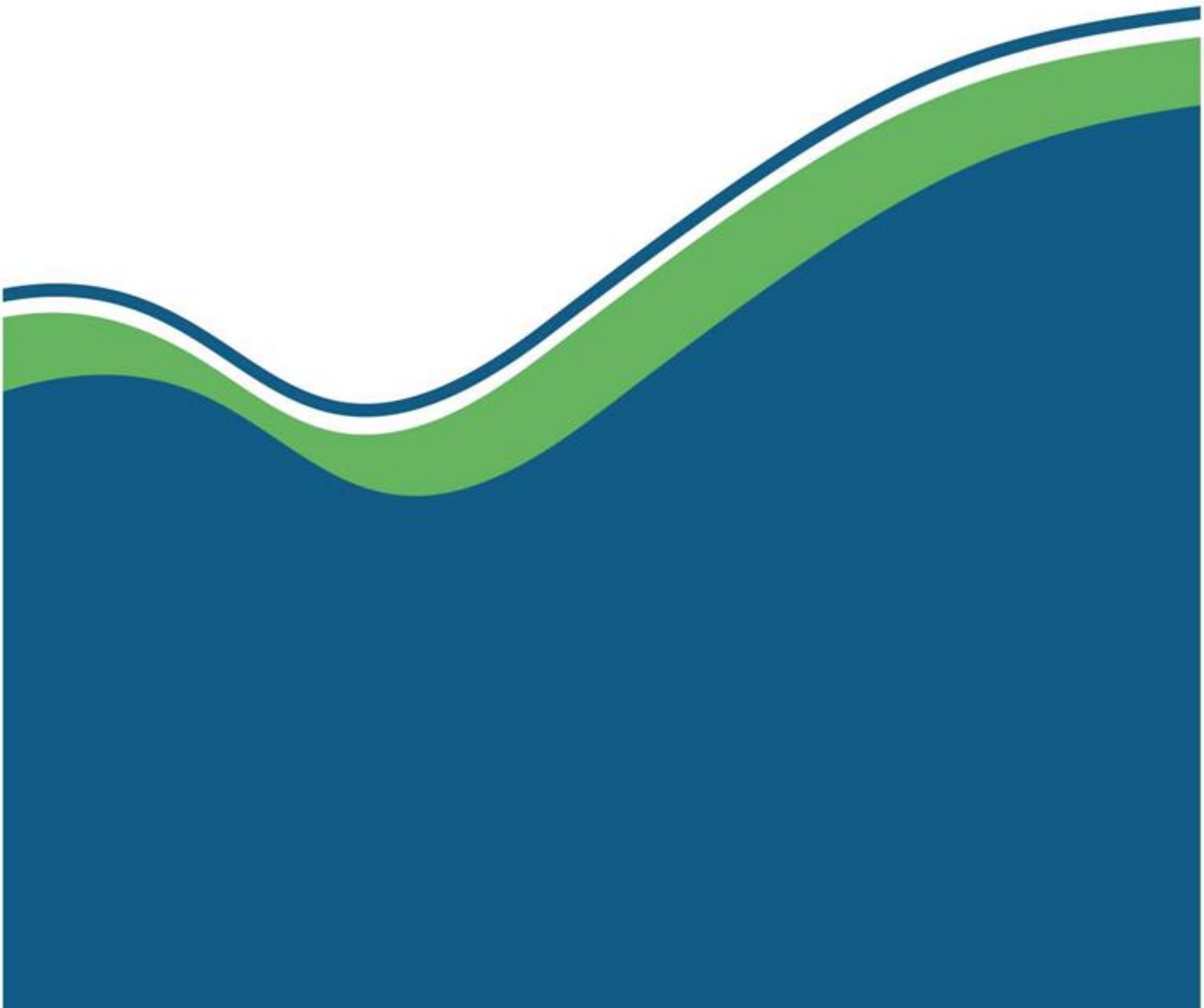
SEPA
Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

Radiological Habits Survey: Torness 2016



Radiological Habits Survey: Torness 2016

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Contents

List of abbreviations and definitions

AGRs	Advanced Gas-Cooled Reactors
ALB	All-weather Lifeboat
BSS	Basic Safety Standards
CEFAS	Centre for Environment, Fisheries and Aquaculture
COS	Carbon Oxide Sulphide
DCC	Dose conversion coefficient
DORIS	Dispersion of Radionuclides into the Sea
EFW	Energy from Waste
ERL	Environmental Radioactivity Laboratory, University of Stirling
GPS	Global positioning system
GRANIS	Gamma Radiation above Nuclides in Soil
HSE	Health and Safety Executive
ICRP	International Commission on Radiological Protection
ILB	In-shore lifeboat
LOD	Limit of Detection
MoGSS	Mobile Gamma Spectrometry System
NA	Not Applicable
NC	Not Consumed
ND	Not Determinable
NDAWG	National Dose Assessment Working Group
NI	Not Identified
ONR	Office of Nuclear Regulation
PC-CREAM	Consequences of Releases to the Environment: Assessment. Methodology
RESUS	The Re-suspension Model
RIB	Rigid Inflatable Boats
RIFE	Radioactivity in Food and the Environment
RNLI	Royal National Lifeboat Institute
RSA	Radioactive Substances Act 1993
RSPB	Royal Society for Protection of Birds
SEPA	Scottish Environment Protection Agency
UKAS	United Kingdom Accreditation Service

Units

Bq - Becquerel
Gy - gray
Sv – Sievert
kg - kilogram
g - gram
l - litre
m - metre
eV – electron-volt
y - year
h - hour
k - kilo
M – mega (one million; E6)
m – milli (one thousandth; E-3)
µ – micro (one millionth; E-6)
per - $^{-1}$

Summary

This report presents the results of the 2016 radiological habits survey to determine the habits, occupancy and consumption patterns of people living and undertaking recreational activities in the vicinity of the Torness Power Station nuclear licensed site. The site is authorised to discharge both liquid effluent, directly into the North Sea via the outfall pipeline, and gaseous waste to the atmosphere from a series of stacks. Sources of direct radiation are also present at this site.

The survey targeted three areas that were determined to be affected by discharges from the site, defined as;

- An aquatic survey area; which covered the 20 km radial distance from the Torness site stretching from North Berwick to Eyemouth, extending 3 km offshore.
- A terrestrial survey area; 5 km zone around Torness.
- The direct radiation survey area; extending 1 km from the site which relates to ionising radiation emanating directly from the site.

Interviews with members of the public were carried out over a period of 14 days and was conducted between 16th – 22nd May and 11th – 15th August between 6am and 9pm at terrestrial and coastal sites. A total of 375 individuals were surveyed and their results are presented and discussed. Those high-rate individuals are identified using established methods comprising a ‘cut-off’ to define the high-rate group and 97.5th percentiles for dose assessment analysis. The face-to face surveys were followed up in the November of 2016 as a means of validation and are discussed within the report. The two survey periods are referred to as Phase 1 (14 day interview period in May and August) and Phase 2 (validating surveys undertaken in November 2016).

The aquatic survey area

Fish, crustaceans, molluscs and wildfowl are all consumed by adults within the survey area. The mean consumption rates for adult high-rate groups for each of these food groups were:

- 101 kg y^{-1} for fish (bass, cod, kipper, mackerel, pollock, salmon, dogfish, haddock and plaice)
- 28.8 kg y^{-1} for crustaceans (brown crab, common lobster, squat lobster, prawns and velvet crab)
- 34.7 kg y^{-1} for molluscs (mussels, winkles and razor clams)
- 116 kg y^{-1} for wildfowl (mallard, pink-footed goose, teal, wigeon and greylag goose)

Children were found to consume fish, crustaceans and wildfowl. The mean consumption rates for the high-rate group for each of these food groups were:

- 12. 5 kg y^{-1} for fish (bass, cod, mackerel and pollock)
- 1.5 kg y^{-1} for crustaceans (brown crab)
- 116 kg y^{-1} for wildfowl (mallard, pink-footed goose, teal and wigeon)

Infants were found only to consume fish and crustaceans. The mean consumption rates for the high-rate group for each of these food groups were:

- 31.2 kg y^{-1} (cod, mackerel, pollock, salmon and haddock)
- 2 kg y^{-1} (common lobster)

Seven individuals reported collecting seaweed from Thorntonloch, Torness outflow, Dunbar harbour, Dunbar east beach and Skateraw for use as a fertiliser on their gardens (for vegetables). Two individuals reported consuming seaweed which was collected from Thorntonloch Beach.

The mean occupancy rates for the adult high-rate group for within the aquatic survey area were:

- 1 047 h y^{-1} for intertidal activities
- 1 372 h y^{-1} for activities in the water
- 4 547 h y^{-1} for activities on the water
- 3 945 h y^{-1} for handling of equipment
- 1 061 h y^{-1} for handling of sediment

The terrestrial survey area

The mean consumption rates for the high-rate groups for terrestrial foods were:

- 24.1 kg y^{-1} for green vegetables
- 5.08 kg y^{-1} for other vegetables
- 23.5 kg y^{-1} for root vegetables
- 84 kg y^{-1} for potatoes
- 72.9 kg y^{-1} for domestic fruit
- 93.2 kg y^{-1} for wild fruit
- 4 kg y^{-1} for wild fungi
- 47 kg y^{-1} for beef
- 50.6 kg y^{-1} for game (all game)
- 4.50 kg y^{-1} for sheep
- 9 kg y^{-1} for poultry
- 14.8 kg y^{-1} for eggs
- 4.50 kg y^{-1} for honey

The direct radiation survey area

The highest occupancy rates in the direct radiation area were as follows (holidays taken into account):

- 8 395 h y^{-1} for the total occupancy rate (for a resident)
- 6 935 h y^{-1} for the indoor occupancy rate (for a resident)
- 3 370 h y^{-1} for the outdoor occupancy rate (for a resident)

A significant portion of the direct radiation survey area was surveyed by car-borne gamma spectrometry.

Suggestions for changes to the monitoring programme

The following suggestions for changes to the current environmental monitoring programme are provided for consideration;

(i) The sampling of milk could be removed,

(ii) Consideration should be given to sampling mussels and an additional sampling site for lobster,

(iii) It is suggested that apples be sampled annually,

(iv) Consideration should be given to sampling elderflower and elderberry,

(v) Consideration should be given to sampling sloe berries, and

(vi) It should be considered that marine waste from Torness be sampled annually.

1. Introduction

1.1 Regulatory Context

Torness nuclear power station is powered by two Advanced Gas-Cooled Reactors (AGRs) and is owned and operated by EDF Energy Generation. The site holds an authorisation under the Radioactive Substances Act 1993 (RSA '93) for the disposal of radioactive wastes. The impact of these wastes is monitored under the requirements of Article 35 of the Basic Safety Standards (BSS) 96/29 Euratom to ensure that the doses to the representative person (see Section 1.2) are below both 1 mSv committed effective and the 50 mSv skin annual dose limits. The power station had an original estimated end of power generation date of 2023, but at the time of writing the decision was made to extend the operational power generation to 2030.

The site discharges radioactivity into the environment which may result in the exposure of the public by three primary sources of potential exposure to the public:

(i) discharges to the aquatic environment;
(ii) discharges to the atmosphere; and
(iii) direct exposure from the site.

From these sources, members of the public may be exposed directly to radiation shine from the licensed site or through inhalation, and/or indirectly due to exposure to contaminated materials and primarily foodstuffs (Smith and Jones, 2003). It is also recognised that enhanced doses from external exposure due to regulated discharges and the consumption of locally sourced foods may occur as a result of contemporary and historical discharges being concentrated through natural processes leading to environments with elevated concentrations of anthropogenic and technologically enhanced radioactivity (Dale *et al.,* 2008; Tyler *et al*., 2013; Tyler *et al*., 2009; Tyler *et al.,* 2006). It is the responsibility of the Scottish Environment Protection Agency (SEPA) to regulate the discharges from the site to ensure that the public are not exposed to doses in excess of legal limits. Exposure to direct shine from nuclear, radiation or waste facilities is the responsibility of the Office of Nuclear Regulation (ONR).

1.2 Definition of the Representative Person

The optimal approach for assessing doses to the public is through a combination of site-specific habit data and an environmental monitoring programme to determine ambient dose rates and concentrations in foodstuffs. In addition to the various interactions an individual may have with exposure routes the actual doses received are also dependent upon age, size and metabolism. Thus, the standard approach is to identify and consider these sources of variability in appropriate groups. The concept of the *representative person* was introduced by the International Commission of Radiological Protection (ICRP) (2006) and recommended in 2007 to replace the previously used concept of the *critical group* (ICRP, 2007). The *representative person* is the individual that represents the more highly exposed members of the public and is typically defined by a cut-off, for example the top 97.5 % of the dose distribution within one or more routes of exposure. Within this concept, if the dose received by the *representative person(s)* can be demonstrated to be within the accepted dose limits and constraints, then the general public are also considered to be protected.

1.3 Dose Limits and Constraints

The system of dose limitation recommended by ICRP, 2007 and subsequently by the Radioactive Substances Basic Safety Standards (BSS) requires that dose equivalents received by individuals shall not exceed the limits set out in Article 13 of Council Directive 96/29/Euratom (CEC, 1996).

The *retrospective* maximum permissible dose limits are set out as 1 mSv y^{-1}. For *prospective* assessments, the maximum permissible doses or constraints used by the Scottish Environment Protection Agency (SEPA) are:

(i) 0.3 mSv y^{-1} for any single source of radioactivity; and

(ii) 0.5 mSv y^{-1} for a single site from which radioactive discharges are made.

It is also accepted by the UK Government that it should be possible to operate existing nuclear facilities without exceeding the 0.3 mSv y^{-1} constraint (Hunt *et al.,* 1982; Leonard *et al.,* 1982; Sherlock *et al.,* 2006). It is therefore incumbent upon SEPA to

ensure that these dose limits/constraints are not exceeded for all authorised discharges of ionising radiation to the environment.

1.4 Habits Survey Aim

The aim of the habits survey is to collect site specific data to allow a bespoke assessment to be made which identifies the representative individual(s). The identification of the representative person is a result of known information on the consumption of local foods and occupancy times in combination with data from SEPA's routine environmental monitoring programme. The survey aims to collect data on the consumption rates of locally grown foods, occupancy times and activities in different areas. The survey should also identify any habits that the routine programme does not currently adequately cover and may recommend the adoption of new monitoring due to new or changing habits or the removal of monitoring that is no longer required. The survey does this by:

(i) Collecting data on a range of habits/activities by the public in the environment immediately surrounding the nuclear site and surrounding areas that might lead to exposure to radioactivity or radiation from any combination of licensed liquid or gaseous discharges, or direct radiation from on-site activities at Torness;

(ii) Collecting information on consumption of food grown or produced (including wild and free foods and any novel pathway) in the survey area and determining an annual rate of consumption for each individual surveyed and household members of all ages; and

(iii) Quantifying the amounts of radioactivity, radiation and subsequent doses to individual members of the public as a result of the disposals or operations of the nuclear site.

This report presents the findings for the 2016 habits survey of the Torness nuclear power station situated on the Berwickshire coast in the east of Scotland. All raw data is presented in Appendix A1. The previous survey was undertaken during the period 29th June to the 13th July 2011 (Clyne *et al*., 2013).

2. The Survey

2.1 Introduction

This chapter describes the site characteristics including recent and prospective site activities, a dose assessment from licensed discharges to air and sea and the surrounding land cover characteristics. In preparation for the survey, a visit to the site and meeting with the site operators was held in March 2016. A stakeholder meeting in early April 2016 was also attended which helped to raise the profile of the planned postal survey, face-to-face surveys and focus groups within the local community.

2.2 Site Activity

2.2.1 Onsite activity

The Torness Nuclear Power Station was commissioned in 1988 by the South of Scotland Electricity Board and is now operated by EDF Energy. The power station is situated some 50 km east of Edinburgh on the Berwickshire coastline. Torness is powered by two Advanced Gas Cooled Reactors (AGRs) that generate approximately 1200 MW of electricity at full capacity. The operational lifetime of the site was recently extended from 2023 to 2030. Around 700 people work on the site but this number almost doubles to 1 200 people during periods of reactor outage (a planned reactor shut down), which typically occurs every 18 months.

The site discharges both liquid effluent, directly into the North Sea via the outfall pipeline, and gaseous waste to the atmosphere from a series of seven stacks under authorisation from the Scottish Environment Protection Agency (SEPA). The site also contains sources of direct radiation. The cooling water intake is filtered and the resultant marine material including seaweed and jellyfish is sent to local contractors. This material is composted and sold locally.

Since the previous habits survey, a new process of Carbon Oxide Sulphide (COS) injection has been introduced to the reactor operation, to prevent carbon build-up on metal surfaces. This has resulted in a four-fold increase in the liquid and atmospheric discharge of ^{35}S.

In May 2013, the Torness visitor centre reopened and had attracted 10 077 visitors by the end of 2015 including 4 309 visitors in 2015 alone.

2.2.2 Offsite changes

A number of new developments have taken place which should attract more visitors to the area. Of note is the extension of the John Muir Way, which opened in April 2014, with the new footpath linking Helensburgh on the west coast with Dunbar on the east coast. Further expansion of the Thurston Manor Holiday Park is underway and a new RSPB reserve has been developed on the site of the old limestone quarry between Torness and Dunbar.

The construction of the new Viridor *Energy from Waste* (EFW) plant has begun and is due for completion in December 2017. The building works may bring an additional 350 workers to the area during the construction phase.

2.3 Estimated Activity Concentrations from Licensed Discharges from Torness Power Station.

Permitted discharges of ^{3}H (7.0E+14 Bq y^{-1}), ^{35}S (3.0E+12 Bq y^{-1}), ^{60}Co (1.0E+10 Bq y^{-1}), alpha (5.0E+8 Bq y^{-1}, assessed as ^{239}Pu), and all other non-alpha (1.5E+11 Bq y^{-1}, assessed as ^{137}Cs) from Torness were used to calculate aquatic activity concentrations in water using the DORIS model within PC-CREAM (Public Health England, 2008). Assuming an effectively continuous release, activity concentrations were modelled in unfiltered seawater, fish, seaweed, crustaceans and molluscs, with outputs at 1, 5, 50, 500, 10 000 and 100 000 000 years. For all element dependent parameters (sediment distribution coefficients, KD and deep water), local compartment details (depth, coastline length, volumetric exchange rate, suspended sediment load, sedimentation rate, sediment density and diffusion rate) and regional model information (volume, depth, suspended sediment load, sedimentation rate, sediment density, diffusion rate) the default values of the Torness area on PC-CREAM were used.

Activity concentration values reported at 50 years for unfiltered seawater in the survey area of Torness were estimated to be:

^{3}H, 8.82E0 Bq l^{-1}

^{35}S, 3.51E-2 Bq l^{-1}

^{60}Co, 1.04E-4 Bq l^{-1}

Alpha, 6.10E-6 Bq l^{-1}

all other non-alpha, 1.88E-3 Bq l^{-1} .

