A11.3 Detailed Estuarine Baseline Information

This appendix presents the detailed baseline data used to inform an evaluation of ecological receptors within the study area and the assessment of ecological impacts.

1 Benthic Habitats

1.1 Sediment Granulometry

1.1.1 Sediment type was characterised with reference to the system given by Hillewaert (2007). This system is based on nine categories and is based on that derived by Folk (1954), which gives 15 categories (the system for the derivation of sediment categories is illustrated in Appendix A11.2 (Detailed Estuarine Baseline Survey Methods)).

1.1.2 Generally, sediments throughout the study were characterised predominantly by grey mud and sand of variable proportions (Figure 11.2a). At 17 of the 33 subtidal sites for which sediment granulometry data were available, the silt and clay content exceeded 50%. Sand was the dominant size fraction at ten sites. Upstream of the bridges, muddier sediments were found towards the north shore with coarser material prevalent at sites located centrally and toward the south shore. Downstream of the bridges, sediments at central sites were characterised by coarser material while sediments became predominantly finer toward both shores.

1.1.3 All intertidal sediments comprised mud and sand. Mud was the dominant component on the south shore, where fines represented on average 78% of material. Sand fines represented over 60% of material at the single sediment site sampled on the north shore.

1.1.4 Sandy mud was the most common sediment type throughout the subtidal survey area (Figure 11.2b). However, coarser sandy sediments were also recorded, particularly in the mid-channel areas, while areas of hard ground occurred towards the north shore between Inchgarvie and North Queensferry. In general, subtidal sediments became coarser with depth ($r=0.85$, $P=0.03$). Sediments at all south shore intertidal sites were characterised as sandy mud while at the single north shore site muddy sand was recorded. This distribution of sediment type generally agrees with that reported by Elliott & Kingston (1987) who reported that upstream of the bridges fine sediments predominated although coarser muddy sands and gravels were evident in scoured and channel areas. Sediments in the Firth of Forth were also reported to contain >50% fine material (FRS & SEPA, 1997). Elliott & Kingston (1987) also discussed the occurrence of scoured clays in areas of fast currents in the vicinity of the Forth Road Bridge, which is reflected in field observations where the presence of firm clays and muds and gravels were recorded in this area in the present study.

1.2 Sediment Metals

1.2.1 Contaminant levels are often examined in isolation, without reference to the possible effects associated with the natural variability of sediment characteristics. Muds and silts tend to have naturally higher levels of metals compared with coarser sands owing to a large surface area, oxyhydride and organic coatings which readily sequester metals. To allow for such variations the data require to be weighted using a factor known to be subject to only naturally driven fluctuations, otherwise spatial and temporal comparisons are uncontrolled and of little use; this is known as normalisation. One way in which normalisation can be achieved is to examine the distribution of geogenic elements within sediments for which background levels will not be altered significantly by any anthropogenic inputs. For instance, as silts and clays are dominated by aluminosilicate minerals, naturally occurring levels of aluminium will dwarf any anthropogenic sources. As metals are sequestered by the fine fraction, aluminium concentrations represent a suitable factor with which to normalise. Therefore, to establish any patterns independent of natural variation normalisation to aluminium was performed by determining metal to aluminium concentration ratios. The level of enrichment of a metal within a sediment can be assessed by comparing the value of the metal to aluminium concentration ratio to the Background Reference Concentration (BRC) for

that metal which is the range of values for the metal to aluminium concentration ratio which would be expected in uncontaminated sediments as determined by OSPAR (Oslo and Paris Commissions) (OSPAR, 2000). Concentrations are considered to be close to background if the metal to aluminium concentration ratio is less than twice the upper limit of the BRC.

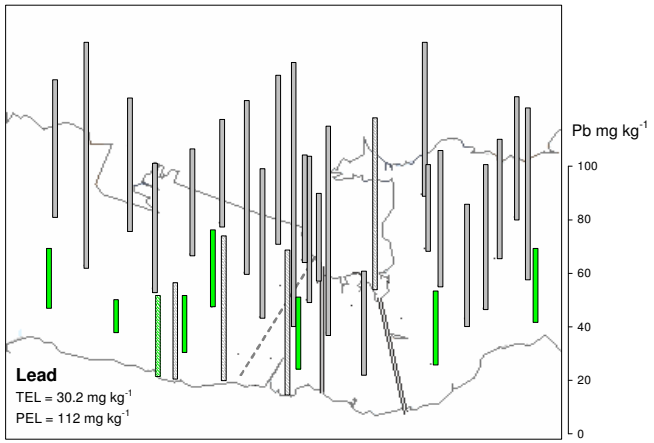
1.2.2 Many metals are essential for life, however even at moderately elevated levels they can become harmful or even lethal to aquatic life. At present there are no statutory environmental quality standards (EQS) for marine and estuarine sediments in the UK. The current recommended procedure is to use the Threshold Effects Levels (TEL) and Probable Effect Levels (PEL) approach developed by Environment Canada (CCME, 1999) which assesses the likelihood of sediment contamination having a biological impact. The TEL and PEL were derived from an extensive database containing direct measurements of the toxicity of contaminated sediments to a range of aquatic organisms exposed in laboratory tests and under field conditions. The TEL of a substance is the concentration below which sediment associated chemicals are not considered to represent significant hazards to aquatic organisms while the PEL represents the lowest concentration of a substance that is known to have an adverse impact on aquatic organisms. Effects may be observed in some sensitive species exposed to the TEL, whereas the PEL is likely to cause adverse effects in a wider range of organisms. Interim Sediment Quality Guidelines (ISQG) based on the TEL values have been adopted in England and Wales by the Environment Agency and as the best practice approach for Habitats Directive Review of Consents in estuaries in the UK (CCME, 1999; UK MSAC Project, 2007). In general, where sediment concentrations of toxic substances are close to exceeding the TEL, conservation agency staff should identify sediment concentrations as a cause for concern and seek to minimise further inputs of these substances to the European marine site (UK MSAC Project, 2007).

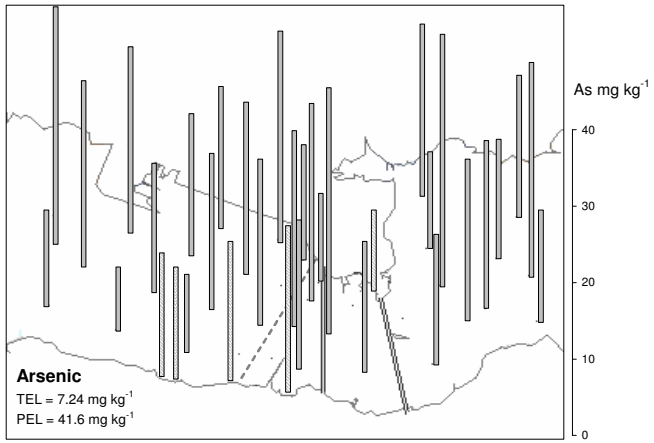
1.2.3 The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Sediment Action Levels, which are derived from a combination of chemical and ecotoxicological data sets, are used to assess the chemical quality of dredged material which is to be disposed of at sea. The levels comprise two values; if contaminant concentrations are below Action Level 1 it is considered that material is unlikely to result in significant contamination of the marine environment and disposal at sea would be considered appropriate. If a contaminant concentration exceeds Action Level 2 it is considered that disposal at sea is likely to result in potentially harmful levels of contamination and alternative disposal methods will be required. If contaminant levels are between Action Level 1 and 2 further investigations would be required to determine the suitability of disposal at sea.

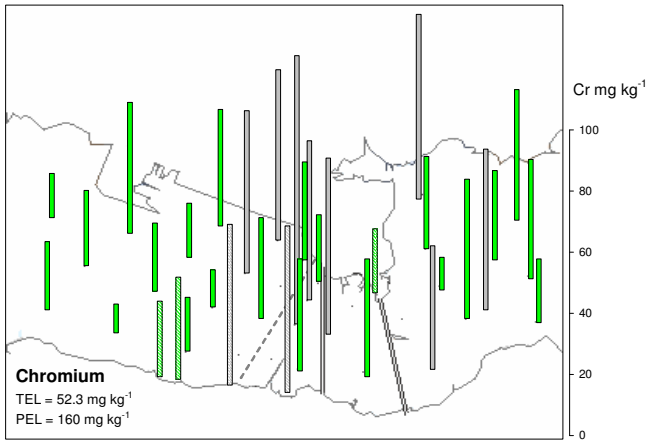
1.2.4 Sediments from the Forth were analysed for a suite of List I and II metals as designated under the Dangerous Substances Directive (76/464/EEC). List I substances are those deemed to be particularly dangerous to the environment owing to their toxicity, persistence and bioaccumulation. List II substances, while less dangerous, are still considered to have a deleterious effect on the aquatic environment. Sediment-bound metal concentrations have been compared to BRCs to determine any current elevation above background levels and to TELs and PELs to assess the likelihood of any biological impacts associated with current sediment quality. Sediment Action Levels have been used to determine whether the release of material associated with the construction of the Main Crossing into the water column is likely to result in significant environmental contamination.

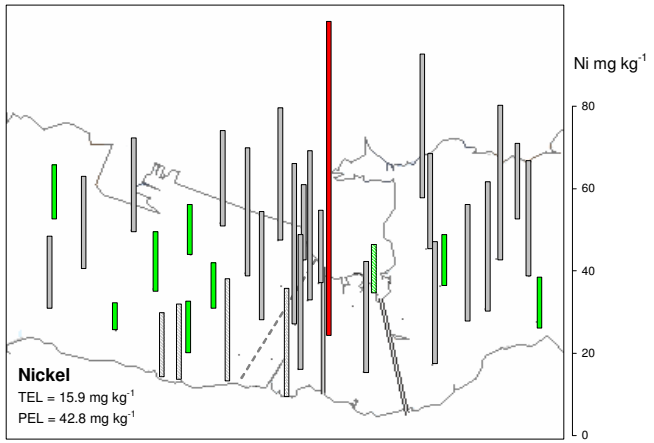
1.2.5 Sediment-bound metal concentrations are illustrated on Plot 1.1 and indicate a relatively homogenous distribution of metals throughout the study area. However, it is evident that the highest concentrations of all metals were recorded in the middle of the estuary between the proposed location of the Main Crossing and the Forth Road Bridge at sites FS18, FS19 and FS22. The highest individual concentrations of cadmium, lead, nickel and zinc occurred at FS22, while highest levels of chromium and copper were recorded at FS18 and for mercury at FS19. The distribution of the lowest sediment-bound metal concentrations was less clear although the lowest levels were recorded predominantly toward the south shore upstream of the Forth Road and Rail Bridges at sites FS02, FS05 and FS09. Sediment-bound levels of cadmium, chromium, copper, nickel and zinc were positively correlated to the mean silt and clay sediment fraction ($r>0.5$, $P<0.007$); arsenic and lead levels were also positively correlated to sediment fine fraction although the relationships were less strong ($r<0.5$).

Plot 1.1: Sediment-bound metal concentrations in Firth of Forth sediments. Green bars = concentration <TEL; grey bars =TEL <concentration <PEL; red bars =concentration >PEL. Striped bars indicate intertidal sites. The base of each bar is located on the sampling point.









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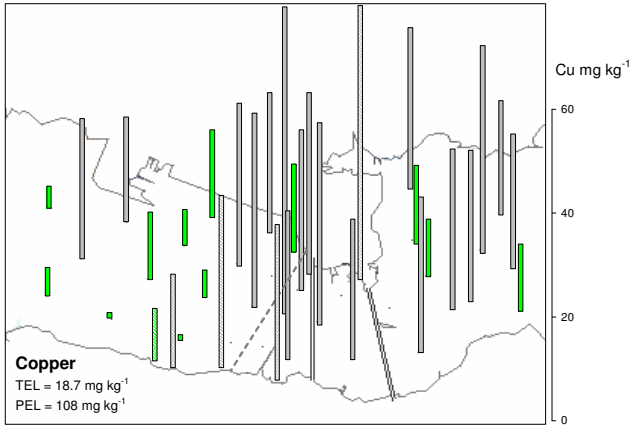
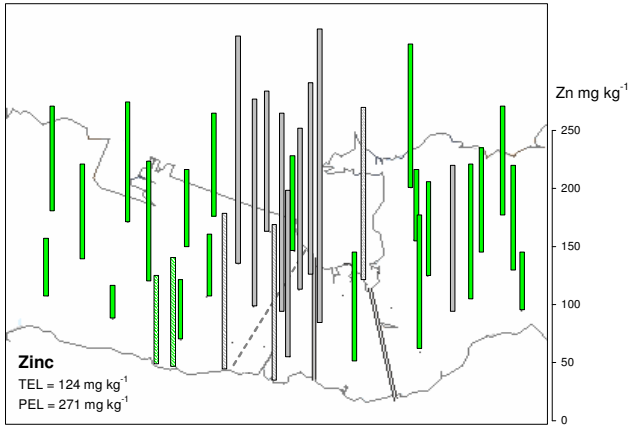
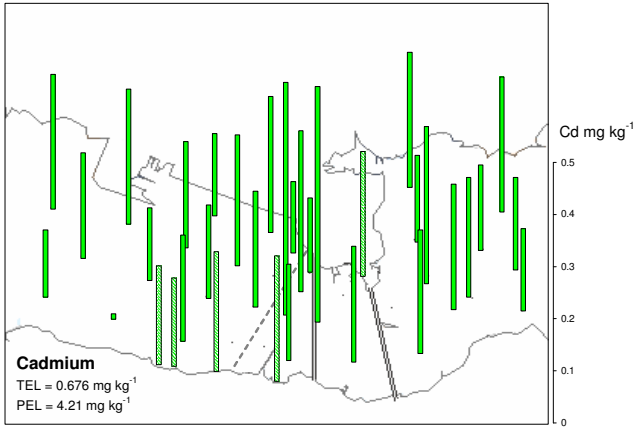
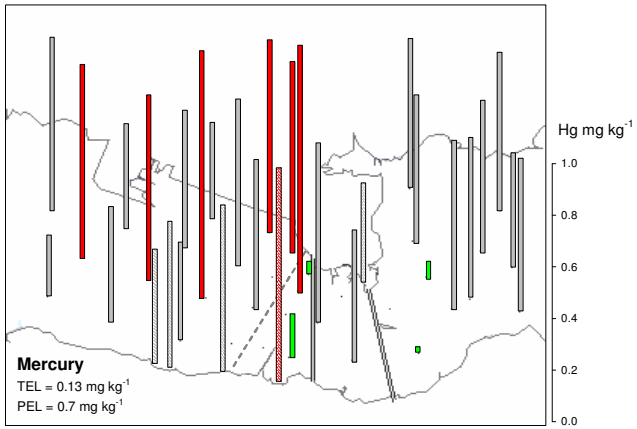








1.2.6 Total sediment metal loads were examined at each site first by standardising each metal concentration against the mean concentration from all sites for that metal. The mean of all standardised metal concentrations was then calculated to give the Total Standardised Metal level (TSM) for each site. The highest value for TSM occurred in sediments collected in the middle of the estuary close to the Forth Road Bridge at site FS22 (18.4), while high values were also recorded at the adjacent site FS18 (13.4) (Figure 11.2c). The lowest values were recorded upstream of the Main Crossing toward the south bank at sites FS02, FS05 and FS09 (4.1, 2.2 and 3.7 respectively). These trends reflect the patterns for individual metals discussed above indicating a consistent pattern in sediment loading for all metals throughout the study area.

1.2.7 All values of the metal to aluminium concentration ratio for zinc, cadmium, lead and arsenic were more than twice the upper Background Reference Condition (BRC) (Table 1.2). On average, values of the lead to aluminium concentration ratios were 11 times the upper BRC while those for zinc and arsenic were five and four times greater than the upper BRC respectively. With the exception of one site, all mercury to aluminium concentration ratios were greater than twice the upper BRC with values being on average 80 times higher. All but four values of the copper to aluminium concentration ratio were more than twice the upper BRC; of these four, two values exceeded the upper BRC, one was lower then the upper BRC and one copper concentration was less than the MRV. Half of the values for the nickel to aluminium concentration ratio exceeded the upper BRC but by no more than twice this upper value; at the remaining 15 sites the ratios were all less than the upper BRC. All chromium to aluminium concentration ratios were less than the upper BRC.

1.2.8 At seven sites, sediment-bound mercury concentrations were greater than the relevant PEL while a further 19 were between the TEL and PEL (Plot 1). The only other PEL exceedance occurred for nickel at site FS22 while the majority of other nickel concentrations were between the TEL and PEL. All arsenic and the majority of copper and lead concentrations were between the TEL and PEL. The levels of zinc and chromium at the majority of sites were less than the relevant TELs. All cadmium concentrations were less than the TEL.

Table 1.1: Background Reference Conditions (BRC) and metal to aluminium concentration ratios for subtidal sediments. Blue indicates ratio >upper BRC; red indicates ratio >2x upper BRC

	BRC Range	FS01	FS02	FS03	FS04	FS05	FS06	FS07	FS08	FS09	FS10	FS11	FS12
Copper	2.2 - 4.5	6.9	5.7	26.5	13.2	-	15.9	9.9	11.7	2.0	10.4	15.8	12.6
Zinc	8.8 - 18	148.4	51.1	79.3	65.6	70.9	123.1	95.7	60.1	88.1	108.4	99.0	57.3
Cadmium	0.007 - 0.03	0.4	0.1	0.2	0.2	0.1	0.2	0.2	0.1	0.2	0.4	0.1	0.1
Mercury	0.0034 - 0.0066	1.1	0.2	0.7	0.3	1.1	0.9	0.8	0.2	0.6	1.9	0.3	0.3
Lead	1.8 - 4.0	84.1	22.7	81.7	31.8	30.3	57.2	57.1	27.0	36.3	57.7	32.6	28.9
Arsenic	2.0 - 4.5	50.7	12.7	23.6	15.4	20.7	25.4	26.5	12.4	17.6	40.7	11.4	12.7
Chromium	9.0 - 20	26.4	26.0	27.2	30.9	25.6	30.6	28.3	29.0	34.7	26.9	30.5	29.1
Nickel	4.4 - 9.1	21.0	17.7	21.7	14.5	16.3	17.4	17.1	15.4	21.1	22.2	15.7	14.7

	BRC Range	FS14	FS16	FS18	FS19	FS20	FS21	FS22	FS24	FS26	FS27	FS28	FS29
Copper	2.2 - 4.5	33.5	14.3	28.2	14.2	43.1	16.9	-	18.8	14.1	12.0	25.5	19.0
Zinc	8.8 - 18	160.4	67.9	80.2	62.1	203.4	87.1	-	65.5	56.6	50.8	193.1	72.3
Cadmium	0.007 - 0.03	0.2	0.1	0.2	0.1	0.2	0.1	0.3	0.2	0.1	0.1	0.7	0.1
Mercury	0.0034 - 0.0066	0.5	0.6	-	0.4	-	0.1	0.4	0.4	0.3	0.5	-	-
Lead	1.8 - 4.0	49.3	33.3	46.4	24.9	40.4	15.9	160.3	26.9	26.0	26.4	120.2	17.2
Arsenic	2.0 - 4.5	19.5	12.3	12.1	11.8	13.8	11.4	20.5	12.0	10.3	10.4	78.3	10.8
Chromium	9.0 - 20	33.9	30.2	47.2	27.1	30.6	24.5	42.1	30.8	31.3	28.2	28.8	29.0
Nickel	4.4 - 9.1	23.4	15.1	18.3	16.5	21.6	19.2	48.8	18.8	15.9	18.9	29.8	18.6

	BRC Range	FS30	FS31	FS32	FS33	FS34	FS35	FE02 A	FE02 B	FE06	FE04	FE15
Copper	2.2 - 4.5	19.9	42.5	16.3	17.7	14.4	20.8	12.8	14.3	15.4	14.4	46.1
Zinc	8.8 - 18	80.1	95.4	66.1	69.1	60.9	70.2	81.7	71.0	62.7	63.9	112.4
Cadmium	0.007 - 0.03	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Mercury	0.0034 - 0.0066	0.4	0.6	0.3	0.8	0.4	0.3	0.5	0.4	0.3	0.4	0.3
Lead	1.8 - 4.0	29.1	46.6	29.9	38.0	29.7	50.6	31.2	28.3	25.6	26.1	48.3
Arsenic	2.0 - 4.5	13.5	16.1	12.2	20.3	11.9	22.2	19.7	13.3	9.9	11.9	9.4
Chromium	9.0 - 20	33.0	34.8	33.1	33.4	31.4	35.3	30.1	29.9	28.3	30.0	18.0
Nickel	4.4 - 9.1	18.1	19.1	17.4	17.0	18.1	29.8	20.3	17.3	14.4	15.5	11.1

Table 1.2: Sediment Action Levels and sediment-bound metal concentrations ($mgkg^{-1}$). Blue numbers indicate metal conc >Action Level 1 and <Action Level 2

Metal	Sediment Action Level 1	Sediment Action Level 2	FS01	FS02	FS03	FS04	FS05	FS06	FS07	FS08	FS09	FS10	FS11	FS12
Copper	20	200	4.18	5.62	27.3	20.8	0.05	13.3	6.92	17.4	1.18	5.18	31.2	27.4
Zinc	65	400	90.5	50.2	81.7	103	28.8	103	66.7	89.6	51	54.1	196	125
Cadmium	0.2	2.5	0.262	0.128	0.204	0.259	0.05	0.204	0.158	0.204	0.14	0.18	0.252	0.263
Mercury	0.15	1.5	0.667	0.231	0.745	0.405	0.445	0.714	0.528	0.371	0.374	0.954	0.642	0.742
Lead	25	250	51.3	22.3	84.2	49.9	12.3	47.9	39.8	40.3	21	28.8	64.6	62.9
Arsenic	10	50	30.9	12.5	24.3	24.2	8.42	21.3	18.5	18.5	10.2	20.3	22.5	27.6
Chromium	20	200	16.1	25.6	28	48.5	10.4	25.6	19.7	43.2	20.1	13.4	60.3	63.5
Nickel	10	100	12.8	17.4	22.4	22.7	6.61	14.6	11.9	22.9	12.2	11.1	31.1	32.1

Metal	Sediment Action Level 1	Sediment Action Level 2	FS14	FS16	FS18	FS19	FS20	FS21	FS22	FS24	FS26	FS27	FS28	FS29
Copper	20	200	37.2	17.3	59.8	31	35.2	28.7	-	26.9	30.9	14.6	10.7	30.2
Zinc	65	400	178	82.2	170	136	166	148	-	93.7	124	62	81.1	115
Cadmium	0.2	2.5	0.221	0.137	0.448	0.314	0.142	0.186	0.452	0.223	0.26	0.166	0.301	0.238
Mercury	0.15	1.5	0.577	0.735	-	0.954	-	0.169	0.685	0.508	0.574	0.572	-	-
Lead	25	250	54.7	40.3	98.3	54.6	33	27	250	38.5	57	32.2	50.5	27.4
Arsenic	10	50	21.7	14.9	25.6	25.8	11.3	19.4	32	17.1	22.5	12.7	32.9	17.1
Chromium	20	200	37.6	36.6	100	59.4	25	41.6	65.7	44	68.6	34.4	12.1	46.1
Nickel	10	100	26	18.3	38.8	36.2	17.6	32.6	76.2	26.9	34.8	23	12.5	29.5

Metal	Sediment Action Level 1	Sediment Action Level 2	FS30	FS31	FS32	FS33	FS34	FS35	FE02 A	FE02 B	FE06	FE04	FE15
Copper	20	200	31.1	40.4	29.3	12.7	22.3	26.2	12	18.4	32.7	29.5	59.5
Zinc	65	400	125	90.6	119	49.6	94.4	88.5	76.4	91.6	133	131	145
Cadmium	0.2	2.5	0.242	0.164	0.23	0.159	0.177	0.26	0.19	0.171	0.225	0.241	0.163
Mercury	0.15	1.5	0.649	0.586	0.613	0.587	0.607	0.44	0.441	0.565	0.642	0.817	0.388
Lead	25	250	45.4	44.3	53.8	27.3	46.1	63.7	29.2	36.5	54.2	53.6	62.3
Arsenic	10	50	21.1	15.3	21.9	14.6	18.5	28	18.4	17.1	20.9	24.4	12.1
Chromium	20	200	51.5	33.1	59.6	24	48.6	44.5	28.1	38.6	60.1	61.6	23.2
Nickel	10	100	28.3	18.1	31.3	12.2	28	37.6	19	22.3	30.6	31.8	14.3

1.2.9 At each site, sediment-bound concentrations of all metals were less than the relevant Sediment Action Level 2 concentration (Table 1.2). However, the majority of concentrations were between Action Levels 1 and 2, although for all metals the highest individual concentrations reported were lass than half the Action Level 2 concentration.

