sterna paradisaea*) and common (*Sterna hirundo*) terns were positively identified in this study along with 'commic' terns (this group includes both common and Arctic terns). Only 'commic' terns were identified in the Atlas and these had peak counts in summer with none observed between October to March.

### **Skuas**

Great skua (*Stercorarius skua*) were observed in very low numbers in the spring, summer and autumn surveys in this study, and Arctic skua (*Stercorarius parasiticus*) was observed in summer, autumn and winter in very low numbers. This corresponds with reports in the Atlas, with no sightings between November and March and only low densities April to October.

### **Auks**

In this study, peak counts of guillemots (*Uria aalge*) were observed in the autumn, with high counts in the summer and lower counts in the winter and spring surveys. Razorbill (*Alca torda*) had peak counts in the summer and autumn. This corresponds

to the high counts for these species in the summer and autumn in the Atlas. This study and the Atlas included a guillemot/razorbill group, due to the difficulty in distinguishing between these species. In this study the observations of guillemot/razorbill were high across the seasons with peak counts in autumn, in the Atlas peak counts were seen in the summer and autumn. Differentiation between the two species is difficult between the survey techniques and this results in the variation in patterns of observations between the two studies. If all guillemot, razorbill and guillemot/razorbill observations are taken together, there are high numbers of individuals observed in the area across the year.

Black guillemot (*Cepphus grylle*) were observed in low numbers across the seasons in this study. This corresponds to the Atlas, where the species were observed throughout the year, although abundance was low, with peak abundance (0.06) in the autumn.

The pattern of puffin (*Fratercula arctica*) observations were similar between the two studies with observations throughout the year and peak counts/densities in the summer.

### **Divers**

In the Atlas, the Moray Firth was described as locally important in winter for divers, even though divers were reported in low densities across the year. Red-throated diver (*Gavia stellata*) were observed in the winter in the Atlas in very low abundances (0.01) whereas this study observed them in the summer, autumn and winter surveys in very low numbers (one-six); great northern diver (*Gavia immer*) were observed between October to May in the Atlas in very low abundances (0.01-0.02) and were observed in the spring, summer and autumn surveys in this study (one).

### **Storm petrels**

Storm petrels (*Hydrobates pelagicus*) were only observed in the summer in this study, this matches the densities reported in the Atlas.

### **Fulmar**

Fulmar (*Fulmarus glacialis*) had high counts and densities throughout the year as reported in this study and the Atlas; in this study the peak numbers were counted in

autumn with high counts in summer and winter surveys, the peak densities in the Atlas were May to November.

### **Shearwaters**

Only Manx shearwaters (*Puffinus puffinus*) were observed in the study, in the summer with low counts and peak numbers in autumn. The numbers were low in the Atlas, with peak numbers in summer.

No other shearwater species were observed in this study, however sooty shearwater (*Puffinus griseus*) was reported in the Northern Isles and Western North Sea areas of the Atlas data between August and November. Also, one Mediterranean shearwater (*Puffinus mauretanicus*) was observed in the relevant areas in the Atlas between July and November.

### **Gannet**

Gannet (*Morus bassanus*) were observed throughout the year for both the Atlas and this study. From the ESAS data the densities of gannet were similar throughout the year whereas in this study there was a high number in summer with the peak counts in the autumn.

### **Cormorant and Shag**

In this study, cormorant (*Phalacrocorax carbo*) and shag (*Phalacrocorax aristotelis*) were observed in the summer and autumn in low numbers. This corresponds to the low densities of cormorants were reported in the Atlas, with observations between March and September, peak density of 0.03 in April. Although for shag the Atlas showed low densities all year round, with peak counts in autumn.

### **Cetaceans**

The data from ESAS, plus other European datasets including Sea Watch and the Small Cetacean Abundance in the North Sea (SCANS) were used to produce the "Atlas of Cetacean Distribution in north-west European Waters" (Reid *et al*, 2003). This Atlas provides accounts of the distribution of 28 cetacean species known to have occurred in north west European waters since the 1980.