Activity concentrations in different foodstuffs (Table 2.1) were estimated to be:

Table 2.1 Estimated activity concentrations in foodstuffs.

	^{3}H Bq kg^{-1}	**^{35}S Bq kg^{-1}**	**^{60}Co Bq kg^{-1}**	**alpha Bq kg^{-1}**	**all other non-alpha kg^{-1} Bq**
Fish	8.82E0	6.99E-2	3.46E-2	3.05E-4	1.83E-1
Crustaceans	8.82E0	3.51E-2	3.46E-1	6.10E-4	5.48E-2
Molluscs	8.82E0	1.40E-1	1.73E-1	9.15E-3	5.48E-2

Atmospheric activity concentrations were also modelled using the PLUME model in PC-CREAM. The permitted discharges from Torness were modelled and included ^{3}H (1.1E+13 Bq y^{-1}), ^{14}C (4.5E+12 Bq y^{-1}), ^{35}S (3.0E+11 Bq y^{-1}), ^{41}Ar (7.5E+13 Bq y^{-1}), ^{131}I (2.0E+9 Bq y^{-1}), and particulate betas (4.0E+8 Bq y^{-1}, assessed as ^{137}Cs) from Torness. PLUME was set to calculate activity concentrations released for a range of stack heights. The activity concentrations in air for discharges from Torness from the 77 m stack height are reported here over a range of distances from 500 m to 25 km The MET sampling scheme was applied using the default settings. However, the data extracted for the dose rates were based on the MET Pasquill D, with rain category as

being most typical, selected by reviewing the local meteorological data. The calculated activity concentrations in air are presented in Table 2.2.

Table 2.2 Calculated activity concentrations in air (Bq m^{-3}) discharged from a stack height of 77 m.

Distance (m)	^{41}Ar	^{14}C	^{3}H	^{131}I	^{35}S	^{137}Cs
500	4.26E-02	2.57E-03	6.29E-03	1.14E-06	1.71E-04	2.28E-07
1 000	1.89E-01	1.15E-02	2.80E-02	5.03E-06	7.56E-04	1.01E-06
5 000	4.08E-02	2.60E-03	6.37E-03	1.06E-06	1.63E-04	2.18E-07
10 000	1.37E-02	9.30E-04	2.27E-03	3.48E-07	5.48E-05	7.30E-08
15 000	7.02E-03	5.09E-04	1.24E-03	1.76E-07	2.81E-05	3.75E-08
20 000	4.32E-03	3.33E-04	8.14E-04	1.07E-07	1.73E-05	2.31E-08
25 000	2.93E-03	2.41E-04	5.89E-04	7.17E-08	1.18E-05	1.57E-08

The GRANIS (external exposure model) and RESUS (resuspension model) modules in PC-CREAM were to estimate the external dose rates at the same specified distances from the Torness site, using the data presented in Table 2.2. The MET sampling scheme was applied using the default settings. However, the data extracted for the dose rates were based on the MET Pasquill D with rain category as being most typical of the Torness area. Table 2.3 reports the estimated external doses modelled from PC-CREAM for Adults, Children and Infants using ^{137}Cs as the analogue for the “all other nuclides”.

Table 2.3 Modelled Total External Doses (micro Sv) to Adults, Children or Infants at the specified distances from a 77 m stack at Torness using ^{137}Cs as the analogue for particulate betas in the 50th year with an integration time of 50 years.

Distance (m)	Adult	Child	Infant
500	3.38E-01	3.34E-01	3.12E-01
1 000	3.46E-01	3.39E-01	2.95E-01
5 000	6.55E-02	6.40E-02	5.48E-02
10 000	2.48E-02	2.42E-02	2.07E-02
15 000	1.40E-02	1.36E-02	1.16E-02
20 000	9.30E-03	9.07E-03	7.71E-03
25 000	6.78E-03	6.62E-03	5.60E-03

2.4 Survey Areas

The modelling from PC-CREAM (Section 2.3) demonstrates low activity concentrations within the environment of the Torness site given that the prevailing wind direction takes the gaseous waste offshore. The actual doses are likely to be lower than those predicted in Table 2.3. The survey areas for the Torness Habits Survey 2016 are shown in Figure 2.1. Three survey areas were defined, encompassing:

(i) The 1 km zone centred on Torness which relates to ionising radiation emanating direct from the site;

(ii) The aquatic survey area, which covered the 20 km radial distance from the Torness site stretching from North Berwick to Eyemouth, extending 3 km offshore; and

(iii) The terrestrial survey area which focussed on the 5 km zone around Torness.

2.5 Land Cover Data

The land cover is presented in Figure 2.2. Torness is immediately surrounded by arable and horticultural land. Limestone rock exposures between Torness and Dunbar are being quarried. The river and stream corridors are characterised by narrow strips of broad leaved, mixed and yew woodland with increasing pockets of coniferous

woodland occurring inland towards the south west. Further inland, and with increasing elevation, dwarf shrubland becomes increasingly dominant. The land cover characteristics for the 1 km, 5 km, 10 km and 20 km zones surrounding Torness are summarised in Table 2.4.

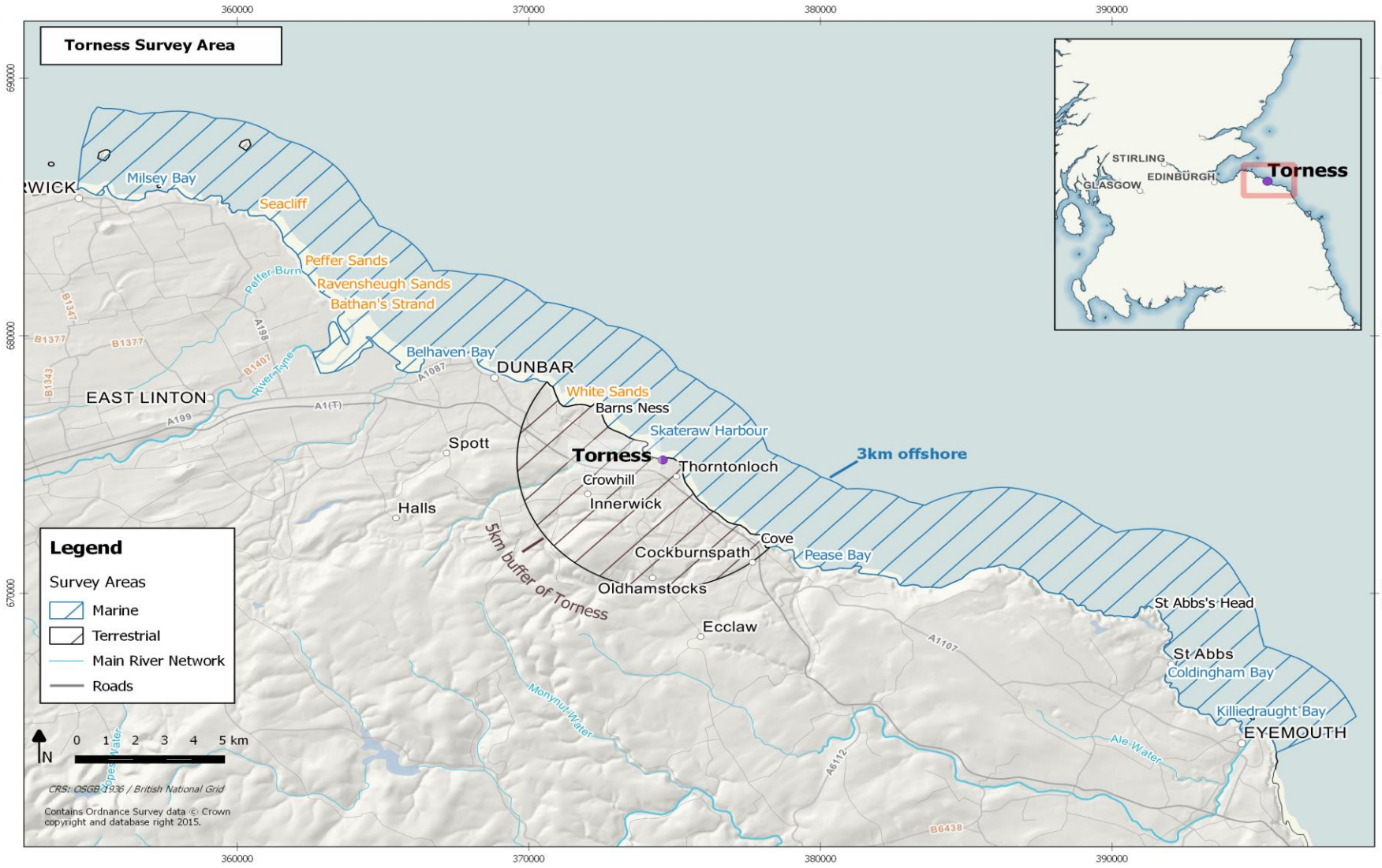

Figure 2.1 Torness aquatic and terrestrial survey areas.

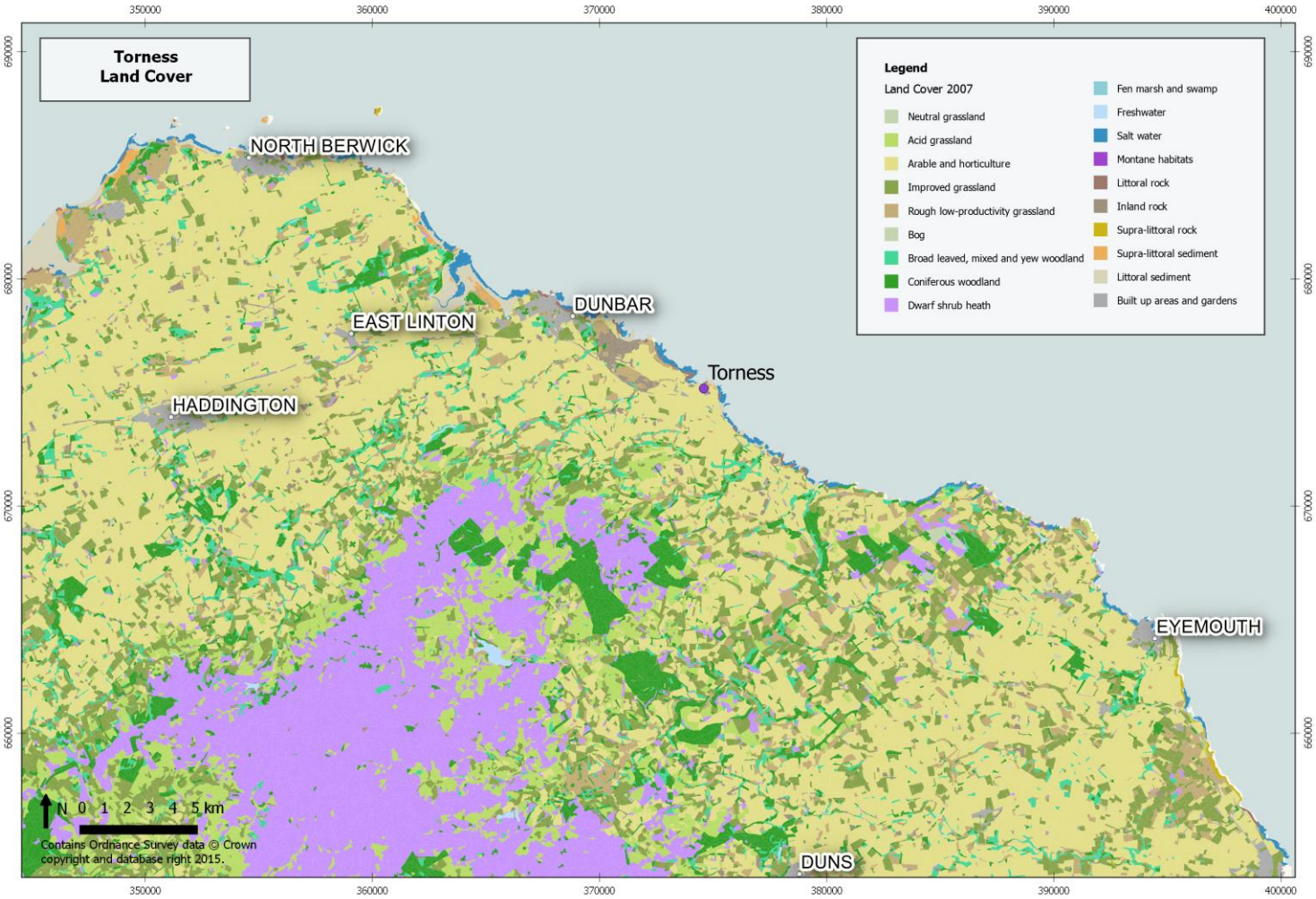

Figure 2.2 The land cover characterising the Torness Habits Survey 2016 (Land Cover Map, 2007).

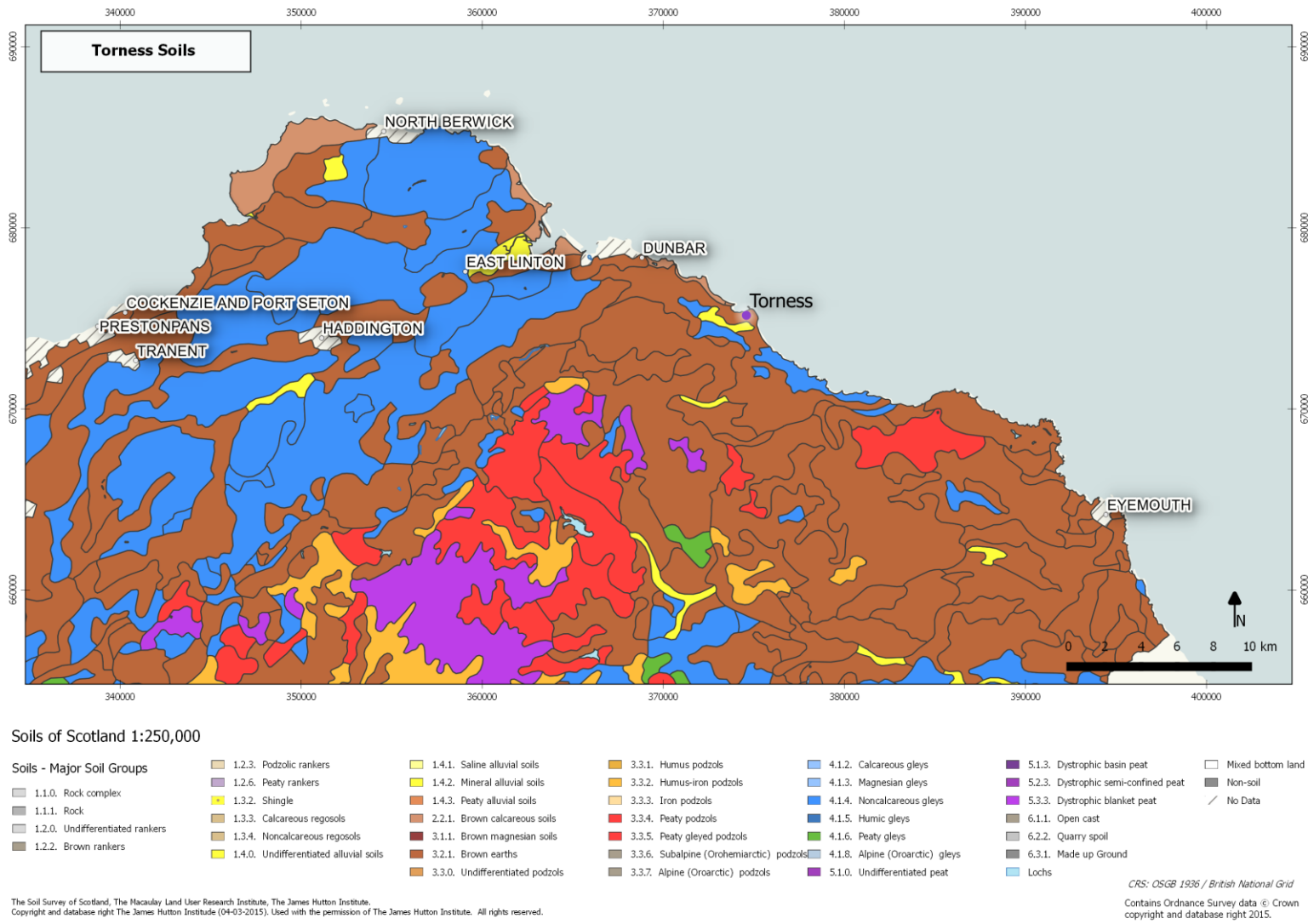

Figure 2.3 Soil types dominating the Torness survey area (The Macauley Institute for Soil Research).

Table 2.4 Quantitative estimates of land cover types with radial distance from Torness at varying distances from the site (1, 5, 10, 20 km).

	1 km	5 km	10 km	20 km
Broad Habitat	**Hectares**	**Hectares**	**Hectares**	**Hectares**
Acid grassland	0	153	1 259	6 268
Arable and horticulture	144	2 316	7 124	27 823
Bog	0	0	0	86
Broad leaved, mixed and yew woodland	0	184	671	2 571
Built up areas and gardens	14	41	281	537
Coniferous woodland	0.6	127	1 311	5 617
Dwarf shrub heath	0	13	1 261	8 608
Freshwater	0	3.0	17	155
Improved grassland	1.0	297	1 888	8 119
Inland rock	3.2	279	399	824
Littoral rock	12	40	76	98
Littoral sediment	17	62	136	473
Neutral grassland	0	0	0	18
Rough low-productivity grassland	0.2	269	825	3 421
Salt water	25	131	234	471
Supra-littoral rock	0	0	0	13
Supra-littoral sediment	3.8	5.3	19	71

2.6 Soil Data

The soil data are presented in Figure 2.3. The coastal sections are characterised by non-calcareous gleys which then transform to brown earths with increasing distance inland and dominate up to 8 km from the site. At this point the soil becomes increasingly organic changing from small areas of humus podzols to undifferentiated peat and peaty podzols with increasing elevation.

2.7 Topographic Wetness Index

Catchment hydrology can be important in the redistribution of radionuclides. For example, organic soils can allow radionuclides (e.g. ^{137}Cs from fallout) to be transported in solution as well as in particulate form. When these hydrological flow paths cross from organic to mineral rich soils, the radionuclides can become bound to clays and oxides within the soil matrices. In extreme conditions, these areas have been shown in the past to result in elevated concentrations of radioactivity (Tyler and Heal, 2000). Building on the soil and 50 m resolution digital elevation model for Scotland using Ordnance Survey Terrain 50 product, (https://www.ordnancesurvey.co.uk/business-and-government/products/terrain-50.html) (50m resolution), Figure 2.4 shows details of the hydrological flow paths within the survey areas. The lighter coloured area indicates regions of low flow, whilst areas of increasing blueness represent wetter areas. This provides more detail of hydrological flow paths than would otherwise be possible from standard maps and highlights areas where radionuclides from atmospheric fallout might accumulate.