1.2.10 Mean sediment-bound metal concentrations reported here are of similar magnitude to those recorded previously from the Forth and other major UK estuaries (Table 1.3).

Table 1.3: Sediment-bound metal concentrations ($mgkg^{-1}$) from the Forth and other major UK estuaries

	Cu	Zn	Cd	Hg	Pb	As	Cr	Ni	Reference
Forth	25.9	105	0.11	0.63	51	24.5	83.0	12.6	FRS/SEPA (1997)
Forth	62.1	193	1.13	1.40	128	16.3	66.6	37.0	FRS unpublished data
Clyde	31.4	187	0.15	0.31	107	39.9	141.8	30.5	FRS/SEPA (1997)
Tyne	92.0	421	2.17	0.92	187	24.8	46.0	34.0	Burt et al. (1992)
Mersey	84.0	379	1.15	3.01	124	-	-	29.0	Burt et al. (1992)
Thames	48.0	120	0.36	0.35	55	13.0	96.0	31.0	NMMP site 455 data
Forth	25.6	107	0.23	0.59	52.3	20.4	40.2	24.8	Current Study

Polycyclic Aromatic Hydrocarbons

1.2.11 Polycyclic aromatic hydrocarbons (PAHs) are well known chemical carcinogens with many being toxins, mutagens and teratogens. PAHs are known to be highly toxic to aquatic organisms. The greatest sources of PAHs are related to human activity, such as the refining of oil and the incomplete combustion of fossil fuels. However, natural sources for PAHs exist, e.g. created during forest fires and from biogenic microbial production. The most immediate marine environmental risk from PAHs is from soluble compounds in the water column. However, PAHs are hydrophobic and readily adsorb onto suspended particulate matter which is then deposited and incorporated into bed sediments. This represents an important reservoir of PAHs which can pose a risk to resident biota. The only current EQS for a PAH is for naphthalene which is the only PAH designated as a List II substance (no PAH is designated as a List I substance), although other PAHs are currently being investigated by the Department for Environment Food and Rural Affairs (DEFRA). However, as for metals, ISQG have been developed by Environment Canada. Subsequently, TELs and PELs have been developed for thirteen commonly occurring PAHs. The Firth of Forth sediments were analysed for all 13 of these PAHs, and the relevant TELs and PELs were used to assess potential biological effects.

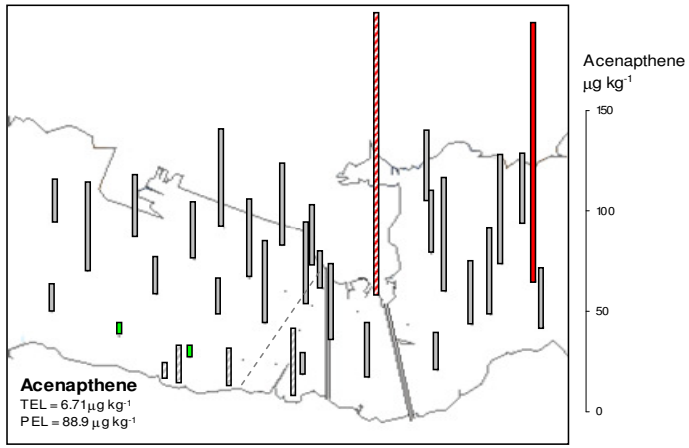
1.2.12 There were two distinct areas where high concentrations of PAHs were present in subtidal sediments. In the vicinity of the Forth Road and Rail Bridges and upstream towards the north shore further high concentrations of PAHs were recorded, particularly at intertidal site FE15 where the highest concentrations of nine PAHs were recorded; the highest levels of three further compounds were recorded in this area at FS08 (Plot 2). At the western end of the survey area high levels of most PAHs were recorded, particularly at FS35 where the highest concentration of naphthalene was recorded; high concentrations also occurred at adjacent sites FS32 and FS31. The lowest levels of all PAHs were recorded upstream of the bridges towards the south shore at sites FS02, FS05 and FS09. There was no strong correlation between the distributions of any PAH and the silt and clay content of the sediments.

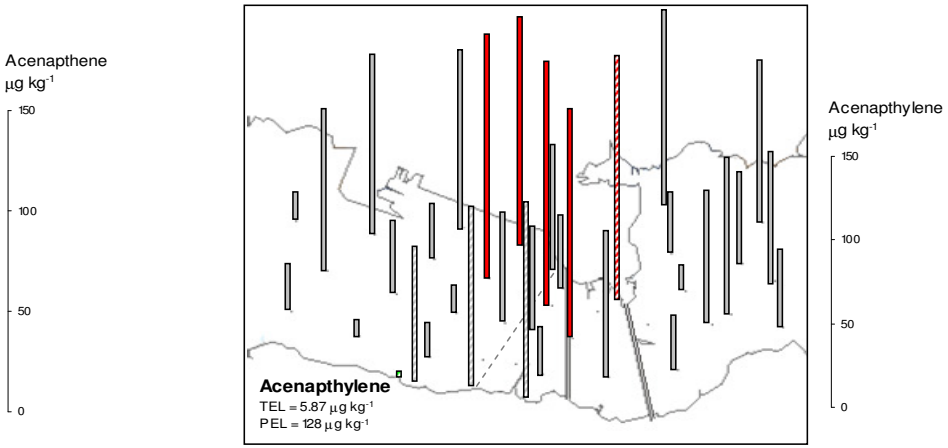
1.2.13 The range of individual PAH and total PAH concentrations were compared to those previously reported from the Forth and other major UK estuaries (Table 1.4). Levels recorded in the present study were similar to those reported from the industrialised estuaries of the Tyne, Mersey and Thames although were considerably lower than those found in dredge material from the vicinity of Rosyth (FRS unpublished data). However, levels were considerably higher than those reported as part of the National Marine Monitoring Programme (NMMP) at the monitoring site in the Firth of Forth (FRS & SEPA, 1997).

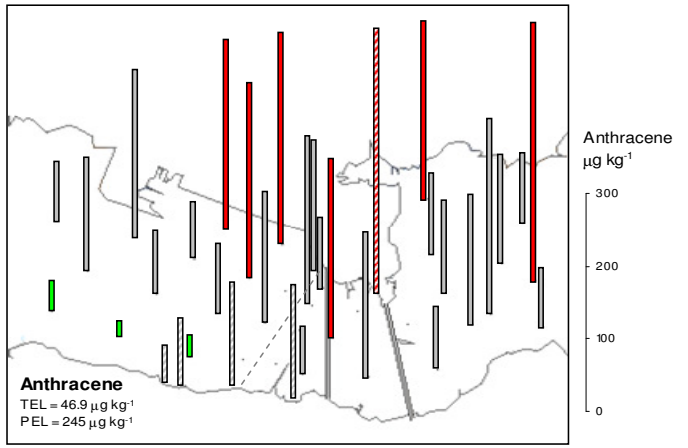
Table 1.4: Sediment-bound PAH concentrations (µgkg^{-1}) from the Firth of Forth and other major UK estuaries

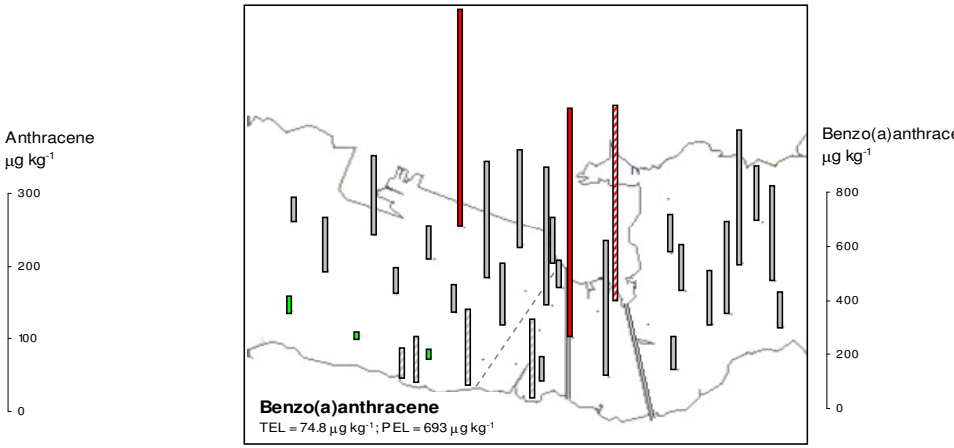
Estuary	Individual PAH range	Total PAH range	Reference
Forth (NMMP)	<0.01 - 20.9	37.8	FRS & SEPA (1997)
Forth	-	4400 - 25000	FRS unpublished data
Clyde	<0.01 - 134.2	854	FRS & SEPA (1997)
Tyne	<17 - 2417	236 - 10720	Sheahan (2006)
Mersey	<5 - 1242	6 - 5236	Sheahan (2006)
Thames	13- 1071	597 - 5350	Sheahan (2006)
Forth	3 - 1400	64 - 5909	Current Study

Plot 1.2: Sediment-bound PAH concentrations in Firth of Forth Estuary sediments. Green bars =concentration <TEL; grey bars =TEL <concentration <PEL; red bars =concentration >PEL. Striped bars indicate intertidal sites. The base of each bar is located on the sampling point.

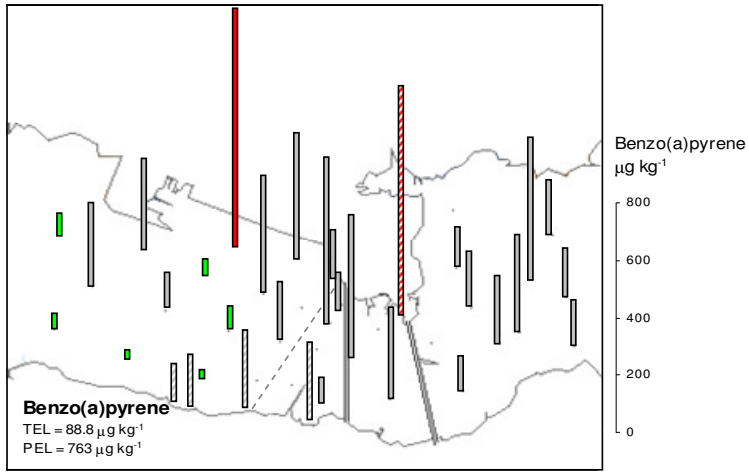


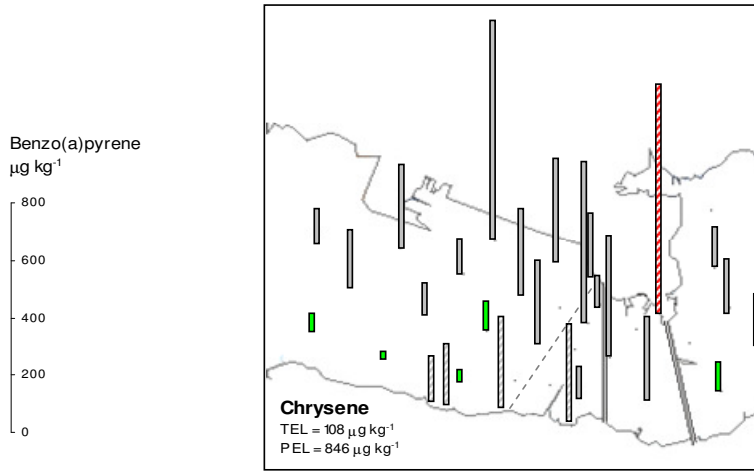


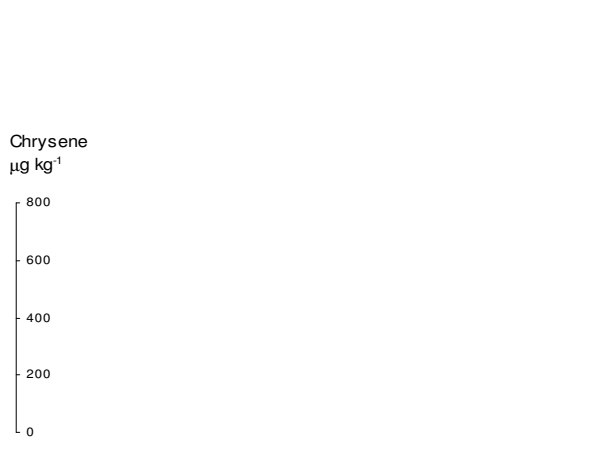


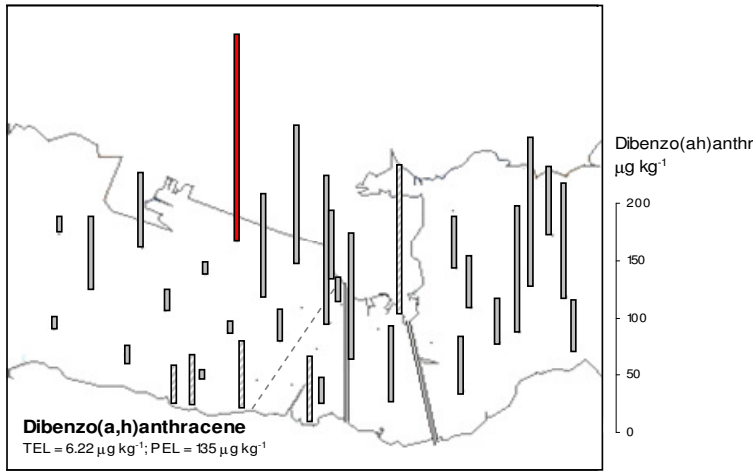


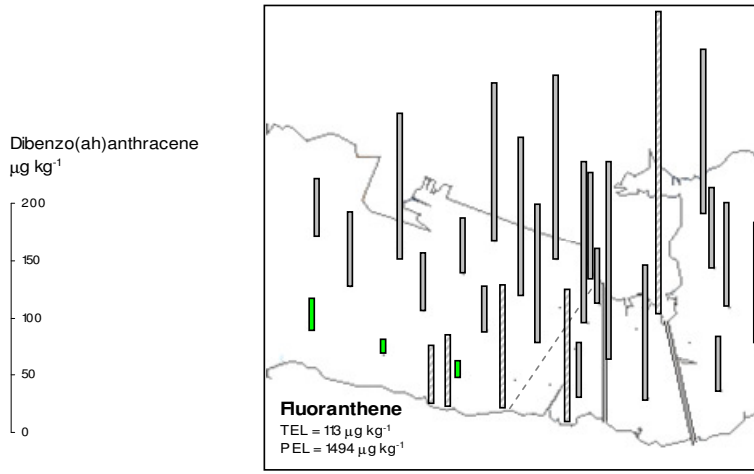
Plot 1.2 continued

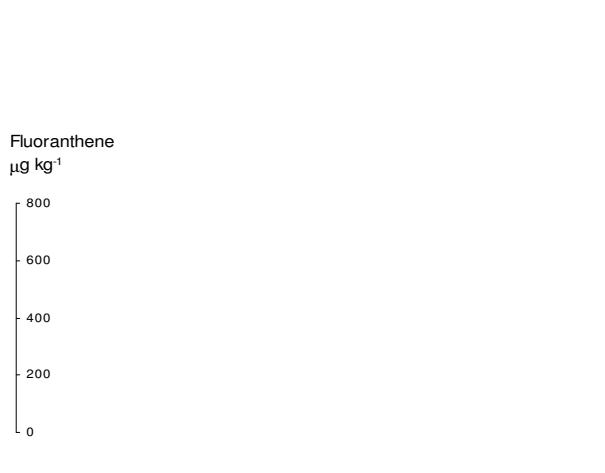




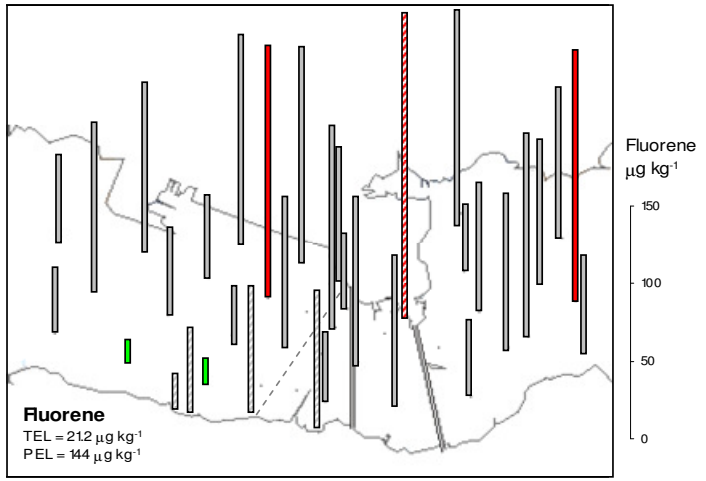


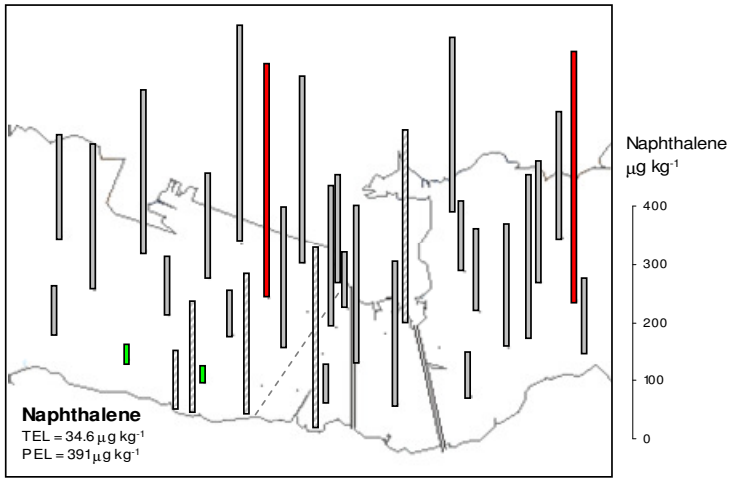


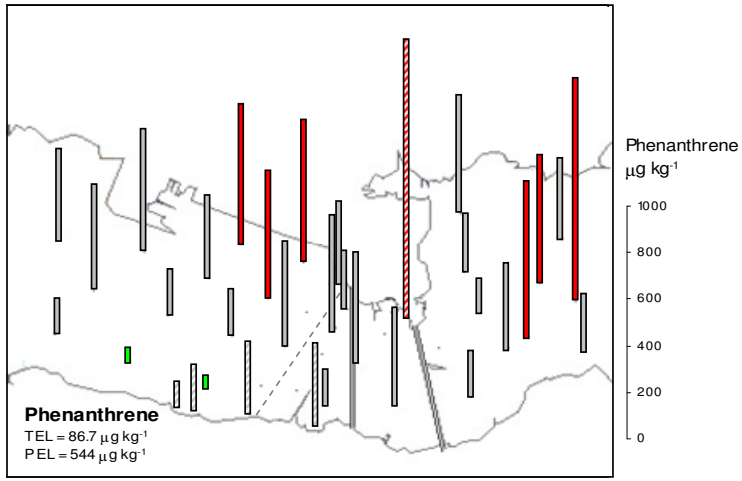


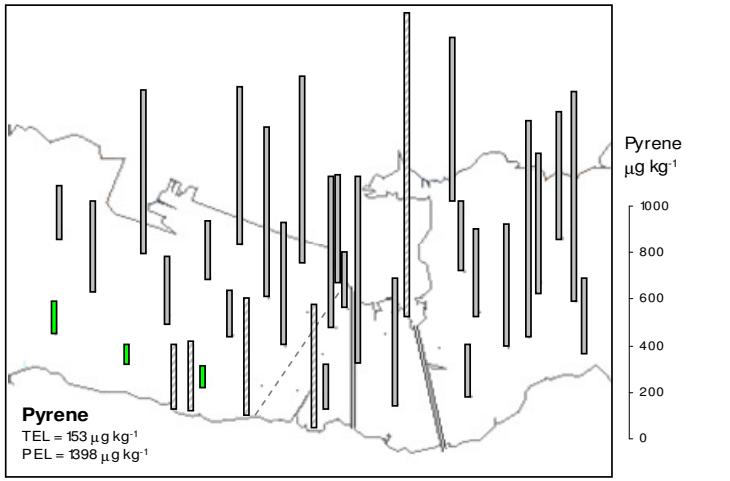


Plot 1.2 continued

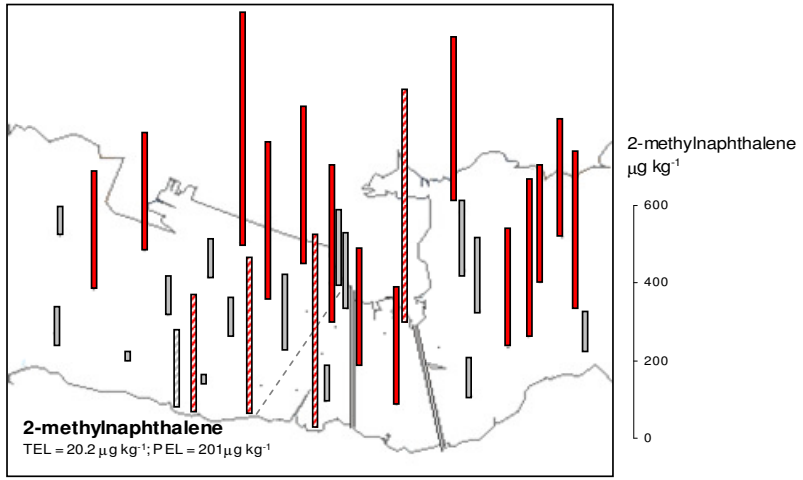


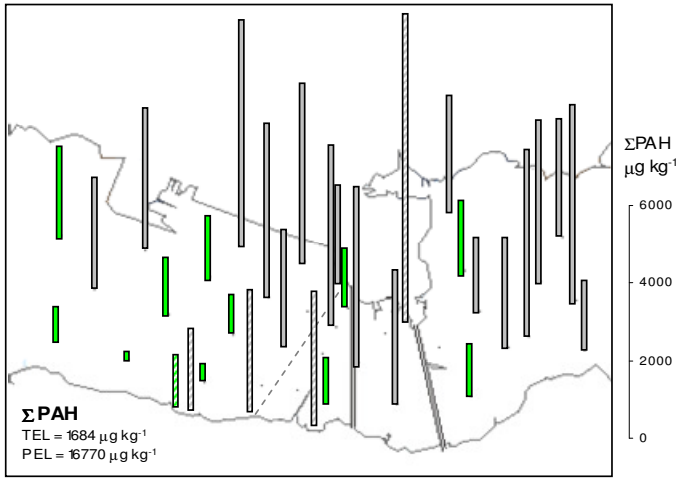






Plot 1.2 continued





1.2.14 Total standardised PAH levels (TSPAH) were calculated using the same methodology as used for metals earlier and are shown on Figure 11.2d. As expected the distribution pattern follows the general distribution of individual PAHs as discussed above. However the TSPAH in the areas of high concentrations indicate the uneven distribution of these compounds throughout the study area. If spatial distribution of PAHs was even, a mean TSPAH of close to 13 would be expected throughout the study area. However, at FE16 the value was 36. Elsewhere in areas of high PAH concentrations in the vicinity of the Forth Road and Rail Bridges and towards Rosyth, TSPAH values range from 21 to 28, while to the west of the study area the range is 19 to 24. In subtidal sediments towards the south shore upstream of the Forth Road and Rail Bridges, low PAH concentrations were recorded with TSPAH values ranging between two and four.

1.2.15 For all 13 measured PAHs the majority of concentrations were greater than the relevant TEL and, with the exceptions of fluoranthene and pyrene, several values also exceeded the PEL (Plot A11.3.2). PEL was exceeded with greatest frequency for 2-methylnaphthalene at 14 sites, predominantly in the northern half of the survey area. Concentrations of other PAHs greater than the relevant PEL were also generally observed in the northern half of the study area, particularly in the areas of high TSPAH levels discussed above. Similarly, the only sites at which individual PAH concentrations were less than the relevant TELs were at sites towards the south bank upstream of the bridges. The PEL for ΣPAH was not exceeded at any site. However, the majority of values were greater than the TEL; the highest ΣPAH recorded (FE15) was over one third of the TEL to PEL range.

