# A11.2 Detailed Estuarine Survey Methods

**This appendix provides supporting information to Section 11.2 (Approach and Methods) of Chapter 11 (Estuarine Ecology) and details full survey methodologies used for estuarine baseline surveys.**

# 1 Benthic Ecology

## 1. 1 Existing Information

1.1.1 Consultation was undertaken with a variety of statutory and non-governmental organisations including:

- Marine Scotland;
- SEPA; and
- SNH.

1.1.2 Information was provided in relation to ongoing and historical monitoring and research work in the Firth of Forth relating to benthic habitats. SEPA was also consulted with regards to survey design and methods.

## 1. 2 Survey Methods

**Site Selection**

1.2.1 The survey design incorporated intertidal and subtidal components; sampling locations and relevant designations are shown on Figure 11.1. Surveys were undertaken in spring 2008.

Subtidal

1.2.2 The Main Crossing is immediately upstream of the Forth Road Bridge, and extends from Port Edgar on the south shore to North Queensferry on the north shore. The spatial extent of the survey area was selected to reflect the area of the Firth of Forth likely to be impacted by the Main Crossing construction and operation. Although the area likely to be influenced could not be defined with great precision, it was evident that impacts may occur at some distance from the Main Crossing. Tidal currents will distribute sediments (and associated historical contamination) appreciable distances; the same will also be true for materials associated with construction activity introduced directly into the Firth of Forth. Consequently, a relatively large spatial area of the Firth of Forth was selected for study to ensure that all areas and habitats likely to be influenced were comprehensively sampled and characterised.

1.2.3 The subtidal survey area extended 4km upstream and downstream of the site of the Main Crossing. A total of 35 sample sites were selected. Eight sites were positioned across the Firth of Forth in close proximity to the Main Crossing and four sites were positioned either side of the Main Crossing. The remaining 19 sites were regularly spaced throughout the study area arranged on a grid of 1km$^2$ with sites positioned approximately at each intersection.

Intertidal

1.2.4 The intertidal areas of the Firth of Forth in the vicinity of the Main Crossing are complex and differ considerably between north and south shores. The intertidal zone on the north shore is generally narrow and is characterised by hard substrata: predominantly boulders and cobbles with some gravel and sand. Intertidal areas on the south shore are wider and comprise a mosaic of habitats with hard substrata in the upper shore, while the mid and low shore areas are comprised predominantly of mud and sand flats.

1.2.5 Owing to the number and complexity of the intertidal habitats, the approach adopted for the intertidal survey was to classify biotopes. The distributions of habitats and biotopes on both shores were identified during a walkover survey and areas for detailed investigation were determined. On the north shore the study extended 1km upstream and downstream of the Main Crossing, while on the south shore surveys were conducted up to 2km either side of the proposed location for the Main Crossing.

**Sampling Methodology**

Subtidal

1.2.6 Samples were collected using a 0.1$m^2$ Day grab deployed from the Newcastle University research vessel 'Bernicia'. Site positions were determined prior to the survey. Survey sites were located with a Global Positioning System (GPS - Garmin 76). Two grabs were collected at each site, one each for biological and physico-chemical samples. Where present, smell, depth of Redox Potential Discontinuity (RPD) layer and presence of surface features (accretions, algae, fauna, etc.) were recorded, as well as texture. Records were made on field data sheets and photographs were taken of each sample for future reference. Biological samples were washed over a 0.5mm (BS410) sieve. All material retained was fixed in 10% formaldehyde.

1.2.7 Samples for physico-chemical analyses were taken from undisturbed sediment in the grab. Material was collected to a depth of 1cm using a plastic spatula for metals analysis and a metal spatula for organic compounds analysis. A sample for particle size analysis was collected to a depth of 5-8cm.

Intertidal

1.2.8 Hard, intertidal habitats were surveyed using Marine Nature Conservation Review (MNCR) intertidal methods (Wilding et al., 2001). Within each habitat, communities were assessed by determining the abundance of each taxa within a 0.25$m^2$ quadrat. Taxa were identified to the lowest taxonomic level practicable. Generally, fauna were enumerated while the abundance of plant species was expressed as percentage cover.