2.8 Agricultural Production

The Scottish Agricultural Census 2015 data for the parishes (defined by postcodes as used by the Scottish Government) surrounding the Torness site have been assessed. Of the 9 000 hectares under arable production within the parishes surrounding Torness, a little over one third is under crop of which half is dedicated to wheat. The rest of the area is dominated by grazing and rough grazing and a little over 7 % is contained commercial woodland. The data are summarised for crop production in Table 2.5 and for other agricultural land use in Table 2.6.

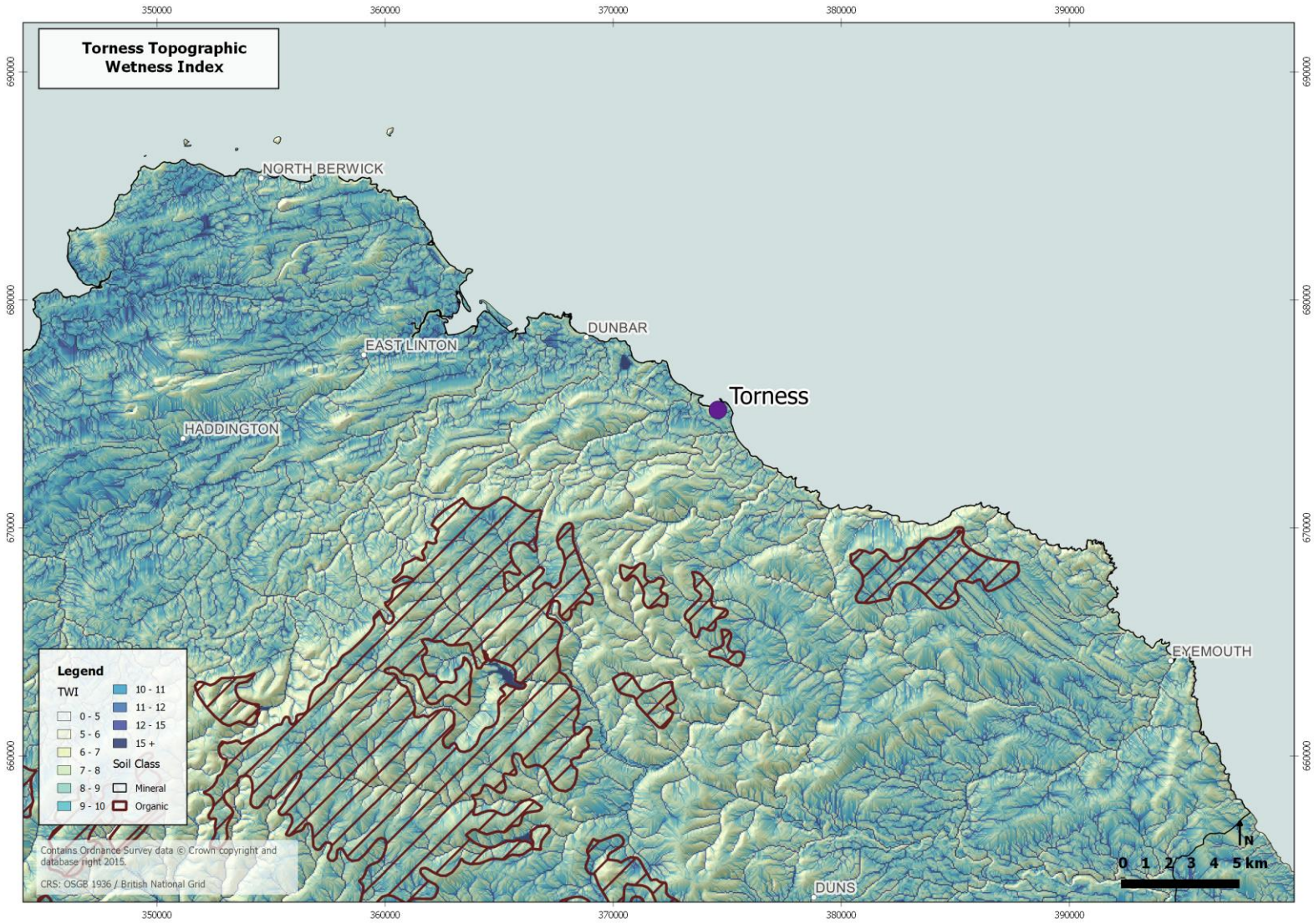

Figure 2.4 The Topographic Wetness Index in the Torness survey area.

Table 2.5 Summary of commercial crop production within the Parishes in the Torness area (2015).

Crops and Fallow Land	Number of Holdings	Area Hectares	Estimated Yield, Tonnes
Wheat	19	1 645	15 307
Winter barley	7	179	1 405
Spring barley	21	780	4 634
Total barley	6	8	221
Oats, tritical, mixed grain and rape for oilseed/linseed	22	976	6 105
Potatoes (seed/ware)	11	198	8 566
Stock feeding crops	6	94	5 147
Other crops	18	54	70
Fallow land	23	133	0
Total crops, fallow and set-aside	32	3 403	

Table 2.6 Summary of other agricultural land within the Parishes in the Torness area (2015).

Cultivated, Grazing and Other	Holdings	Hectares
Grass under 5 years old	23	326
Grass 5 years and older	43	2 398
Rough grazing	23	2 200
Common grazing land	0	0
Total grass and rough grazing	**53**	**4 924**
Utilised agricultural area	54	8 326
Woodland	28	664
Other land	36	287
Total agricultural area	**56**	**9 277**

Of the land given to livestock production, Table 2.7 summarises the data provided by the Scottish Agricultural Census for 2015. Livestock is dominated by sheep. No

commercial milk or honey production is present in the area. A small number of holdings have deer, goat and camelids.

Table 2.7 Summary of the livestock production within the Parishes in the Torness area (2015)

	Holdings	**Hectares**	**Head**
Total female beef cattle	12	4 531	1 999
Total male cattle	13		466
Total calves	11		1 420
Total cattle	14		3 886
Lambs	11		11 727
Total sheep	12	3 732	22 934
Fowls for producing eggs	6		220
Fowls for breeding	6		16 865
Total poultry	9		17 210
Total horses	14		58

3. Methods

3.1 Introduction

To provide consistency and traceability to previous habit surveys, the methods employed and described in this chapter are largely based on the approach outlined in Leonard *et al.* (1982), Green *et al.* (2001) and National Dose Assessment Working Group (NDAWG) (2013). The previous habit surveys provided a useful frame of reference for the Torness site.

The 2016 Habits Survey of Torness covers activities and food consumption. The survey introduced the following new methods:

(i) a mobile radiometric survey to characterise the heterogeneity of radiation in the environment surrounding the Torness site;
(ii) GPS tracking on a limited number of volunteers to better understand the time spent by individuals as they interact with the environment; and
(iii) information meetings during and after the face-to-face surveys to validate the data and findings.

3.2 Postal Survey

To obtain a provisional independent assessment of the activity and food consumption habits of the local community living within the study area through the survey, a postal questionnaire for households was designed, piloted and distributed to 2 000 households. The households were selected using a random sampling method (R Core Team, 2016). The survey included questions on food consumption, activities and a map for identifying the range of activities undertaken by household members. The sample included populations living within 25 km of the site. Further information is presented in Appendix A2.

3.3 Radiometric Surveys

The radiometric surveys comprised a carborne gamma spectrometry survey, in-situ air-kerma dosimetry and beta skin dosimetry. The carborne survey work is described in Appendix A3.

3.3.1 *In Situ* Dosimetry

The ERL has ISO 17025:2005 accredited procedures for the deployment and recording of gamma dose rate in air, using ISO 17025:2005 accredited (UKAS) calibrations for two Thermo Radeye instruments. Measurements were undertaken at all locations where occupancy or location was likely to lead to higher exposure to radioactivity or radiations as a result of site activities. These included areas that may have elevated radionuclide concentrations where fine sediment is known to accumulate (e.g. salt marshes and mudflats). The effective dose from terrestrial gamma radiation was calculated and reported in μSv h^{-1}. Further details of the in-situ methodology are presented in Appendix A4.

3.3.2 Beta Dosimetry

A ruggedized Thermo BP19RD /Electra instrument was deployed to assess the Beta dosimetry of skin dose [H'(0.07)]. The BP19RD provided a wide area monitor instrument (100 cm^2) and was used to monitor items that were potentially exposed to the higher radioactivity concentrations, i.e. close to licensed discharge points. Items monitored included: creels, fishing nets, waders. Further details of the beta skin dosimetry are presented in Appendix A5.

3.4 Sampling

Sample analysis of sand, soil, broccoli, egg, red onion, beetroot, rhubarb and seaweed were undertaken. This is detailed in Section 7.5.

3.5 GPS Tracking

Over a period of two to five days GPS tracking units were provided to a number of individuals to provide empirical data on areas visited and duration. To ensure consistency in data a wearable GPS tracking device was considered the most suitable device for the Torness Habits Survey. Further details of the system deployed are described in Appendix A6.

3.6 Conduct of the Survey

The pre-survey preparations involved a range of investigations with SEPA being contacted to discuss the requirements for the Torness survey. Past surveys reports and maps for this site were investigated giving substantial and vital information. A directory of key groups involved in activities in the area was compiled from web searches and from contacting people within the local area with relevant knowledge pertaining to the survey. A proposed programme for the fieldwork being undertaken was then established and passed to SEPA for their view.

A meeting with Torness site representatives provided details of the sites current activities, local information and the potential radiation pathways. The University of Stirling staff were invited to attend a stakeholders meeting which was between the site, local businesses and local residents within the area. This provided further relevant information.

3.7 Meetings and Informal Contacts

In the 2016 survey, a variety of data were gathered by a variety of approaches. This included holding a range of meetings including focus groups and sometimes using action-research techniques with relevant parties and individuals as well as the 'standard' face-to-face interview schedule. The multi-methods approach provided a means to 'triangulate' (verify) the data acquired through the different approaches: for example to check occupancy and activity data against the 'snapshot' observations recorded over a limited number of days in one season acquired from the individual face-to-face interviews. The meetings also provided some additional information about local produce grown and consumed by householders, allotment owners, horticulturalists and farmers and consumption of particular types of local food such as honey and game. Such information also facilitated some snowballing of the survey because the individual meetings provided additional contacts to follow-up. These groups were approached prior to, during and after the face-to-face interviews by telephone and email.

Prior to the survey a directory of local groups, bodies and organisations relevant to the survey was compiled. The directory proved an invaluable resource through the survey period both for contacting groups and for use as a checklist against which responses and non-responses from potentially important groups with regard to activity, occupancy, exposure and local food consumption could be recorded. For future surveys, the directory will provide a useful starting point and a means of monitoring any changes in group/business or other activity in the area. The directory development required extensive web searches, follow-up telephone calls and use of earlier contacts across organisations and businesses.

3.8 Data Conversion

During the face-to-face interviews, data on food consumption were recorded in units provided by respondents (e.g. pounds, grams, and ounces) and later converted into kilograms per year. The weights provided are for the fresh weight prepared and consumed. In some cases, respondents were unable to estimate food consumption in kilograms per year and instead gave the number of plants grown or the length and number of rows. These data were converted into consumption rates using conversion weights where possible e.g. one broccoli plant yields 700 g (Garden Forum Horticulture, 2009; Hessayon, 2014) so that all consumption figures were reported in kilograms per year. Some individuals were precise with the weight of some foods consumed with these figures mainly given as an annual consumption. Data from the paper copies of each survey were transferred to a bespoke database for analyses. The figures reported from individuals were utilised within the report with the percentage of any gifting or waste deducted from the final figure.

3.9 Data Rounding and Grouping

All data collected from the face-to-face and postal surveys were reported to two significant figures. For the food consumption data the total annual consumption (kg) of different food types were calculated by multiplying the quantity (kg) and frequency (times per year). The food items were placed into groups with similar attributes (Table 3.1). These groups are similar to those used in previous survey reports but focussed on the most common food items. Individuals were given the option to add any additional food items in ‘Other’ food category.

Table 3.1 Food groups used in Habits Survey

Food group	Example of foods within this group
Green leafy vegetables	asparagus, broccoli, brussel sprouts, cabbage, calabrese, cauliflower, celery, chard, herbs, kale, kohl rabi, lettuce, pak choi, rhubarb, marrow, spinach
Other domestic vegetables (legumes)	broad bean, french bean, pea, runner bean
Root vegetables	beetroot, carrot, celeriac, fennel, garlic, Jerusalem artichoke, leek, onion, parsnip, radish, shallot, spring onion, swede, turnip
Potato	potato
Domestic fruit	apple, blackberry, blackcurrant, blueberries, corn, courgette, cucumber, gooseberry, grape, pear, pepper, plum, raspberry, redcurrant, strawberry, tayberry, tomato
Milk	milk, yoghurt, cheese
Cattle meat	beef, buffalo
Pig meat	pork
Sheep meat	lamb, mutton
Poultry	chicken, duck, goose, turkey
Eggs	eggs
Wild/free foods	blackberry, chestnuts, crab apples, damson, dandelion root, garlic, elderberry, elderflower, nettle, raspberry, rowanberry, sloe, strawberry
Honey	honey
Venison	venison
Fish	bass, cod, Dover sole, kipper (herring), mackerel, pollock, salmon, sea trout, trout (freshwater)
Crustaceans	brown crab, common lobster, shrimps
Molluscs	mussels, razor clams, scallops, winkles
Wildfowl	mallard, pink-footed goose, teal, wigeon
Game - bird	partridge, pheasant, quail

The time respondents spent carrying out activities was calculated by multiplying frequency (occasions per year) and duration (hours) taking into account seasonality where appropriate. Respondents accounted for any holidays and working hours within their survey replies. In addition to food consumption a 'liquid' category was also added and respondents who carried out aquatic activities that could result in the inadvertent ingestion of water, e.g. outdoor swimming/sailing, were identified to account for this pathway.

The age groupings used in this report are based on the International Commission of Radiological Protection (ICRP) recommendations and are listed below in Table 3.2.

Table 3.2 ICRP age groups used in the dose assessment

Name of age group	Age range
Group 1 -Infant	0-5 year old
Group 2 - Child	6-15 year old
Group 3 - Adult	16 year old and over

3.10 Qualitative and Quantitative Observations

Whilst undertaking the face-to-face surveys, observational data were acquired on obvious changes to each location such as new build housing, along with information on site usage and numbers of individuals undertaking specific habits. Observations were acquired over a specified time period, e.g. 20 minutes, and on-shore and offshore (including intertidal) activities were noted. The number of individuals, their gender and their approximate age group undertaking each activity were also noted or estimated where large numbers were observed, e.g. beach activities. Some individuals were approached where possible and subsequent face-to-face surveys were conducted. Contact with individuals during face-to-face interviews frequently allowed the accuracy of observations to be checked and sometimes to be expanded: for example dog walkers might also engage in beachcombing and sailing at other times. Along with noting the weather conditions at the time of survey, this approach provided a basis for making a comparison with habits at different times and within and out with the period of the local school holidays.

3.11 Dose Assessment Tool

The Habits Dose Assessment Spreadsheet Tool collated the data from the face-to-face survey for Torness and then used the consumption rates and habits data to calculate the retrospective dose to each interviewed member of the public, covering the total exposure from all pathways. It should be noted that only the consumption of locally produced food has been included in the retrospective dose assessment (i.e. food from outwith the survey area is not included within the assessment). Dose

assessment was carried out following the guidance in NDAWG and ICRP for the *Representative Person*.

Activity concentration values came from modelling Torness discharges for 2014 using the default settings in PC-CREAM 08 (PHE, 2008) and measurements of samples collected in the field. Dose coefficients for different age groups are described by ICRP (2012). As described in Section 3.9, data for the 2016 Torness Habits Survey were collected in three age groups. The dose conversion coefficients (DCCs) for each age group were taken from ICRP: Group 1 for infants; Group 2 for 10 year olds; and Group 3 for adults.

The tool analyses four general exposure pathways:

(i) *Internal terrestrial*, which includes the consumption of locally produced meat, fruit and vegetables
(ii) *External terrestrial,* which determines the external doses from exposure to radiation present in the terrestrial environment as a result of deposition from atmospheric discharges and direct exposure through shine from on-site activities with radioactive materials
(iii) *Internal aquatic*, which includes consumption of fish, crustaceans, molluscs and inadvertent ingestion of seawater. A proxy for inadvertent drinking of water was calculated by multiplying the time spent on aquatic activities by the known average of water ingested in such activities as described in Leonard *et al.* (2015) and Stone *et al.* (2008)
(iv) *External aquatic,* which estimates the dose from external exposure through aquatic activities e.g. from radionuclides present in the aquatic environment (in water and sediments in saltmarshes or intertidal areas)

The direct exposure to shine from on-site activities was included in the analysis using in-situ measurements. These data were used to calculate direct exposure to members of the public that regularly travelled through the site.

The representative person was calculated independently for the total consumption and habits first and then by each exposure pathway. To identify the representative person, the 97.5 percentile rate cut off method was applied (Chapter 1). The representative person was calculated separately for external terrestrial and external marine exposure,

internal terrestrial and internal marine consumption related exposure. The combined calculated total integrated all routes of exposure to find the most exposed by all routes. The representative pathway for each exposure pathway is described separately in Chapter 10.

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4. Postal Survey

4.1 Introduction

The results from the postal survey provide an overview of the habits within the area centred on the Torness Power Station site extending 20 km for the aquatic and intertidal areas and 5 km around the site for the terrestrial survey area.

Of the 2 000 postal surveys that were sent out to households in the survey area, 142 of these subsequently returned. Of those returned, 59 were either incomplete or illegible leaving a total of 83 complete responses for further analysis (a response rate of 4.15% consistent with other surveys. The postal survey will be reviewed for future habit surveys and an amended version will be used). The respondents were asked to mark down which zone they carried out their activities on a map of the survey area (Figure 4.1).

The postal survey proved useful for identifying popular activities along with the zone in which the respondent undertook specific activities. Households were asked to indicate how often and for how long they participate in certain activities. The respondents were further asked to indicate on a map where they undertake these activities (Figure 4.1). This information was subsequently used to identify areas of high occupancy and inform the schedule for the face-to-face surveys. Zone 1 covered an area within 1 km of the Torness site, Zone 2 was between 1 km and 5 km of the site and Zone 3 was between 5 km and 10 km of the site. The postal survey results are detailed in Appendix A7.