1.3 Polychlorinated Biphenyls

1.3.1 Polychlorinated biphenyls (PCBs) are organic compounds comprised of a biphenyl group (i.e. composed of two benzene rings) with between one and ten bonded chlorine atoms. PCBs have been used in a wide variety of applications such as use as coolants, flame retardants, lubricating oils, hydraulic fluids, sealants and adhesives. However, as PCBs are highly toxic, persistent pollutants and are readily bioaccumulated in animals, production in the UK ceased in the 1970s and sales of PCB formulations stopped in the mid 1980s. PCBs still enter the marine environment following the destruction and disposal of industrial plants and equipment, emissions from old electrical equipment and from landfill sites. Owing to their persistence in the environment PCBs have the potential to be transported over considerable distances and are ubiquitous in the marine environment. PCBs have low solubility in water and are hydrophobic in nature and in marine environments tend to accumulate in fine sediments, particularly those with high organic content. Of the total of 209 PCB congeners, Firth of Forth sediments were analysed for the ICES 7 group of PCBs (congeners 28, 52, 101, 118, 138, 153 and 180). These congeners occur in relatively high concentrations in technical mixtures, have a high chlorination range and are known to be persistent in the environment.

1.3.2 In the present study levels of all seven ICES 7 PCBs at all sites were less than the MRV (minimum recording value) which was set at 1µgkg^{-1} for all congeners analysed.

1.3.3 The Sediment Action Levels for PCBs is derived from the ICES 7 group of PCB congeners and is given as single values for the concentration of all congeners combined. Sediment Action Level 1 for PCBs is 10µgkg^{-1}. As the reported values for each individual congener at all sites were <1µgkg^{-1} it is evident that the levels of PCBs in sediments throughout the study area were below Sediment Action Level 1.

1.4 Subtidal Faunal Analysis

1.4.1 A total of 198 infaunal taxa and 26,421 individuals were identified from subtidal samples; a further 18 epifaunal taxa were also recorded.

1.4.2 A variety of univariate analyses were undertaken, the results of which are given in Table 1.5. The number of taxa recorded at each site ranged from five to 68. Stations FS02, FS33, FS34 and FS35

had the highest numbers of species, whereas the lowest numbers were recorded at FS10, FS11 and FS12. Community abundance varied appreciably between six and 2900 per 0.1m^2 with the highest numbers recorded at FS14 and FS30-32. The number of individuals at FS10 (6 per 0.1m^2) was considerably lower than at any other site. Relatively low numbers of individuals were also recorded at FS05 and FS12.

Table 1.5: Univariate faunal parameters

Station	No. of Taxa	No. of individuals	Species Richness	Evenness	Shannon-Weiner Diversity
FS01	31	188	5.729	0.7684	3.807
FS02	65	360	10.87	0.8336	5.02
FS03	26	539	3.975	0.4836	2.273
FS04	30	451	4.745	0.4503	2.209
FS05	37	83	8.147	0.9142	4.763
FS06	28	229	4.969	0.605	2.908
FS07	43	544	6.668	0.4504	2.444
FS08	41	425	6.609	0.7257	3.888
FS09	46	163	8.834	0.8626	4.765
FS10	5	6	2.232	0.9697	2.252
FS11	11	179	1.928	0.6149	2.127
FS12	12	92	2.433	0.6282	2.252
FS13	47	430	7.586	0.5746	3.191
FS14	47	2429	5.901	0.4422	2.456
FS15	37	1270	5.037	0.338	1.761
FS16	57	1027	8.076	0.6972	4.067
FS18	17	222	2.961	0.5804	2.372
FS19	23	268	3.935	0.6787	3.07
FS20	51	299	8.771	0.7922	4.494
FS21	52	496	8.217	0.7486	4.268
FS22	33	1853	4.253	0.4345	2.192
FS24	39	433	6.26	0.7267	3.841
FS25	45	557	6.959	0.5001	2.747
FS26	26	590	3.918	0.5825	2.738
FS27	53	291	9.166	0.8159	4.673
FS28	27	200	4.907	0.7166	3.408
FS29	38	1586	5.021	0.2458	1.29
FS30	29	2430	3.592	0.3803	1.848
FS31	45	2618	5.591	0.1909	1.048
FS32	27	2913	3.259	0.3672	1.746
FS33	68	762	10.1	0.8086	4.922
FS34	60	1223	8.299	0.3794	2.241
FS35	58	1265	7.98	0.4566	2.675

1.4.3 The Shannon-Wiener index (H') is widely used to analyse ecological data. The index integrates the number of species and individual abundance to provide a summary value with resulting values falling with increasing stress. Evenness (J) is derived from Shannon-Wiener with values ranging between zero and one. Low values for J indicate high dominance and are indicative of stressful conditions while higher values indicate a more even distribution of individuals between species and are representative of stress free conditions.

1.4.4 Shannon-Wiener values for the communities at each site ranged between 1.05 and 5.02 with a mean of 3.02 (±1.1 standard deviation) while values for Evenness varied between 0.19 and 0.97 with a mean of 0.60 (±0.2 standard deviation). Relatively low Shannon-Weiner values (<2) were recorded at a number of sites to the east of the Forth Road and Rail Bridges (FS31, FS29, FS32 and FS30) which corresponded to low values for Evenness (<0.4) indicating some level of stress influencing the benthos in this area.

1.4.5 The communities at each site were examined using the Infaunal Quality Index (IQI) developed for the classification of transitional and coastal water bodies for the Water Framework Directive. The IQI is a multi-metric tool composed of the AZTI Marine Biotic Index, Simpson's Evenness, and number of taxa giving results ranging from zero (bad status) to one (high status). Results for the subtidal benthic communities (Table 1.6) indicate that at the majority of sites the quality status of the subtidal communities ranged between good and high with moderate status occurring at FS10 and FS26.

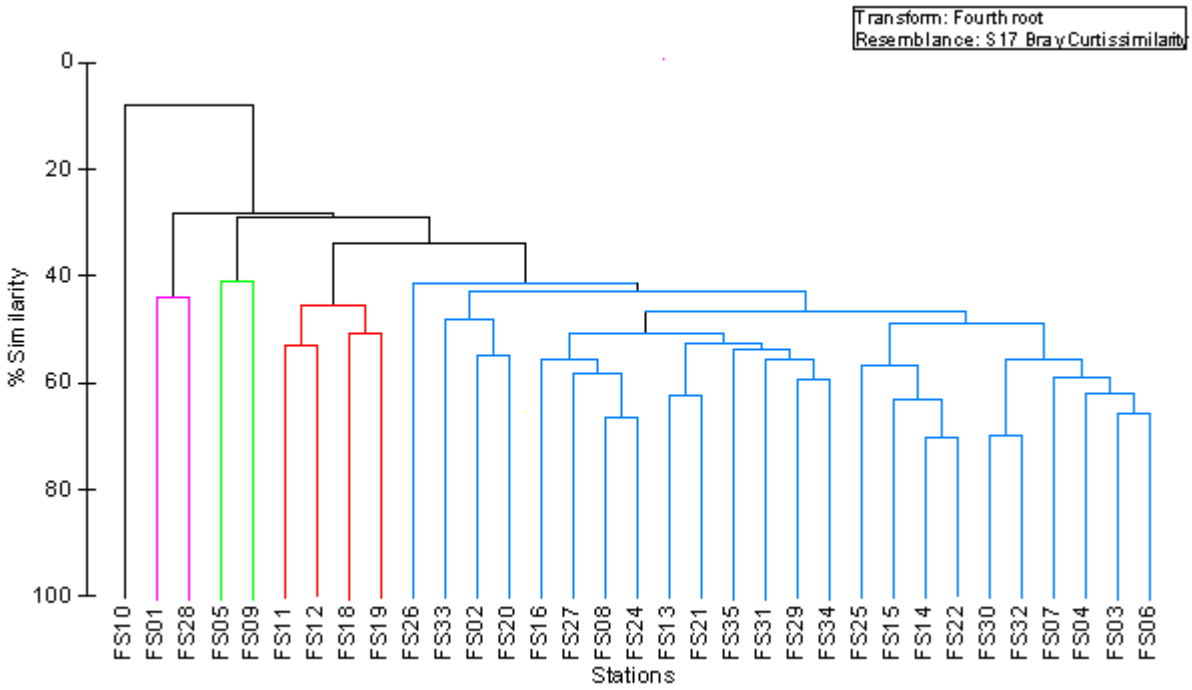
Table 1.6: Infaunal quality status at each subtidal station

Site	Quality Status	Site	Quality Status	Site	Quality Status
FS01	HIGH	FS12	GOOD	FS25	HIGH
FS02	HIGH	FS13	HIGH	FS26	MODERATE
FS03	GOOD	FS14	HIGH	FS27	HIGH
FS04	GOOD	FS15	GOOD	FS28	HIGH
FS05	HIGH	FS16	HIGH	FS29	GOOD
FS06	GOOD	FS18	GOOD	FS30	GOOD
FS07	HIGH	FS19	GOOD	FS31	GOOD
FS08	HIGH	FS20	HIGH	FS32	GOOD
FS09	HIGH	FS21	HIGH	FS33	HIGH
FS10	MODERATE	FS22	GOOD	FS34	HIGH
FS11	GOOD	FS24	HIGH	FS35	HIGH

1.4.6 Biological data was further analysed using the PRIMER statistical package which facilitates the examination of biological and environmental data by multivariate techniques to detect differences within the data and to determine the cause of any differences.

1.4.7 To detect differences within the communities the faunal data was examined using cluster analysis. This multivariate statistical tool compares the faunal composition at each site with that of all other sites, thus examining the communities on the basis of the identity of the component species as well as their relative importance. To reduce the influence of highly dominant species the data underwent fourth root transformation. The resulting similarity matrix is displayed in the form of a dendrogram, a branching diagram which illustrates the progressive linking of sites. The level of similarity is indicated on the ordinate measured by the Bray Curtis matrix, showing the greater similarity between groups linked towards the bottom of the diagram. The dendrogram for the subtidal community data is given on Plot 1.3.

Plot 1.3: Dendrogram for subtidal data using fourth root transformed data. Clusters are indicated in the different colours (Pink – Group A, Green – Group B, Red – Group C, Blue – Group D)



1.4.8 From the dendrogram it is evident that the communities at 24 out of the 33 sites had a common similarity of over 40% indicating a relatively uniform community across these areas and these sites are classed as cluster Group D. The most consistently dominant two species in this community were the bivalve *Abra alba* and the polychaete *Scalibregma inflatum*. Sub-dominant taxa included juvenile bivalves, common mussel (*Mytilus edulis*), oligochaetes *Tubificoides swirencoides* and *Tubificoides amplivisatus*, and polychaetes *Mediomastus fragilis* and *Ophelina acuminate.*

1.4.9 Stations FS11, FS12, FS18 and FS19 comprised Group C sharing a common similarity of over 40%. The communities at these sites were considered to be different from those in Group A owing to the absence of the polychaetes *Ophelina acuminata*, *Scoloplos armiger* and *Chaetozone gibber* and to the lower number of taxa recorded.

1.4.10 The communities at FS01 and FS28 (Group A) showed a common similarity of over 40% while sharing only 28% similarity to other communities at other sites and had different dominant taxa from other groups. The dominant species in group A was the hesionid polychaete *Microphthalmus*. The lack of silt fraction in the sediment at these stations could explain the difference in community here (FS01 had no silt-clay content and FS28 had only 3% silt-clay content).

1.4.11 The communities at FS05 and FS09 (Group B) showed over 40% common similarity and only 29% with communities elsewhere owing to a difference in dominant species present. The disappearance of the *Abra alba* bivalve community would have been a major contributor to the isolation of these two stations (FS05 had none and FS09 had only 12 present). These two stations also had a considerable reduction in the number of *scalibregmid* polychaetes when compared to other stations. The explanation for the different faunal community at these two stations was possibly related to the location of the sites in the shallow sublittoral (<3m); in addition the silt-clay percentage of substrate at both sites was very low (<6.2%).

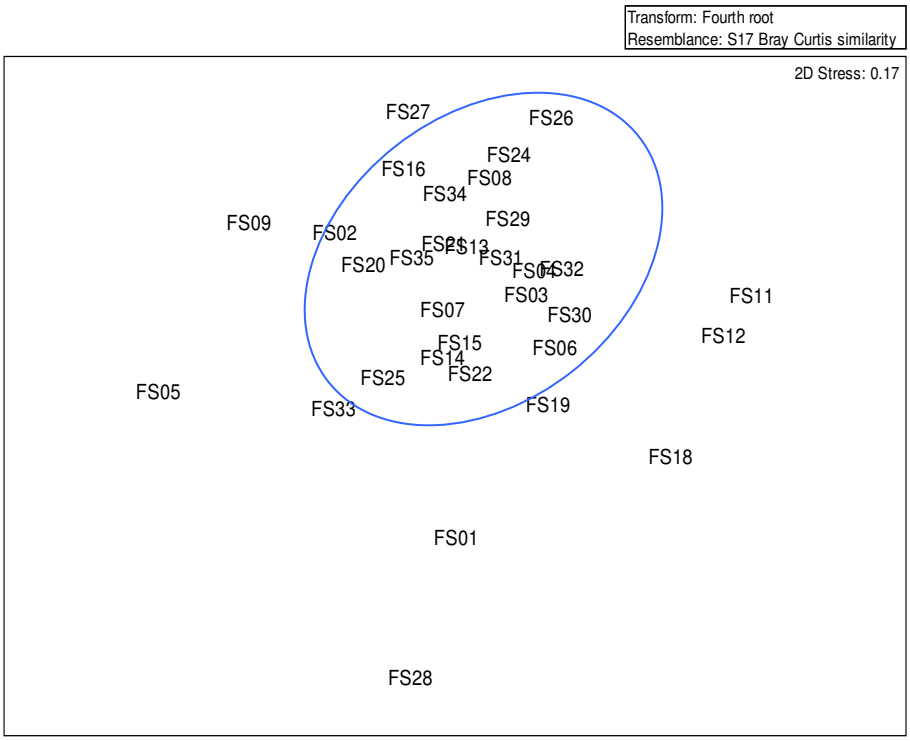
1.4.12 The community at FS10 was considerably different from those at other sites exhibiting only 8% similarity to all other sites. FS10 supported an impoverished community with appreciably lower

numbers of taxa and individuals recorded than elsewhere in the survey area. This pattern reflects the coarse, mobile substrate which represents an inhospitable habitat for benthic invertebrate fauna.

1.4.13 The patterns indicated by cluster analysis are further illustrated by displaying the similarity matrix on a multi-dimensional scaling (MDS) plot which presents the data in the form of a 2-dimensional map with levels of similarity reflected by the proximity of sites to each other. The MDS plot is given in Plot A11.3.4 with FS10 excluded as this would result in the coalescing of the data points in to a dense group thus concealing any patterns.

1.4.14 The plot supports the grouping of sites as identified by cluster analysis with the relative proximity of the majority of sites comprising Group D indicating the relatively high level of common similarity (>40%). The dissimilarity of the other identified groups from Group D and each other is indicated by the distance of their separation.

Plot 1.4: MDS ordination of species abundance for all stations, with the main cluster group from Plot 1.3 indicated. (FS10 not included)



1.4.15 In order to identify whether the observed biological patterns were associated with any abiotic factors the BIO-ENV method was applied (using PRIMER v6, a software package for multivariate statistical analysis). This method considers all possible combinations of environmental variables to determine which show the greatest association to the biological patterns using biotic and abiotic similarity matrices and weighted spearman rank as a measure of correlation. The results of the BIO-ENV (Table 1.7) procedure list the best correlations between the biotic data and up to five environmental variables. The highest correlation for a single environmental variable was for chromium (r=0.228). For two variables the highest correlation corresponded to a combination of depth and chromium (r =0.275). The greatest correlation (r =0.327) occurred for four variables.

Table 1.7: Correlations between biotic and environmental variables

k	Best variable combination (rw)
1	Chromium
	0.228
2	Depth, Chromium
	0.275
3	Depth, % gravel, Chromium
	0.325
4	Depth, % gravel, median diameter, Chromium
	0.327
5	Depth, % gravel, median diameter, Cadmium, Chromium
	0.326

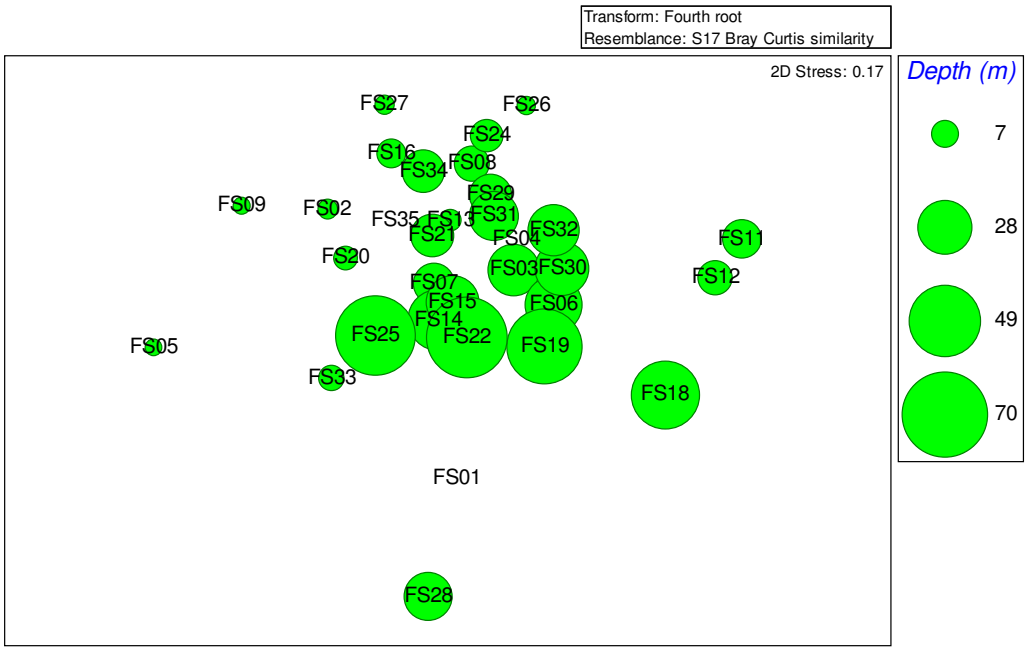
1.4.16 To further examine the correlation between community patterns and the environmental factors the environmental variables were super-imposed onto the MDS plot with CONPLOT, thus allowing a visual indication of correlation between clusters and these environmental factors.

1.4.17 Plot 1.5 shows the relationship between community patterns and depth. It is evident that the communities within Group D were from relatively deep water sites while those from other groups were from relatively shallow areas, particularly Group B. The sediments at sites in Groups A and B were generally coarse while those in Group C were characterised by much finer material; sediment at Group D was generally intermediate in texture.

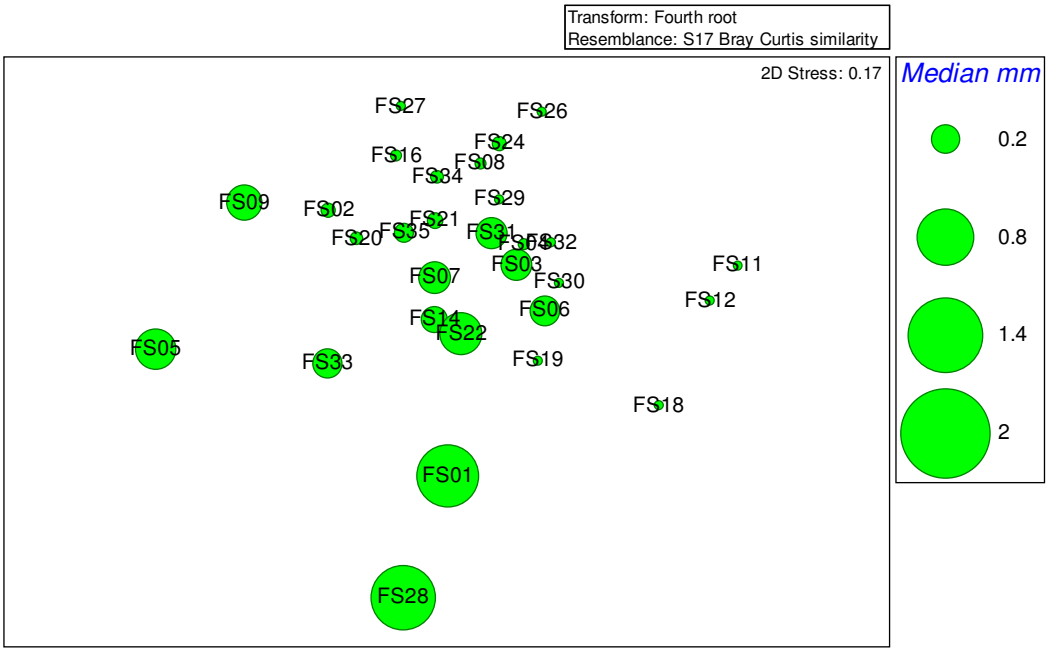
1.4.18 These results would indicate that depth and sediment granulometry were the principal environmental factors governing the distribution of communities; it is considered that the correlation of community patterns with sediment-bound chromium levels is coincidence rather than cause and effect as chromium is not recorded in sediments at concentrations considered to be harmful to aquatic life (Plot 1.7).

1.4.19 It has been demonstrated that in response to environmental stress (both biotic and abiotic) marine benthic invertebrates will develop adaptive traits for survival involving behavioural responses and/or metabolic and physiological processes (Blackstock, 1984). The severity of impact will depend on the level of stress and the ability of organisms to cope with the stressor and may be exhibited at different levels of biological organisation each of which require different approaches to assess adequately. The methodologies employed here are aimed at the community level which is considered as the most complex level of biological organisation and changes at the community level would indicate high levels of stress (McLusky & Elliott, 2004). In the current study area, the biological patterns indicate that the level of contamination observed has no significant impact on the benthos at the community level and that natural factors are driving the community patterns i.e. depth and sediment characteristics.

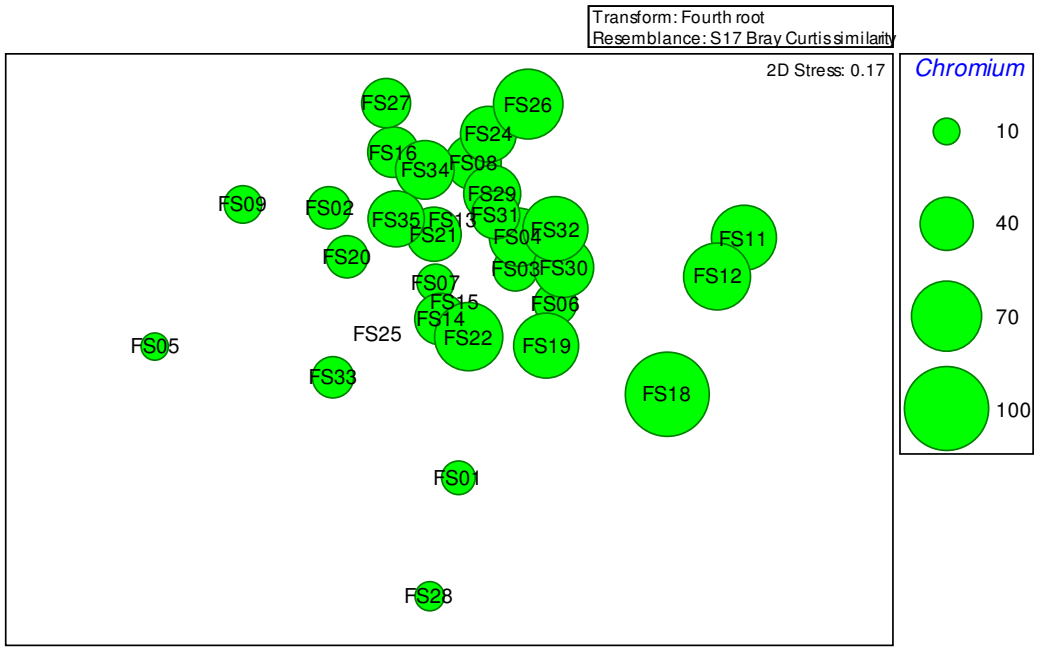
Plot 1.5: MDS ordination as in Plot 1.4 (above), with all stations represented by circles of diameter proportional to the depth



Plot 1.6: MDS ordination as in Plot 1.4 with all stations represented by circles of diameter proportional to the median particle diameter in the sediment



Plot 1.7: MDS ordination as in Plot 1.4 with all stations represented by circles of diameter proportional to the concentration of chromium in the sediment



1.4.20 DOMPLOT was used to investigate abundance/biomass patterns from which the *W* statistic was obtained which describes the relationship between the cumulative abundance and biomass curves in ABC plots. Values of the *W* statistic vary between 1 and -1 with values between 0 and 1 representing an undisturbed community, 0 and -0.5 moderately disturbed and -0.5 and -1 highly disturbed. Values for the *W* statistic (Table 1.8) indicate that the majority of subtidal communities were undisturbed with the value for *W* at nine sites indicating moderately disturbed status.