1.2.9 Sedimentary intertidal habitats were sampled using a 0.01$m^2$ hand corer. Five replicate cores were taken for biological analysis to a depth of 15cm. A visual inspection of sediment characteristics was made at each site and records made of colour, smell, texture and depth of RPD layer. Photographs of the sediment and surrounding area were taken for future reference as were GPS coordinates. Samples were washed over a 0.5mm (BS410) sieve, with all material retained on the sieve fixed in 10% formaldehyde.

1.2.10 Biotopes were assigned to all biological communities according to Joint Nature Conservation Committee (JNCC) marine habitat classification scheme (Connor et al., 2004).

1.2.11 Sediment samples for physico-chemical analyses were taken directly from areas of undisturbed sediment surface. Material was collected to a depth of 1cm using a plastic spatula for metals analysis and a metal spatula for organic compounds analysis. A sample for particle size analysis was collected to a depth of 5-8cm.

## 1. 3 Analytical Techniques

**Physico-chemical Analyses**

1.3.1 All sediment analyses were undertaken by the Environment Agency and the National Laboratory Service, which are accredited by the United Kingdom Accreditation Service (UKAS)

1.3.2 Sediment Particle Size Analysis (PSA) was undertaken by a combination of laser granulometry and dry sieving. Analysis was designed to assess the amounts of mud, sand and gravel in the sediments; mud, sand and gravel represents particles <63µm, 63–2000µm and >2000µm

respectively (shown in Table 1.1). Sediments were wet sieved through a 1000µm sieve and the fine material analysed using a Malvern Laser instrument to produce data between 20µm and 1000µm. Material retained on the sieve was oven dried at ~90°C for 24 hours then dry sieved through a range of sieves (2000µm, 4000µm and 8000µm).

**Table 1.1: Particle size range for sediment granulometric characteristics**

| φ scale | Size Range (Metric) | Aggregate Name (Wentworth class) |
|---|---|---|
| < -8 | > 256mm | Boulder |
| -6 to -8 | 64-256mm | Cobble |
| -5 to -6 | 32-64mm | Very coarse gravel |
| -4 to -5 | 16-32mm | Coarse gravel |
| -3 to -4 | 8-16mm | Medium gravel |
| -2 to -3 | 4-8mm | Fine gravel |
| -1 to -2 | 2-4mm | Very fine gravel |
| 0 to -1 | 1-2mm | Very coarse sand |
| 1 to 0 | ½ - 1mm | Coarse sand |
| 2 to 1 | ¼ to ½ mm | Medium sand |
| 3 to 2 | 125-250µm | Fine sand |
| 4 to 3 | 63µm | Very fine sand |
| 8 to 4 | < 63µm | Mud (silt and clay) |

1.3.3 Sediments were analysed for a range of materials including List I and II metals, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). These target materials were selected as they are of environmental concern and are known to be present in the Firth of Forth, with inputs from both current and historical sources. The suite of determinands is given in Table 1.2.

**Table 1.2: List of chemical determinands**

| Metals | PCB | PAH |
|---|---|---|
| Aluminium | PCB 28 | Acenapthene |
| Arsenic[2] | PCB 52 | Acenapthylene |
| Cadmium[1] | PCB 101 | Anthracene |
| Chromium[2] | PCB 118 | Benzo(a)anthacene |
| Copper[2] | PCB 138 | Benzo(a)pyrene |
| Lead[2] | PCB 153 | Chrysene |
| Mercury[1] | PCB 180 | Dibenzo(ah)antracene |
| Nickel[2] | | Fluoranthene |
| Zinc[2] | | Fluorene |
| | | Naphthalene[2] |
| | | Phenantrene |
| | | Pyrene |
| | | 2-methylnapthalene |

[1]List I - substances that are those most toxic to aquatic life and are selected on the basis of their persistence, toxicity and bioaccumulation. [2]List II substances are other materials which have a deleterious effect on aquatic life.