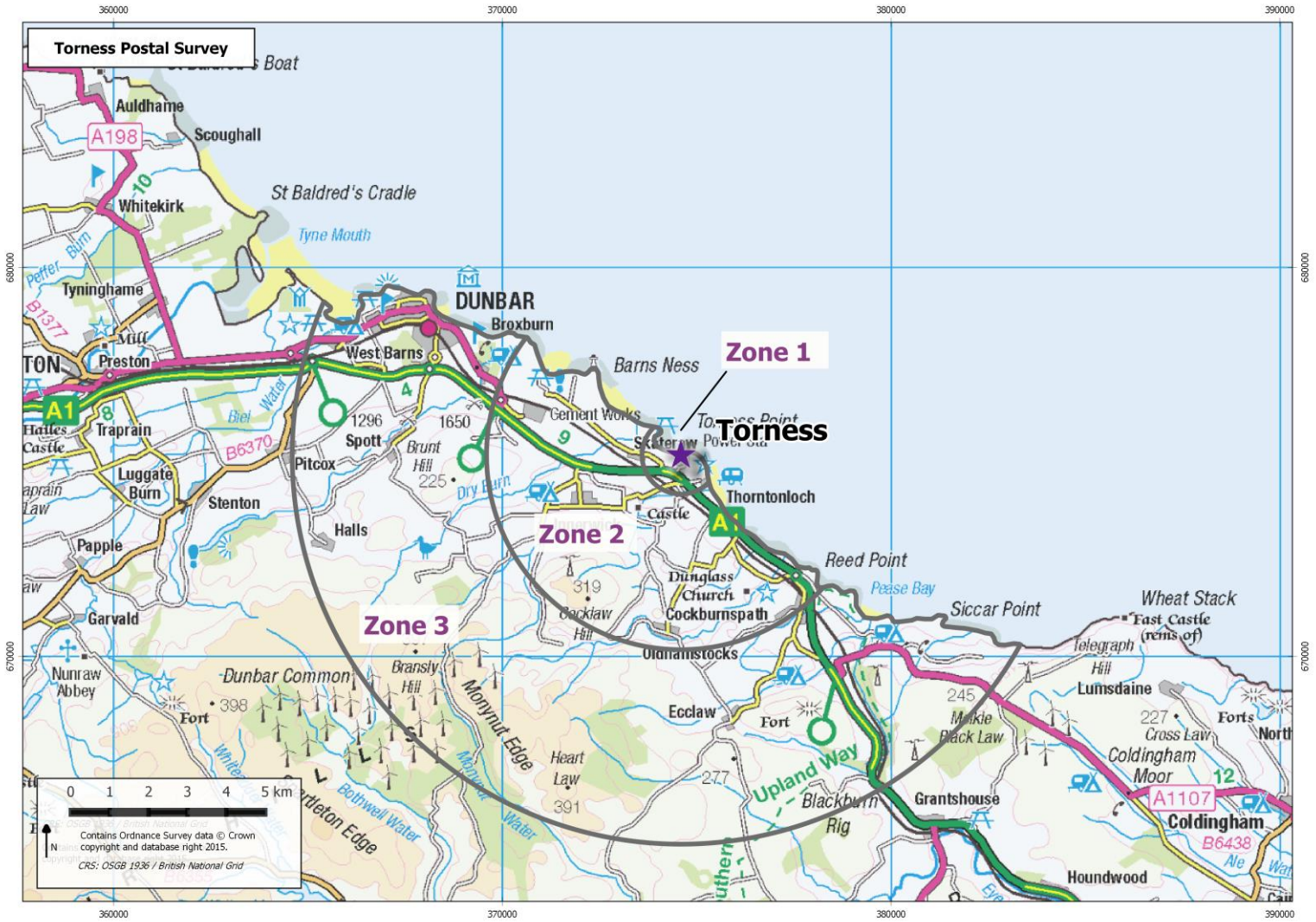

Figure 4.1 Torness postal survey map showing the zones used to assess occupancy.

5. Marine Radiation Pathways

5.1 Introduction

The survey locations were established following the desktop review of the site characteristics presented in Chapter 2 and to allow effective comparison with the previous Torness Habits Survey undertaken in 2011 (Clyne et al., 2013). The sites were visited throughout the survey period and observations of offshore and onshore activities were undertaken at each site. Each site was visited at different times of day according to the survey schedule, which reflected the activities occurring at each site and the site activity and proximity to the Torness site.

5.2 Aquatic Survey Area Descriptions

The survey locations were revisited through two survey periods, the first before (16th to 22nd May) and the second during the school holiday period (11th to 15th August) of 2016. Offshore and onshore observations were undertaken at each site. Each site was visited for varying lengths of time according to the survey schedule, site activity and proximity to the Torness site.

The survey area stretched from North Berwick in East Lothian to Eyemouth in Berwickshire and extended 3 km offshore (Figure 2.1). There are several watercourses that flow into the sea within this area. These include the Eye Water, Heriot Water, Thornton Burn, Biel Water, River Tyne and Peffer Burn. Part of the survey area forms a National Nature Reserve and Scottish Site of Special Scientific Interest, which attract bird watchers and wildlife enthusiasts to the area to observe the intertidal birdlife.

The survey sites are reported from North Berwick in the northwest to Eyemouth in the southeast. Site descriptions and observations are presented in Appendix A8.

5.3 Commercial seafood operations

Commercial seafood operations operate within the survey area. Fish are landed at North Berwick, Seacliffe, Dunbar, Cove, St Abbs and Eyemouth. Fish landed are lobster, crab (brown and velvet) and prawn. Mackerel are also landed but are mainly for use as bait for crab and lobster creels and only a small amount is consumed locally.

However, the survey team were unable to precisely determine how much mackerel was consumed locally from all sites.

North Berwick: Four lobster creelers were moored at North Berwick. Occasionally they caught velvet crabs too. Landings were sold to two shellfish wholesalers with the majority of the landings are exported to Europe (France and Spain) and a small percent sold locally. A new harbour restaurant opened four years ago and all lobster for sale is sourced from local fishermen at North Berwick. Fishermen at North Berwick reported that the velvet crab population is now increasing after three to four very poor years. They also reported mackerel, not usually caught until July, were being landed as early as May in 2016.

Seacliffe: Two creel boats operate out of Seacliffe harbour and this is shared between two individuals fishing for mainly lobster and some velvet crab and mackerel. Of the lobster caught, approximately 50 % is sold locally within the survey area, the remainder being sold abroad to Spain and once annually lobster is sold by order to Sweden. Mackerel and velvet crab are sold to Spain (Barcelona) with some of the mackerel being sold locally.

Dunbar: Twenty nine fishing boats operate out of Dunbar. Two of the boats fish for prawns and the remaining all fish for lobster and crab. All landings were sold to two fish wholesalers with both exporting most of the catch to the European market (France and Spain).

Cove: Two full time creel boats operate all year from Cove Harbour and one part time creel boat (May to November) operate from Cove Harbour. The catch landed was crab and lobster and sold to a fish wholesaler to be exported to Europe.

St Abbs: Approximately ten fishing boats are moored at St Abbs and fish for crab, lobster and mackerel. Most of the catch landed was exported to Europe and is sold through a fish wholesaler. One creeler however sold his catch to a fish wholesaler outwith the survey area, it is not known whether this is subsequently resold locally or abroad.

Eyemouth: Ten prawn fishing boats operate out of Eyemouth harbour along with nine fishing boats that creel for lobster and crab. All fish landed is reported to be exported by a local fish merchants.

Three fish wholesalers operate within the survey area with the majority of the landings subsequently being sold to the European market. It was reported that approximately 1 % is sold within the aquatic survey area.

Lobster pots were marked by buoys to the west of Eyemouth harbour and a small fishing boat was observed on one occasion to check each site.

One local fishmonger sourced their produce seasonally from a local fish merchant. A second local fishmonger sourced their prawns from a local creeler.

One individual was identified picking winkles at Killiedraught Bay and reported that they undertake this activity three times weekly with 30 kg of winkles collected per occasion. The winkles were sold outwith the survey area. The same individual also landed lobster and this was sold to a local fish wholesaler.

A trout re-stocking supplier and distributer re-stock fisheries and private lochs and lakes across Scotland and England, the nearest fishery stocked is a fishery outwith the survey area. The survey team was unable to determine a % of trout consumption. It was reported that no individuals consumed the trout but that some trout may be consumed after distribution.

5.4 Non-commercial fishing and angling

With new European ruling as of the 1st July 2016, the licensing for rod fishing for sea bass quota will be reduced to one adult bass per fishing session. This is to conserve depleted fish stocks in a bid to improve their numbers. It was reported that net fishing is available on Tyninghame Bay from a council lease to fish for sea trout and salmon but no-one at present has taken out this lease. Table 5.3 shows hobby fishing activities within the aquatic survey area.

Table 5.3 Locations associated with hobby fishing activities

Bait Digging	Fishing from shore/rocks/pier/kayak	Mollusc/crustaceans picking (non-commercial)
White Sands Dunbar Beach	Torness Power Station – mackerel, bass, cod Thorntonloch – mackerel From St Abbs Head (in kayak) – fishing with rod Eyemouth harbour wall Skateraw from shore – mackerel and pollock	Dunbar rocks – winkles Within 10 km of Torness – mussels Torness spillway – winkles and mussels Razor clams - Tantallon

5.5 Wildfowling

The East of Scotland Association for Wildfowling and Conservation (ESAWC) were contacted and they were able to provide information for wildfowling within the survey area. Two wildfowlers were found to shoot at Belhaven Bay and Tyninghame. Information regarding wildfowling season permits (issued by East Lothian Council) and birds shot during 2014/15 was provided by East Lothian Council. The number of licences (as stated below) issued by East Lothian Council has remained the same for over 30 years, with no request for change. East Lothian Council reported that the number of wildfowlers at present were falling. Wildfowling is permitted in the John Muir Country Park and 195 permits were issued with 410 total visits. This is reported to be the lowest number of visits recorded. Individuals interviewed reported that in the Belhaven Bay area (John Muir Country Park) 30 % of the permits issued are believed to be bought by people trying to prevent the shooting of wildfowl. It was reported that wildfowl numbers had been in decline over the past few years, due to the weather and a warming climate affecting migration. A total of 280 birds were shot, comprising of 64 geese (pink foot geese, 35, greylag 28 and one Canadian goose), 200 waders and ducks (80 wigeon, 69 teal, 45 mallard, 5 golden eye and one woodcock). Sixteen wood

pigeon were also shot and are included in the total figures received from the wildfowl report. A further 30 permits are also available in the Aberlady Bay on a two yearly rotation of which 19 permits were issued. Of the 19 permits issued to wildfowlers, only six permits were used. Of the six permits used, there were 13 visits to Aberlady Bay where 18 mallard, three teal and five widgeon were shot. The wildfowling season commences on the 1st September and runs to 20th February.

Mallard, pink-footed goose and teal were shot at the John Muir Country Park and Belhaven Bay. Pink-footed goose and teal were also found to be shot at Tyninghame. These were consumed by the wildfowlers interviewed and their families.

5.6 Royal National Lifeboat Institute

Royal National Lifeboat Institute has lifeboats moored at Dunbar and Torness Power Station. The Dunbar lifeboat is a small in-shore lifeboat (ILB) for approximately three to four people. The ILB covers the area from St Abbs Head to Bass Rock and up to three miles offshore. The Torness lifeboat is the all-weather lifeboat (ALB) for approximately five to seven people. The ALB covers the area between St Abbs Heat to Fyffe Ness going up to 100 miles offshore. The lifeboat crews train twice weekly for two to three hours each session. Last year there were 20 ILB call outs for rescue and 15 ALB call outs for rescue.

St Abbs now has an independently owned lifeboat (Appendix 8).

5.7 Rowing

One individual was interviewed from a local rowing club, which has approximately 55 members, and arranges rowing events of approximately one hour duration three times weekly. It is reported the route normally taken is from Dunbar to Belhaven Bay in the west and to White Sands in the east.

A second rowing club based in North Berwick arrange rowing events, both competitive and for leisure, and involve one or more training sessions weekly.

A local yacht club runs two racing sessions and four training sessions per week. They also run a children's club sea cadet section for children aged 8 – 18 years old. All

boats tended to be hosed down with fresh water following rowing events. Wetsuits and clothing are rinsed and/or washed at home.

Dunbar Sea Cadets are based in Dunbar and launch from the harbour having access to use the water both within and outwith the harbour. The children and adults go onto the water once a week for two hours over a 50 week period. The activities undertaken are kayaking, canoeing, power boating and sailing. The boats are all cleaned with fresh water on site and stored at the Dunbar Sea Cadets Unit. The children and adults all take their wetsuits and clothing home to clean.

5.8 Professional Dog Walkers

Professional dog walkers operate within the survey area. These groups will be active along the coastal strip for much longer periods. As dogs can enter the sea and the route of walks often encompasses muddy and sandy areas, the group may potentially have greater exposure to intertidal substrates. The survey team were unable to obtain any information from this group.

5.9 Ramblers/walking

The survey area is popular with ramblers and walkers, especially with the Berwickshire Coastal Path which follows part of the survey area coastline. The survey team however were unsuccessful in contacting any local rambling or walking groups. With the presence of the National Nature Reserve and SSSI within the survey area many walkers/bird watchers were noted.

5.10 Animals Grazing

Cows (no dairy herds identified) and sheep were observed grazing in several fields within and around the survey area. No cattle or sheep were observed grazing on seaweed or within intertidal areas anywhere within the survey area.

5.11 Other Pathways

A running club within the aquatic survey area run once a year along the coast from Eyemouth to St Abbs running by road on the return journey. The rest of the year the

runs are usually by road. Four outdoor swimmers were observed at Coldingham Bay but were unable to be interviewed.

A local Dunbar based surf school was interviewed and they reported that surfing courses for adults and children. During the summer it runs activity weeks (two hours in the morning and two hours in the afternoon) for a local high school which includes the activities of surfing, surf skateboarding, beach volleyball and a beach clean-up. Over the course of one year the school may teach 1 000 adults and more than 1 000 children. It reported that approximately 50 local children and adults surf regularly although the area also attracts surfers from Glasgow, Stirling, Perth and St Andrews with around 10 000 surfers in total. It was reported that the most popular surfing areas within the survey area were Belhaven Bay, Pease Bay and Coldingham Bay though surfing also occurs in other areas within the survey area. It was reported to the survey team that up to 150 surfers can be surfing at Belhaven Bay with 70 – 80 surfers on the same day at Pease Bay and Coldingham Bay. Highest occupancy would be a combination of good weather and a good swell during the summer holiday periods of June, July, August and September (accounting for school holiday periods and students).

The school also coach development teams which involve teaching the most proficient children twice monthly, in addition each child would individually train two to three times a week themselves (approximately two hours each session).

5.12 Seaweed and Foraging

Seven individuals interviewed reported to collect seaweed Thorntonloch, Torness outflow, Dunbar harbour, Dunbar east beach and Skateraw for use on their allotment (Thistly Cross Allotments with over 40 plots in use) and on their garden which was used to grow vegetables. Seaweed was also collected by two individuals interviewed for human consumption. The seaweed collected by both individuals was sourced from Thorntonloch beach. Details are as follows:

- One individual interviewed collects 3 kg of seaweed from the Thorntonloch beach south of Torness. Direct application of the seaweed is used in the individual's garden. The individual and one other family member collect a small amount of seaweed (150 g annually) for their own consumption. This individual

is embarking on a new sales venture with seaweed collection from Thorntonloch aiming to be sold for human consumption. This is still in the planning stages but the individual reported that tests upon the seaweed had been undertaken by the University of Glasgow to ensure its quality; and,

- A second individual interviewed collects between 1.8 kg – 3 kg of seaweed (sea caviar) annually from Thorntonloch beach. This seaweed is then dried and bottled and used for their consumption.

Seaweed has been reported to collect along Dunbar East beach and appears to become caught on the beach due to a shore-lain Scottish Water sewage pipe which acts as a barrier. No seaweed removal for composting from Dunbar East Beach occurs at present, in contrast to the 2011 report. Currently there is no green waste facility willing to accept the material and, as a consequence, East Lothian Council reported that the seaweed was typically pushed back into the sea (due to local pressure and kelp fly infestation) when the tides were appropriate to break up offshore or it is moved further south along the beach where it may be exposed to beach erosion and decomposition. In a community council report (Dunbar Community Council, 2016) it was noted that designing of new groynes, pipe haunching (sewage pipe) and beach re-profiling (summer 2016) is to be undertaken and that farmers are unable to remove seaweed because it was reported to become mixed with litter and other materials on the beach.

It was reported that one individual provides coastal foraging courses from Seacliff however the survey team were unable to obtain any further information regarding this. Coastal foraging courses were also reported to be available south from Dunbar but no further information was achieved regarding this area.

5.13 Internal Exposure

5.13.1 Adults' Consumption Rates

Table 5.4 presents a summary of the consumption rates for aquatic food types including; fish, crustaceans, molluscs and wildfowl. Mean adult consumption rates for the high-rate groups and the observed 97.5th percentile rates are included in Table 5.4. The high-rate group was determined using a 'cut-off' method described by Hunt *et al*., (1982). This 'cut-off' method calculates the high-rate value by taking the mean

of the values between the maximum observed rate and one third of the maximum observed rate. Therefore, the 'cut-off' method within this report is represented as the individuals derived to obtain the 'high-rate group'. The table also includes mean consumption rates and 97.5th percentile rates based on the full dataset. The generic mean and generic 97.5th percentile rates based on National Habit Data is also included (Smith and Jones, 2003). The national data is used to compare the high-rate mean and high-rate maximum consumers within the habits survey. During the course of the Torness habits survey it became apparent that the national data does not consider any extreme habits of consumption. For example, there may be regional or local differences in habits which may result in very different rates of consumption, such as fish (Table 5.4), which is vastly greater than the national estimate and may represent an important local pathway. It may be necessary to consider that the national data cannot capture local or regional variations in habits, which may have local significance within habits based assessments.

Adults consumed bass (34 individuals), cod (47 individuals), kipper (herring) (one individual), mackerel (68 individuals), pollock (27 individuals), salmon (four individuals), dogfish (one individual), haddock (five individuals) and plaice (three individuals) all sourced from within the aquatic survey area. It should be noted that some adults consumed more than one fish type (flat and/or round). The observed maximum consumption (quantity*frequency) of fish was 208 kg y^{-1} and this individual consumed cod (104 kg y^{-1}), and bass (104 kg y^{-1}), bought from a fishmonger in Eyemouth where the fish is sourced from local boats.

Table 5.4 Summary of adults' consumption rates of foods from the aquatic survey area.

ND – Not Determined

Food Group	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (kg y^{-1})	Observed minimum for the high-rate group (kg y^{-1})	Observed mean for the high-rate group (kg y^{-1})	Observed 97.5th percentile (kg y^{-1})	Full dataset – Observed mean (kg y^{-1})	Full dataset – 97.5th percentile (kg y^{-1})	National Data mean (kg y^{-1})	National data 97.5th percentile (kg y^{-1})
Fish	95	11	208	72	101	187	20.3	111	15	40
Crustaceans	54	12	47.5	17.4	28.8	44.5	9.2	36.3	4	10
Molluscs	10	2	45.4	24	34.7	44.9	7.5	40.6	4	10
Wildfowl	5	1	116	116	116	116	25.3	104	ND	ND
Seaweed	4	4	0.50	0.50	0.50	0.50	0.50	0.50	ND	ND

Crustacean consumption consisted of brown crab (35 individuals) and common lobster (42 individuals), squat lobster (one individual), prawns (five individuals), and velvet crab (one individual). The highest consumption was 47.5 kg y^{-1}, this individual consumed common lobster (25.9 kg y^{-1}) and brown crab (21.6 kg y^{-1}) which were self-caught at Cove, Barns Ness and around Torness. It should be noted that some adults consumed more than one crustacean type.