Table 1.8: Value for the W statistic

Site	W	Site	W	Site	W
FS01	-0.297	FS12	0.204	FS25	0.020
FS02	0.187	FS13	0.074	FS26	0.117
FS03	-0.029	FS14	0.005	FS27	0.254
FS04	-0.026	FS15	-0.032	FS28	0.163
FS05	0.567	FS16	0.119	FS29	-0.017
FS06	0.156	FS18	0.064	FS30	0.022
FS07	-0.013	FS19	0.112	FS31	-0.022
FS08	0.164	FS20	0.307	FS32	0.045
FS09	0.389	FS21	0.163	FS33	0.121
FS10	0.758	FS22	-0.011	FS34	0.019
FS11	0.141	FS24	0.149	FS35	-0.02

1.5 Subtidal Biotope Classification

1.5.1 It proved difficult to assign a biotope to the data collected (as per Connor et al., 2004) owing to some of the patchy distributions of communities, and also probably owing to some anthropogenic influences. The biotope that most resembled the habitat was the broad classification of

SS.SMX.SMxVS (sublittoral mixed sediment in variable salinity) but was missing one of the most dominant species present, the polychaete *Scalibregma inflatum*, and other dominant species such as *Ophelina acuminata*, *Chaetozone gibber* and *Pholoe* sp. Connor et al. (2004) described this habitat as complex and therefore often quite rich, developing diverse epifaunal and infaunal communities.

1.6 Intertidal Biotope Classification

North Shore

1.6.1 The distribution of intertidal biotopes on the north shore is shown on Figure 11.8a. The north shore intertidal survey area extended between 500m upstream and 1km downstream of the Main Crossing. Between the northern extent of the survey area at FE11 and the Railway Pier at North Queensferry, the intertidal zone was relatively narrow, extending little over 50m below the high water mark. Throughout this section the top of the shore was characterised by bedrock cliffs, the foot of which represented the "splash zone". The shore shelved relatively steeply and was comprised of a mosaic of boulders, cobbles, gravel and sand. This heterogenous habitat gave way to less course material at the extreme low shore where muddy sand was apparent. At FE11 at the northern end of the study area a small bay was characterised by a beach of muddy sand. East of the Railway Pier at North Queensferry, mudflats were the dominant intertidal feature, extending up to 200m below the thin strip of bedrock, boulders and cobbles which comprised the upper shore.

1.6.2 The splash zone throughout the majority of the survey area was characterised by a band of the lichen biotope LR.FLR.Lic which covered much of the bedrock cliffs from the existing Forth Road Bridge to the northerly extent of the study area (Figure 11.8b). A particular feature of this biotope was black tar lichen (*Verrucaria maura*), with yellow lichens also evident. Below this there was a band of the biotope LR.MLR.BF.PelB, varying in width between 5m to 10m; this biotope was characterised by channelled wrack (*Pelvetia canaliculata*) and barnacles. East of the Forth Road Bridge, the upper shore was also colonized by a thin strip of a channelled wrack community, although algal growth was more dense and the biological community more diverse, reflecting the less exposed nature of the habitat; this biological community was assigned the biotope LR.LLR.F.Pel.

1.6.3 Seaward of the *Pelvetia* zone the bedrock and boulder habitat between the Forth Road Bridge and FE11 the upper to mid-shore zone was covered by relatively dense populations of barnacles with limpets and littorinids occurring frequently; mussels were also present. This biotope was assigned as LR.HLR.Mus.Sem.sem and occurred in a band 10–20m wide. Below this the mid to low shore was characterised by the biotope LR.LLR.FVS which was comprised primarily of the seaweeds knotted wrack (*Ascophyllum nodosum*) and bladder wrack (*Fucus vesiculosus*) with abundant populations of littorinids. This biotope also extended to the east of the Forth Road Bridge and throughout the harbour at North Queensferry.

1.6.4 At the extreme low shore, mobile muddy sands were recorded, which were classed as the biotope LS.Lsa.MoSa. This habitat formed a narrow band at low water, stretching from the Forth Road Bridge to FE11. The small bay at FE11 was characterised by this mobile sand habitat, which extended 40m from the shingle and gravel at the top of the shore. East of the Forth Road Bridge, the lower shore was comprised of sandy mud with extensive flats present in North Queensferry harbour. The sediment fauna was relatively diverse, with the polychaetes *Pygospio elegans* and *Mediomastus fragilis* and the bivalve mollusc *Cerastoderma* sp. the most common taxa. This sediment dwelling fauna was assigned the biotope LS.LMx.Mx.

South Shore

1.6.5 The distribution of intertidal biotopes on the south shore is shown on Figure 11.8b, 11.8c and 11.8d.The area surveyed extended over approximately 4km of the south shore of the Firth of Forth from Society Point in the west to Hawes Pier in Queensferry in the east. This intertidal area was made up of a mosaic of habitats comprised of bedrock, boulders, cobbles, gravel, sand and mud.

Rocky outcrops were evident throughout, particularly at Society Point and downstream of the Forth Road Bridge at South Queensferry. The width of the intertidal zone varied from over 500m on Hopetoun Bank to less than 50m immediately to the east of Port Edgar with a general decrease in width from west to east. Much of the upper limit of the shore had been modified, either by the building of seawalls as between sites FE03 and FE04 and harbour structures (particularly at Port Edgar–site FE06), or by the introduction of large boulders as in the vicinity of Port Edgar (sites FE06 and FE07). Substrates in the upper shore were predominantly coarse with sand, gravel and cobbles in varying proportions, although areas of bedrock were evident in the upper shore in the vicinity of sites FE02A and FE05A. Mid shore areas comprised of a mosaic of boulders, cobbles, gravel and sand with some exposed bedrock, particularly in the vicinity of site FE04 and between the Forth Road and Rail Bridges (site FE07). Much of the low shore was sedimentary in nature with sandy muds prevalent (Figure 11.8a).

1.6.6 Throughout much of the south shore survey area, the top of the shore was characterised by shingle, gravel and cobbles, which were generally devoid of macroflora and macrofauna. However, in some places exposed rock and boulders were present (e.g. upstream of FE02A and downstream of FE02B) where lichens were recorded. This community was characterised by black tar lichen,, yellow lichens (*Caloplaca* sp. and *Xanthoria* sp.), grey lichen (*Lecanora atra*.) and green lichens (*Ramalina siliquosa* sp.) and the biotope assigned as LR.FLR.Lic; this biotope was also evident on the wall between FE02A and FE02B and immediately downstream of Port Edgar.

1.6.7 A thin strip of the biotope LR.LLR.F.Pel was recorded in the upper shore between FE04 and Port Edgar. The flora here was dominated by the seaweeds channelled wrack and spiral wrack (*Fucus spiralis*) whilst barnacles and littorinid gastropod molluscs were also relatively important. Three small areas of green-seaweed-dominated biotope were recorded between FE02A and FE03. These small areas extended from the upper shore into the mid shore zones and were characterised by the dense growth of gut weed (*Ulva intestinalis*). They were clearly influenced by freshwater run-off and were assigned the biotope LR. FLR. Eph.Ent.

1.6.8 Throughout the south shore survey area, much of the mid-shore was characterised by a biotope dominated by fucoid seaweeds and knotted wrack (LR.LLR.FVS) which colonised the mixed, hard substrate found throughout the survey area. Littorinid gastropods were common, living on seaweed fronds and underlying hard substrates, while the shore crab (*Carcinus maenas*) was also present.

1.6.9 Appreciable areas of exposed bedrock were evident throughout the mid-shore, particularly downstream of Port Edgar. The majority of areas of exposed bedrock were characterised by high densities of barnacles, with littorinid gastropods and limpets abundant and mussels common, and were assigned the biotope LR.HLR.Mus.Sem.sem. This biotope was particularly common to the west of Port Edgar. The rocks immediately upstream of FE03 were colonised by the brown seaweeds spiral wrack and knotted wrack while the green seaweed slender sea lettuce (*Ulva linza*) was also important. This community was assigned the biotope LR.LLR.FVS.FspiVS. This biotope was also recorded in a narrow band in the mid to upper shore area directly upstream of Port Edgar.

1.6.10 The lower middle and low shore zones throughout the south shore study area were sedimentary in nature with sandy muds predominating with no macrofloral communities were evident. The sediment dwelling faunal communities were relatively diverse with a total of 34 taxa identified with the polychaetes *Pygospio elegans* and *Mediomastus fragilis*, the bivalve molluscs *Macoma balthica* and *Cerastoderma* sp. common throughout the survey area. At FE06 at Port Edgar the cirratulid polychaete *Aphelochaeta marioni* was dominant. However, it was considered that the mud dwelling fauna was generally consistent throughout and was assigned the biotope LS.LMx.Mx.

2 Marine Fish

2.1 Consultation

2.1.1 Fish assemblages within estuaries may be assigned to one of six ecological guilds (Table 2.1).

Table 2.1: List of ecological guilds, their abbreviated forms and notes on estuarine use (Elliott & Taylor, 1989)

Number	Ecological Guild (abbreviated form)	Use of estuary
1	Adventitious freshwater species (FW)	Freshwater species with no estuarine requirement
2	Estuarine residents (ER)	Spend whole life in estuary
3	Adventitious marine species (MA)	Marine species with no estuarine requirement
4	Marine seasonal species (MS)	Marine species with seasonal migrations to the estuary as adults
5	Marine juvenile (MJ)	Marine species using the estuary as a nursery area
6	Diadromous species (DA)	Species that use the estuary during migrations between marine and freshwater habitats

2.1.2 Fish populations fluctuate annually owing to the spatial and temporal variations in the utilisation of the estuary by different species and their different life stages (Elliott et al., 1990). The greatest population of sprat and herring occurs from January to March, although there is a level of annual variability in the size of these populations (Elliott et al., 1990). Dab fry (*Limanda limanda*) appear in the estuary in September, whilst plaice fry are present from July for the duration of a year, with maximum abundance in the summer and minimum from January to April (Greenwood & Hill, 2003; Elliott et al., 1990). Whiting (*Merlangius merlangus*) populations peak in the winter after juveniles move in to the estuary during spring/summer and emigrate the following year. The population of viviparous blenny (*Zoarces viviparous*), an estuarine resident, peaks in spring and summer (Elliott et al., 1990). Greenwood & Hill (2003) found cod (*Gadus morhua*) to have a minimum abundance in March/April and no obvious peak through the rest of the year. Short-spined sea scorpion (*Myoxocephalus scorpius*) and goby (*Pomatoschistus* spp.) population abundances peak in winter.

SEPA Trawling Data

2.1.3 SEPA and its predecessor (the Forth Purification Board) have conducted subtidal fisheries monitoring in the Firth of Forth since 1977. Four monitoring sites, extending from Longannet Power Station in the east to Port Edgar in the west have been surveyed by the use of Agassiz, pelagic trawls and fyke netting.

2.1.4 To date, 38 fish species have been recorded by SEPA from marine fish surveys of the Firth of Forth Estuary, ranging from marine species with no estuarine requirements to estuarine resident species (Table 2.2). The available fishing data obtained from SEPA were not quantitative and only provided a list of species present in the Firth of Forth Estuary.

Table 2.2: Species (ecological guild in brackets) recorded in SEPA fisheries surveys, 1977 – 2006

Species			
3-bearded rockling (MA)	European eel (DA)	Montagu's sea snail (MA)	Sea snail (MA)
3-spined stickleback (FW)	Flounder (MJ)	Nilsson's pipefish (MA)	Smelt (DA)
5-bearded rockling (MA)	Greater pipefish (MA)	Plaice (MA)	Sole (MA)
Angler fish (MA)	Greater weeverfish (MA)	Pogge (MA)	Sprat (MS)
Bull-rout (MA)	Grey gurnard (MA)	Pollack (MJ)	Trout (DA)
Butterfish (ER)	Herring (MS)	Poor cod (MA)	Two-spot goby (ER)
Cod (MA)	Lamprey (DA)	Red gurnard (MA)	Cod (MA)
Common dragonet (MA)	Lemon sole (MA)	Saithe/coley (MA)	Whiting (MA)
Dab (MA)	Ling (MA)	Sand eel (MA)	Viviparous blenny (ER)
Dogfish (MA)	Long rough dab (MA)	Sand goby (MA)	

2.1.5 Agassiz trawl catches between 1982 and 2001 fluctuated annually with a general decrease shown in the total annual abundance caught over this period (Table 2.3) (Greenwood et al., 2002). Significant declines were recorded in whiting and viviparous blenny in particular. There is a suspected correlation between the decline in viviparous blenny and an increase in water temperatures reducing reproductive success. In contrast the short-spined sea scorpion showed a significant increase in annual abundance (Greenwood et al., 2002).

2.1.6 Greenwood & Hill (2003) analysed temporal and spatial variations in the fish population data (Table 2.3). Highest abundances of whiting, dab, pogge (*Agonus cataphractus*), short-spined sea scorpion, gobies and Montagu's sea snail (*Liparis montagui*) were found to occur in the winter, with low abundances in the summer. Plaice (*Pleuronectes platessa*), flounder (*Platichthys flesus*) and viviparous blenny were at lowest abundance at winter and highest during the summer. Cod were present in low abundances in late spring but did not show any annual peak. Flounder were the most abundant at the mid-estuarine point near Longannet; it is expected that this is due to feeding on the nearby mudflats (Greenwood & Hill, 2003).

Table 2.3: Composition of the Agassiz trawl catches in the lower Firth of Forth Estuary 1982 – 2001

Species	Max yearly Total	Min yearly total	Mean of all years	Total caught 1982 - 2001
Whiting	483	36	227.3	4545
Viviparous blenny	669	17	200.7	4013
Pogge	182	55	116.9	2338
Plaice	353	29	103.6	2071
Flounder	349	20	103.2	2064
Gobies	196	3	68.0	1360
Cod	293	2	61.2	1224
Dab	137	4	48.4	967
Short-spined sea scorpion	114	4	26.4	527
Common sea snail	73	5	21.6	431
Lesser sandeel	62	0	5.7	113
Butterfish/gunnel	18	0	4.9	97
River lamprey	12	0	2.5	49
Long rough dab	18	0	2.0	39
Grey gurnard	19	0	1.8	36
Lesser pipefish	3	0	1.3	26
Saithe/coley	8	0	0.9	17
Great pipefish	6	0	0.5	10
Dover sole	3	0	0.5	10
Lemon sole	4	0	0.5	9
Pollack	7	0	0.5	9
Common dragonet	2	0	0.4	7
European eel	2	0	0.3	5
Five-bearded rockling	1	0	0.2	4
Red gurnard	4	0	0.2	4
Ling	3	0	0.2	4
Montagu's sea snail	3	0	0.2	3
Poor cod	1	0	0.1	2
Fifteen-spined stickleback	1	0	<0.1	1
Lesser spotted dogfish	1	0	<0.1	1

Longannet Power Station Impingement Monitoring

2.1.7 Longannet Power Station is situated on the north bank of the Firth of Forth, 1.8km west of the estuary mouth. Greenwood (2008) carried out sampling of impinged fish on the cooling water intake screens. The sampling occurred for 30-minute periods up to eight times a month for the period between January 1999 and December 2000 (160 sampling sessions). The total number of fish counted from screen catches and the percentage species occurrence over all sampling occasions during both 1999 and 2000 are shown in Table 2.4. These data are a good indication of the species present in the Firth of Forth, however it should be noted that numbers impinged at the intake of the power station are likely to be biased as some species or life stages are more susceptible owing to their poor swimming ability, whilst others may be too small to be impinged and pass easily through the screens.

Table 2.4: Species collected from the cooling water intake of Longannet Power Station from January 1999 to December 2000 (taken from Greenwood, 2008)

Species	Total number (n) (1999)	Total mass (g) (1999)	Occurrence in samples (%) (1999)	Total number (n) (2000)	Total mass (g) (2000)	Occurrence in samples (%) (2000)
Total	35,559	229,616.6	100.0	101,977	494,457.1	100.0
Sprat	17,304	68,340.2	98.8	43,292	152,611.9	100.0
Atlantic herring	8,531	54,265.6	94.0	39,157	151,828.5	100.0
Whiting	3,411	44,993.0	100.0	5,895	80,610.9	96.4
Gobies	2,580	9,029.1	81.9	5,498	15,995.6	81.9
Plaice	1,023	6,643.4	85.5	3,292	17,843.3	95.2
European smelt	527	7,675.3	66.3	1,524	14,884.6	73.5
Flounder	837	21,386.0	90.4	808	28,204.6	92.8
Pipefishes	426	225.1	68.7	841	391.3	91.6
Cod	289	3,542.8	49.4	764	14,470.9	57.8
Pogge	138	922.2	50.6	226	921.0	68.7
River lamprey	137	3,303.5	55.4	149	3,116.3	43.4
Sea snail	129	2,265.7	33.7	67	729.9	25.3
Saithe/coley	88	2,741.7	19.3	76	3,763.3	31.3
Common dab	7	6.9	3.6	100	175.4	22.9
Three-spined stickleback	38	91.2	18.1	66	174.5	33.7
European eel	31	1,356.4	21.7	38	1,414.8	28.9
Atlantic salmon	-	-	-	56	911.3	6.0
Lesser sandeel	6	55.9	7.2	31	307.9	20.5
Sea trout	-	-	-	36	3,611.5	20.5
Eelpout (Viviparous blenny)	14	236.9	15.7	17	281.9	15.7
Fatherlasher (Short-spined sea scorpion)	6	176.2	3.6	16	625.1	16.9
Unidentified salmonids	13	1,523.0	10.8	-	-	-
Common sole	2	137.2	1.2	6	760.5	6.0
Thick-lip grey mullet	6	15.4	3.6	0	0.0	0.0
Butterfish	4	23.8	4.8	2	11.2	2.4
Fivebeard rockling	1	10.0	1.2	5	91.9	6.0
Grey gurnard	1	3.8	1.2	3	21.4	3.6
European perch	2	4.1	2.4	1	3.1	1.2
Ling	1	162.0	1.2	2	506.7	2.4
Silvery cod (Silver pout)	1	11.3	1.2	1	8.0	1.2
Common dragonet	1	3.4	1.2	1	18.6	1.2
Pollack	1	9.6	1.2	1	19.9	1.2
Bib/pout	0	0.0	0.0	2	62.9	2.4
Fourteen-spined stickleback [*sic*.]	1	8.7	1.2	0	0.0	0.0
Haddock	1	18.2	1.2	0	0.0	0.0
Atlantic mackerel	1	148.0	1.2	0	0.0	0.0
European sea bass	1	281.0	1.2	0	0.0	0.0
Sand smelt	0	0.0	0.0	1	12.8	1.2
Hatchet	0	0.0	0.0	1	1.0	1.2
Greater sandeel	0	0.0	0.0	1	45.9	1.2
Lesser weever	0	0.0	0.0	1	18.7	1.2

2.1.8 SEPA has undertaken fish impingement monitoring at Longannet Power Station between 2001 and 2006. Results of this work are presented in Fish Impingement Monitoring at Longannet Power Station (SEPA, 2008).

2.1.9 Between 2001 and 2006, 36 species of fish were recorded from the impingement monitoring (Table A11.3.13). Herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) represented 40% of all species caught.

2.1.10 SEPA data were transformed to standardise for pump volume and sample time to allow for comparison between years (Table 2.5). The standardisation was calculated as follows;

2.1.11 Fish per 10^7l = Fish abundance (Pump capacity x # operational pumps @ sample point x sample duration).

Table 2.5: Standardised (number of fish per 10^7l) abundance of species recorded at Longannet Power Station 2001-2006

Species	2001	2002	2003	2004	2005	2006
Three-bearded rockling	-	-	-	-	0.5	-
Three-spined stickleback	14.3	14.2	6.4	1.5	0.9	3.7
Angler (monk) fish	0.5	-	-	-	-	-
Bass	-	-	-	-	0.2	-
Clupeid juvenile	-	-	-	-	1186.6	57.0
Cod	1.1	52.9	42.4	22.6	109.4	183.4
Dover sole	-	-	0.2	-	-	0.2
Dragonet	-	-	0.0	-	-	-
European eel	5.5	0.3	2.5	-	0.9	0.5
Flatfish juvenile	2.3	4.0	23.8	7.4	51.2	16.5
Flounder	81.4	30.2	35.7	34.8	27.1	41.2
Gadidae sp. juvenile	-	-	-	-	-	119.3
Goby	27.9	87.2	120.7	46.2	21.1	22.9
Greater pipefish	0.2	0.0	0.7	1.9	28.2	6.4
Herring	149.2	1563.3	535.7	172.5	282.1	161.9
Lemon sole	-	-	-	-	-	0.2
Lesser pipefish	52.8	84.0	94.8	31.9	-	-
Ling	-	-	-	-	-	0.2
Lumpsucker	-	0.0	0.5	0.0	-	-
Montagu's sea snail	-	0.0	0.0	0.7	-	-
Plaice	185.6	40.2	23.4	17.9	64.1	92.5
Pogge	6.1	9.7	14.0	8.8	14.8	2.1
Pollack	-	0.2	-	0.2	5.7	3.4
Poor cod	-	0.9	0.2	-	0.2	-
Red gurnard	-	-	-	-	0.5	-
River lamprey	0.2	2.1	5.5	2.5	2.5	0.5
Saithe/coley	-	5.0	0.5	4.3	0.7	5.0
Atlantic salmon	0.5	0.2	1.4	0.3	0.5	0.7
Sand goby	-	-	0.5	-	-	-
Sandeel	0.7	1.1	1.6	1.6	0.9	0.7
Sea lamprey	-	-	-	-	-	0.7
Sea snail	-	0.7	-	0.7	-	-
Sea trout	3.1	1.0	1.6	0.2	0.2	-

Species	2001	2002	2003	2004	2005	2006
Fatherlasher (Short-spined sea scorpion or bull-rout)	0.2	0.2	0.5	0.5	0.2	0.5
European smelt	124.4	13.6	71.9	9.4	12.9	16.0
Snake pipefish	-	-	-	-	-	41.7
Sprat	1189.8	476.0	674.0	367.7	140.1	239.7
Whiting	233.5	78.1	27.5	33.3	81.7	123.4
Eelpout/viviparous blenny	0.9	0.7	1.1	0.2	-	0.2

2.1.12 Eleven species of fish caught at Longannet are of conservation value, including Atlantic salmon (*Salmo salar*), river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*) which are listed in Annex II of the Habitats Directive, and European eel (*Anguilla anguilla*), smelt (*Osmerus eperlanus*), sea trout (*Salmo trutta*), cod, herring, plaice, sole and whiting which are UKBAP listed priority species. A further three species are of commercial importance including sprat, flounder and anglerfish (*Lophius piscatorius*).

2.1.13 SEPA data from Longannet indicate a decline in total fish abundance between 2001-2006. However adult flatfish species, cod, whiting and sprat have all shown increases in abundance from 2005.

Commercial Landings Data

2.1.14 The Firth of Forth Estuary lies in ICES fishing area IVb. Annual commercial landings from the two local ports of Eyemouth and Pittenweem are recorded by the Scottish Government (Table 2.6). The total tonnage of demersal and pelagic fish landed during this period peaked in 2004. Norway Lobster (*Nephrops norvegicus*) was the most abundant (by weight) of the shellfish and finfish species landed at both ports (Table 2.7).

Table 2.6: Live weight of commercial landings by UK vessels from 2003- 2007 at ports Eyemouth and Pittenweem (SG, 2008)

Site		2003	2004	2005	2006	2007
		Tonnes				
Eyemouth	Demersal	1882	2472	1776	1123	437
	Pelagic	-	1	0	0	17
	Shellfish	1002	1295	1235	1965	2403
	Total	2884	3768	3010	3088	2858
Pittenwean	Demersal	24	103	5	16	7
	Pelagic	0	0	0	0	1
	Shellfish	892	1313	1444	1631	1824
	Total	916	1416	1449	1648	1832

Table 2.7: Live weight composition of commercial landings by UK vessels in 2007 at ports Eyemouth and Pittenweem (SG, 2008)

	Eyemouth	Pittenweem
Species	**Tonnes**	
Cod	21	-
Haddock	214	-
Lemon sole	25	-
Whiting	123	-
Other demersal	54	-
Total demersal	437	7
Total pelagic	17	1
Edible crab	149	134
Lobster	98	84
Norway lobster	1835	1274
Scallops	112	42
Squid	78	112
Surf clams	-	60
Velvet crabs	109	94
Whelks	21	-
Other shellfish	0	25
Total shellfish	2403	1824
Total landings	2858	1832

2.1.15 Elliott et al. (1990) estimated that the Firth of Forth supports 0.54%, 0.45% and 0.05% of the total North Sea stocks of similar sized plaice, cod and herring, respectively (Table 2.8). These species have been identified as being close to their Safe Biological Limit (SBL) and are therefore vulnerable to a fishery collapse if excessive exploitation occurs (UKBAP, 2007).