1.3.4 For chemical analysis, sediments were dried then sieved to >10cm before being crushed by pestle and mortar. For metals analysis samples were digested in aqua regia to extract metals (with the exception of mercury) and the digest was analysed by Inductively Cooled Plasma/Optical Emission Spectrometry (ICPOES) for all metals. For mercury analysis, sediments were treated with acidic potassium dichromate solution to oxidise mercury compounds followed by bromide/bromate digestion. The mercury was converted to mercury vapour by reduction with acidic tin(II) chloride and subsequently removed from solution by a stream of argon and detected by atomic

fluorescence. For hydrocarbon analysis, air-dried sediment samples were extracted in dichloromethane after which a portion of the solvent layer was removed and exchanged into hexane. The resultant extract was analysed by Gas Chromatography Mass Spectrometry (GC-MS).

**Biological Analysis**

1.3.5 In the laboratory, samples were gently washed across a 0.5mm mesh sieve. The retained material was then hand sorted to extract all macrofauna from the sample. Elutriates from the sample residues were examined further under a binocular microscope. All organisms retained on the sieve were identified and counted to produce a species list for each grab and core sample. Sample residues were checked by a second individual to provide a degree of quality control.

1.3.6 For all subtidal samples in addition to species abundance, species biomass was measured using the blotted wet weight (BWW) method to the nearest 0.0001g, with anything less than this weight recorded as <0.0001g.

1.3.7 All taxa were distinguished to at least family level and identified to species level where possible. Flatworms and nemerteans were unattributable when fixed and preserved, and many of the molluscs were damaged and/or decalcified; these factors prohibited confident identification to species level.

1.3.8 Nomenclature followed that of the Species Directory of the Marine Fauna and Flora of the British Isles and Surrounding Seas (Howson & Picton, 1997).

## 1. 4 Limitations to Assessment

1.4.1 None identified.

# 2 Marine Fish

## 2. 1 Existing Information

2.1.1 Consultation was undertaken with a range of statutory and non-governmental organisations including SEPA, FRS, Forth District Salmon Fisheries Board (FDSFB) Scottish Fisheries Protection Agency (SPFA) and the Scottish Government (Marine Directorate, Sea Fisheries Management Division).

2.1.2 A literature review of historic data was undertaken to establish baseline information on fish communities within the Firth of Forth, including species of conservation value and commercially important species (Chapter 11: Section 11.3).

2.1.3 The following data sources have been used to obtain baseline fisheries data:

- SEPA routine monitoring of the Firth of Forth Estuary from trawls between Longannet Power Station in the west to Port Edgar in the east. Data was made available from 1977–2006;
- SEPA routine monitoring (2001–2006) and published literature of fish impingement at Longannet Power Station;
- commercial catch statistics from the SPFA and FRS; and
- available published literature on fisheries research, including Elliott & Taylor (1989), Elliott et al. (1990) and Greenwood (2008).

## 2. 2 Survey Methods

2.2.1 Estuarine habitats are particularly dynamic, requiring a range of quantitative techniques, repeated at the same site over multiple seasons to adequately assess the status of local fisheries

populations. These methods were in accordance with Water Framework Directive (WFD) and JNCC methods incorporating both intertidal and subtidal fishing techniques.

**Intertidal Fisheries Surveys**

2.2.2 Initially, walkover surveys were undertaken during April 2008 to identify key sites for intertidal fisheries surveys. During these surveys extensive notes on tidal regime and heights, beach gradient and substrates and access requirements were recorded.

2.2.3 Six intertidal sites were identified within the intertidal zone around the Forth Road and Forth Rail Bridges; the locations are shown in Table 2.1 and on Figure 11.3. Sites were selected to take account of local variations in exposure to weather and tidal regime, beach morphology and substrate type.