Mollusc consumption consisted of mussels (nine individuals), winkles (three individuals) and razor clam (one individual). The observed maximum consumption was 45.4 kg y^{-1}, this individual consumed mussels (22.7 kg y^{-1}) and winkles (22.7 kg y^{-1}) all self-caught from around Torness spillway. Five individual's consumed wildfowl which consisted of mallard (five individuals), pink-footed goose (three individuals), teal (five individuals), wigeon (three individuals) and grey lag goose (two individuals). The

highest consumption was 116 kg y^{-1}, this individual consumed mallard (39.6 kg y^{-1}), pink-footed goose (48 kg y^{-1}), Teal (3.96 kg y^{-1}) and wigeon (24 kg y^{-1}) which were all self-caught from Tyninghame and Belhaven Bay.

5.13.2 Children and Infant Consumption Rates

Table 5.5 presents a summary of children and infants' consumption rates of fish, crustaceans, molluscs and wildfowl from the aquatic survey area. Mean consumption rates for the high-rate groups and the observed 97.5th percentile rates are included in Table 5.5. The table also includes mean consumption rates and 97.5th percentile rates based on the full dataset.

Table 5.5 Summary of children's and infants' consumption rates of foods from the aquatic survey area.

NA – Not Applicable

Food Group	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (kg y^{-1})	Observed minimum for the high-rate group (kg y^{-1})	Observed mean for the high-rate group (kg y^{-1})	Observed 95.7th percentile (kg y^{-1})	Full dataset – Observed mean (kg y^{-1})	Full dataset – 97.5th percentile (kg y^{-1})
Child age group (6 - 15 years old)								
Fish	15	5	20.0	7	12.5	19.9	6.03	19.4
Crustaceans	2	1	1.50	1.50	1.50	1.50	0.85	1.47
Wildfowl	4	1	116	116	116	116	31.7	107
Infant age group (0 - 5 years old)								
Fish	5	1	31.2	31.2	31.2	31.2	9.48	28.8
Crustaceans	1	1	2	2	2	NA	2	2

For the child age group, bass (10 individuals), cod (six individuals), mackerel (eight individuals) and pollock (six individuals) were consumed by children. The observed

maximum consumption was 20.0 kg y^{-1} (bass) which was sourced from around Torness. Crustacean consumption consisted of brown crab consumed by two individuals. The highest consumption was 1.5 kg y^{-1} and this was sourced from off the coast at Dunbar. Wildfowl consumption consisted of mallard, pink-footed goose, teal and wigeon by four individuals and grey lag goose by three individuals. The highest consumption was 116 kg y^{-1} and this individual consumed mallard (39.6 kg y^{-1}), pink-footed goose (48 kg y^{-1}), Teal (3.96 kg y^{-1}) and wigeon (24 kg y^{-1}) which were all sourced from Tyninghame and Belhaven Bay. No consumption of molluscs was found for the child age group.

For the infant age group, cod (four individuals), mackerel (four individuals), pollock (one individual), salmon (one individual) and haddock (one individual) were consumed. The observed maximum consumption was 31.2 kg y^{-1}, this individual consumed cod (7.81 kg y^{-1}), mackerel (7.81 kg y^{-1}), pollock (7.81 kg y^{-1}) and salmon (7.81 kg y^{-1}) which was sourced from a family member fishing at Eyemouth. Crustacean consumption consisted of common lobster consumed by one individual (2 kg y^{-1}), this was sourced from a family member (self-caught) at Eyemouth. No consumption of mollusc or wildfowl was found for the infant age group.

It should be noted that some children and infants consumed more than one fish, crustacean and wildfowl type.

5.14 External Exposure

Occupancy rates for adults in intertidal, aquatic (in water), aquatic (on water), handling rates of equipment and handling rates of sediment can be found in Table 5.6. Intertidal activities for adults included bait digging, beachcombing, boat maintenance, collecting mussels, collecting razor clams, collecting seaweed, collecting winkles, crabbing, dog walking, fixing moorings, handling creels, horse-riding, paddling, playing, rock pooling, wildfowling, walking, jogging, litter picking, bbq/picnicking/sitting, beach clean-up, fishing, bird/nature watching, life guard duties, power kiting, coastguard duties, camping and metal detecting. The highest intertidal occupancy rate was 1 829 h y^{-1} for an individual who spent time dog walking (1 825 h y^{-1}) and collecting seaweed (4 h y^{-1}).

Activities in the water included diving, sub-aqua diving, outdoor swimming, underwater photography and snorkelling. The highest occupancy rate for adults in the water was 1 372 h y^{-1} for an individual (a competitive swimmer) who undertakes outdoor swimming from North Berwick beach (this occupancy has been checked and confirmed with the individual). Activities on the water included sea angling, boat maintenance, canoeing, commercial creeling/fishing, rowing, safety boat duties, sailing, power boating, working on a boat, surfing, body boarding, kayaking and creel fishing (non-commercial). The highest occupancy rate for adults on the water was 5 864 h y^{-1}, this individual undertakes boat maintenance (1 460 h y^{-1}), commercial fishing/creeling (4 380 h y^{-1}) and safety boat duties (24 h y^{-1}). This high occupancy has been checked and confirmed with the individual. Adults were also found to handle equipment within the survey area, the activities for adults involved handling boats and boating equipment, handling clothes and overalls and fishing gear. The highest level of handling equipment was 5 960 h y^{-1}, this individual spent time handling boats and boating equipment (1 460 h y^{-1}), commercial fishing/creeling (4 380 h y^{-1}) and handling clothes and overalls (1 205 h y^{-1}). The highest level of handling sediment was 1 829 h y^{-1} and this is for an individual (the same individual with the highest intertidal occupancy) who spent time dog walking (1 825 h y^{-1}) and collecting seaweed (4 h y^{-1}). The occupancy data for intertidal activities were used for estimating the external gamma dose rate. Selected relevant intertidal activity occupancy data were also used to derive the handling sediment category which was then used for estimating the beta skin dose rate.

Table 5.6 Summary of adults' external exposure for intertidal, aquatic, handling of equipment and handling of sediment.

Activity	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (h y^{-1})	Observed minimum for the high-rate group (h y^{-1})	Observed mean for the high-rate group (h y^{-1})	Observed 97.5th percentile (h y^{-1})
Intertidal	224	23	1 829	635.9	1 047	1 828
Aquatic (in water)	48	1	1 372	1 372	1 372	1 372
Aquatic (on water)	75	2	5 864	3 230	4 547	5 798
Handling equipment	63	3	5 961	2 590	3 945	5 827
Handling sediment	181	14	1 829	663	1 061	1 709

Table 5.7 presents a summary of the children and infants' intertidal, aquatic (in water), aquatic (on water) occupancy rates, handling rates of equipment and handling rates of sediment. Intertidal activities for children included beachcombing, crabbing, dog walking, horse riding, paddling, playing, rock pooling, walking, BBQ/picnicking/sitting and fishing from the intertidal area. The highest intertidal occupancy rate for children was 811 h y^{-1} for two individuals who spent time fishing (148 h y^{-1}), dog walking (156 h y^{-1}), rockpooling (156 h y^{-1}) and playing (351 h y^{-1}). Intertidal activities for infants included beachcombing, crabbing, paddling, playing, rock pooling and BBQ/picnicking/sitting. The highest intertidal occupancy was 313.6 h y^{-1} for an infant who spends time beachcombing (105 h y^{-1}), playing (105 h y^{-1}) and rock pooling (105 h y^{-1}). The only activity that children and infants undertook in the water was outdoor swimming and the highest occupancy rate for this was 228.1 h y^{-1} at Pease Bay and Cove for both age groups. Children's activities on the water included canoeing, sailing, power boating, surfing and body boarding. The highest occupancy rate for children carrying out activities on the water was 548 h y^{-1}, this individual undertakes sailing at North Berwick. For infants, activities on the water included surfing and body boarding. The highest occupancy rate for infants carrying out activities on the water was 65 h y^{-1}, this infant undertakes surfing at Thorntonloch Beach and Pease Bay.

The highest level for handling of equipment for children 148 h y^{-1} by two children who spend time fishing at Torness Spillway. No infants were found to handle equipment.

The highest level of handling sediment was 663 h y^{-1} for two children who spent time dog walking (156 h y^{-1}), rock pooling (156 h y^{-1}) and playing (351 h y^{-1}). The highest level of handling sediment was 314 h y^{-1} for an infant who spends time beachcombing (105 h y^{-1}), playing (105 h y^{-1}) and rock pooling (105 h y^{-1}). The occupancy data for intertidal activities were used for estimating the external gamma dose rate. Selected relevant intertidal activity occupancy data were also used to derive the handling sediment category which was then used for estimating the beta skin dose rate.

Table 5.7 Summary of children's and infants' external exposure for intertidal, aquatic and handling of equipment. (All figures rounded to three significant figures).

Activity	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (h y^{-1})	Observed minimum for the high-rate group (h y^{-1})	Observed mean for the high-rate group (h y^{-1})	Observed 97.5th percentile (h y^{-1})
Child age group (6 - 15 years old)						
Intertidal	55	10	811	104	328	811
Aquatic (in water)	24	4	228	140	162	222
Aquatic (on water)	21	1	548	548	548	548
Handling equipment	2	2	148	148	148	148
Handling sediment	55	3	663	663	663	663
Infant age group (0 – 5 years old)						
Intertidal	19	6	314	130	198	300
Aquatic (in water)	5	1	228	228	228	228
Aquatic (on water)	2	1	65	65	65	65
Handling sediment	19	6	314	130	198	300

Gamma dose rate measurements over different substrates within the survey area can be found in Chapter 7.

6. Terrestrial Radiation Pathways

6.1 Introduction

Chapter 6 reports on inland routes of exposure immediately adjacent to the Torness site, coastal and intertidal areas (Figure 2.1). This chapter reports the results from the face-to-face consumption levels for privately produced food stuffs.

6.2 Terrestrial Survey Area Descriptions

The terrestrial survey area stretches a 5 km radial from the southern outskirts of Dunbar to Cove and inland taking in all conurbations with communities ranging from as small as one house to villages. Much of the land within the survey area is agricultural, predominantly arable and livestock (mostly cattle and sheep).

The survey sites are reported from northwest to northeast and are presented in Appendix A9.

6.3 Private Food Production

No allotments were found within the 5 km radius from the Torness site but there are several allotments within Dunbar itself. Thistly Cross Allotments (with over 40 plots) were visited with five individuals interviewed obtaining fruit and vegetable consumption data. Two of these individuals source seaweed from within the aquatic survey area for use on their allotment and one of the individuals sells some of their produce to a local shop within Dunbar. Following discussion with SEPA these data (from the allotments) have been included in the results. During the survey period within and outwith the school holidays many individuals were found to produce a wide variety of fruit and vegetables. Of those individuals interviewed, some were specific with the yield of their products, many of whom maintained detailed records of the crop grown and the respective yield. Face-to-face interviews indicated that much of the produce on the survey list was produced by one or more individual and the food grown was consumed by their families and friends. Over the survey period, 40 individuals grew their own fruit and vegetables within their own home gardens. These individuals yielded data of sufficient quality for quantitative estimates of food quantities grown and consumed. A

total of 22 individuals surveyed reported to keeping chickens with eight of these 22 individuals keeping ducks also.

One individual interviewed within the terrestrial survey area grows chillies in a greenhouse and once picked they are dried, chopped and mixed with rock salt. This is then sold through farmers' markets locally and outwith the survey area with some sales online. The same individual is embarking on a new sales venture collecting seaweed for human consumption (Section 5.12).

One individual interviewed reported that they shoot approximately 300 pigeon annually from within the terrestrial survey area. This was sold to a game dealer, where it was sold on and subsequently sold to restaurants outwith the survey area.

A local Estate (within the 5 km terrestrial survey area) organise shoots approximately every two weeks for pheasant and roe deer within the shooting seasons. Individuals participating in the shoots come from all over the UK and Europe. Only a few people that participate in the shoot take a brace of pheasants to consume. Two individuals involved with the shooting were contacted. Both pheasant and deer are consumed by them and their families. No interview however was achieved with these two individuals. The remainder of the pheasant and deer is sold to a game dealer outwith the survey area and subsequently sold within the United Kingdom and Europe.

6.4 Commercial Food Production

Local butchers were contacted to determine where there produce was sourced. One farm within the terrestrial survey area supplied seasonal vegetables and some chicken eggs to a shop within the terrestrial survey area. Of butchers contacted, only one butcher within the terrestrial survey area sold produce (game) that was sourced from within the survey area.

6.5 Wild Foods

Within the terrestrial survey area wild food foraging was reported by 33 individuals. A breakdown of the foods, number of individuals, consumption and locations are detailed in Table 6.1.

Table 6.1 Wild food summary of total number of individuals, highest annual consumption and locations

Food type	Total number of individuals	Maximum individual consumption (kg y^{-1})	Location of maximum consumption foraged	Other locations of foraging
Apple	5	90	Crowhill	Skateraw, Torness Power Station
Blackberry	23	5.45	Innerwick	Cockburnspath, Cove, Crowhill, Skateraw, Thorntonloch, Torness Power Station, White Sands
Cherry	6	0.58	Crowhill	-
Elderberry	2	4	Torness Power Station	Crowhill
Elderflower	13	1.2	Torness Power Station	Crowhill, Innerwick, Cove
Gooseberry	2	0.25	Crowhill, Innerwick	-
Mushroom	4	4	Crowhill	Torness Power Station
Raspberry	2	1	Skateraw	-
Sloe berry	10	5	Thorntonloch	Cove, Crowhill, Skateraw, Torness Power Station, White Sands
Wild garlic	2	1	Skateraw	-
Wild herbs	2	0.05	Cove	-

6.6 Production of Honey

Beekeepers are not required to be a member of a bee keeping association or to be registered therefore the precise numbers in the survey area are unknown. It is recognised that commercial large scale selling of honey and related products is

regulated by the local authority and Food Standards Scotland through legislative requirements.

The Dunbar Beekeepers Group was contacted and reported that within Dunbar there are approximately 10 beekeepers with one or more hives. The group promotes sustainable beekeeping in a bid to maintain stocks of honeybees. Although honey can be harvested the main aim of the group is to sustain the bee population by providing a stable environment for the bees. East Lothian Beekeepers Association were contacted on several occasions with no response. Two beekeepers were interviewed within the survey area with an annual total yield of 9 kg of honey. One other individual was reported but the survey team were unable to contact them.

6.7 Farms

Within the Torness terrestrial survey area eight working farms were identified with one farm reporting to have three tenants farming the land. Some of the farms reported that lamb, beef and chicken and duck eggs were consumed by family members and gifted to friends. Venison, pheasant and partridge were also reported to be consumed by family members. Some farms surveyed have water provided for human consumption with a private water supply with animal (cow and sheep) water consumption being provided by mains water supply, private water supply and burn/ditch water supply. It should be noted that all farm houses are situated within the 5 km terrestrial zone, though for a few farms, some of their land lie's outwith the 5 km terrestrial zone.

6.8 Other pathways

A local brewery have their own private water supply via a well on site. No further information was obtained.

A natural mineral water company based near Dunbar was identified within the 2011 Torness Habits Survey sourcing within the terrestrial survey area. The company however closed down a couple of years ago.

A local cider making company based near Dunbar was contacted. Throughout the survey period several individuals interviewed reported to supply the company with apples home grown from within the terrestrial survey area at Crowhill and

Thorntonloch. The company reported to grow some of their own apples in their small orchard but the majority of the apples come from collecting donations exchanging 7 kg of apples for one bottle of cider. One individual interviewed provided 500 kg of apples from within the terrestrial survey area. Of the cider produced (entering the market via pub food chains and supermarkets), approximately 75 – 80 % stays within Scotland with very little being sold locally. The remaining 25 % is sold to the rest of the United Kingdom and exported to Europe, America and the Far East.

A local seed business near Dunbar was contacted. It was determined on enquiry that no seeds or produce are grown here with all seeds bought in from outwith the survey area for mixing (undertaken indoors with no seeds being exposed outdoors).

6.9 GPS Survey Results

To provide more details on the use of the environment around the Torness survey area, five individuals were selected to wear trackers based from the knowledge gained of their habits from the face-to-face interviews. Trackers were deployed for a period of several days. From comparing the GPS tracker results with the paper copies the validation varied with participants. It seemed that an over estimation of time and frequency spent in the terrestrial survey area was given, although this may partly be due to the short period the GPS trackers were actually deployed. Thereby indicating a longer period than several days may be necessary to achieve a more robust comparison.

6.10 Internal Exposure

6.10.1 Internal Exposure Adult Consumption Rate

Consumption data for locally produced foodstuffs potentially affected by atmospheric releases from Torness are presented in Table 6.2 for adults and Table 6.3 for children. No infant consumption was identified.

Table 6.2 presents a summary of the adult consumption rates. The table summarises the number of observations made, the number of people in the high-rate consumer group, the minimum and maximum observed consumption rates for the high-rate

consumer group and the observed 97.5% consumption rate. The table also contains the mean consumption rate for both the high-rate consumer group and the whole dataset collected from around Torness. The table also provides the mean and 97.5% consumption rates from national data (Smith and Jones, 2003) for comparison. The national data is used to compare the high-rate mean and high-rate maximum consumers within the habits survey. During the course of the Torness habits survey it became apparent that the national data does not consider any extreme habits of consumption. For example, there may be regional or local differences in habits which may result in very different rates of consumption, with many food groups (Table 6.2), which are vastly greater than the national estimate and may represent an important local pathway. It may be necessary to consider that the national data cannot capture local or regional variations in habits, which may have local significance within habits based assessments.

Table 6.2 Summary of adult consumption rate of foods from the terrestrial survey area.