Table 2.8: Fish population size estimated for the Forth Estuary by Elliott et al. (1990)

Species	Maximum population estimate for Forth Estuary ($x10^6$)
Sprat	6.04
Atlantic Herring	2.72
Plaice	1.34
Common dab	5.95
Cod	1.13
Whiting	4.56
Eelpout (viviparous blenny)	6.43

2.1.16 In the outer Firth of Forth there is significant trawling activity for *Nephrops* sp., although this does not extend westwards as far as the Main Crossing. Crab, lobster, whelk and clams are also landed commercially within the Firth of Forth.

2.1.17 A single vessel is known to operate out of Port Edgar between the Forth Road and Rail Bridges, fishing sixty creels for whelk. There are no data currently available on this fishery.

2.2 Survey Results

Intertidal

2.2.1 In total 3,045 fish (22 species) were caught during intertidal fish surveys in spring and autumn 2008 (Table 2.9). The site at St. Margaret's Marsh supported the largest fish catch in both spring and autumn surveys.

Table 2.9: Abundance of fish caught during 2008 intertidal fisheries surveys (methods combined)

	Society Point NT10192 79114		Long Rib NT14697 78957		St. Margaret's Marsh NT12237 81238		N Queensferry NT13221 80275		Port Laing NT13566 81274		St Davids NT14586 82450	
	Sp	**Au**	**Sp**	**Au**	**Sp**	**Au**	**Sp**	**Au**	**Sp**	**Au**	**Sp**	**Au**
Plaice	3	-	1	10	497	564	40	-	99	150	271	19
Flounder	6	1	1	1	1	1	1	-	1	4	2	6
Herring	-	165	24	56	98	5	-	-	1	1	2	50
Greater pipefish	-	-	3	-	-	-	-	-	-	-	2	-
Sand goby	-	-	-	8	8	519	-	-	1	96	19	53
Long-spined sea scorpion	-	-	17	4	34	1	1	-	-	4	2	1
Juvenile clupeid	-	-	-	-	4	-	1	-	-	-	-	1
European eel	-	-	-	-	-	-	1	-	-	-	-	-
Pogge	-	-		-	-	-	1	-	-	-	-	-
Viviparous blenny	-	-	1	-	5	3	1	-	-	6	8	1
Sandeel spp.	-	14	-	-	1	2	-	-	22	2	41	-
Three-spined stickleback	-	-	-	-	-	-	-	-	1	-	-	-
Cod	-	-	2	-	2	1	-	-	-	-	2	-
Lumpsucker	-	-	-	-	-	-	-	-	-	-	1	-
Pollack	-	4	1	-	-	-	-	-	-	1	1	-
Whiting	-	-	-	-	-	-	-	-	-	3	-	-
Lesser weever	-	-	-	-	-	-	-	-	-	1	-	-
Common goby	-	1	-	-	-	1	-	-	-	1	1	13
Dab	-	-	-	-	-	31	-	-	-	2	-	-
Brill	-	-	-	-	-	-	-	-	-	1	-	-
Snake pipefish	-	-	-	-	-	-	-	-	-	1	-	-
Nilsson's pipefish	-	1	-	-	-	-	-	-	-	2	-	-
TOTAL	**9**	**186**	**50**	**79**	**650**	**1128**	**46**	**-**	**125**	**275**	**352**	**144**

2.2.2 Three species dominated the catch across all sites and seasons with juvenile plaice, sand goby (*Pomatoschistus minutus*) and herring dominating 91% of the total catch (54%, 23% and 14% respectively). Dab, sandeel spp. (Ammodytidae spp.) and long-spined sea scorpion (*Taurulus bubalis*) were numerically dominant over the remaining sixteen species.

2.2.3 Site utilisation by intertidal fish species was highly variable, with the north shore sites of St. Margaret's Marsh, Port Laing and St. David's contributing most fish to total catch observed. Large numbers of juvenile plaice characterised the fish communities at these sites, with peaks in abundance in autumn at St. Margaret's Marsh and Port Laing whilst more plaice were observed in

spring at St. David's. Sand gobies were also prevalent at these three sites, predominantly during the autumn survey.

2.2.4 Port Laing demonstrated the highest marine diversity of all surveyed sites with 15 species recorded. Whiting, brill (*Scophthalmus rhombus*), lesser weever fish (*Echiichthys vipera*), snake pipefish (*Entelurus aequorus*), Nilsson's pipefish (*Syngnathus rostellatus*) and three-spined stickleback (*Gasterosteus aculeatus*) were only recorded at Port Laing. The presence of so many different species indicates the importance of the intertidal areas for fish populations. The extensive kelp beds immediately below low water might affect the number and diversity of fish observed as they provide shelter from predators and environmental diversity.

2.2.5 During intertidal fish surveys a range of invertebrates was recorded within the push and seine nets and were identified as:

- moon jellyfish (*Aurelia aurita*);
- blue jellyfish (*Cyanea lamarckii*);
- sea gooseberry (*Pleurobrachia* sp.);
- sea gooseberry (unidentified sp.);
- common whelk (*Buccinum undatum*);
- common periwinkle (*Littorina littorea*);
- flat periwinkle (*Littorina obtusata*);
- clams (*Bivalvia* sp.);
- common cockle (*Cerastoderma edule*);
- edible mussel (*Mytilus edulis*);
- hermit crab (Decapoda);
- spider crab (Decapoda);
- shore crab (*Carcinus maenus*);
- crangon (*Crangon crangon*);
- mysid shrimp (Mysidacea);
- barnacles (Thoracica);
- little cuttle (*Sepiola* sp.); and
- chiton (Polyplacophora).

Subtidal

2.2.6 A total of 7,490 fish were recorded during the subtidal surveys, represented by 22 species. As expected, the otter trawls were dominated by pelagic and demersal species such as herring and whiting, while flatfish and gobies dominated the beam trawls.

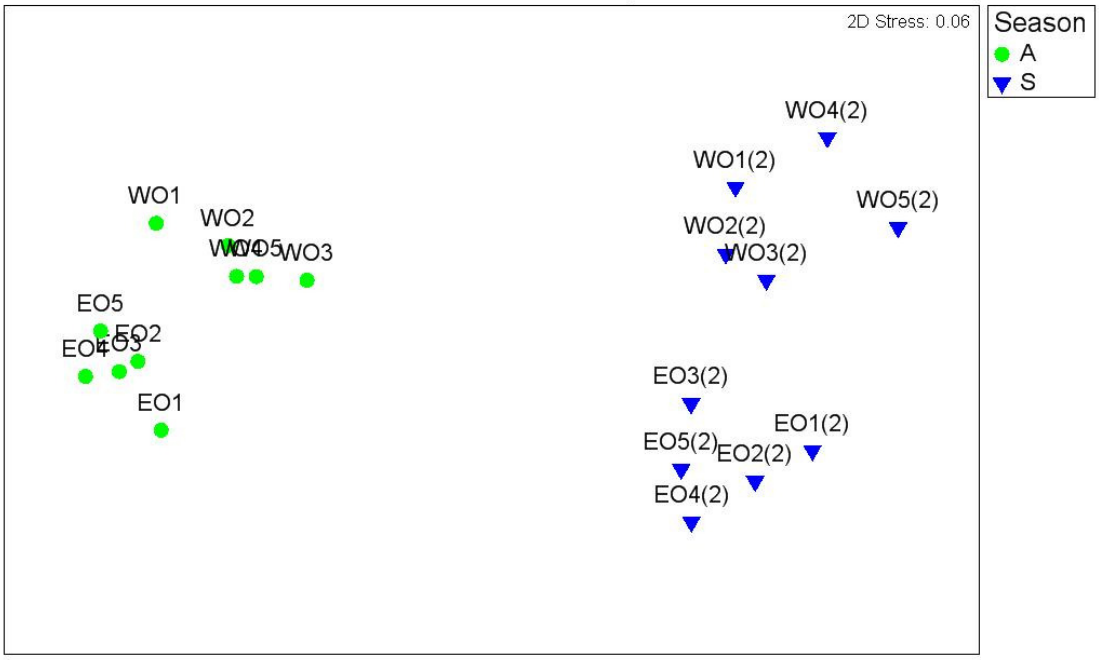
2.2.7 Statistically significant differences (ANOSIM, R-values ranged 0.71-1.0, $P<0.002$) in subtidal fish community assemblages were observed between the spring and autumn sampling dates and sampling sites. The highest number of fish was recorded at the eastern sampling site during the autumn trawls, where herring, cod and whiting dominated. Cod and single specimens of mackerel (*Scomber scombrus*) and sole (*Solea solea*) were only observed during the autumn surveys, while plaice were recorded in both seasons, at all sites and with each method. The autumn survey yielded 94% (7,002 fish) of the total subtidal catch for all methods and seasons.

2.2.8 The most diverse fish assemblage was sampled at the eastern trawl site in both survey seasons (16 species in spring, 14 species in autumn). All trawls recorded a diverse range of species with various marine requirements and habitat preferences. Seven species were observed from subtidal trawls that were not recorded from intertidal surveys. These were dragonet (*Callionymus lyra*), gunnel (*Pholis gunnellus*), grey gurnard (*Eutrigla gurnardus*), long rough dab (*Hippoglossoides platessoides*), sea snail (*Liparis liparis*), snake pipefish and mackerel. These species were recorded in low numbers and represented a range of functional guilds using the subtidal habitats.

2.2.9 MDS plots of the otter and beam trawl catches (Plot 2.1 and Plot 2.2) provided a spatial representation of the degree of similarity/dissimilarity between replicates, sampling sites and dates. The similarity plots illustrated that the site and seasonal variability was generally greater than that observed between individual replicate trawls. Tight clustering of replicates showed strong similarity at each site. There was a clear difference in the otter trawl samples between the two sampling dates in spring and autumn 2008 (Plot 2.1). While differences existed between the eastern and western sites on each sampling date, they were less pronounced when compared with the seasonal differences. The beam trawl (Plot 2.2) data showed similar but less pronounced differences between the trawl samples by sampling date and site.

2.2.10 During the deployment of each trawl benthic and pelagic invertebrates and algae were also caught in the beam and otter nets (Table 2.10). These species indicate underlying substrate types and potential food sources in the subtidal zone, as well as providing useful observations of mobile species not captured during benthic invertebrate surveys.

Plot 2.1: MDS plot of the otter trawl catch assemblages from the east (EO) and west (WO) trawl sites around the Main Crossing in spring (S) and autumn (A) 2008



Plot 2.2: MDS plot of the beam trawl catch assemblages from the east (EB) and west (WB) trawl sites around the Main Crossing in spring (S) and autumn (A) 2008

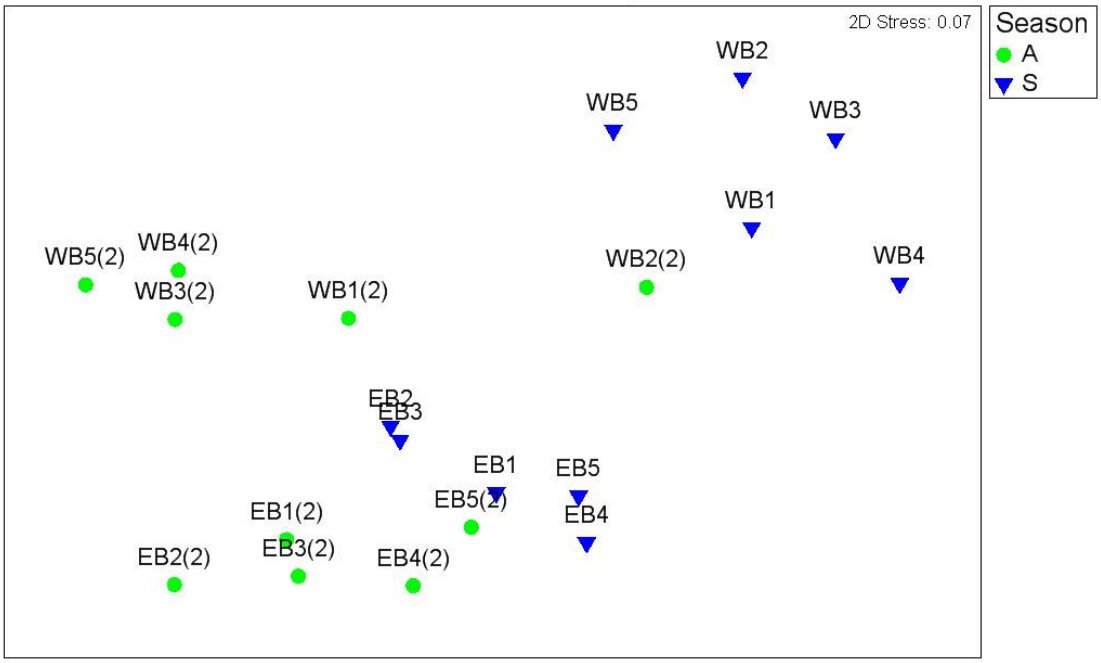


Table 2.10: Presence (shaded boxes) of invertebrate and algal species sampled during subtidal trawls, 2008

Common Name	Scientific Name	Spring East	Spring West	Autumn East	Autumn West
Bivalve	*Abra alba*	■			■
Strawberry anemone	*Actinia fragacea*	■	■	■	
Queen scallop	*Aequipecten opercularis*	■	■	■	
Deadman's fingers	*Alcyonium digitatum*	■	■	■	
Brittlestar	*Amphiura* sp.	■		■	
Saddle oyster	*Anomia ephippium*	■			
Sea mouse	*Aphrodita aculeata*	■	■	■	■
Sea lemon	*Archidoris pseudoargus*			■	
Sea squirts	*Ascidiacea* sp.	■			
Common starfish	*Asterias rubens*	■	■	■	■
Hydroid	*Athecate hydroid*	■			
Common whelk	*Buccinum undatum*	■	■	■	■
Common whelk eggs	*Buccinum undatum*	■			
Edible crab	*Cancer pagurus*		■		■
Shore crab	*Carcinus maenas*	■	■	■	■
Prawn	*Caridea* sp.	■	■	■	■
Rhodophyta	*Ceranium* spp.		■		
Crangon sp.	*Crangon* sp.	■	■	■	■
Hornwrack	*Flustra foliacea*	■	■	■	
Squat lobster	*Galatheidae* sp.	■	■	■	

Common Name	Scientific Name	Spring East	Spring West	Autumn East	Autumn West
Scale worm	*Harmothoe lunulata*				
Common lobster	*Homarus gammarus*				
Great spider crab	*Hyas araneus*				
Swimming crab	*Liocarcinus arcuatus*				
Squid	*Loligo forbesii*				
Spider crab	*Macropodia* sp.				
Plumose anemone	*Metridium senile*				
Edible mussel	*Mytilus edulis*				
Velvet swimming crab	*Necora puber*				
Norway lobster	*Nephrops norvegicus*				
Sea slug	*Nudibranch* sp.				
Brittlestar	*Ophiura* sp.				
Hermit crab	*Paguridae* sp.				
Fanworm	*Pectinaridae* sp.				
Long clawed porcelain crab	*Pisidia longicornis*				
Sea gooseberry	*Pleurobrachia pileus*				
Sea spider	*Pycnogonida* sp				
Sea anemone	*Sagartia* sp.				
Cuttlefish	*Sepia officinalis*				
Hydroid	*Sertulariidae* sp.				
Sea lettuce	*Ulva lactuca*				
Dahlia anemone	*Urticina felina*				

3 Marine Mammals

3.1 Consultation

3.1.1 All cetacean species are protected by The Wildlife and Countryside Act 1981 (WCA) as amended, the Bern Convention, and also under grouped species action plans of the UKBAP. All odontocetes (toothed cetaceans) excluding sperm whale (*Physeter macrocephalus*) are protected by the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS). The Bonn Convention offers protection for all migratory species throughout their range and is concerned with conservation of wildlife and habitats on a global scale. In addition, the harbour porpoise (*Phocoena phocoena*) and the bottlenose dolphin (*Tursiops truncatus*) are listed as EC Habitats Directive Annex II species.

3.1.2 As with cetaceans, pinnipeds are protected through the Wildlife and Countryside Act 1981, in addition they are listed on Appendix II of The Bern Convention and Appendix II and V of the EC Habitats Directive. Pinniped populations are offered further protection through the Conservation of Seals Act (1970). The Conservation of Seals (Scotland) Order 2007 offers year round protection for common seal populations in the Shetland and Orkney areas and an area of the east coast between Stonehaven and Dunbar (Wild-Scotland, 2007).

3.1.3 Many cetacean species are known to have large home ranges and evidence suggests that certain coastal populations of cetaceans might exploit food sources up to 200km from their residence (Stockin et al., 2006) with a core area of 86km^2 (Corkerton & Martin, 2004). Other migratory species are known to cover large distances between their feeding and breeding grounds. Pinnipeds

are known to have home ranges extending up to 6,400km^2 although in most cases they stay within 75km of their colony (Reeves et al., 2002).

3.1.4 Information supplied by consultees includes mammal data outside of the Firth of Forth and therefore outside of the scope of the assessment, as set out in Chapter 11 (Estuarine Ecology). However, the information presented in this section includes all consultation data, including those outside of the scope.

Sea Watch Foundation (SWF)

Cetaceans

3.1.5 Information on cetacean status and distribution comes primarily from the national sightings database (1973-present) maintained by the SWF.

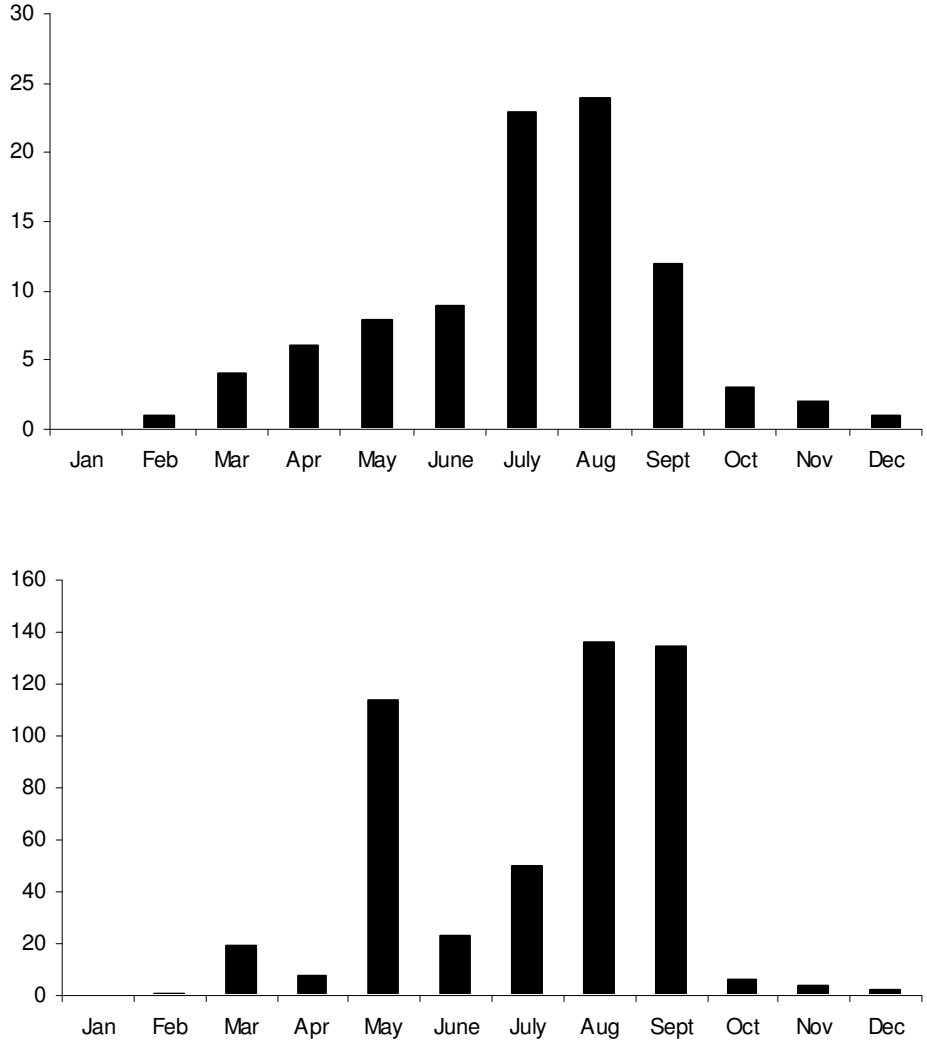
3.1.6 Table 3.1 details the cetacean species recorded by SWF. Harbour porpoise is the most frequently occurring with a total of 469 sightings and 1,538 individuals sighted. Of the other species the bottlenose dolphin and minke whale (*Balaenoptera acutorostrata*) and the white-beaked dolphin (*Lagenorhynchus albirostris*) are regarded as common.

Table 3.1: Summary of sightings records in Sea Watch Foundation database

Species	Scientific name	No. Records	% Records	No. Individuals	% Individuals
Harbour porpoise	*Phocoena phocoena*	469	45.6	1,538	27.9
Bottlenose dolphin	*Tursiops truncatus*	122	11.9	1,324	24.0
White-beaked dolphin	*Lagenorhynchus albirostris*	97	9.4	511	9.3
Minke whale	*Balaenoptera acutorostrata*	91	8.8	133	2.4
Killer whale	*Orca orcinus*	40	3.9	165	3.0
Short-beaked common dolphin	*Delphinus delphis*	9	0.9	80	1.5
Long-finned pilot whale	*Globicephala melas*	8	0.8	26	0.5
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	7	0.7	39	0.7
Humpback whale	*Megaptera novaeangliae*	4	0.4	4	0.1
Risso's dolphin	*Grampus griseus*	3	0.3	13	0.2
Sperm whale	*Physeter macrocephalus*	3	0.3	13	0.2
Fin whale	*Balaenoptera physalus*	2	0.2	2	0.05
Striped dolphin	*Stenella coeruleoalba*	2	0.2	8	0.2
Sowerby's beaked whale	*Mesoplodon bidens*	2	0.2	2	0.05
Beluga	*Delphinapterus leucas*	1	0.1	1	0.02
Unidentified dolphin species	*Delphinidae*	125	12.1	1,464	26.6
Unidentified cetacean species	*Cetacean*	18	1.8	55	1.0
Unidentified *Lagenorhynchus* sp.	-	14	1.3	49	0.9
Unidentified whale species	-	4	0.4	4	0.1
Unidentified large whale species	-	4	0.4	4	0.1
Patterned dolphin species	-	3	0.3	67	1.2
TOTAL		**1,028**	**100.0**	**5,502**	**100.0**

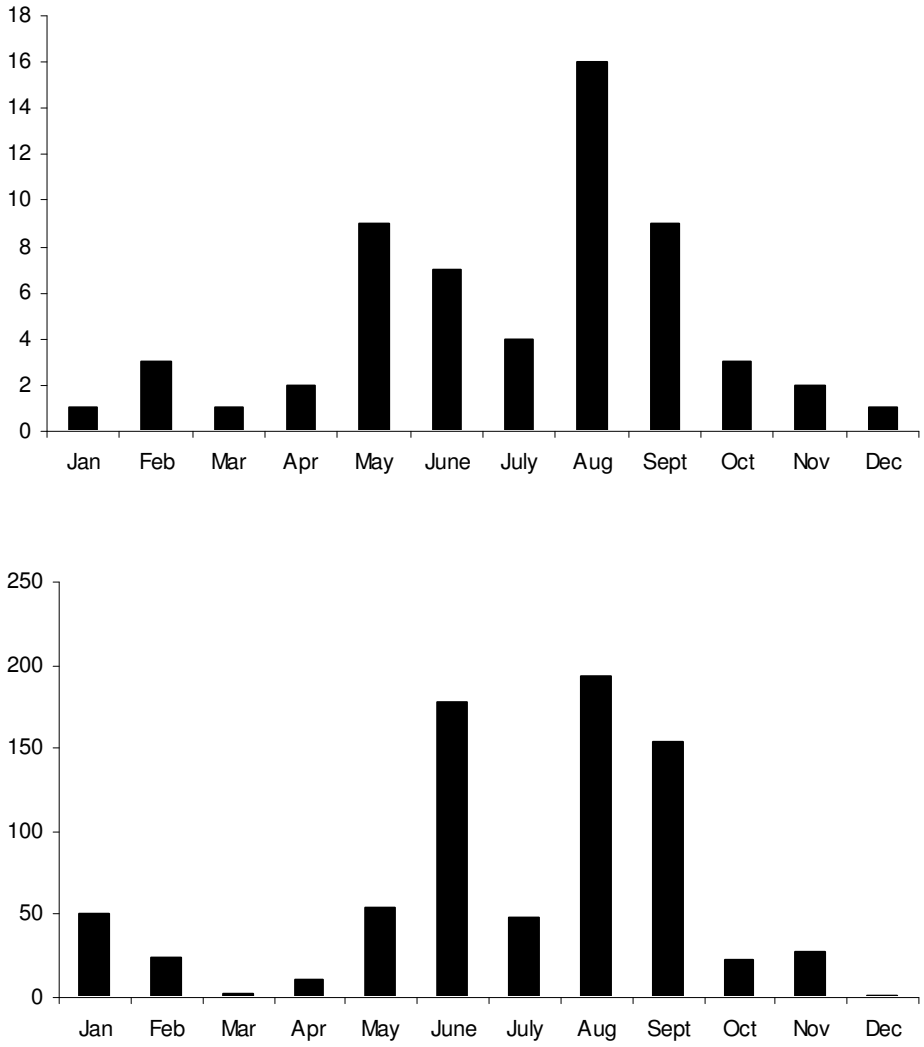
3.1.7 Distributional data have been provided by Evans & Anderwald (2008) for the four most frequently occurring species (Plot 3.1 to Plot 3.4). Between the months of July and August, a peak in sightings of harbour porpoise was observed, with highest numbers of individuals recorded in May and again in August and September (Plot 3.1). Harbour porpoises generally occurred year round with the exception of January where no sightings were recorded.