**Table 2.1: Intertidal fisheries sites**

| Site | Location | Site details |
|---|---|---|
| Port Laing | NT1356681274 | Shallow sandy beach, limited areas soft mud at low water |
| St. Margaret's Marsh | NT1223781238 | Sand high to mid shore, soft mud at low water, very shallow slope |
| North Queensferry | NT1322180275 | Steep rock shore with soft mud at low water |
| Long Rib | NT1469778957 | Gravel/pebble steep mid to low shore, shallower high shore sand, shingle and rock |
| Society Point | NT1019279114 | Soft mud at mid–low shore. Shingle high shore, shallow beach slope |
| St David's | NT1458682450 | Firm mud and rock shallow mid to low shore, gravel at high water, |

2.2.4 Sites were chosen to represent the predominant intertidal habitat types commonly found around the Main Crossing. Site morphology differed greatly between shoreline and exposure to the prevailing tidal and weather conditions. Much of the southern shoreline adjacent to the Main Crossing alignment comprised extensive mid to low shore mudflats and steep shingle high shore areas. Further to the west the occurrence of mudflats declined, with more gravel and rock habitats dominant. The north shoreline presented a different range of habitats, including sand beaches, soft mud zones and large areas of rock outcrops. Each habitat was surveyed to ensure representative sampling was achieved, thus providing the most representative characterisation of species using the intertidal areas around the Main Crossing alignment.

2.2.5 A description of each site is presented below:

- Port Laing is an east facing beach located on the north shoreline, 2.2km from the Main Crossing. The Port Laing site was chosen as a representative sand beach, with sand extending across the entire intertidal zone. Below the intertidal zone were large kelp beds and sporadic rock outcrops.
- St. Margaret's Marsh lies on the north shore of the estuary approximately 250m west of the Main Crossing. The upper shoreline is dominated by artificial flood defence structures in the form of large, placed boulders. The top of the southwest facing beach is predominantly shingle and sheltered from the tidal currents and prevailing weather in the main estuary. The shallow mid shore, extending down to the sheltered edge of the headland is sand, giving way to soft mudflats around low water. There is no intertidal zone in front of the adjacent flood defences (protecting St. Margaret's Marsh) or headland, and substrates are a mix of soft mud and rock outcrops in these areas.
- North Queensferry is situated on the north shore, 1.1km from the Main Crossing. The sheltered harbour and mooring areas along this shoreline comprise very soft mud substrates at low to mid water. The short intertidal zone backs onto residential properties and is defended from flooding with large rock breakwaters. The North Queensferry site was chosen to represent the variety of habitats along the north shore, and sampling took place close to the cover of the Forth Rail Bridge.

- Long Rib is situated on the south shoreline, 3km east of the Main Crossing, beyond the Forth Road and Forth Rail Bridges. Long Rib was chosen to characterise the upper Firth of Forth, owing to the lack of access to suitable intertidal areas around the bridges. It is a north facing beach comprised entirely of coarse shingle and larger rocks. Long Rib differs from Society Point, shelving steeply from mid to low shore.
- Society Point is situated on the south shoreline, 1.2km west of the Main Crossing. It is a north facing beach and the shoreline is predominantly shallow sloping mudflats, stretching from the low water mark to approximately 50m of the high water mark. The upper shore is steeper and comprised of shingle and larger stones.
- St. David's is situated on the north shore of the Firth of Forth, 4.1km east of the Main Crossing. This site exhibited a heterogeneous mix of substrates throughout the intertidal zone, with shingle and rock defences characterising the high intertidal, giving way to soft mud, rock outcrops and localised gravel patches towards the low water mark.

2.2.6 A multi-method approach based upon replicated seine and push nets was used at the six intertidal sites described previously in paragraph 2.2.5. No push net sampling was undertaken at North Queensferry due to the soft sediment. A restricted intertidal zone and soft sediment prevented viable and representative sampling from this location. Fyke nets were deployed at Long Rib and St. Margaret's Marsh where substrate and tidal regime were suitable. Seine and push net sampling were undertaken during spring and autumn 2008 with fyke netting undertaken in spring only. Fish capture rates from fyke netting were deemed too low to warrant further use of this method in the autumn sampling period.