ND – Not Determined

Food type	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (kg y^{-1} or l y^{-1})	Observed minimum for the high-rate group (kg y^{-1} or l y^{-1})	Observed mean for the high-rate group (kg y^{-1} or l y^{-1})	Observed 97.5th percentile (kg y^{-1} or l y^{-1})	Full dataset – Observed mean (kg y^{-1} or l y^{-1})	Full dataset – 97.5th percentile (kg y^{-1} or l y^{-1})	National mean (kg y^{-1} or l y^{-1})	National 97.5th percentile (kg y^{-1} or l y^{-1})
Vegetables-Green	32	15	44.7	15.3	24.1	43.0	13.9	41.1	15	45
Vegetables-Other	21	8	8.25	2.75	5.08	8.25	2.50	8.30	20	50
Vegetables - Root	30	9	39.3	14.5	23.5	37.6	10.7	33.1	10	40
Vegetables - Potatoes	25	4	118	50	84	118	27.04	118	50	120
Fruit - Domestic	30	12	133.1	49.6	72.9	130	40.6	124	20	75
Fruit - Wild	28	1	93.2	93.2	93.2	93.2	6.29	39.2	7	25
Wild Fungi	4	2	4	4	4	4	4	4	3	10
Meat - Beef	2	2	47	47	47	47	47	47	15	45
Game - rabbit and hares	8	2	13	13	13	13	3.63	13	6	15
Game - birds	17	4	11.6	7.3	9.45	11.6	3.1	11.6	ND	ND
Game - venison	12	2	26	26	26	26	6.43	26	ND	ND
Meat - Sheep	2	2	4.50	4.50	4.50	4.50	2.40	4.50	10	30
Meat - Poultry	5	2	9	9	9	9	9	9	8	25
Eggs	28	22	26.3	9.05	14.8	26.3	12.2	26.3	8.50	25
Honey	2	2	4.50	4.50	4.50	4.50	4.50	4.50	2.50	9.50

Consumption of locally produced foods was identified for all food groups with the exception of water and milk.

One observed mean consumption rate for the high-rate consumer group was found to be greater than the 97.5% value for the full 2016 dataset. This was for wild fruit. Two of the observed mean consumption rates for the high-rate consumer group were found to exceed the national 97.5% consumption rate. These were for wild fruit and beef. Four of the observed 97.5 % consumer groups exceeded the national 97.5% consumption rate. This was for domestic fruit, wild fruit, beef and eggs.

6.10.2 Children and Infant's Consumption Rates

Table 6.3 presents a summary of the child consumption rates. The table summarises the number of observations made, the number of people in the high-rate consumer group, the minimum and maximum observed consumption rates for the high-rate consumer group and the observed 97.5% consumption rate. The table also contains the mean consumption rate for both the high-rate consumer group and the whole dataset collected from around Torness.

Child consumption of locally produced foods was identified for wild fruit, domestic fruit, game, poultry and eggs. No consumption of green vegetables, other vegetables, root vegetables, potatoes, wild fungi, beef, sheep, pork, honey, milk and water was identified. No observed mean consumption rates for the high-rate consumer group were found to be greater than the 97.5% value than the full 2016 dataset.

Table 6.3 Summary of children's consumption rates.

Food type	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (kg y^{-1} or l y^{-1})	Observed minimum for the high-rate group (kg y^{-1} or l y^{-1})	Observed mean for the high-rate group (kg y^{-1} or l y^{-1})	Observed 97.5th percentile (kg y^{-1} or l y^{-1})	Full dataset – Observed mean (kg y^{-1} or l y^{-1})	Full dataset – 97.5th percentile (kg y^{-1} or l y^{-1})
Fruit - Domestic	4	4	49.6	20.3	42.3	49.6	42.3	49.6
Fruit - Wild	5	2	0.90	0.90	0.90	0.90	0.42	0.90
Meat - Game	3	3	0.16	0.16	0.16	0.16	0.16	0.16
Meat - Poultry	3	3	1	1	1	1	1	1
Eggs	5	5	13.9	6.03	10.7	13.9	10.7	13.9

7. Direct Radiation Exposure

7.1 Introduction

A gamma-ray spectrometry survey was undertaken to estimate the dose received by the general public around the Torness facility. Areas of particular focus were within a one kilometer radius of the facility and any potential access points to intertidal areas. Nevertheless, all major roads and a large section of the coast around the power station were surveyed covering more than 100 km.

MoGSS data were used to help target the follow-up in-situ terrestrial gamma dose rate measurements, which were undertaken at all face-to-face survey locations, access points to intertidal areas or at any location where an apparent anomaly was observed. Beta dosimetry was undertaken over intertidal environments and objects frequently handled and immersed in the offshore environments to estimate the skin dose that

may be associated with contamination from radioactivity. Measurements in these areas were made on fishing equipment, boats and articles of clothing that were frequently immersed in the coastal waters surrounding the Torness site.

7.2 Mobile Gamma Spectrometry Survey

7.2.1 Mobile Gamma Survey Results

In total, over 10 hours of data were captured encompassing 36806 spectral measurements. (20 335 – road survey; 16 468 – backpack). The estimated dose distribution for both systems are presented in Figure 7.1. Notice that the natural population for the carborne system are slightly higher possibly as a result of measurements being taken around sources of natural radioelements such as concrete and the geological formations in elevated areas (Figure 7.3). Additionally, ^{137}Cs dose is marginally higher in the backpack system. This could be due to two possibilities. Firstly, noise arising as a result of the stripping process in the handheld devices. For example, very few counts tend to be recorded in the high energy windows in the handheld devices, leaving the system vulnerable to under or over stripping. ^{137}Cs being the lowest energy window can be significantly influenced by this effect, producing a much broader population of estimated activity and ultimately dose contribution. Therefore, it would be appropriate to exercise caution when interpreting handheld results. The second reason for this could be that slightly elevated ^{137}Cs could be found on the coast as a result of discharges from the power station.

In terms of general spatial patterns in dose rate, much of the dose rate can be attributed to ^{40}K contributions and further contributions from the natural series (Figure 7.2). Elevated areas of dose are found in the hills, more than likely originating from the geological formations or elevated ^{40}K in the road surface.

In close proximity to the Torness site the dose rate is relatively low in terms of the entire survey area (Figure 7.3). It would appear that elevated areas are associated with ^{40}K contributions from concrete, for example under bridges and the concrete seawall protecting the power station (Figure 7.4).

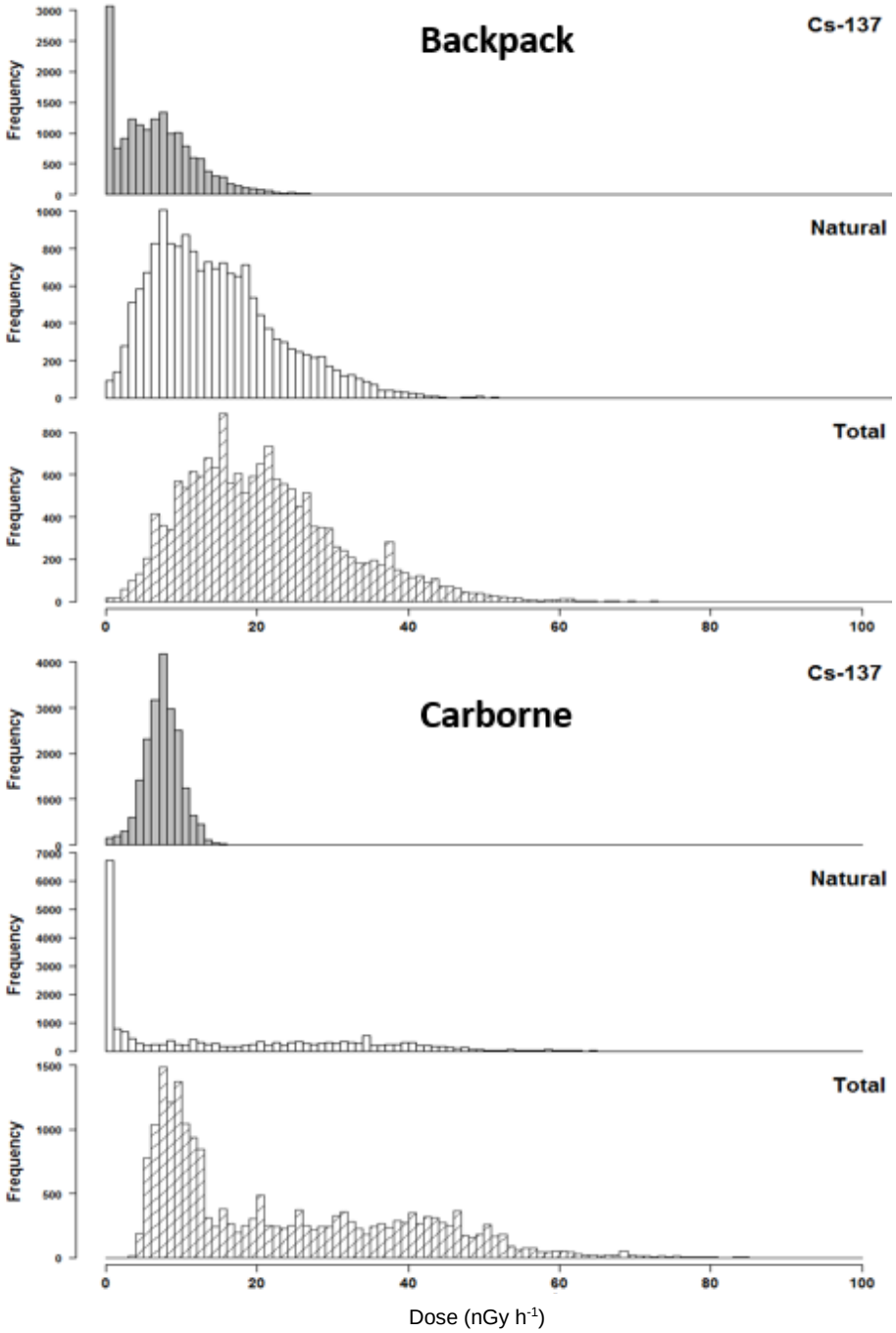

Figure 7.1 Dose rates distributions estimate from carborne and backpack systems for the Torness site. Dose contribution is separated into ^{137}Cs, the natural radioelements and the total dose.

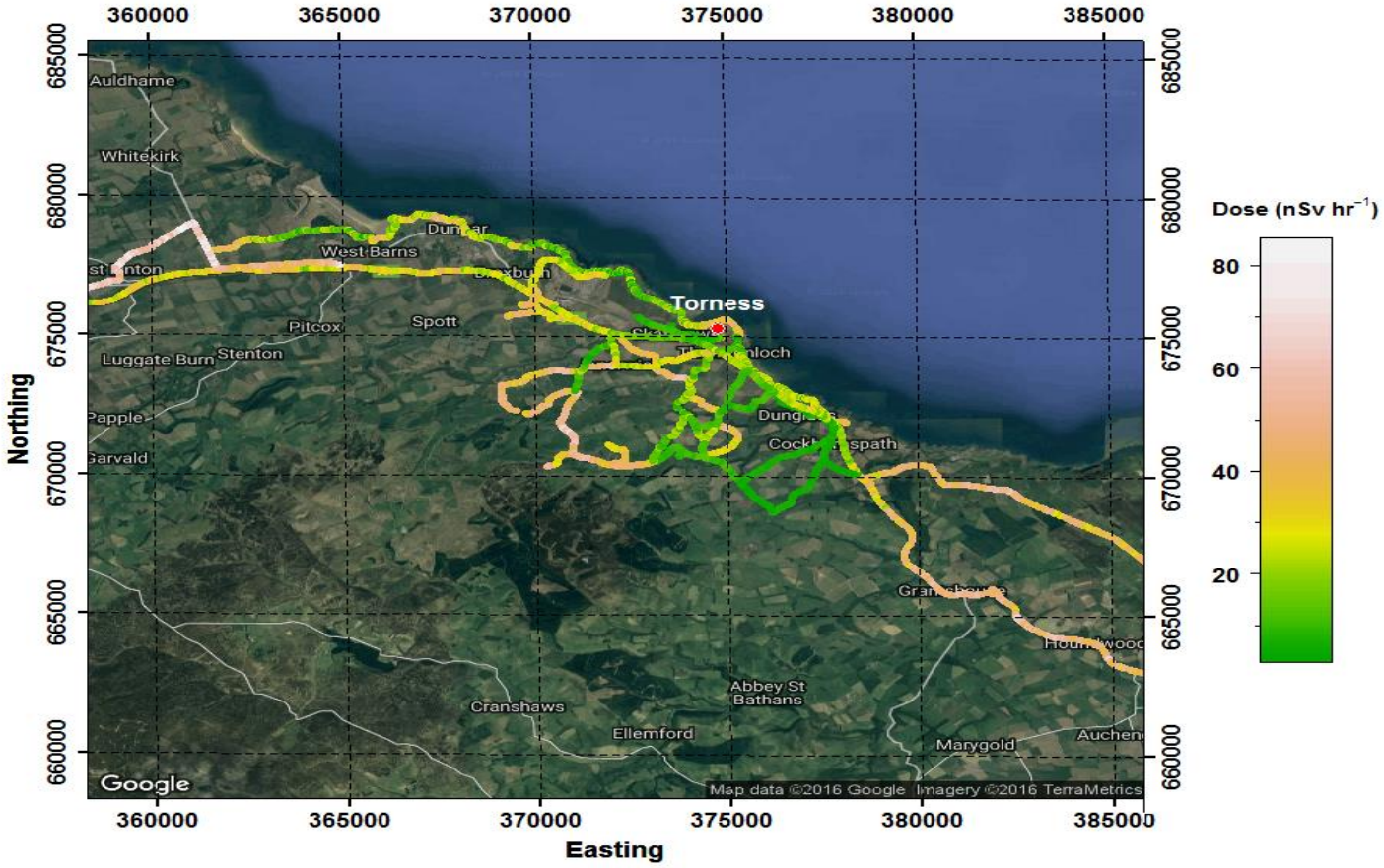

Figure 7.2 MoGSS data calibrated to total gamma dose rate measurements (background included) across the Torness site

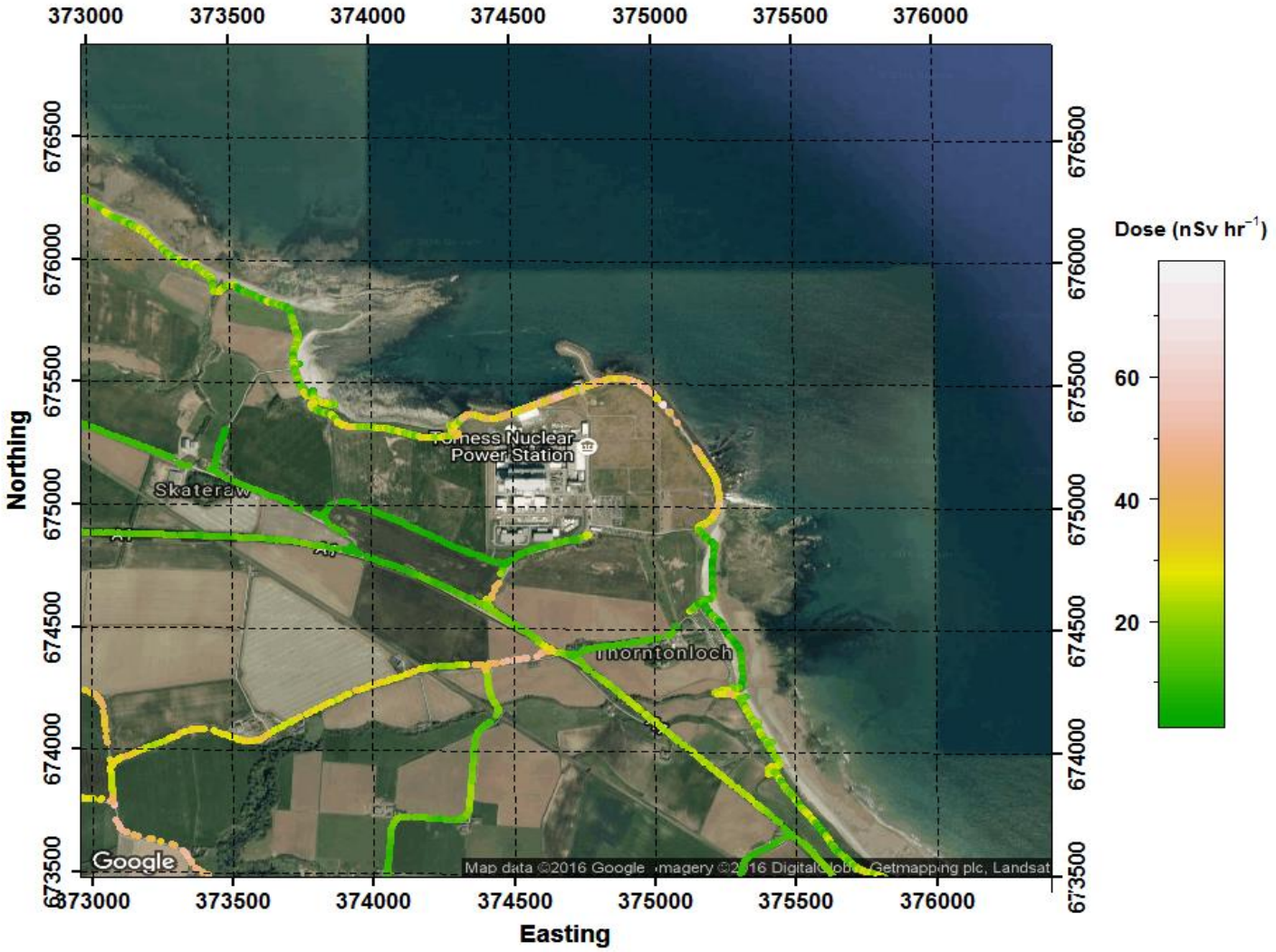

Figure 7.3 Dose rates close to the Torness facility.