Plot 3.1: Seasonal occurrence of harbour porpoise as number of sightings per month (upper) and number of individuals per month (lower) for the Firth of Forth and adjacent sea areas



3.1.8 The occurrence of pods of bottlenose dolphins in this region peaked during August and September with a smaller peak earlier in the year during May (Plot 3.3). The number of individuals spotted in the Firth of Forth and adjacent sea areas were high, with the highest numbers occurring during the months of June, August and September.

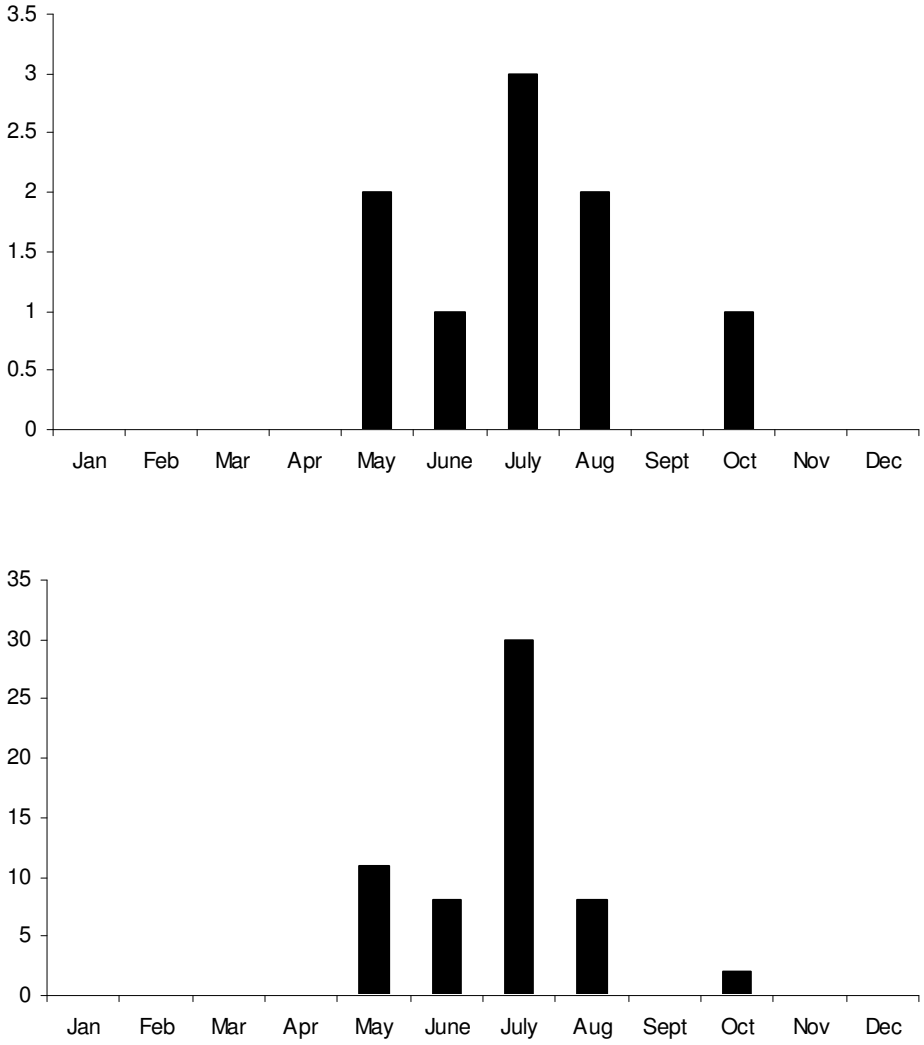
Plot 3.2: Seasonal occurrence of bottlenose dolphin as number of sightings per month (upper) and number of individuals per month (lower) for the Firth of Forth and adjacent sea areas



3.1.9 The white-beaked dolphin is resident in British waters year round, and typically occurs in this region between June and September. It was rarely reported between November and April (3.3). This species uses the Firth of Forth for feeding and breeding (Evans & Anderwald, 2008); the latter occurs during the months of May and August.

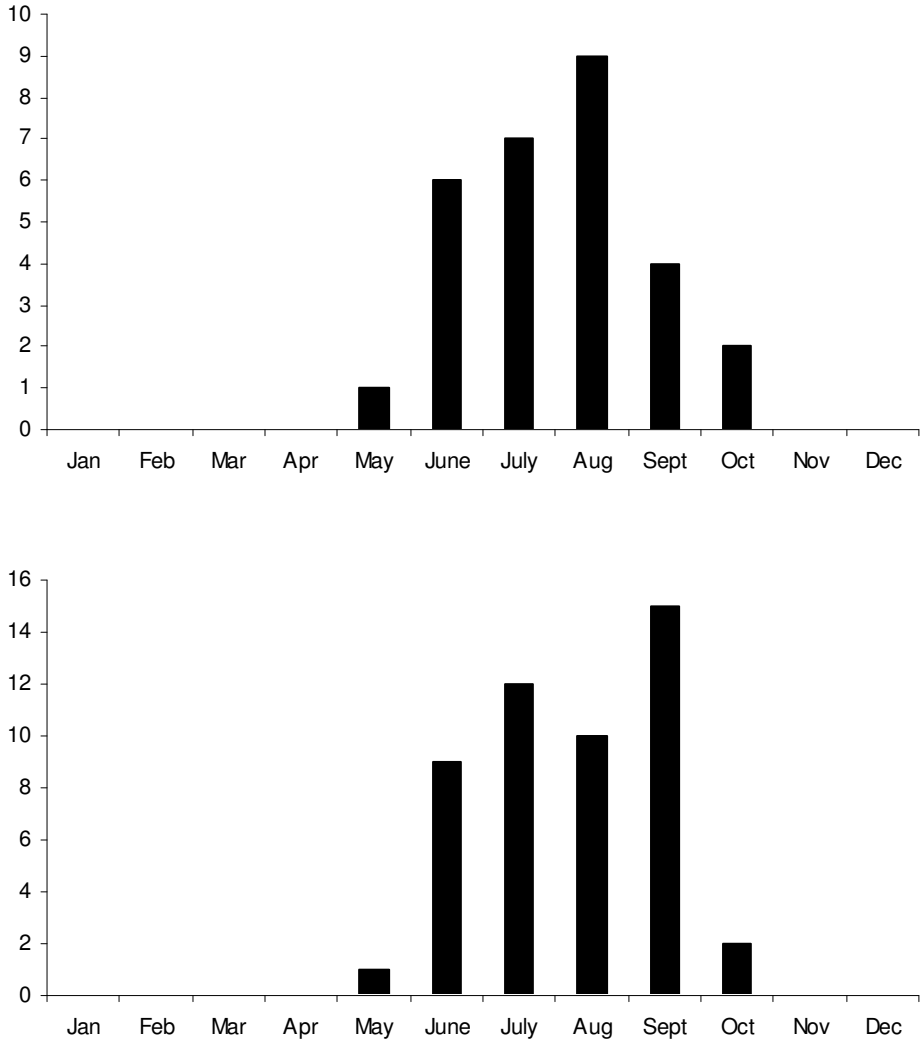
3.1.10 Minke whale sightings occurred regularly between May and October, peaking during August (Plot 3.3).

Plot 3.3: Seasonal occurrence of white-beaked dolphin as number of sightings per month (upper) and number of individuals per month (lower) for the Firth of Forth and adjacent sea areas



3.1.11 Plot 3.4 provides some evidence of a winter movement out of the area. It is thought that minke whale migrate to tropical waters to breed, followed by the movement north during the summer to their feeding grounds. However, this theory is based on anecdotal evidence rather than systematic surveys.

Plot 3.4: Seasonal occurrence of minke whale as number of sightings per month (left) and number of individuals per month (right) for the Firth of Forth and adjacent sea areas



Lothian Wildlife Information Centre (LWIC)

Cetaceans

3.1.12 Information on cetacean sightings was collated by LWIC from a variety of sources including Isle of May yearly reports, FSG, East Lothian Rangers, Scottish strandings and Fife Cetacean Reports. Owing to the nature of these sightings and the process by which they are recorded, some duplication of the data may exist between those obtained through SWF and the Forth Seabird Group (FSG). A total of 14 cetacea have been identified by LWIC as present in the Firth of Forth and surrounding seas, dating back to 1990 (Table 3.2).

3.1.13 The harbour porpoise was found to be the most abundant species with a total of 268 sightings documented between 1990 and 2006. Other regularly occurring species included the minke whale, the bottlenose dolphin and the white-beaked dolphin.

Table 3.2: The LWIC number of sightings for cetaceans and pinnipeds during 1990-2006 inclusive

Common name	Scientific name	Number of sightings
Harbour porpoise	*Phocoena phocoena*	268
Minke whale	*Balaenoptera acutorostrata*	118
Bottlenose dolphin	*Tursiops truncatus*	62
White-beaked dolphin	*Lagenorhynchus albirostris*	22
Humpback whale	*Megaptera novaeangliae*	15
Common dolphin	*Delphinus delphis*	13
Sperm whale	*Physeter catodon*	11
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	9
Long-finned pilot whale	*Globicephala melas*	7
Killer whale	*Orca orcinus*	7
Sowerby's beaked whale	*Mesoplodon bidens*	6
Striped dolphin	*Stenella coeruleoalba*	5
Fin whale	*Balaenoptera physalus*	4
Risso's dolphin	*Grampus griseus*	1
Unidentified dolphin species	*Delphinidea* sp	34
Unidentified Cetacean species	*Cetacea*	21
Grey seal	*Halichoerus grypus*	13
Common seal	*Phoca vitulina*	3

3.1.14 Out of 268 sightings of the harbour porpoise, only one of these occurred outside the Firth of Forth with the majority sighted within 50km of the Main Crossing; and a high number occurring within the 10km zone. Although the bottlenose dolphin was found in the Firth of Forth, the highest numbers of sightings occur in the outer reaches of the Firth of Forth both within and outside of the 50km zone. Of the other regularly occurring species, the minke whale has been found to frequent the inner Firth of Forth and has been sighted within the 10km zone of the Main Crossing. Although the white-beaked dolphin enters the estuary it has not been recorded in high numbers in this area.

3.1.15 Seasonal occurrence for the harbour porpoise, the bottlenose dolphin and the minke whale (based on sightings data provided by LWIC) is displayed in Table 3.3. A further ten species have been recorded within the Firth of Forth and adjacent seas and are deemed as sporadic or incidental in nature; the species include humpback whale (*Megaptera novaeangliae*), long-finned pilot whale (*Globicephala melas*), striped dolphin (*Stenella coeruleoalba*) and killer whale (*Orca orcinus)*.

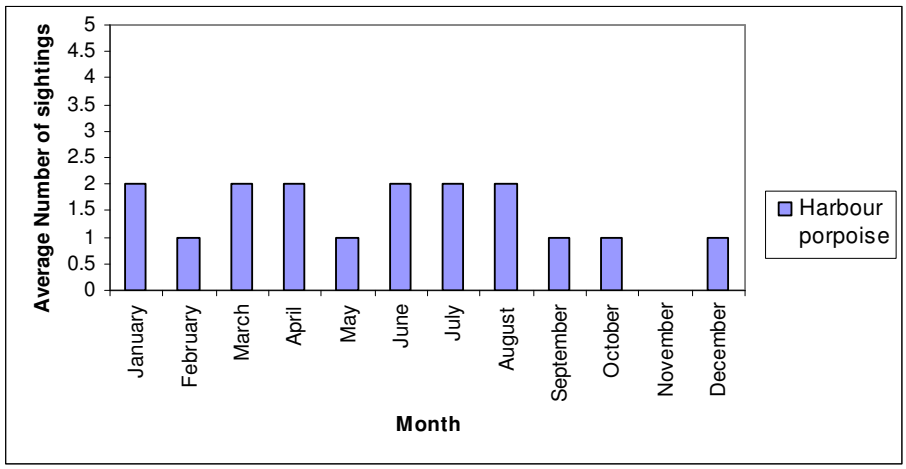
3.1.16 Table 3.3 and Plot 3.5 show the seasonal distribution of three species found within this region and regarded as the most frequently occurring of the cetaceans. The table displays the total number of sightings each month over a 16-year period. The harbour porpoise occurs here year round with slightly greater numbers of animals found during August.

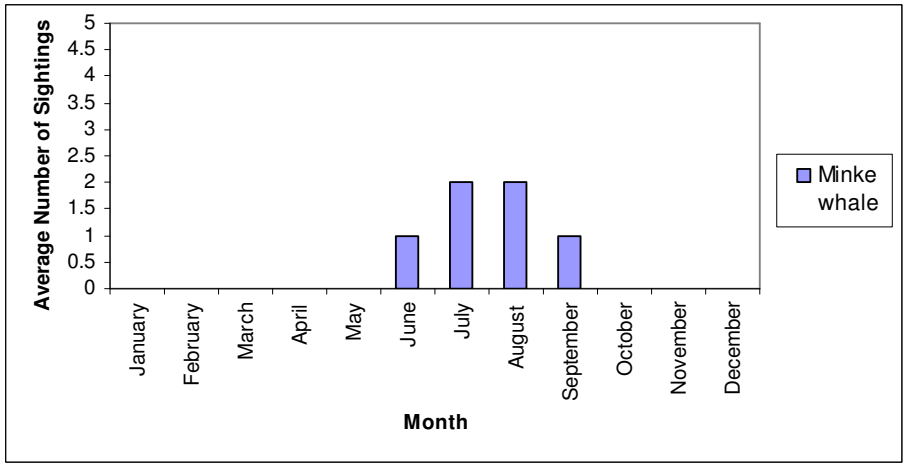
Table 3.3: Seasonal occurrence data (total number of sightings) for harbour porpoise, bottlenose dolphin and minke whale using data obtained from the LWIC for all years between 1990 and 2006

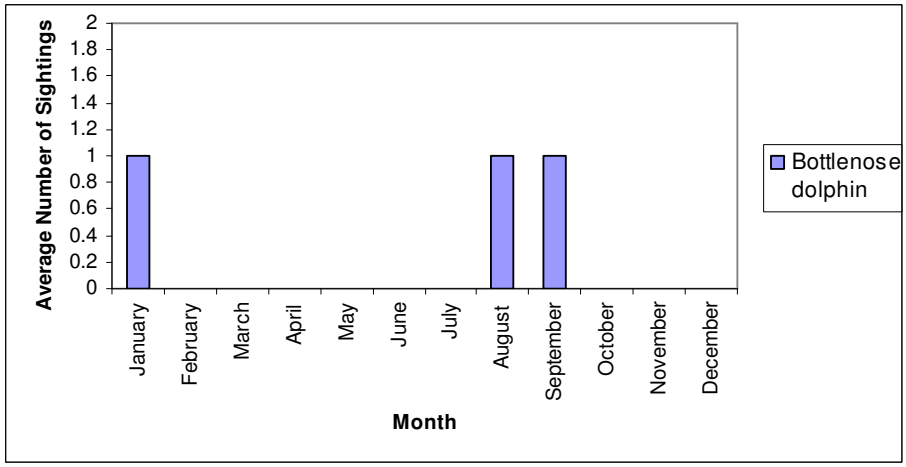
Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Harbour porpoise	28	20	32	32	12	25	34	39	12	15	5	14
Bottlenose dolphin	10	5	1	2	3	4	6	13	16	1	0	1
Minke whale	4	1	1	6	6	15	33	30	17	4	0	1

3.1.17 The bottlenose dolphin has only been recorded occasionally during early spring and summer with a greater number of sightings occurring during late summer (August and September) (Plot 3.5).

3.1.18 The occurrence of minke whale increased over the summer months with a small peak during July. Total and average sightings from LWIC show July and August to be the months with highest numbers of minke whale individuals.







Plot 3.5: Seasonal distribution of the main marine mammal species recorded in the Firth of Forth region by the LWIC. Distributional data was based on sightings provided by SWF and LWIC

3.1.19 Figure 11.4 shows the combined distribution of SWF and LWIC data illustrating the species that occur in the Firth of Forth area. There were four species that frequently occurred here; the harbour porpoise, the bottlenose dolphin, the minke whale and the white-beaked dolphin.

3.1.20 The harbour porpoise was the most frequently recorded cetacean with sightings occurring throughout the Firth of Forth and along the coastline to the north and south of the region. Concentrations of this species appeared both in the Firth of Forth and around the Farne Islands. The harbour porpoise has been sighted upstream in the Firth of Forth, beyond the Main Crossing, as well as in areas over 100km offshore.

3.1.21 The bottlenose dolphin is less common than the harbour porpoise with concentrations of this species occurring predominantly around the coastline to the north and south of the Firth of Forth. Sightings of this species were less common than the harbour porpoise but were a common sight within the Firth of Forth and Tay Estuaries.

3.1.22 The minke whale has been spotted in a variety of habitats including estuarine, coastal and offshore waters. Concentrations of this species occur around the Isle of May and the Farne Islands and are found regularly throughout the Firth of Forth, often to within 5km of the Main Crossing.

3.1.23 In contrast to these three species, the white-beaked dolphin, although spotted in the Firth of Forth, was seen more frequently in offshore waters, with a total of 97 sightings recorded by Evans & Anderwald (2008). In addition to the four frequently occurring species, other species such as the long-finned pilot whale, killer whale, short-beaked common dolphin and Atlantic white-sided dolphin are regarded as occasional visitors to the Firth of Forth. The fin whale (*Megaptera novaeangliae*), sperm whale, beluga (*Delphinapterus leucas*) and striped dolphin have all been recorded in the surrounding sea areas but regarded as rare.

Pinnipeds

3.1.24 Two species of pinnipeds (common and grey seals) have been identified by LWIC as present in the Firth of Forth and surrounding seas, dating back to 1990 (Table 3.2).

Isle of May Yearly Reports

Cetaceans

3.1.25 The Isle of May and its surrounding waters are important for cetaceans year round (Table 3.5). Owing to the nature of cetacean sightings, some repetition of data may be likely for the year 2006 with the LWIC data set out in paragraph 3.1.14.

Pinnipeds

3.1.26 The Isle of May, situated in the mouth of the Firth of Forth, is home to a breeding grey seal (*Halichoerus grypus*) colony and is believed to be the fifth largest breeding site in the UK. Scottish Natural Heritage (SNH) are responsible for the general management of the island, including biological monitoring work and visitor management work (SNH, 2005a). SNH produces yearly reports and all available cetacean and pinniped data have been displayed in Table 3.4.

3.1.27 The yearly reports indicate the importance of this island for the breeding grey seal colony with 1,953 pup born on the Isle of May during 2004, 1,954 pups during 2005 and 1,827 pups born on the island during 2006 (SNH, 2005b).

3.1.28 The numbers shown in Table 3.4 indicate the importance of the Isle of May and its surrounding waters for pinnipeds year round.

Table 3.4: Numbers of marine mammals sighted on and around the Isle of May, Firth of Forth (situated between 50 and 60km from the Main Crossing). Data obtained from SNH (2005b and 2005c)

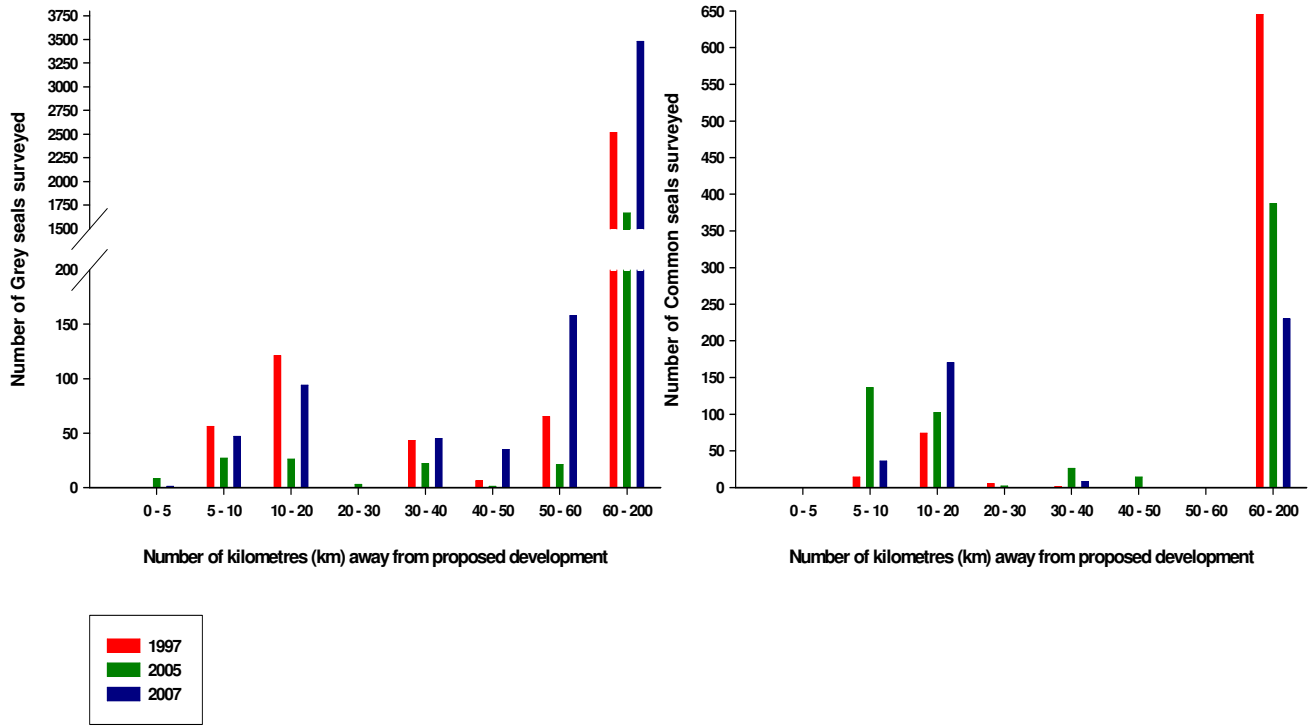
	2006						2007					
Species	**April**	**May**	**June**	**July**	**August**	**September**	**April**	**May**	**June**	**July**	**Aug**	**Sept**
Bottlenose dolphin							20		6			8
Common dolphin								35				
Unidentified dolphin species	6										9	
Grey Seal							519					
Harbour porpoise			2			1						11
Minke whale					2	4				3	4	6
Killer whale									8			
Pilot whale												1

Sea Mammal Research Unit (SMRU)

Pinnipeds

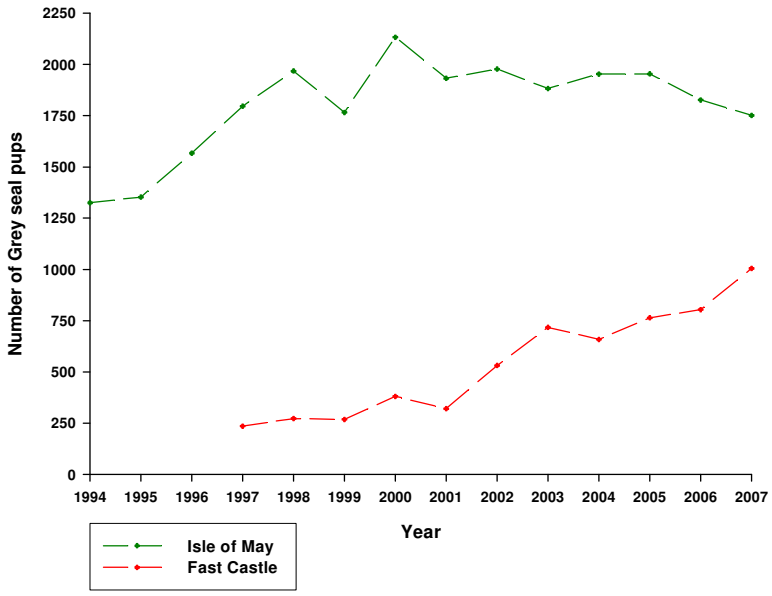
3.1.29 Surveys are carried out during the common seal (*Phoca vitulina*) annual moult in August, when it is believed that the greatest and most consistent numbers of common seals are hauled ashore. The seals are surveyed using a helicopter equipped with a thermal imaging camera that can detect seals hauled ashore over a distance of up to 3km. Grey seals are also counted during the August surveys. Counts of grey seals during the summer months are highly variable and are not used as a population index in this species (SMRU, 2008).