2.2.7 Seine netting was undertaken using a small inflatable boat at low water (LW) ±2 hours. A 45m long (3m deep) net with 20mm wings with a 5mm centre mesh was deployed twice from the boat. The method used follows JNCC Procedural Guideline No. 4-3 (Wilding et al., 2001). With one end of the net secured on the shore the boat was reversed out in a loop against the current, and the net was deployed from the bow. Once fully deployed, the net ends were brought together on the shore and net pulled in recovering the heavier lead line before the float line ensured that the net was brought in under the fish preventing loss under the net. All fish present in the net were removed, recorded and measured (total length) and returned to the water.

2.2.8 Push netting was completed around LW±1 hour using a Riley push net fitted with a 5mm mesh cod liner (Riley et al., 1986). The surveys were carried out on foot and the net pushed along a transect parallel to the shore in water deep enough to cover the net mouth (approximately 0.5-1m). At the end of each transect, the net was pushed perpendicularly shorewards and lifted out of the water so as not to lose any fish with breaking waves along the beach. Any fish present were removed, recorded and measured (total length), before being released back into the water. Specimen data obtained from push netting surveys are directly comparable with those from the 1.8m beam trawl as used in the subtidal surveys (Rogers et al., 1998).

2.2.9 Fyke nets were set perpendicular to the shore approximately at HW-2. Two, single-ended fyke nets with 5.3m long (1m deep) leader, fitted with 14mm mesh throughout were securely staked along their length, and tied off to a stake at both ends. Staff remained to ensure that the nets were deployed low enough on the shore to be fully covered during the four hour fishing period. The nets were retrieved approximately two hours after high water (HW+2), while still partially covered. Any fish trapped were removed by untying the cod end, recording and measured (total length), before being released back to the water.

**Subtidal Fisheries Surveys**

2.2.10 Subtidal sites were selected in consultation with SEPA prior to surveying (A. Pearce, SEPA, pers.comm, 15th May). Two subtidal trawl transects were identified, up- and downstream of the Forth Road Bridge (shown in Table 2.2). Site selection ensured that water depth and substrate type were suitable for both pelagic and demersal trawling types. Figure 11.3 shows the position of the intertidal and subtidal fisheries sites.

**Table 2.2: Subtidal fisheries sites**

| Site | Deployment location | Hauling location | Site details |
|---|---|---|---|
| East transect | 56° 00.793' N 03° 22.833' W | 56° 01.126' N 03° 22.204' W | Mixed substrate trawl, predominantly firm mud substrate |
| West transect | 56° 00.602' N 03° 25.486' W | 56° 00.722' N 03° 26.297' W | Mixed substrate trawl with areas of dominant gravel and broken shell and thick mud |

2.2.11 Surveys were undertaken on the RV 'Bernicia' - a 16m stern trawler - using both beam and otter trawls at each site. Each technique was designed to target demersal species (living on or near the bottom) and pelagic species (living in the water column). Both trawl types were conducted against the prevailing current to ensure maximum capture of tiring fish swimming in front of the nets.

2.2.12 The beam trawl comprised of a 1.8m beam and a 4.5m net which had a 40mm mesh in the throat that reduced to 5mm in the cod end. Trawling was undertaken at each site for approximately 10 minutes at a speed of 2 knots. On completion of the trawl the net was winched aboard the vessel and catch emptied from the cod end onto a sorting tray. Any catch was then washed and fish were removed, recorded, measured (total length) and returned to the water. Any invertebrates captured within the trawl were recorded and returned to the water. Five replicate tows were made at each site in spring and autumn 2008. The time and position of each sampling site and net deployment/hauling was recorded using a hand held GPS (Garmin, GPS 76) and recorded on survey logs.