Five cetacean species were positively identified in the surveys from this study. The Ried *et al* (2003) Atlas provides maps of the sightings rates across the NE Atlantic and NW Europe region. Limited information on seasonal variation is provided. The text and maps were used to compare with the observations from this study.

- Common minke whale (*Balaenoptera acutorostrata*): observed across the seasons with peak counts in the summer. This is reflected in the Atlas where the whales are shown to have high sighting rates across the area, they are also observed throughout the year.
- Common dolphin (*Delphinus delphis*): observed in the winter, summer and autumn surveys, peak counts in summer. The Atlas shows they have high sightings around the coast of Scotland; but the survey effort was limited in the offshore areas outside of the Firth of Forth.
- White-beaked dolphin (*Lagenorhynchus albirostris*): observed in the winter and summer surveys of this study, peak counts in summer. The Atlas shows they have high sighting rates across the area for this study and are most frequently seen in the summer.
- Risso's dolphin (*Grampus griseus*): observed in a winter survey of this study. The Atlas shows they are uncommon in the study area and are seen most frequently in the winter.
- Harbour porpoise (*Phocoena phocoena*): observed across spring, summer and autumn, peak numbers were recorded in the summer surveys; in the Atlas the sighting rate is high and highest observations in the summer.

Data was not provided on the ESAS observations of grey seals or common seal which were observed in the surveys for this study. In addition, this study observed one unidentified shark species, one basking shark (*Cetorhinus maximus*) and one ocean sunfish (*Mola mola*).

#### **4.2. Any significant changes and possible explanations of any changes**

Environmental changes at sea will greatly influence the distribution and abundance of seabirds in offshore areas. The changes in seabirds seen between the ESAS data reported in "An atlas of seabird distribution in north-west European waters" (Stone *et al.* 1995) and the observations recorded during aerial surveys undertaken in 2019-2021 could be due to a large number of factors. A few of the factors that could have caused changes to seabird populations in the last 25 years include (JNCC, 2020):

- Changes to food discard by commercial fishing;



- Bycatch;
- Climate change;
- Protective legislation;
- Effects in wintering areas;
- Mink predation.

The cetaceans observed in the surveys for this study do not greatly differ from the observations reported in the “Atlas of Cetacean Distribution in north-west European Waters” (Reid *et al.* 2003). However, there are changes within the marine ecosystem that will impact on these species (Waggitt *et al.* 2019), such as:

- Bycatch;
- Habitat loss;
- Energy extraction;
- Noise disturbance;
- Prey reductions;
- Pollution;
- Vessel traffic.

The key differences between the ESAS bird data (Stone *et al.* 1995) and the observations from this study are: in the surveys for this study:

- wader species were observed;
- no little auks (*Alle alle*) were observed;
- no sooty shearwaters were observed; and
- fewer European shags were observed.

The differences between the ESAS bird data (Stone *et al.* 1995) and the surveys from this study could stem from differences in survey techniques. However, they can also suggest changes in the bird populations.

The wader observations in 2020 are unlikely to indicate an increase in the populations as the numbers were small and wader abundance in Scotland has decreased over the last 20 years (NatureScot, 2018). The observations could highlight differences in the survey technique with waders being disturbed from boat surveys whereas they are not disturbed by aerial digital survey aircraft and can be detected in aerial digital stills survey images.

Little auk and sooty shearwaters are passage migrants or winter visitors (Robinson, 2005) and would be expected to have been recorded in the winter survey (2019/2020). Although none were recorded in the 2019-2021 surveys, this may indicate the population wintering in waters around the UK is reducing. Sooty shearwaters are vulnerable to bycatch from demersal longline fisheries across their global distribution.

The reduction in European shag observations between the ESAS database and the surveys in 2020 is in line with the current population trends. The shag population in Scotland is expected to be decreasing with reductions in population in 2020 and a reduction in breeding abundance from 1992 to 2018 (JNCC, 2020). The low breeding abundance has been linked to winter “wrecks” of shags along the east coast from which numbers are slow to recover or do not recover at all.