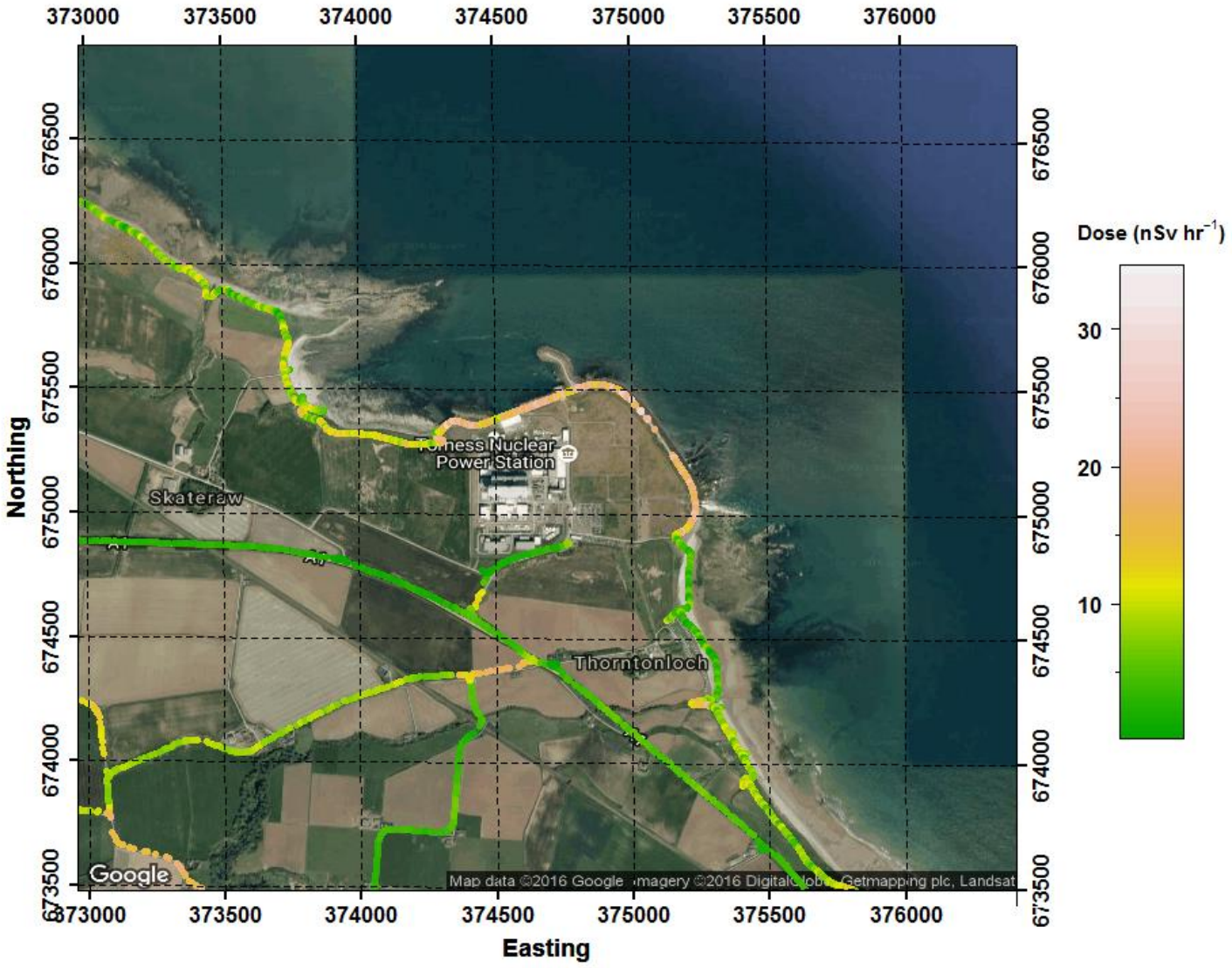

Figure 7.4 ^{40}K dose rate in the vicinity of the Torness facility

7.3 In-Situ Gamma Dosimetry

7.3.1 Terrestrial areas

Sixteen in-situ gamma dose rate measurements were collected at terrestrial sites during the survey. Most of which were made along the coastline including six around the power station itself (Figure 7.5). A UKAS accredited procedure was followed to estimate the terrestrial gamma dose rate. Since the vast majority of dose contribution was thought to be from the natural radionuclides, a ^{226}Ra calibration was used to estimate dose rate for all gamma dose rate measurements given that ^{226}Ra occurs naturally in the environment.

A summary of the dose rate measurements made across the site for terrestrial areas can be found in Table 7.1 and are in good agreement with the MoGSS data.

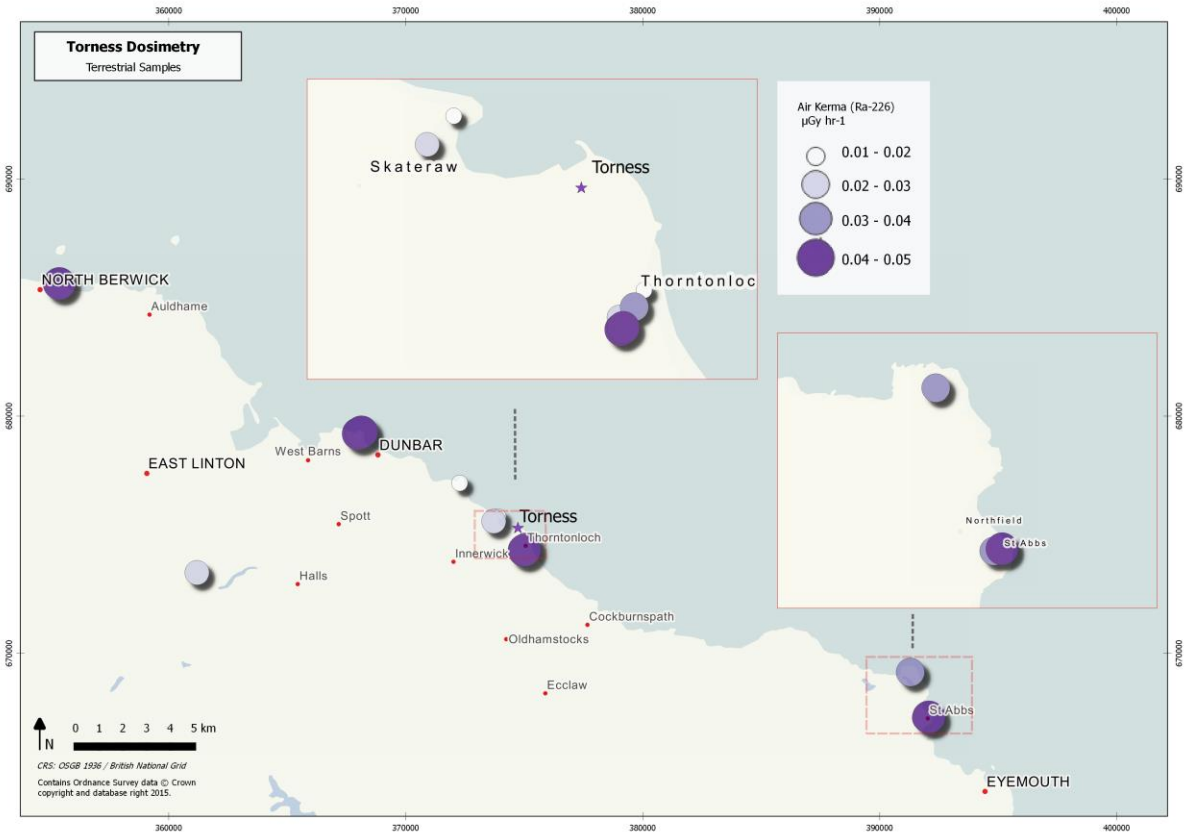

Figure 7.5 Summary of the gamma dose rate measurements in the terrestrial environments surrounding Torness.

Table 7.1 Summary of gamma dose rate measurements collected across the terrestrial environments.

Location	GPS Location	Surface	Gamma Dose Rate (μGy h^{-1})	Uncertainty 2 σ (μGy h^{-1})
Dunbar Harbour	NT 68005 79255	Concrete	**0.0409**	0.0042
St Abbs Head	NT 91301 69201	Grass	**0.0335**	0.0039
St Abbs Harbour	NT 91980 67290	Grass	**0.0379**	0.0041
St Abbs Harbour	NT 92076 67316	Rock/Concrete	**0.0477**	0.0044
Thorntonloch CP	NT 74988 74418	Gravel	**0.0291**	0.0038
Outside Thorntonloch house	NT 75000 74337	Gravel	**0.0477**	0.0044
Inside Thorntonloch house	NT 75000 74337	In house	**0.0479**	0.0044
Thornton House	NT 74983 74327	Garden	**0.0235**	0.0036
Barns Ness lighthouse	NT 72282 77185	Grass	**0.0119**	0.0033
Skateraw beachhouse	NT 73712 75567	Grass	**0.0241**	0.0037
Skateraw headland memorial	NT 73887 75757	Grass	**0.0129**	0.0034
Thortonloch CP	NT 75090 74487	Grass	**0.0305**	0.0038
Thorntonloch dunes	NT 75154 74598	Sand dunes	**0.0186**	0.0035
North Berwick	NT 55377 85593	Hard standing	**0.0485**	0.0045
Dunbar Harbour	NT 68133 79330	Rock/pebbles	**0.0425**	0.0043
Crowhill	NT 6119173402	Cut wheat	**0.0263**	0.0037

7.3.2 Intertidal areas

Forty-one in-situ gamma dose rate measurements were made over intertidal surfaces (Figure 7.6). At each site, gamma dose rate measurements were made over the dominant intertidal surfaces observed; in the study area this surface tended to be sand, pebbles or rock and some of the sites were observed to be an aggregate of sand and pebbles. In Table 7.2 it can be seen that on average a higher dose rate was observed over pebbled surfaces (0.0315 µGy h^{-1}), compared to that of sand covered areas (0.0159 µGy h^{-1}). This could be explained by the increase in density of the composite geological material.

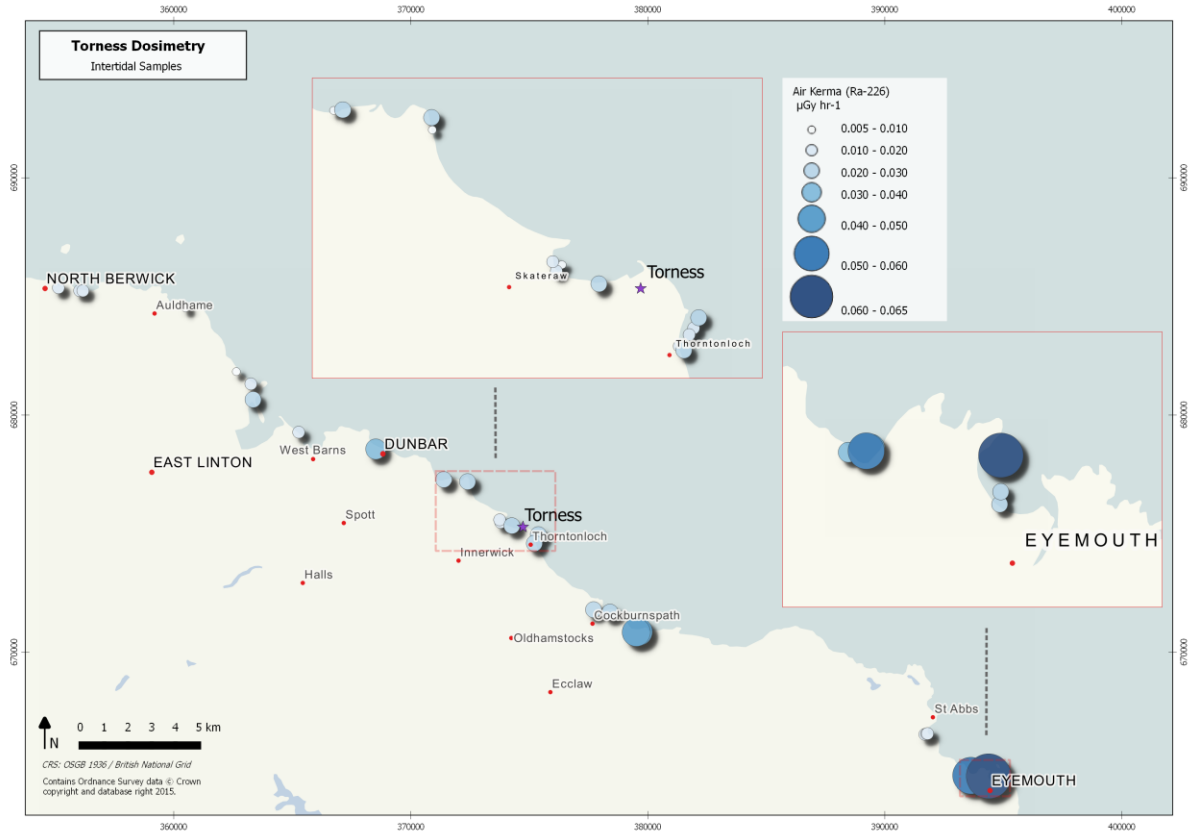

Figure 7.6 Summary of the gamma dose rate measurements in the intertidal environments surrounding Torness.

The combination of MoGSS and gamma dose rate data would suggest there is little spatial pattern in dose rate, indicative of the natural background driving the dose rate; particularly the density of underlying material for example rock compared to sand.

Table 7.2 Gamma dose rate recorded over different intertidal substrates

Location (n)	**GPS Location**	**Gamma dose rate over Substrate type (µGy h^{-1})**			
		Sand	**2 σ**	**Pebbles**	**2 σ**
Barns Ness (1)	NT 72401 77056	**0.0098**	0.0033		
Barns Ness lighthouse (1)	NT 72393 77195			**0.0213**	0.0036
Bathan Strand (1)	NT 63341 80651			**0.0273**	0.0037
Belhaven Beach (1)	NT 65274 79271	**0.0115**	0.0033		
Coldingham Bay (3)	NT 91773 66555	**0.0147**	0.0035		
Cove (2)	NT 78407 71690	**0.0189**	0.0039		
Dunbar East Beach (1)	NT 68520 78562	**0.0363**	0.0041		
Eyemouth Beach (4)	NT 94369 64775	**0.0243**	0.0036	**0.0552**	0.0047
Killiedraught Bay (4)	NT 93639 64793	**0.0336**	0.0039	**0.049**	0.0042
Milsey Bay (1)	NT 56167 85241	**0.0137**	0.0034		
North Berwick (1)	NT 56029 85247	**0.0121**	0.0034		
North Berwick East Beach (1)	NT 55130 85369	**0.0119**	0.0034		
Pease Bay (4)	NT 79539 70865	**0.0223**	0.0036	**0.0401**	0.0042
Peffer Sands (1)	NT 62634 81834	**0.0083**	0.0033		
Ravensgheugh Sands (1)	NT 63250 81314	**0.0140**	0.0034		
Seacliff (1)	NT 60469 84587	**0.0084**	0.0033		
Skateraw (2)	NT 73793 75472	**0.0152**	0.0036		
Thorntonloch Beach (3)	NT 75172 74632	**0.0117**	0.0033	**0.0206**	0.0036
Torness Beach (2)	NT 73854 75543	**0.0090**	0.0033	**0.0177**	0.0035
Torness discharge point (2)	NT 75387 74952			**0.0255**	0.0037
White Sands (3)	NT 71294 77275	**0.0105**	0.0034	**0.0276**	0.0038
	Mean	**0.0159**		**0.0315**	
	Maximum	**0.0363**		**0.0552**	

7.4 *In-Situ* Beta Dosimetry

Beta dosimetry of skin dose [H*(0.07)] was measured over intertidal areas (pebbles, mud, sand and seaweed) and fishing boats, rowing boats and fishing equipment such as nets that were stored close to the coast.

A total of 28 measurements were made, the majority of which were below the 0.2 μSv h^{-1} detection limit and thus are not summarized in Table 7.3. A total of seven readings were found to be above this detection limit; beta doses and locations of these measurements are summarised in Table 7.3.

Table 7.3 Estimated beta dose rates for Torness survey area

Location	GPS Location	Surface	Beta Dose Rate (μSy h^{-1})	Uncertainty 2 σ (μGy h^{-1})
Cove	**NT 78435 71778**	Pebbles	**0.225**	0.121
Belhaven beach	**NT 65274 79270**	Sand	**0.898**	0.121
Ravensheugh Sands	**NT 63250 81314**	Sand	**0.260**	0.102
Coldingham Bay	**NT 91694 66533**	Sand	**0.282**	0.126
Skateraw	**NT 73793 75472**	Gravel	**0.219**	0.100
Torness discharge pipe	**NT 75291 74952**	Seaweed on concrete	**0.216**	0.097
Dunbar West Harbour	**NT 67900 79262**	Fishing Net	**0.213**	0.118

7.5 Sample Analyses

Single samples of broccoli, egg, red onion, beetroot and rhubarb were kindly donated by the owners of Thorntonloch house along with two soil samples (Table 6.3). Two seaweed samples and a sample of sand was also collected from the nearby Thorntonloch beach. The beach sand and soils contained the highest concentrations of ^{137}Cs (above 1.58 ± 0.17 Bq kg^{-1}). The highest concentration of ^{131}I (0.94 Bq kg^{-1})

was found in the beetroot sample, although this was noted to be below the limit of detection (Table 6.3). Egg, beetroot and rhubarb contained the highest concentrations of ^{228}Th with 23.08, 25.84, 25.12 ± 15.37 Bq kg^{-1}, respectively. Importantly, the majority of measurements were below the limit of detection.

Table 7.4 Radionuclide content from various environmental samples (LOD given in table)

			Bq/kg					
Sample	**Location**	**Coordinates**	**^{137}Cs**	**2σ**	**^{131}I**	**2σ**	**^{228}Th**	**2σ**
Beach sand	TLB	NT 75185 74588	1.58	0.17	0.16	< LOD	3.36	< LOD
Broccoli	TLH	NT 75058 74428	0.10	< LOD	0.12	< LOD	3.80	< LOD
Egg	TLH	NT 75058 74428	0.41	< LOD	0.38	< LOD	23.08	< LOD
Red Onion	TLH	NT 75058 74428	0.19	< LOD	0.43	< LOD	11.12	< LOD
Beetroot	TLH	NT 75058 74428	0.67	< LOD	0.94	< LOD	25.84	< LOD
Rhubarb	TLH	NT 75058 74428	0.19	< LOD	0.14	< LOD	25.12	15.37
Seaweed 1	TLB	NT 75185 74588	0.12	< LOD	0.16	< LOD	7.22	< LOD
Seaweed 2	TLB	NT 75185 74588	0.31	0.15	0.09	< LOD	6.44	3.51
New soil	TLH	NT 75058 74428	1.89	0.19	0.13	< LOD	16.19	8.01
Old soil	TLH	NT 75058 74428	2.15	0.21	0.10	< LOD	5.51	< LOD

TLH = Thorntonloch house; TLB = Thorntonloch Beach

7.6 Occupancy Rates

7.6.1 Occupancy Data for the Survey Area

The face-to-face interviews revealed that individuals take part in a range of terrestrial, aquatic and intertidal activities within the survey area (Table 7.7). For terrestrial activities the most popular activity was gardening (44 individuals) with the individual with the highest occupancy spending 1 248 h y^{-1} at Thorntonloch. For the aquatic activities, outdoor swimming was the most popular (69 individuals) and the individual with the highest occupancy spent 1 368.75 h y^{-1} (a competitive swimmer). For intertidal activities playing was the most popular activity (102 individuals) with the highest individual occupancy being 365 h y^{-1} at North Berwick Beach.

Table 7.7 Summary of the activities and total number of individuals that take part in the activities. The location of the maximum occupancy is also given.