Plot 3.6: Number of grey seals (left) and common seals (right) counted at various distances away from the Main Crossing on one day during August 1997, 2005 and 2007 (Data provided by (SMRU, 2008)



3.1.30 Plot 3.6 provides a snapshot for grey and common seal distribution during the moulting period (one day in August) and where they were located in relation to the Main Crossing. Common seals were found in greater numbers (136 individuals) than the grey seal within 10km of the Main Crossing. Very few seals occupied the area between 20km and 30km away from the Main Crossing. The high number of grey and common seals found over 60km away from the Main Crossing shows the importance of the habitats surrounding this region; the Farne Islands, Tentsmuir and the Firth of Tay are included in these figures.

Plot 3.7: Numbers of grey seal pups counted on Isle of May (50 to 60km) and Fast Castle (70 to 80km) during 1994 and 2007 a comparison



3.1.31 Plot 3.7 illustrates the importance of the Isle of May as a grey seal breeding colony, which lies between 50km and 60km of the Main Crossing. The Isle of May is used yearly as a breeding colony for grey seals and records dating back to 1994 detail numbers over 1,250 individuals, numbers have fluctuated over the last 13 years and reached a maximum of 2,133 individuals in the year 2000. Fast Castle, situated approximately 65km due east of the Main Crossing, has seen a steady rise in grey seal pup numbers from 250 individuals in 1997 to 1,000 individuals during 2007.

Forth Seabird Group (FSG)

Pinnipeds

3.1.32 The FSG carries out yearly surveys on seabirds, cetaceans and pinniped populations on the Isle of May and a number of the Forth Islands. These locations are visited over a number of days throughout the year and cover the grey seal breeding season. The data obtained for the grey and common seals have been split into total yearly counts and separate pup counts for the years 2002 and 2007 inclusive (Table 3.5) (FSG, 2002; 2003; 2004; 2005; 2006 and 2007). Any cetacean species recorded by FSG is addressed within the data supplied by LWIC for the years 1990 and 2006 inclusive to prevent repetition of data.

Table 3.5: Distribution and total abundance of grey and common seals on the Forth Islands (with their designations) 2002 to 2007 inclusive. N.B. Shaded cells are islands surveyed and show total number of seals. Numbers within parentheses show total number of grey seal pups. Distance from the Main Crossing increases from left to right.

Year	Species	Beamer Rock	Long Craig	Inchgarvie	Downing Point Rocks	Long Craig Rocks	Haystack	Inchcolm	Little Craigs	Meadulse Rocks	Carr Craig	Oxcars	Inchmickery	Inchkeith	Eyebroughy	Fidra	The Lamb	Craigleith	Bass Rock	Isle of May
2002	Grey seal (*Halichoerus grypus*)				2	8	74	147 (29)		46	12	36	25	30 (1)						
	Common seal (*Phoca vitulina*)										4		12							
2003	Grey seal (*Halichoerus grypus*)						25	62 (10)			18	42	1	174 (62)				107 (16)	3	314 (314)
	Common seal (*Phoca vitulina*)							8					3	1						
2004	Grey seal (*Halichoerus grypus*)							29 (14)			2 (1)		7 (1)	184 (77)				80 (36)	7	253 (251)
	Common seal (*Phoca vitulina*)												9							
2005	Grey seal (*Halichoerus grypus*)						29	26 (8)			4 (3)		8	142 (66)	1			71 (30)		
	Common seal (*Phoca vitulina*)												2							
2006	Grey seal (*Halichoerus grypus*)						10	26 (2)			4		15	432 (216)				65 (31)	3 (3)	
	Common seal (*Phoca vitulina*)							4					6							
2007	Grey seal (*Halichoerus grypus*)						2	61 (6)				7	174 (101)	258 (123)				22 (12)		
	Common seal (*Phoca vitulina*)										3									

2002

3.1.33 During 2002, nine islands within the Firth of Forth were visited between June and November. It is apparent from the abundances shown that Inchcolm (situated within the 10km buffer zone of the Main Crossing) is important for both adult grey seals and pups with a total of 147 animals of which, 29 were identified as pups. All the islands visited throughout 2002 were found to have seals hauled out; indicating how important the Inner Islands are for the grey seal population.

3.1.34 Only 16 common seals were recorded during 2002 on Carr Craig and Inchmickery; all were adults and occurred during late summer and November.

2003

3.1.35 The Forth Islands were surveyed during the breeding season (September to December). The surveys results indicated that the Isle of May (outside the 50km buffer zone) is an important location for seal reproduction with a total of 314 pups present on the island during October and November (Table 3.6). Pups were also present on other islands within the Inner Firth of Forth including Inchcolm and Inchkeith that lie within the 10km and 20km buffer zone respectively.

3.1.36 Despite investigating many of the Firth of Forth inner islands, common seals were only sighted at three separate locations during 2003; Inchcolm and Inchmickery. Both of these islands are situated within 10km of the Main crossing. One individual was recorded on Inchkeith. A total of 12 individuals were recorded throughout the survey season.

2004

3.1.37 The Isle of May was surveyed during the breeding season of 2004 and boasted 251 pups throughout October into the beginning of November. Other islands that appear to be a suitable breeding ground for grey seals include Inchcolm, Inchkeith and Craigleith, the latter being situated in the 40 to 50km buffer zone from the Main Crossing. As with 2003, seals occupy the Firth of Forth year round and use many of the Inner Forth islands as suitable haul-out sites including those islands situated within the 5km and 10km buffer zone.

3.1.38 Despite 11 locations surveyed over the course of 2004, only common seals were recorded on Inchmickery. Furthermore, while the Isle of May is a known breeding location and haul-out site for the grey seal, the common seal does not appear to use this location at all.

2005

3.1.39 Surveys carried out during the breeding season of 2005 indicated a decline in numbers in comparison to the previous years. Carr Craig (lying near to Inchcolm within the 10km buffer zone), Inchkeith and Craigleith supported a number of grey seal pups. Nine locations visited in the Firth of Forth including Inchcolm and Haystacks (both of which are situated just outside the 5km buffer zone of the Main Crossing) were shown to be a common haul-out site for grey seals but yielded no common seals.

3.1.40 The distribution of common seals throughout 2005 and the numbers surveyed indicate that this area is less important for common seal haul-outs, since only two seals were found on Inchmickery during June.

2006

3.1.41 Nine islands were surveyed during 2006 and again suggest the importance of Inchkeith and Craigleith as breeding colonies. Carr Craig, Inchmickery and Inchcolm were also found to be used regularly as haul-out sites by grey seals.

3.1.42 The island of Inchmickery was used by common seals and six seals were found here over the survey season.

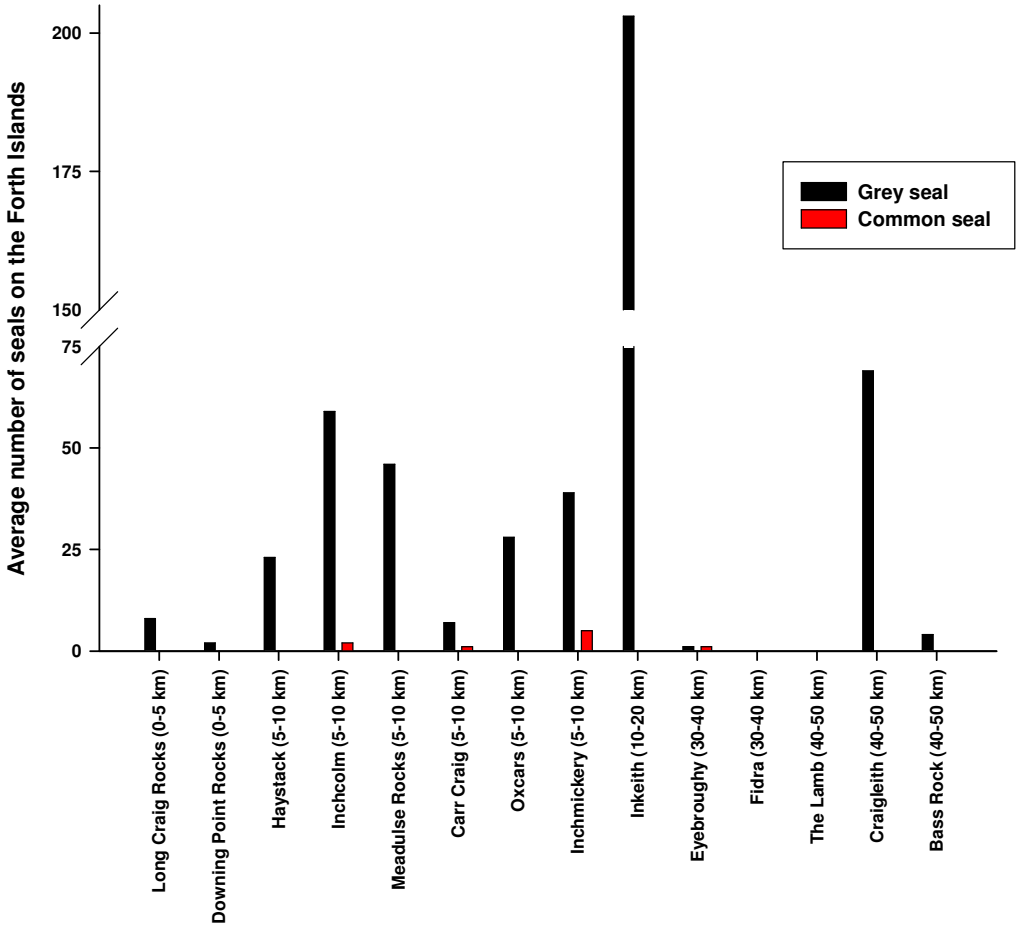
2007

3.1.43 In 2007, Inchmickery and Inchkeith dominated the breeding colonies with 123 and 101 pups respectively over the survey period. Inchcolm and Craigleith were also used by grey seals in the breeding season; Oxcars and Haystack were seen to be used occasionally as haul-out locations.

3.1.44 Only two common seals were spotted in the Firth of Forth during 2007 and these occurred on Carr Craig.

3.1.45 Plot 3.8 illustrates the importance of the Forth Islands for the grey seal population, using them as haul-out sites and breeding sites. Inchkeith is a suitable habitat for grey seals supporting on average 200 seals at any one time during the breeding season and from the data displayed in Table 3.8, Inchkeith is an important breeding site for the grey seals, supporting on average 91 seal pups a year. Of the other Islands, Inchcolm, Meadulse and Craigleith all show importance as suitable grey seal habitat with an average of more than 50 seals recorded at each site.

Plot 3.8: Average number of pinnipeds occupying Forth Islands. All data obtained from FSG 2002-2007 inclusive and averaged over the number of years that the Island was surveyed



British Divers Marine Life Rescue (BDMLR)

Cetaceans and Pinnipeds

3.1.46 Data relating to all strandings since 2004 within the Firth of Forth and nearby coastal areas have been obtained from the BDMLR (Table 3.6).

Table 3.6: Marine mammal stranding data for the Firth of Forth and adjacent coastal areas between Bamburgh in the south and Arbroath in the north between 2004 and 2007. Data supplied by BDMLR (2007)

Date (dd/mm/yyyy)	Location	Distance Away from Development (river km)	Marine Mammal Strandings/Sightings				
			Pinnipeds		Cetacea		
			Grey seal (*Halichoerus grypus*)	Unidentified seal species	white-beaked dolphin (*Lagenorhynchus albirostris*)	Harbour porpoise (*Phocoena phocoena*)	Other cetacean species
24/09/2004	Tentsmuir Forest, Tayforth	56° 25.0' N/2° 48.0' W - 80 km	1 (pup)	-	-	-	-
15/11/2004	Anstruther, Fife	56° 13.3' N/2° 41.1' W - 50-60 km	-	1 (pup)	-	-	-
29/03/2005	On the Forth Elie end of beach (Fife)	56° 11.3' N/2° 49.0' W - 40-50 km	-	-	-	1	-
03/02/2006	Kingsbarns, Fife	56° 23.1' N/2° 37.4' W - 80-90 km	-	1	-	-	-
12/06/2006	Tayport, Tayforth	56° 26.9' N/2° 52.2' W - 80 km	-	-	-	1	-
26/06/2006	Berwick upon Tweed	55° 46.2' N/1° 59.0' W - 55 km	-	-	1	-	-
07/08/2006	Belhaven Bay, West Barns	56° 00.1' N/2° 33.4' W - 100+ km	-	-	-	-	large whale
22/08/2006	Limekiln Beach, Fife	56° 01.8' N/3° 28.6' W - 5-10 km	-	1 (pup)	-	-	-
02/11/2006	Kingsbarn Beach, Scotland	56° 17.9' N/2° 37.8' W - 80-90 km	-	1 (pup)	-	-	-
20/11/2006	West Sands, St Andrews	56° 21.1' N/2° 48.3' W - 80 km	-	1 (pup)	-	-	-
21/11/2006	West Sands, St Andrews	56° 21.1' N/2° 48.3' W - 80 km	-	1 (pup)	-	-	-
28/11/2006	Arbroath Beach	56° 33.3' N/2° 34.6' W - 90 km	-	1 (pup)	-	-	-
30/01/2007	Dalmeny, River Forth	55° 59.6' N/3° 22.9' W - 0-5 km	-	-	-	-	9 killer whale (Orca orcinus) feeding
29/03/2007	Eyemouth,	55° 52.4' N/2° 04.8' W - 90-100 km	-	1	-	-	-
04/04/2007	Firth of Forth nr Alloa	56° 06.2' N/3° 47.9' W - 20-30 km	-	-	-	1	-
03/05/2007	Kingsbarn, Fife	56° 23.1' N/2° 37.4' W - 80-90 km	-	1	-	-	-

3.1.47 Pinniped pups were found to be the most frequently stranded species with a total of nine reported instances between 2004 and 2007 inclusive; of these only one was formally identified as a grey seal. Three harbour porpoise were reported stranded on separate occasions over the three years, two occurring in the Fife region. In January 2007 a pod of killer whales was seen to be feeding near Dalmeny situated under the Forth Road Bridge.

Incidental Observations

Cetaceans and Pinnipeds

3.1.48 Numerous incidental sightings were made, such as during bird and fish surveys undertaken by Jacobs Arup in 2008/2009, in addition to those reported in local newspaper articles (Table 3.7). There were a number of reported instances where pinnipeds (in particular the grey seal) were found hauled-out on Beamer Rock and the navigational buoys to the east and west of the Main Crossing: they have also been recorded throughout the survey season near North Queensferry, Carlingnose Point and Port Edgar.

3.1.49 Minke whales were observed within the Firth of Forth with one particular sighting occurring near to Beamer Rock (Mark Jackson, Jacobs Arup, 6th November 2008, pers. comm.). In addition to this, harbour porpoise were regularly seen foraging between the Forth Rail Bridge and the Forth Road Bridge.

Table 3.7: Incidental sightings within the Firth of Forth region during the survey season 2007/2008/2009

Date	Grid Reference Location	Number	Species	Behaviour
17/10/2007	NT 730 795	3	Grey seal	Hauled-out
24/10/2007	NT 121 788	1	Grey seal	Hauled-out
05/11/2007	NT 121 788	1	Grey seal	Foraging
22/11/2007	NT 135 811	3	Grey seal	Hauled-out
22/11/2007	NT 135 811	2	Grey seal	Hauled-out
18/12/2007	NT 109 803	1	Grey seal	Foraging
07/01/2008	NT 130 795	1	Harbour porpoise	Foraging
11/01/2008	NT 109 803	1	Grey seal	-
11/01/2008	NT 109 803	1	Grey seal	-
05/03/2008	NT 135 811	1	Grey seal	-
20/03/2008	NT 135 811	1	Grey seal	-
27/03/2008	NT 121 788	2	Grey seal	Hauled-out
30/05/2008	NT 144 792	2	Grey seal	Hauled out
25/07/2008	NT 120 799	3	Common seal	Hauled out
29/07/2008	NT 072 831	1	Minke whale	Stranded (BBC, 2008)
02/09/2008	NT 120 799	4	Grey seal	Hauled-out
09/09/2008	NT 136 807	1	Grey seal	Foraging
15/09/2008	NT 100 818	1	Grey seal	Foraging
15/09/2008	NT 144 789	1	Grey seal	Hauled-out
17/09/2008	NT 144 792	2	Grey seal	Hauled-out
06/11/2008	NT 120 799	1	Minke whale	Foraging
20/02/2009	NT 126 796	3	Harbour porpoise	Foraging
24/02/2009	NT 135 789	3	Harbour porpoise	Foraging
25/02/2009	NT 135 793	1	Harbour porpoise	Foraging
26/02/2009	NT 135 789	2	Harbour porpoise	Foraging

Date	Grid Reference Location	Number	Species	Behaviour
27/02/2009	NT 130 801 (1/2 km radius)	1	Grey seal	-
03/03/2009	NT 114 788	1	Grey seal	-
03/03/2009	NT 137 803	1	Harbour porpoise	Foraging
04/03/2009	NT 140 799 (1/2 km radius)	1	Harbour porpoise	Foraging
04/03/2009	NT 140 799 (1/2 km radius)	1	Grey seal	Bobbing
04/03/2009	NT 155 829	1	Harbour porpoise	Foraging
05/03/2009	NT 151 799	2	Harbour porpoise	Foraging
06/03/2009	NT 120 791	1	Common seal	-
06/03/2009	NT 151 799	2	Harbour porpoise	Foraging
09/03/2009	NT 156 796	1	Pinniped	Bobbing
10/03/2009	NT 138 795	2	Harbour porpoise	Foraging
11/03/2009	NT 130 794	1	Harbour porpoise	Foraging
11/03/2009	NT 138 795	1	Harbour porpoise	Foraging
01/04/2009	NT 130 794	1	Harbour porpoise	Foraging
01/04/2009	NT 130 794	1	Harbour porpoise	Foraging
01/04/2009	NT 130 794	1	Pinniped	Bobbing
08/04/2009	NT 136 807	1	Harbour porpoise	Foraging
08/04/2009	NT 156 823	1	Harbour porpoise	Dead
08/04/2009	NT 130 821	1	Pinniped	Bobbing

4 Estuarine Birds

4.1 Consultation

Firth of Forth SPA

4.1.1 The Firth of Forth SPA qualifies under Article 4.1 of EU Birds Directive by regularly supporting wintering populations (1993/94-97/98 winter peak means) of European importance of the following Annex 1 species:

- red-throated diver (*Gavia stellata*) (90 individuals; 2% of UK);
- Slavonian grebe (*Podiceps auritus*) (84; 2% of NW Europe, 21% of UK);
- golden plover (*Pluvialis apricaria*) (2,949; 1% of UK); and
- bar-tailed godwit (*Limosa lapponica*) (1,974; 2% of Western Europe, 4% of UK).

4.1.2 The site further qualifies under Article 4.1 of EU Birds Directive by regularly supporting a post-estuarine (passage) population of European importance of another Annex 1 species, the sandwich tern (*Sterna sandvicensis*) (1,617, 6% of GB; 1% of East Atlantic).

4.1.3 The Firth of Forth SPA qualifies under Article 4.2 by regularly supporting wintering populations (1993/94-97/98 winter peak means) of both European and international importance of the migratory species pink-footed goose *Anser brachyrhynchus* (10,852; 6% of Icelandic/Greenlandic), shelduck *Tadorna tadorna* (moulting flock of 4,509; 2% of NW European), knot *Calidris canutus* (9,258; 3% of western European/Canadian), redshank Tringa totanus (4,341; 3% of European/West African) and turnstone *Arenaria interpres* (860 individuals; 1% of European).

4.1.4 The Firth of Forth SPA further qualifies under Article 4.2 by regularly supporting a wintering waterfowl assemblage of European importance: a 1993/93 to 1996/97 winter peak mean of 95,000

water fowl, comprising a 45,000 wildfowl and 50,000 waders. This assemblage includes nationally important numbers of 15 migratory species:

- great crested grebe (*Cristatus podiceps*) (720; 7% of GB);
- cormorant (*Phalacrocorax carbo*) (682; 5% of GB);
- scaup (*Aythya marila*) (437; 4% of GB);
- eider (*Somateria mollissima*) (9,400; 13% of GB),
- long tailed duck (*Clangula hyemalis*) (1,045; 4% of GB);
- common scoter (*Melanitta nigra*) (2,880; 8% of GB);
- velvet scoter (*Melanitta fusca*) (635; 21% of GB);
- goldeneye (*Bucophala clangula*) (3,004; 18% of GB population);
- red-breasted merganser (*Mergus serrator*) (670: 7% of GB);
- oyster catcher (*Haematopus ostralegus*) (7,846; 2% of GB);
- ringed plover (*Charadrius hiaticula*) (328; 1% of GB);
- grey plover (*Pluvialis squatarola*) (724; 2% of GB);
- dunlin (*Calidris alpina*) (9,514; 2% of GB); and
- curlew (*Numenius arquata*) (1,928; 2% of GB).

4.1.5 The assemblage also includes large numbers of the following species; wigeon (*Anas Penelope*) (2,139 [1991/2 to 1995/96]), mallard (*Anas platyrhynchos*) (2,564 [1991/2 to 1995/96]) and lapwing (*Vanellus vanellus*) (4,148 [1991/2 to 1995/96]).

Forth Islands SPA

4.1.6 The Forth Islands SPA qualifies under article 4.1 of the EU Birds Directive by regularly supporting breeding populations of European importance of the Annex 1 species, including:

- Sandwich tern (average of 440 pairs, 1997-2001, 3% of GB);
- roseate tern (*Sterna dougallii*) (average 8 pairs 1997-2001, 13% of GB); and
- common tern (*Sterna hirundo*) (average of 334 pairs, 1997-2001; 3% of GB).

4.1.7 The roseate tern colony is the most northerly of only six regular British colonies.

4.1.8 The Forth Islands SPA additionally qualifies under article 4.2 of EU Birds Directive by regularly supporting internationally important populations of the following migratory species;

- 21,600 gannet (*Morus bassanus*);
- 2,400 shag (*Phalacrocorax aristotelis*);
- 1,500 lesser black-backed gull (*Larus fuscus*) ;
- 14,00 puffin (*Fratercula arctica*);
- 200 cormorant (*Phakacrocorax carbo)*;
- 8,400 kittiwake (*Rissa tridactyla*);
- 16,000 guillemot *(Uria aalge*); and
- 1,400 razorbill (*Alca torda*).

The Firth of Forth RAMSAR Site and SSSI

4.1.9 The Firth of Forth SPA is also designated as a Ramsar site, and regularly supports over 20,000 waterfowl in the winter. This site is underpinned by the Firth of Forth SSSI, which is considered to be of special interest due to a number of habitats and species. The SSSI supports a large number and density of waders and wildfowl and represents the second most important estuarine area for wintering bird species in Scotland.