2.2.13 The otter trawl comprised of a cone-shaped net with 4mm cod-end mesh. The net shape was maintained by the use of otter boards, to ensure the net remained horizontal and headline floats to ensure vertical shape (as described in JNCC Procedural Guidelines No. 4-3 (Wilding et al., 2001)). Trawling was undertaken for approximately 10 minutes at a speed of 3.5 knots. On completion of the trawl the net was winched aboard the vessel and catch emptied from the cod-end onto a sorting tray. If necessary the catch was then washed. Fish were removed, recorded, measured (total length) and returned to the water. Any invertebrates captured within the trawl were recorded and returned to the water. Five replicate tows were completed at each location in the spring and autumn. The time and position of each sampling site and net deployment/hauling was recorded using a hand-held GPS and recorded on survey logs.

2.2.14 Depending on the fishing technique used, the catch per unit effort (CPUE) or area (CPUA) was calculated to apply statistics to the catch data. Otter trawls are corrected for effort (being distance trawled) due to the variable area of the net throughout towing. Beam trawls are corrected for area due to the standard width of the net; therefore a known area of seabed is trawled. The resultant data show the number of fish per 100m trawled for the otter trawling, and fish per $100m^2$ for the beam trawling.

2.2.15 Statistical analysis of the subtidal fisheries data was undertaken using the multivariate statistical package PRIMER (Clarke & Warwick, 2001). PRIMER analysis was used to identify differences in species contribution between sites and season as well as similarities in trawl catches. All data was log-transformed to prevent large values masking more subtle differences in species composition and abundance. Data were then converted into a Bray-Curtis similarity matrix.

2.2.16 Multi Dimensional Scaling (MDS) ordinations were produced from the converted data to provide a visual representation of the similarity of catch assemblages between trawl replicates. An analysis of similarity (ANOSIM) was used to compare site and seasonal grouping, to elucidate significant differences in species composition.

## 2. 3 Limitations to Assessment

2.3.1 There were no limitations to this assessment.

# 3 Marine Mammals

## 3. 1 Existing Information

3.1.1 Previous survey data were gathered from a number of sources, through internet searches, existing literature and from a variety of statutory and non-governmental organisations including:

- Sea Watch Foundation (SWF);
- Lothian Wildlife Information Centre (LWIC);
- Forth Seabird Group (FSG);
- SNH (Isle of May Reports);
- British Divers Marine Life Rescue (BDMLR); and
- Sea Mammal Research Unit (SMRU).

## 3. 2 Survey Methods

3.2.1 A variety of marine mammal data has been obtained from the FSG where yearly seabird population surveys were carried out and additional marine mammal data recorded. The SMRU has supplied data from five-yearly air surveys of seal populations within the Firth of Forth region as well as information gathered from annual surveys carried out during the grey seal breeding season. For consistency, SMRU carried out surveys within two hours either side of afternoon low tides on days with no rain. Distributional data from 1990 to 2008 inclusive, supplied by SWF and LWIC was collated and plotted using Geographic Information System (GIS).

**Survey Area Covered**

3.2.2 It is known that, while the number and diversity of marine mammal species in the Firth of Forth itself is poor, adjacent sea areas support several cetacean species (Evans & Anderwald, 2008) and a number of these are likely to use the estuary for foraging. Only two pinniped species present in UK waters are likely to utilise the estuary for foraging and breeding with many of the inner islands likely to represent suitable haul-out locations.

3.2.3 Various buffer rings have been selected at distances of 5km and 10-50km in 10km increments from the location of the Main Crossing (Figure 11.4). These are used when describing the seal sightings data reported by SWF, LWIC, SMRU and FSG.

## 3. 3 Limitations to Assessment

3.3.1 Most records in the Firth of Forth are opportunistic and without associated effort, and can therefore potentially contain bias in other areas with observer coverage. Observations tend to be concentrated when sea conditions are more suited to spotting cetaceans; this is usually between April and September. As a consequence of this, winter sightings are likely to be under represented (Evans & Anderwald, 2008). Systematic, land-based watches have been conducted by SWF at a few coastal locations near to the Firth of Forth, and this will be reflected in the distribution of sightings on the Isle of May, Fife Ness in St Andrews Bay and in North Berwick.