#### **4.3. Recommendations for improvements to the methodology and further possible research**

##### **Methodology limitations**

A limitation of this study is that the data from the study are not directly comparable to the previous ESAS datasets. However, the surveys undertaken for this study (2019-2021) have benefited from being digital aerial surveys compared to visual aerial surveys or boat surveys which were previously used for the ESAS data collection.

Aerial digital surveys have been shown to provide higher numbers of bird sightings and identified species with higher spatial accuracy (Žydelis *et al.* 2019) than aerial visual surveys. In addition, aerial digital surveys have been shown to be more effective at detecting megafauna in the marine environment (Garcia-Garin *et al.* 2020). The technology on board survey aircraft means that each animal identified in the survey imagery can be accurately georeferenced and data does not need to be corrected for distance-related detection bias (Buckland *et al.* 2012; Coppack *et al.* 2017). In addition, the higher flight height for aerial digital surveys compared to visual aerial surveys has the benefit of no observed disturbance to the marine species being observed and prevents flushing for the seabirds (Thaxter & Burton, 2009; Buckland *et al.*, 2012; Coppack *et al.*, 2017) and this is of much greater benefit when compared to disturbance and attraction provided by boat surveys.

Although aerial digital surveys rely on good weather, the speed at which the area can be covered allows for these large-scale surveys to be undertaken. However, in

winter particularly the weather windows are short lived and therefore the survey data has been collected across a number of days. Good weather is required for the safety of the aircraft as well as for optimal identification of species from the imagery.

In addition, aerial surveys are not able to reliably monitor species migration, with birds known to migrate at high altitudes and at night (MacArthur Green *et al.* 2015).

### **Recommendations for future research**

APEM would recommend that the observations of species across the area are used to create new estimates of the offshore abundance and density of the observed species. This would be useful to compare to the density and abundances laid out in “An atlas of seabird distribution in north-west European waters” (Stone *et al.* 1995) and allow for greater interrogation of changes in species distributions or abundance. In addition, more complex analysis techniques could be used to produce density maps for seabirds and marine mammals across the surface area. This would have the advantage of being comparable to the density maps of seabirds and cetaceans across European waters created by Waggitt *et al.* (2020) from ESAS data compiled with other databases on seabird and cetacean distributions.

In addition, it would be beneficial to have another year of surveys to be able to understand inter-annual variation in species observations.

For future surveys in this area, closer lines would be recommended to cover more of the survey area, however, more transect lines would increase the reliance on good weather windows and would increase the risk of surveys covering days/weeks. As well as greatly increasing the cost of the surveys.

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## Appendix I: Species and groupings List in Taxonomic Order

Common Name	Scientific Name	Family	Class
<b>Avian</b>			
Bird sp.	-	-	Aves
<b>Wildfowl</b>			
Common Eider	<i>Somateria mollissima</i>	Anatidae	Aves
<b>Wader</b>			
Curlew	<i>Numenius arquata</i>	Scolopacidae	Aves
Redshank	<i>Tringa totanus</i>	Scolopacidae	Aves
Wader sp.	-	-	Aves
<b>Gull</b>			
Gull sp.	-	Laridae	Aves
<b>Small Gull</b>			
Kittiwake	<i>Rissa tridactyla</i>	Laridae	Aves
Black-headed Gull	<i>Chroicocephalus ridibundus</i>	Laridae	Aves
Common Gull	<i>Larus canus</i>	Laridae	Aves
Small Gull sp.	-	Laridae	Aves
<b>Large Gull <i>Black-backed Gull [Bb]</i></b>			
Great Black-backed Gull [Bb]	<i>Larus marinus</i>	Laridae	Aves
Herring Gull	<i>Larus argentatus</i>	Laridae	Aves
Lesser Black-backed Gull [Bb]	<i>Larus fuscus</i>	Laridae	Aves
Large Gull sp.	-	Laridae	Aves
<b>Tern 'Commic' Tern [CA]</b>			
Common Tern [CA]	<i>Sterna hirundo</i>	Laridae	Aves
Arctic Tern [CA]	<i>Sterna paradisaea</i>	Laridae	Aves
Tern sp.	-	Laridae	Aves
<b>Skua</b>			
Great Skua	<i>Stercorarius skua</i>	Stercorariidae	Aves
Arctic Skua	<i>Stercorarius parasiticus</i>	Stercorariidae	Aves
Skua sp.	<i>Stercorarius spp.</i>	Stercorariidae	Aves
<b>Auk <i>Guillemot / Razorbill [GR]</i></b>			
Guillemot [GR]	<i>Uria aalge</i>	Alcidae	Aves
Razorbill [GR]	<i>Alca torda</i>	Alcidae	Aves
Black Guillemot	<i>Cephus grylle</i>	Alcidae	Aves
Puffin	<i>Fratercula arctica</i>	Alcidae	Aves
Auk sp.	-	Alcidae	Aves
<b>Diver</b>			
Red-throated Diver	<i>Gavia stellata</i>	Gaviidae	Aves
Great Northern Diver	<i>Gavia immer</i>	Gaviidae	Aves
Diver sp.	<i>Gavia spp.</i>	Gaviidae	Aves