4.2 Survey Results

Coastal Birds

Core Bird Count Sectors

4.2.1 A total of 28 species of bird were recorded within the three core bird count sectors (C1-C3, Figure 11.6). Over a third of these (11 species) were species of wildfowl (ducks, divers and geese). There were also six species of gull/petrol and four species of waders. The remaining seven were species of auk (guillemot, razorbill) and cormorants/heron (cormorant, grey heron (*Ardea cinerea*), shag), and terns together with mute swan (*Cygnus olor*) and one raptor species, peregrine (*Falco peregrinus*). Although only 21% of species seen were gulls, 76% of all birds recorded were of this type. Wildfowl species accounted for 12% and waders only 2%.

4.2.2 The wildfowl species recorded in the three core sectors were eider, goldeneye, great crested grebe, greylag goose (*Anser anser*), mallard, red-breasted merganser, red-throated diver, scaup, teal (*Anas crecca*), tufted duck (*Aythya fuligula*) and wigeon. The gull/petrol species were black-headed gull (*Larus ridibundus*), common gull (*Larus canus*), fulmar (*Fulmarus glacialis*), great black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*) and lesser black-backed gull, whilst the waders were curlew, oystercatcher, redshank and turnstone.

4.2.3 Of the species observed, 25 also had some sort of conservation status applied to them; two species were classed as JNCC Red list species (herring gull and scaup) while 23 were classed as a JNCC 'Amber' status (JNCC, 2008). Four were also listed as either a national or BAP species (Edinburgh BAP, 2008; Fife BAP, 2008; UK BAP, 2008) (Table 4.1).

Table 4.1: Conservation status of bird species recorded in the core bird count sectors

Bird Species	Status
Black-headed gull	JNCC Amber
Common gull	JNCC Amber
Cormorant	JNCC Amber
Curlew	JNCC Amber
Eider	JNCC Amber
Fulmar	JNCC Amber
Goldeneye	JNCC Amber
Great black-backed gull	JNCC Amber
Great crested grebe	Edinburgh Local BAP
Greylag goose	JNCC Amber
Guillemot	JNCC Amber
Herring gull	JNCC Red, UK BAP
Lesser black-backed gull	JNCC Amber
Mallard	JNCC Amber
Mute swan	JNCC Amber
Oystercatcher	JNCC Amber
Peregrine	JNCC Amber

Bird Species	Status
Razorbill	JNCC Amber
Redshank	JNCC Amber; Fife Local BAP
Red-throated diver	JNCC Amber
Scaup	JNCC Red, UK BAP
Shag	JNCC Amber
Teal	JNCC Amber
Tufted duck	JNCC Amber
Turnstone	JNCC Amber
Wigeon	JNCC Amber

4.2.4 The maximum number of species recorded in each of the three core sectors was similar at 15-17 species but with slightly fewer, on average, seen in sector C1 (10.9) than C2 (11.3) and C3 (12.5). The least number of species recorded was eight (sector C2 in September and sectors C1 and C2 in March). The greatest number of birds recorded was 17 in sector C3 in January. More species were recorded in October (14.0) than in any other month, with slightly fewer in December-January (13.7). The lowest number recorded was in March (8.3).

4.2.5 On average, the greatest number of birds was recorded from sector C3 (318). Lowest average numbers were in sector C2 (107) whilst 157 were recorded in sector C1. Only 20 birds were recorded in sector C1 in March whilst the greatest number recorded (599) was also in this month from sector C3. Averaging over all core sectors, peak numbers were recorded in January-April (263-414) with most in February. Numbers were lower in the September-December period (58-115) with least number of birds recorded being in September.

Northern Bird Count Sectors

4.2.6 A total of 55 species were recorded within the nine northern bird count sectors (N1-N9, Figure 11.6). The majority of species recorded were wildfowl (ducks, divers, geese etc) with 25 representatives, followed by waders (12 species; bar-tailed godwit, curlew, dunlin, golden plover, knot, lapwing, oystercatcher, purple sandpiper (*Calidris maritima*), redshank, ringed plover, turnstone, whimbrel (*Numenius phaeopus*)) and gulls/petrols (seven species; black-headed gull, common gull, fulmar, glaucous gull (*Larus hyperboreus*), great black-backed gull, herring gull, lesser black-backed gull). Wildfowl accounted for 19% of all bird records, while waders accounted for 34% and gulls accounted for 42%.

4.2.7 For 45 species, some type of conservation classification had been applied to them; 40 were on the JNCC Amber list whilst five species was on the Red list (common scoter, dunlin, herring gull, lapwing, scaup and whimbrel) and seven species were listed as either a national or local BAP species (Edinburgh BAP 2008; Fife BAP, 2008; UK BAP, 2008) (Table 4.2). Eight species were on Birds Directive Annex 1 (black-throated diver (*Gavia arctica*), great northern diver (*Gavia immer*), Greenland white-fronted goose (*Anser a. flavirostris*), kingfisher (*Alcedo atthis*), peregrine, red-throated diver, Slavonian grebe, whooper swan (*Cygnus cygnus*)) and 11 were on WCA Schedule 1 (black-throated diver, common scoter, great northern diver, peregrine, purple sandpiper, red-throated diver, scaup, Slavonian grebe, velvet scoter, whimbrel, whooper swan.

Table 4.2: Conservation status of bird species recorded in the northern bird counts sectors.

Bird Species	Status
Bar-tailed godwit	JNCC Amber
Taiga bean goose	JNCC Amber
Black-headed gull	JNCC Amber
Black-throated diver	JNCC Amber
Brent goose (*Branta bernicla*)	JNCC Amber

Bird Species	Status
Common gull	JNCC Amber
Common scoter	JNCC Red; UK BAP
Cormorant	JNCC Amber
Curlew	JNCC Amber
Dunlin	JNCC Red
Eider	JNCC Amber
Fulmar	JNCC Amber
Gadwall (*Anas strepera*)	JNCC Amber
Glaucous gull	JNCC Amber
Goldeneye	JNCC Amber
Golden plover	JNCC Amber
Great black-backed gull	JNCC Amber
Great crested grebe	Edinburgh Local BAP
Great northern diver	JNCC Amber
Greylag goose	JNCC Amber
Guillemot	JNCC Amber
Herring gull	JNCC Red; UK BAP
Kingfisher	JNCC Amber; Edinburgh Local BAP; Fife Local BAP
Knot	JNCC Amber
Lapwing	JNCC Red; UK BAP; Edinburgh Local BAP; Fife Local BAP
Lesser black-backed gull	JNCC Amber
Long-tailed duck	JNCC Amber
Mute swan	JNCC Amber
Oystercatcher	JNCC Amber
Peregrine	JNCC Amber
Pink-footed goose	JNCC Amber
Purple sandpiper	JNCC Amber
Razorbill	JNCC Amber
Redshank	JNCC Amber; Fife Local BAP
Red-throated diver	JNCC Amber
Ringed plover	JNCC Amber
Scaup	JNCC Red; UK BAP
Shag	JNCC Amber
Shelduck	JNCC Amber
Shoveler (*Anas clypeata*)	JNCC Amber
Slavonian grebe	JNCC Amber
Teal	JNCC Amber
Turnstone	JNCC Amber
Velvet scoter	JNCC Amber
Whimbrel	JNCC Red
Whooper swan	JNCC Amber
Wigeon	JNCC Amber

4.2.8 The maximum number of species recorded in the northern sectors was 34 (sector N1 in October) whilst the lowest recorded was zero (sector N2 in September-October). The average was 16.9 species across all nine sectors; the lowest average was sector N2 (6.0) whilst the highest was from

sector N7 (24.3). Generally, more species were recorded in October-January (19.2-17.9) with most recorded in October, whilst the least number of species recorded was in September (11.9).

4.2.9 Across all sectors and months, an average of 275 birds was recorded. However, this varied between 88-430, with most birds originating from sector N1 (430) and less from sector N2 (88). There was also variation between months with the least number of birds recorded in September (156) and most in October (367). Numbers were generally greatest in the October-February period.

Southern Bird Count Sectors

4.2.10 Within the six southern bird count sectors (S1-S9), 48 bird species were recorded including the amalgam 'gulls'. A total of 18 wildfowl species were recorded and 13 species of wader. As well as the 'gulls' amalgam, six species of gull were recorded (black-headed gull, common gull, fulmar, great black-backed gull, herring gull, lesser black-backed gull). There were also two species of auk (guillemot, razorbill), three species of cormorant and heron (cormorant, grey heron, shag), two species of swan (mute swan, whooper swan), a raptor (peregrine) and two other species (kingfisher and raven (*Corvus corax*) recorded. The total numbers of birds recorded showed that 57% were waders, 29% were gulls and 12% were wildfowl.

4.2.11 The 18 wildfowl species recorded were Canada goose (*Branta canadensis*), common scoter, coot (*Fulica atra*), eider, goldeneye, great crested grebe, greylag goose, little grebe (*Tachybaptus ruficollis*), mallard, pink-footed goose, pochard (*Aythya ferina*), red-breasted merganser, red-throated diver, shelduck, Slavonian grebe, teal, tufted duck and wigeon. The 13 wader species recorded were bar-tailed godwit, black-tailed godwit (*Limosa limosa*), curlew, dunlin, greenshank (*Tringa nebularia*), grey plover, knot, lapwing, oystercatcher, redshank, ringed plover, turnstone and whimbrel.

4.2.12 Eight of the 47 species recorded (not including the gulls amalgam) had no conservation classification; 34 were JNCC Amber species and six species were on the Red list (dunlin, herring gull, lapwing, whimbrel, black-tailed godwit, common scoter). Five of these species were listed as either a national or local BAP species and one species was a local BAP species only (Edinburgh BAP 2008; Fife BAP, 2008; UK BAP, 2008) (Table 4.3). Five species were Birds Directive Annex 1 species (kingfisher, peregrine, red-throated diver, Slavonian grebe, whooper swan) and eight species were on the WCA Schedule 1 (black-tailed godwit, common scoter, greenshank, peregrine, red-throated diver, Slavonian grebe, whimbrel, whooper swan).

Table 4.3: Conservation status of bird species recorded in the southern bird count sectors

Bird Species	Status
Bar-tailed godwit	JNCC Amber
Black-headed gull	JNCC Amber
Black-tailed godwit	JNCC Red; UK BAP
Taiga bean goose	JNCC Amber
Common gull	JNCC Amber
Common scoter	JNCC Red; UK BAP
Cormorant	JNCC Amber
Curlew	JNCC Amber
Dunlin	JNCC Red
Eider	JNCC Amber
Fulmar	JNCC Amber
Goldeneye	JNCC Amber
Great black-backed gull	JNCC Amber
Great crested grebe	Edinburgh Local BAP
Grey plover	JNCC Amber
Greylag goose	JNCC Amber

Bird Species	Status
Guillemot	JNCC Amber
Herring gull	JNCC Red; BAP
Knot	JNCC Amber
Lapwing	JNCC Red; UK BAP; Edinburgh Local BAP; Fife Local BAP
Lesser black-backed gull	JNCC Amber
Little grebe	JNCC Amber
Mallard	JNCC Amber
Mute swan	JNCC Amber
Oystercatcher	JNCC Amber
Peregrine	JNCC Amber
Pink-footed goose	JNCC Amber
Pochard	JNCC Amber
Razorbill	JNCC Amber
Redshank	JNCC Amber; Fife Local BAP
Red-throated diver	JNCC Amber
Ringed plover	JNCC Amber
Shag	JNCC Amber
Shelduck	JNCC Amber
Slavonian grebe	JNCC Amber
Teal	JNCC Amber
Tufted duck	JNCC Amber
Turnstone	JNCC Amber
Whimbrel	JNCC Red
Whooper swan	JNCC Amber
Wigeon	JNCC Amber

4.2.13 In the southern sectors, an average of 17.7 species was recorded across all sectors and months, with a range of 15.8-21.0. Lowest average numbers were from sector S4 and highest numbers from sector S3. The maximum number of species recorded was in sector S3 in October (31) whilst the lowest number was recorded in sector S1 in September (4). Generally, more species were recorded in October-January (19.0-23.8) and least were recorded in April (11.2).

4.2.14 An average of 561 birds was recorded across all six sectors and surveys, with a range of 244-999. The highest average was from sector S3, whilst the lowest was in sectors S4 and S5. Only 37 birds were recorded in sector S1 in April whilst 2458 birds were recorded in sector S4 in January. More birds were seen in January and February (785-896) than in the other months and least were recorded in April (231).

4.2.15 Table 4.4, Table 4.5 and Table 4.6 present the results of the coastal bird surveys for the core, northern and southern sectors respectively (full species lists are presented at the end of this appendix). Bird count sectors are presented in Figure 11.6.

Table 4.4: Coastal Birds - Survey Results - Core Bird Count Sectors

Core Sectors	Total Number of Birds/Species	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
C1	Total no. of birds	59	118	38	48	243	591	20	141
	Number of species	10	15	10	14	12	9	8	9
C2	Total no. of birds	38	102	53	129	59	152	192	134
	Number of species	8	11	11	15	12	13	8	12
C3	Total no. of birds	77	126	120	66	486	499	599	568
	Number of species	10	16	11	12	17	12	9	13

Table 4.5: Coastal Birds - Survey Results -Northern Bird Count Sectors

North Sectors	Total Number of Birds/Species	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
N1	Total no. of birds	99	981	557	703	420	521	283	279
N1	Number of species	8	34	25	25	20	20	22	18
N2	Total no. of birds	0	0	229	93	56	47	144	138
N2	Number of species	0	0	11	9	9	3	9	7
N3	Total no. of birds	56	83	79	151	123	65	131	180
N3	Number of species	13	14	12	12	12	11	12	12
N4	Total no. of birds	128	97	117	100	263	98	77	122
N4	Number of species	14	11	15	15	15	12	6	11
N5	Total no. of birds	225	235	287	221	336	243	206	233
N5	Number of species	17	19	20	20	20	21	18	17
N6	Total no. of birds	128	206	183	66	267	331	138	333
N6	Number of species	16	25	25	17	24	23	21	25
N7	Total no. of birds	709	839	791	745	928	1004	704	299
N7	Number of species	23	28	26	25	26	26	19	21
N8	Total no. of birds	20	574	468	228	108	113	92	66
N8	Number of species	5	21	14	19	23	15	10	13
N9	Total no. of birds	41	286	199	263	281	355	331	332
N9	Number of species	11	21	17	19	21	21	24	21

Table 4.6: Coastal Birds - Survey Results - Southern Bird Count Sectors

South Sectors	Species	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
S1	Total no. of birds	37	932	767	882	1247	1058	606	217
S1	Number of species	4	23	21	18	27	17	14	10
S2	Total no. of birds	633	1013	421	557	621	502	215	434
S2	Number of species	21	27	21	20	21	16	12	11
S3	Total no. of birds	699	821	983	679	2458	1449	598	305
S3	Number of species	21	31	24	20	22	21	15	14
S4	Total no. of birds	374	261	176	215	308	229	244	148
S4	Number of species	16	20	16	16	18	16	13	11
S5	Total no. of birds	139	241	202	121	345	644	127	133
S5	Number of species	13	19	17	22	20	17	16	11

South Sectors	Species	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
S6	Total no. of birds	382	848	1016	587	399	830	679	146
S6	Number of species	19	23	15	18	17	14	19	10

Breeding Terns

Common Terns

4.2.16 Two common tern (a Birds Directive Annex 1 and JNCC Amber List species) breeding colonies were recorded within the study area; Long Craig Island and an artificial tern breeding raft at West Breakwater, Port Edgar.

4.2.17 It is estimated that approximately 139 pairs of common terns nesting on Long Craig Island during the 2007 breeding season which is 30% more than the number of terns recorded nesting in 2008 (90-100 pairs) (Mr Mark Oksien, August 2008, pers. comm., Colin Nisbet, Jacobs Arup).

4.2.18 Neither the cable tower piers of the Forth Road Bridge nor Beamer Rock, which is completely inundated during the twice monthly spring tide events, were used as a nesting area for terns.

4.2.19 The results of the 2007 survey work suggest that there may be a common tern colony near Rosyth Royal Dock, although this was not confirmed.

4.2.20 A peak count of approximately 180 flying adult common terns was recorded during the peak egg-laying period at the common tern breeding colony at Long Craig Island during a single daytime 'dread' flight event.

Roseate Terns

4.2.21 Two pairs of roseate terns (a Birds Directive Annex 1 species and JNCC Red List species) were recorded displaying within the study during the early and late parts of the 2007 breeding season. A pair of roseate terns with fledged young was observed within the study area at the end of the 2007 breeding season.

4.2.22 In 2008, two apparently incubating female roseate terns were recorded within the study area on 4 June. Two abandoned eggs were found in these nest sites on 13 August, suggesting both nests were abandoned before egg-laying was complete. A single roseate chick was recorded on 13 August 2008 suggesting that one pair had re-laid (Mr Mark Oksien, July 2008, pers. comm., Colin Nisbet, Jacobs Arup).

4.2.23 A report was received of a pair of roseate terns breeding outside the study area (Mr Iain Bray, SNH, 2008, pers. comm., Dr Helen Riley, Jacobs Arup).

Other Tern Species

4.2.24 No evidence of any other nesting tern species was recorded throughout the study area.

4.2.25 Post breeding aggregations of adult and juvenile Sandwich terns (a Birds Directive Annex 1 and JNCC Amber List species) from nests out with the study area (such as the Isle of May) used Long Craig Island as a nursery, loafing or roosting area.

Passage Migrants

4.2.26 Table 4.7 presents the results of the passage migrant flight activity surveys for the each of the three vantage points. The locations of the vantage points are illustrated on Figure 11.6.

4.2.27 In total, ten species of passage migrant where recorded; eight from VP1, six from VP2 and five from VP3. Three species (Arctic skua (*Stercorarius parasiticus*), gannet and kittiwake) were observed from all three vantage points – four species were seen from only one.

4.2.28 More individual birds were also recorded from VP1 than the other two vantage points and overall more birds were recorded in August and September than any other month. The least number of birds recorded was in April. Kittiwake and gannet were the most frequently observed species (594 and 358 respectively) across all surveys and vantage points. One species, Manx shearwater (*Puffinus puffinus*), was recorded only once.

4.2.29 Passage migrants were additionally recorded during the sector counts. Flocks of gannet were recorded during two main periods (September to November 2007 and March and April 2008). Throughout this period, numbers ranged from individual birds to a flock of 237 birds recorded in Section N9 (September 2007).

4.2.30 Arctic, great, long-tailed and pomarine skuas were additionally recorded during the sector counts. Arctic skua were recorded throughout most of the study area in September and October 2007 where numbers ranged from single birds to a flock of five birds recorded in Section N6 (October 2007). Similarly, large numbers of pomarine skua were recorded from September – December 2007. The largest number of birds was recorded in Sector C2 in October 2007. As with arctic skua, pomarine skua was recorded throughout much of the study area including Sectors N5-N7, N9, and S2, S3 and S5). In comparison, small numbers of great skua (two recorded in September 2007 and one bird recorded in October 2007) and long-tailed skua (two single birds were recorded in September and October 2007) were recorded throughout a smaller area comprising Sectors N6 and C1-2.

4.2.31 Arctic skua is a JNCC Red list species while gannet, great skua, arctic tern, kittiwake, little gull and manx shearwater are JNCC Amber List species.

Table 4.7: Results from passage migrant flight activity surveys

Species	August 2007	September 2007	October 2007	November 2007	March 2008	April 2008
Vantage Point #1 – Carlingnose Point						
Arctic skua	4	7	-	2	-	-
Arctic tern (*Sterna paradisaea*)	-	2	-	-	-	-
Gannet	15	148	-	11	-	-
Great skua (*Stercorarius skau*)	1	10	-	-	-	-
Kittiwake	-	200	-	62	-	21
Little gull (*Larus minutus*)	-	-	-	3	-	-
Pomarine skua (*Stercorarius pomarinus*)	-	3	-	19	-	-
Sabine's gull (*Larus sabini*)	-	1	-	-	-	-
Total no. of birds	**20**	**371**	**0**	**97**	**0**	**21**
Number of species	**3**	**7**	**0**	**5**	**0**	**1**
Vantage Point #2 – Hound Point						
Arctic skua	2	1	-	-	-	-
Gannet	-	130	19	-	-	-
Kittiwake	220	10	-	-	-	-
Long-tailed skua (*Stercorarius longicaudus*)	-	60	-	-	-	-
Pomarine skua	-	1	1	-	-	-
Sabine's gull	-	1	-	-	-	-
Total no. of birds	**222**	**203**	**20**	**0**	**0**	**0**
Number of species	**2**	**6**	**2**	**0**	**0**	**0**
Vantage point #3 – Port Edgar Harbour (West Breakwater)						
Arctic skua	1	6	-	-	-	-
Arctic tern	-	1	-	-	-	-
Gannet	-	35	-	-	-	-
Kittiwake	-	10	-	-	71	-
Manx shearwater	-	1	-	-	-	-
Total no. of birds	**1**	**53**	**0**	**0**	**71**	**0**
Number of species	**1**	**5**	**0**	**0**	**1**	**0**

Table 4.8: Estuarine bird species list

English Name	Latin Name
Arctic skua	*Stercorarius parasiticus*
Arctic tern	*Sterna paradisaea*
Bar-tailed godwit	*Limosa lapponica*
Black-headed gull	*Larus ridibundus*
Black-tailed godwit	*Limosa limosa*
Black-throated diver	*Gavia arctica*
Brent goose	*Branta bernicla*
Canada goose	*Branta canadensis*
Common gull	*Larus canus*
Common scoter	*Melanitta nigra*
Common tern	*Sterna hirundo*
Coot	*Fulica atra*
Cormorant	*Phalacrocorax carbo*
Curlew	*Numenius arquata*
Dunlin	*Calidris alpina*
Eider	*Somateria mollissima*
Fulmar	*Fulmarus glacialis*
Gadwall	*Anas strepera*
Gannet	*Morus bassanus*
Glaucous gull	*Larus hyperboreus*
Golden plover	*Pluvialis apricaria*
Goldeneye	*Bucephala clanga*
Great black-backed gull	*Larus marinus*
Great crested grebe	*Cristatus Podiceps*
Great northern diver	*Gavia immer*
Great skua	*Stercorarius skua*
Greenland white-fronted goose	*Anser a. flavirostris*
Greenshank	*Tringa nebularia*
Grey heron	*Ardea cinerea*
Grey plover	*Pluvialis squatarola*
Greylag goose	*Anser anser*
Guillemot	*Uria aalgae*
Herring gull	*Larus argentatus*
Kingfisher	*Alcedo atthis*
Kittiwake	*Rissa tridactyla*
Knot	*Calidris canutus*
Lapwing	*Vanellus vanellus*
Lesser black-backed gull	*Larus fuscus*
Little grebe	*Tachbaptus ruficollis*
Little gull	*Larus minutus*
Long-tailed duck	*Clangula hyemalis*
Long-tailed skua	*Stercorarius longicaudus*
Mallard	*Anas platyrhynchos*
Manx shearwater	*Puffinus puffinus*
Mute swan	*Cygnus olor*
Oystercatcher	*Haematopus ostralegus*

English Name	Latin Name
Peregrine	*Falco peregrinus*
Pink-footed goose	*Anser brachyrhynchus*
Pochard	*Aythya ferina*
Pomarine skua	*Stercorarius pomarinus*
Puffin	*Fratercula arctica*
Purple sandpiper	*Calidris maritima*
Raven	*Corvus corax*
Razorbill	*Alca torda*
Red-breasted merganser	*Mergus serrator*
Redshank	*Tringa totanus*
Red-throated diver	*Gavia stellata*
Ringed plover	*Charadrius hiaticula*
Roseate tern	*Sterna dougallii*
Sabine's gull	*Larus sabini*
Sandwich tern	*Sterna sandvicensis*
Scaup	*Aythya marila*
Shag	*Phalacrocorax aristotelis*
Shelduck	*Tadorna tadorna*
Shoveler	*Anas clypeata*
Slavonian grebe	*Podiceps auritus*
Taiga bean goose	*Anser fabalis fabalis*
Teal	*Anas crecca*
Tufted duck	*Aythya fuligula*
Turnstone	*Arenaria interpres*
Velvet scooter	*Melanitta fusca*
Whimbrel	*Numenius phaeopus*
Whooper swan	*Cygnus cygnus*
Wigeon	*Anus penelope*

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