3.3.2 The SMRU data (SMRU, 2008) are based on five-yearly surveys concentrated around the grey seal moult period and incorporates numbers based on three survey days where weather and tides permit. All other pinniped data gathered by FSG reports (FSG, 2002-2007) and the LWIC data are opportunistic and based on sporadic surveys concentrated mainly during the breeding season. Therefore, pinniped numbers recorded during the remainder of the year will be under represented.

# 4 Estuarine Birds

## 4. 1 Existing Information

4.1.1 Consultation was undertaken with the following statutory and non-governmental organisations to establish the existence of new and/or updated ecological data relating to the survey area and to ensure the correct approach was undertaken for the surveys:

- SNH;
- Forth Seabird Group (FSG);
- East of Scotland Tern Group;
- Scottish Wildlife Trust (SWT); and
- Faber Maunsell (2007), Jacobs/Faber Maunsell/AECOM (2007), ERM (1996), Mackenzie Bradshaw Environmental Consulting (MBEC) (2008) and Scottish Office Development Department (1996) – estuarine bird survey data.

4.1.2 Consultation was undertaken by MBEC in 2007/2008 with SNH with respect to proposed methodology for assessing coastal birds. Additional consultation regarding tern surveys methods was undertaken by Faber Maunsell in 2007/2008 with SNH, SWT and FSG.

4.1.3 A desk study was undertaken by Jacobs Arup to establish the presence of statutory and non-statutory designated sites and bird species within and adjacent to the estuarine bird study areas. Scientific names of bird species recorded are presented in Appendix A11.3 (Detailed Estuarine Baseline Information).

## 4. 2 Survey Methods

4.2.1 Surveys for non-breeding coastal birds and passage migrants were developed and undertaken by MBEC from October 2007 to April 2008.

4.2.2 The breeding and passage migrant tern surveys were undertaken by Faber Maunsell from April–October 2007.

4.2.3 Surveys methods for each of the three bird groups are summarised below.

**Coastal Birds**

Method

4.2.4 The study area for coastal birds, located between Limekilns and Donibristle Bay on the northern shore and Abercorn Point and Hound Point on the southern shore of the Firth of Forth was delineated by key geographic features (e.g. headlands). The study area was selected to encompass an area large enough so that all birds and supporting habitats potentially affected by the Main Crossing were included. The study area was divided into 18 bird count sectors following geographic boundaries (where possible); nine on the northern shore and six on the southern shore (N1 to N9 and S1 to S6 respectively). In addition, three core bird count sectors (C1 to C3) were established to cover the mid-water areas adjacent to the Main Crossing (shown on Figure 11.6).

4.2.5 It can be considered that accuracy of bird identification and counting and mapping decreases with distance from the observer. The spread of count points was designed to minimise this distance.

4.2.6 Some sections of the wider survey area were not surveyed as intensively as was originally intended owing to difficulties in obtaining immediate access permission for the coastal bird surveys. The main area where this occurred was the Ministry of Defence Naval Base at Rosyth. However,

access permission was in place by October 2007 from which time onwards this area was regularly counted. This initial access restriction is not considered to be a significant gap in the dataset as relatively low densities of coastal waterbirds have been recorded within Rosyth dockyard.

4.2.7 Coastal birds were surveyed using a modified version of the Wetland Bird Survey (WeBS) (Gilbert et al., 1998): a monitoring programme of non-breeding waterbirds at wetland sites throughout the UK, developed and co-ordinated by the British Trust for Ornithology.

4.2.8 Systematic counts were undertaken throughout a range of tide states, i.e. high, low and on ebbing and flooding tides, between October 2007 and April 2008. Counts were postponed or curtailed when visibility was judged to be less than 1km.

4.2.9 Within core sectors, approximately four high, mid and low tide counts were undertaken each month at each sector, while within the wider survey area four high and low tide counts were undertaken each month at each sector. Count dates were selected to include both neap and spring tides and timed so that the mid-point of the survey would be synchronised with the turn of the tide (i.e. high water or low water).

4.2.10 Surveyors were rotated between areas on a monthly basis and the order in which each site was visited was varied to prevent surveyor bias.