<b>Storm Petrel</b>			
Storm Petrel sp.	-	Oceanitidae Hydrobatidae	Aves
<b>Fulmar</b>			
Fulmar	<i>Fulmarus glacialis</i>	Procellariidae	Aves
<b>Shearwater</b>			
Manx Shearwater	<i>Puffinus puffinus</i>	Procellariidae	Aves
Shearwater sp.	-	Procellariidae	Aves
<b>Gannet</b>			
Gannet	<i>Morus bassanus</i>	Sulidae	Aves
<b>Cormorant / Shag</b>			
Cormorant	<i>Phalacrocorax carbo</i>	Phalacrocoracidae	Aves
Shag	<i>Phalacrocorax aristotelis</i>	Phalacrocoracidae	Aves
<b>Unidentified Avian</b>			
Bird sp.	-	-	Aves
<b>Mammal</b>			
<b>Marine Mammal</b>			
Marine Mammal sp.	-	-	Mammalia
<b>Seal</b>			
Grey Seal	<i>Halichoerus grypus</i>	Phocidae	Mammalia
Seal sp.	-	Phocidae	Mammalia
<b>Whale</b>			
Common Minke Whale	<i>Balaenoptera acutorostrata</i>	Balaenopteridae	Mammalia
Whale sp.	-	-	Mammalia
<b>Dolphin / Porpoise</b>			
<b>Dolphin</b>			
Common Dolphin	<i>Delphinus delphis</i>	Delphinidae	Mammalia
White-beaked Dolphin	<i>Lagenorhynchus albirostris</i>	Delphinidae	Mammalia
Dolphin sp.	-	Delphinidae	Mammalia
<b>Porpoise</b>			
Harbour Porpoise	<i>Phocoena phocoena</i>	Phocoenidae	Mammalia
<b>Fish</b>			
<b>Shark</b>			
Basking Shark	<i>Cetorhinus maximus</i>	Cetorhinidae	Chondrichthyes
Shark sp.	-	-	Chondrichthyes
<b>Bony fish</b>			
Ocean Sunfish	<i>Mola mola</i>	Molidae	Actinopterygii

## **Appendix II: Survey observations**

During the Survey an APEM Camera Technician was stationed within the aircraft to oversee data collection. The technician also recorded observational data, such as vessels, large marine mammals and weather data. Windspeed, wind direction and air temperature are all observed from instruments within the aircraft. Visibility was determined by how far the observer could see out the aircraft. Sea State was recorded using the Beaufort Sea State (see below), cloud cover recordings were based on Okta (see below).

### **Sea State Scale**

- 0 - Calm
- 1 - Rippled
- 2 - Smooth
- 3 - Slightly moderate
- 4 - No Surveys conducted in these conditions

### **Cloud Cover Scale**

- 0 % - Clear
- 1–10% - Few
- 11–50% - Scattered
- 51–95% - Broken
- 96–100% - Overcast



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