4.2.11 Wetland birds recorded included gulls, terns, divers, grebes, cormorants, herons, swans, geese, ducks, rails, waders and kingfisher as defined by Wetlands International (Rose & Scott, 1997).

**Breeding Terns**

Method

4.2.12 A survey grid covering 500m either side of the Main Crossing was divided along the main channel axis of the Firth of Forth. The grid was divided into count sub-sectors and each count sub-sector measured 300m x 250m.

4.2.13 The count sectors to the north and south of the central channel axis were referred to as Area NQ and Area SQ, which were sub-divided into 16 count sectors and 20 count sectors respectively.

4.2.14 At fixed, frequent and constant timed intervals, all active (i.e. fishing/foraging) and loafing or roosting terns were counted within a count sector, from April to October 2007. Counts were made from one of two vantage points (shown on Figure 11.7). These were:

- Vantage Point 1 (VP 1) was located close to the lifeboat station at North Queensferry, underneath the Forth Road Bridge (NT 12551 80514).
- Vantage Point 2 (VP 2) was located approximately 500m west of Port Edgar near to The Fisheries (NT 11281 78804).

4.2.15 Area NQ was counted from VP 1 whereas Area SQ was counted from VP 2.

4.2.16 Distinctive landmark features (such as the two cable towers on the existing Forth Road Bridge and terrestrial geographic features) were used as guides to aid differentiation of each respective sector (shown on Figure 11.7).

4.2.17 Two distinct tidal races develop east of Beamer Rock on an ebbing tide (Race A) and west of Beamer Rock on a flooding tide (Race B). These races can be important feeding areas for terns therefore, both tidal races are considered as separate counting units when they are operating and visible from the respective vantage points. Race A and Race B could be counted from both vantage point locations.

4.2.18 Each survey visit included a total of five one-hour watches per vantage point and for each one-hour watch a summary count was conducted every five minutes for each count sector within either Area NQ or SQ, depending on the vantage point used. This was considered to be the most suitable method of recording differences relating to the spatial and temporal distribution of feeding terns within the survey area.

4.2.19 The surveys comprised sequential counts from VP 1 and VP 2 respectively, involving a single field surveyor. They were conducted within 1.5 hours either side of low and high tides, concentrating on each spring and neap tide period during the tern breeding season.

4.2.20 Dense aggregations of flying/loafing birds in the immediate vicinity of the breeding colony made quick and accurate counts of these birds difficult and it was not possible to view the total area occupied by nesting terns from either vantage point. However, the common tern colony located on the floating pontoon at Port Edgar was easily viewed and the nesting terns were monitored. This provided an indication of the timing of the tern breeding season in the locality (shown on Figure 11.7).

4.2.21 The Long Craig Island breeding season survey comprised eleven four-day survey visits between 02 June 2007 and 16 August 2007.

**Passage Migrants**

Method

4.2.22 The study area for passage migrants was located between Whitehouse Point (east of the Forth Rail Bridge at NT 148 794) and Port Edgar Harbour Breakwater (west of the Forth Road Bridge at NT 119 793) on the southern shore of the Firth of Forth and Carlingnose Point (east of the Forth Rail Bridge at NT 135 806) on the north shore of the estuary (shown on Figure 11.6).

4.2.23 Within the study area, timed watches from strategic vantage points (VPs) were undertaken to record waterbird flight activity in relation to the existing railway and road bridge structures and the location of the Main Crossing as it crosses the estuary.

4.2.24 Three VPs were established to provide visibility of the Main Crossing route and also the area to the east of the Forth Rail Bridge. These were at White House Point, Carlingnose Point and Port Edgar west breakwater.

4.2.25 A total of 80 observations, each comprising three-hour watches were completed, providing a total of 240 hours of observation for all VPs, from October 2007 to April 2008.

## 4. 3 Limitations to Assessment

4.3.1 The whole survey area was not observed in vantage point surveys owing to small coves, undulating nature of coast line and inaccessibility of some areas which may have resulted in an under-estimate of bird numbers.

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