Activity type	Activity	Number of individuals	Maximum occupancy (h y^{-1})	Location (if provided)
Terrestrial	At caravan	2	390	Cockburnspath
Terrestrial	Beekeeping	2	90	Innerwick
Terrestrial	Bird/nature watching	12	1 460	Thorntonloch village
Terrestrial	Collecting wild produce	26	65	White Sands, Barns Ness, Crowhill, Skateraw
Terrestrial	Community woodland walk	1	52	Cove
Terrestrial	Cycling	33	364	Skateraw, Innerwick
Terrestrial	Dog walking	37	1 095	Thorntonloch
Terrestrial	Farming	5	4 380	Elmscleugh Farm
Terrestrial	Gardening	44	1 248	Thorntonloch
Terrestrial	Horse riding	1	1 460	White Sands (Dunbar)
Terrestrial	Jogging	1	52	Crowhill
Terrestrial	Playing	8	821	Crowhill
Terrestrial	Rambling/walking	21	365	Oldhamstocks
Terrestrial	Running	5	104	Dunbar to White Sands
Terrestrial	Shooting	1	416	Crowhill
Terrestrial	Sitting/picnicking	9	365	Crowhill
Terrestrial	Sports	5	365	Crowhill
Aquatic	Angling - sea	12	270	Torness Power Station, Dunbar
Aquatic	Boat maintenance	10	1 460	Dunbar

Activity type	Activity	Number of individuals	Maximum occupancy (h y^{-1})	Location (if provided)
Aquatic	Body boarding	17	16	Coldingham Bay
Aquatic	Canoeing	21	1 040	North Berwick, Dunbar
Aquatic	Commercial fishing/creeling	11	4 380	Dunbar
Aquatic	Creel fishing/handling creels (non-commercial)	1	5	Dunbar
Aquatic	Diving	3	40	St Abbs, Coldingham Bay, Killiedraught Bay
Aquatic	Kayaking	1	2	Seacliff
Aquatic	Outdoor swimming	69	1 369	North Berwick
Aquatic	Power boating	6	156	North Berwick
Aquatic	Rowing	4	156	Belhaven Bay, White Sands, Dunbar
Aquatic	Safety boat duties	4	30	North Berwick
Aquatic	Sailing	7	548	North Berwick
Aquatic	Snorkelling	1	8	Dunbar
Aquatic	Stand-up paddle boarding	4	40	North Berwick, Seacliff, Belhaven Bay
Aquatic	Sub aqua diving	6	58.5	St Abbs, Eyemouth, Bass Rock
Aquatic	Surfing	37	1 040	Thorntonloch, Pease Bay
Aquatic	Underwater photography	1	192	Torness Spillway, Thorntonloch, Cove Bay
Aquatic	Working on a boat	1	300	Torness Power Station
Intertidal	Bait digging	3	26	Dunbar Harbour, White Sands

Activity type	Activity	Number of individuals	Maximum occupancy (h y^{-1})	Location (if provided)
Intertidal	BBQ/picnicking/sitting	40	273	North Berwick Beach
Intertidal	Beach clean	1	52	North Berwick, Milsey Bay, Cove Bay, Cove Harbour
Intertidal	Beachcombing	42	78	Cove Bay, Pease Bay
Intertidal	Bird/nature watching	1	312	Barns Ness, Torness Power Station, Skateraw
Intertidal	Boat maintenance	2	16	Dunbar Harbour
Intertidal	Camping	2	24	Ravensheugh Sands
Intertidal	Coastguard duties	1	204	St Abbs area, Killidraught Bay, Eyemouth
Intertidal	Collecting mussels	5	12	Torness Power Station
Intertidal	Collecting razor clams	1	2	Tantallon
Intertidal	Collecting seaweed	7	48	Thorntonloch Beach
Intertidal	Collecting winkles	7	730	North Berwick to Skateraw coast
Intertidal	Crabbing	11	26	Cove Bay
Intertidal	Dog walking	90	1 825	Dunbar East Beach, White Sands
Intertidal	Fishing	41	1 800	Torness Spillway
Intertidal	Fixing moorings	2	120	Dunbar
Intertidal	Handling creels	4	780	Dunbar Harbour
Intertidal	Horse riding	2	104	White Sands
Intertidal	Jogging	1	26	Coldingham Bay
Intertidal	Lifeguard duties	4	720	Coldingham Bay
Intertidal	Litter picking	5	52	North Berwick Beach, Milsey Bay
Intertidal	Metal detecting	1	312	Skateraw Beach
Intertidal	Paddling	56	300	Pease Bay, St Abbs, Coldingham Bay
Intertidal	Playing	102	365	North Berwick Beach
Intertidal	Power kiting	1	12	Belhaven Bay

Activity type	Activity	Number of individuals	Maximum occupancy (h y^{-1})	Location (if provided)
Intertidal	Paddle board set-up and deconstruction	1	48	Belhaven Bay
Intertidal	Research/education	1	4	-
Intertidal	Rock pooling	82	260	Killiedraught Bay, Eyemouth
Intertidal	Walking	37	365	Milsey Bay
Intertidal	Weekend visits	2	48	Cove Harbour
Intertidal	Wildfowling	2	234	Belhaven Bay, Tyninghame Bay
Maintaining equipment	Boats and boating equipment	17	1 460	Dunbar Harbour
Maintaining equipment	Clothes and overalls	15	121	-
Maintaining equipment	Fishing gear	47	4 380	Dunbar Harbour

7.6.2 Occupancy rates within the one kilometer of Torness (inside/outside work or home)

Individuals living or working within the immediate area of Torness were asked to estimate how much time they spend inside and outside their home or workplace. The results presented in Table 7.8 show the time spent indoors and outdoors on an annual basis. A total of seven individuals interviewed worked within 1 km of Torness. The highest amount of time spent indoors for one individual was 2 295 h y^{-1} and the highest amount of time spent outdoors was 2 240 h y^{-1}. These totals take into account holiday periods. A total of 22 individuals were interviewed who lived within 1 km of Torness. The highest amount of time spent indoors for one individual was 6 935 h y^{-1} and the highest amount of time spent in the immediate area outside their house was 3 370 h y^{-1}. All figures take into account any holiday period away from home. It should be noted that some individuals interviewed spend extended/regular holiday periods within the one kilometer area and for this reason their occupancy was determined.

Table 7.8 Occupancy rates of those individuals working or living within 1 km of Torness

Unique ID	Indoors at home ($h\ y^{-1}$)	Outdoors at home ($h\ y^{-1}$)	Indoors at work ($h\ y^{-1}$)	Outdoors at work ($h\ y^{-1}$)
20			-	1 840
22	2 506	1 074	2 295	765
40	-	-	-	2 000
75	-	-	-	1 792
76	-	-	-	2 240
234	-	-	1 920	720
271	-	-	-	480
21	5 012	2 148		
58	2 696	3 370		
61	288	144		
62	288	144		
63	288	144		
64	288	144		
75	3 036	2 024		
76	2 530	2 530		
77	700	700		
78	700	700		
79	700	700		
80	700	700		
81	700	700		
82	700	700		
132	6 935	1 460		
133	6 204	1 825		
273	5 110	1 825		
284	2 856	714		
285	3 570	714		
286	5 712	357		
342	2 380	1 428		

8 Torness Phase 2 Surveys

8.1 Introduction

The aim of the Phase 2 surveys was to validate the Phase 1 surveys from earlier in the year and to identify any major changes to both internal and external exposure paths or any new pathways not previously reported. Through discussion with SEPA it was determined that Phase 2 surveys for nine individuals (three from each of the high, medium exposure group and low exposure group), who agreed to be re-surveyed, would be contacted via telephone or e-mail in November 2016. These groups were determined according to the total dose received as calculated from the dose assessment tool. Surveys are anonymised with letters with corresponding survey IDs listed in the appendices.

8.2 Internal Terrestrial

Data are compiled in Table 8.1. For most food groups, the Phase 2 surveys did validate responses given in the first survey with similar quantities reported. The exceptions to this are the consumption of leafy green vegetables, domestic fruit and eggs.

Table 8.1. Internal terrestrial comparison data

	Survey ID	A	B	C	D	E	F	G	H	I
Food Group	**Exposure Group:**	**Low**	**High**	**Med**	**High**	**High**	**Med**	**Low**	**Low**	**Med**
Vegetables-Green Leafy	**Phase 1**		16.4	16.4	44.7	40.0				
	Phase 2		8.6	8.6	35.9	17.5				
Vegetables-Others	**Phase 1**		0.25	0.25	2.75	0.30				
	Phase 2		0.25	0.25	2.75	2.50				
Vegetables-Roots	**Phase 1**		10.0	10.0	17.9	10.0				
	Phase 2		11.9	11.9	11.3	10.0				
Vegetables Potatoes	**Phase 1**		7.70	7.70					2.70	
	Phase 2		7.70	7.70					3.60	
Fruit-Domestic	**Phase 1**		63.3	63.3	74.1	38.00				
	Phase 2		53.8	53.8	120	55.00				
Food-Wild	**Phase 1**		1.45	1.45					2.72	
	Phase 2		1.45	1.45					3.40	
Wild Fungi	**Phase 1**									
	Phase 2									
Meat-Beef	**Phase 1**									
	Phase 2									
Meat-Game	**Phase 1**					3.00				
	Phase 2									
Meat Poultry	**Phase 1**									
	Phase 2									
Meet-Sheep	**Phase 1**									
	Phase 2									
Meat-Pork	**Phase 1**									
	Phase 2									
Eggs	**Phase 1**				6.03	3.02			9.05	
	Phase 2				6.03	3.02				
Honey	**Phase 1**									
	Phase 2									
Milk	**Phase 1**									
	Phase 2									
Drinking Water	**Phase 1**									
	Phase 2									

Overall, individuals reported lower consumption rates for leafy green vegetables than when first surveyed, with three reporting less than half the original quantity. One individual (survey D) in the high exposure group, reported domestic fruit consumption increasing from 74.1 kg y^{-1} to 120 kg y^{-1} in the Phase 2 survey. In most cases these differences can be explained by differing answers given at the time of each survey and by differing people answering on behalf of their partners in the Phase 2 surveys which also reflects the subjectivity in such cases. Egg consumption by survey H fell from 9.05 kg y^{-1} in the initial survey to zero with the individual stating he had no hens at the time of Phase 2 survey.

8.3 Internal Aquatic

Comparison data are compiled in Table 8.2. Most individuals reported similar quantities of aquatic foodstuff consumption in both surveys with the exceptions of crustacean and molluscs.

Table 8.2. Internal aquatic comparison data

	Survey ID	A	B	C	D	E	F	G	H	I
Food Group	**Exposure Group:**	**Low**	**High**	**Med**	**High**	**High**	**Med**	**Low**	**Low**	**Med**
Fish	**Phase 1**				3.50		112	2.00		
	Phase 2				4.50		116	2.00		11.0
Crustaceans	**Phase 1**							3.00		25.0
	Phase 2							3.00		7.00
Molluscs	**Phase 1**						45.4			
	Phase 2						22			
Wild Fowl	**Phase 1**									
	Phase 2									

Changes in crustacean consumption (survey I) can be attributed to clarification of answers given at the time of each survey. Mollusc consumption also fell by the single individual identified when re-surveyed. The higher figure was confirmed with the individual by telephone soon after the Phase 1 survey but then lower quantities confirmed in the Phase 2 survey. No wildfowl were consumed by any person in the Phase 2 surveys.

8.4 External Intertidal

Of the seven individuals reporting intertidal activities, five recorded similar occupancies in both surveys (Table 8.3) with the highest occupancy associated with shore based fishing from Torness spillway. The other two individuals reported a change in occupancy times in the Phase 2 survey related to changes in their activities.

One individual from the low exposure group (survey D) initially reported walking their dog for three hours per week (total annual occupancy of 156 h y^{-1}) but then stated in the Phase 2 survey spending 1 hour daily (365 h y^{-1}).

Table 8.3. Intertidal occupancy, handling of equipment and sediment comparison data

	Survey ID	A	B	C	D	E	F	G	H	I
	Exposure Group:	Low	High	Med	High	High	Med	Low	Low	Med
ALL Intertidal	Phase 1		196	40.0	168	48.0	1 566		156	608
	Phase 2		196	40.0	580	61.0	1 572		365	672
Occupancy ON Water	Phase 1	486		30.0				1 460		
	Phase 2	482		30.0			36.0	845		24.0
Handling Equipment	Phase 1	25.0		33.0	104		1 560	1 460		108
	Phase 2	25.0		33.0	104		1 608	845		384
Handling Sediment	Phase 1		40.0	40.0	24.0	48.0	6.00		156	500
	Phase 2		40.0	40.0	554	61.0	12.0		365	312

The other individual (survey D) reported collecting seaweed in the summer (6 h y^{-1}) and fishing (104 h y^{-1}) in the Phase 1 survey but stated, in the Phase 2 survey, they also walked their dog for 1.5 hours daily in the intertidal zone explaining the large increase in the occupancy times (574 h y^{-1}).

8.5 Handling Equipment

Of the nine people re-surveyed in Phase 2, six individuals initially stated they engaged in activities which involved handling equipment (Table 8.3).

Of these, four reported similar occupancy times in the Phase 2 survey. Of the other two individuals, one individual (survey G) recorded a decrease in the length of time they conducted commercial fishing activities. In the initial survey they reported fishing daily for six months of the year (1 095 h y^{-1}) and only 10 weeks in the Phase 2 survey (480 h y^{-1}). It was confirmed with the individual that since the Phase 1 interview they had greatly reduced the amount of time they spent fishing. Another individual (survey I) reported an increase in the length of time they were handling creels from 108 h y^{-1} to 324 h y^{-1}.

8.6 Handling Sediment

Seven individuals reported activities in the Phase 2 surveys that involved handling sediment (Table 8.3). Of these, five recorded changes in occupancy times associated with activities with two reporting the similar occupancy times. The largest difference was an increase in occupancy time in the intertidal zone whereby survey D initially stated they only walked their dog in the terrestrial zone but then reported dog walking in both terrestrial and intertidal zones in the Phase 2 survey. Changes by survey H are

attributed to with an increase in the frequency of dog walking in the intertidal zone from a weekly to daily event. Differences in the number of times survey F reported they collected mussels and winkles explain the increase in these activities in the Phase 2 survey. The reduction in handling sediment by survey I was due to a significant decline in the length of time they spent beachcombing, falling from 500 h y^{-1} to 156 h y^{-1}. However, they did report dog walking in the intertidal zone as an additional activity (156 h y^{-1}).

8.7 Occupancy on and in the water

Two individuals reported new activities on the water in the Phase 2 surveys (Table 8.3). Survey F stated they went sea angling from a boat off shore at Eyemouth for 36 h y^{-1} whilst survey I reported fishing off St Abbs head during the summer for 24 h y^{-1}.

Survey G reported a large decrease in occupancy on water in the Phase 2 survey from 1 460 h y^{-1} to 845 h y^{-1}. This was due to a reduction in the hours spent creel fishing from the Phase 1 survey to the Phase 2 survey. No one reported any activities in the water in the Phase 2 surveys.

8.8 Living and working within 1km

Most individuals living within 1km of the Torness power station, reported no differences (Table 8.4) in occupancy times either indoors or outdoors with only one person reporting a slight fall in overall residency times.

Table 8.4. Occupancy comparisons within 1km of site

	Survey ID	A	B	C	D	E	F	G	H	I
	Exposure Group:	Low	High	Med	High	High	Med	Low	Low	Med
Living Within 1 km	Phase 1		5 021	2 506	2 696	6 935				
Indoors	Phase 2		5 021	2 506	2 696	6 802				
Living Within 1 km	Phase 1		2 148	1 074	3 370	1 460				
Outdoors	Phase 2		2 148	1 074	3 370	1 432				
Working Within 1 km	Phase 1			2 295						
Indoors	Phase 2			2 295						
Working Within 1 km	Phase 1			765						
Outdoors	Phase 2			765						

The only individual who stated they worked within 1km of the site reported no change in occupancy times.

9 Comparisons with the Previous Survey

9.1 Introduction

The results for the 2016 survey have been reported in chapters 4, 5 and 6 for both the postal survey and the face-to-face survey and can be compared with results from the previous habits survey, undertaken in Torness in 2011 by the Centre for Environment Fisheries and Aquaculture Science (CEFAS). The 2016 habits survey undertook pre-survey fieldwork which included a postal survey. The aquatic and terrestrial face-to-face survey area in the 2016 survey extended (for the aquatic survey) from North Berwick to Eyemouth and (for the terrestrial survey) the area 5 km radius from the Torness site. This is consistent with the 2011 survey undertaken by CEFAS. The postal survey area was a 25 km radius from the site.

9.2 Aquatic Survey

9.2.1 Phase 1 - Adult Consumption Rates – Internal Exposure

In 2016 the mean consumption rate for the adult high-rate group in the face-to-face interviews substantially increased for fish, crustaceans, molluscs, seaweed and wildfowl compared with 2011. In 2011 and 2016 the main species of fish consumed by adults in the high-rate group were cod, mackerel and bass. In 2011 and 2016 the main crustacean species consumed by adults in the high-rate group were the common lobster and brown crab. In 2011 the only species of molluscs consumed were winkles compared to mussels, winkles and razor clams in 2016. In 2011 the species of wildfowl consumed by the adult high-rate group were unidentified species of duck and goose. In 2016 the species of wildfowl consumed were mallard, pink-footed goose, teal, wigeon and grey lag goose. In 2011 samphire was consumed compared to no consumption of samphire in 2016. Seaweed was found to be consumed in 2016 though this was not identified in 2011.

A comparison between 2011 and 2016 adult consumption rates of aquatic foods in the face-to-face interviews is presented in Table 9.1. The table also provides the mean consumption rates from national data (Smith and Jones, 2003) for comparison. Refer to Section 5.9.1 for further details.

Table 9.1 Comparison between 2011 and 2016 adult consumption rates of aquatic foods.

NI – Not Identified

ND – Not Determined

Food Group	2011			2016			National
	Number of people in the high-rate group	Maximum consumption rate (kg y^{-1})	Mean consumption rate (kg y^{-1})	Number of people in the high-rate group	Maximum consumption rate (kg y^{-1})	Mean consumption rate (kg y^{-1})	Mean (kg y^{-1})
Fish	18	56.1	33.2	11	208	101	15
Crustaceans	13	18.3	10.0	12	47.5	28.8	4
Molluscs	1	11.6	11.6	2	45.4	34.7	4
Wildfowl	5	1.6	1.6	1	116	116	ND
Seaweed	NI	NI	NI	4	0.5	0.5	ND

9.2.2 Phase 1 - Children and Infants' Consumption Rates – Internal exposure

A comparison between 2011 and 2016 children and infants consumption rates of aquatic foods in the face-to-face interviews is presented in Table 9.2.

In 2016 child fish consumption increased compared to 2011. The consumption of crustaceans decreased in 2016 compared to 2011. Consumption of wildfowl was identified in 2016 and the species of wildfowl consumed were mallard, pink-footed goose, teal, widgeon and grey lag goose. Wildfowl was not consumed in 2011. The consumption of molluscs was not identified in either 2011 or 2016.

Both fish and crustacean consumption increased for infants in 2016 compared to 2011. No infants were found to consume molluscs or wildfowl in either the 2011 or 2016 habits surveys. Refer to Section 5.8.2 for further details.

Table 9.2 Comparison between 2011 and 2016 children and infants consumption rates of aquatic foods.

NI – Not Identified

Food group	2011			2016		
	Number of people in the high-rate group	Maximum consumption rate (kg y^{-1})	Mean consumption rate (kg y^{-1})	Number of people in the high-rate group	Maximum consumption rate (kg y^{-1})	Mean consumption rate (kg y^{-1})
Child (6 - 15 years old)						
Fish	4	10.2	7.3	5	20.0	12.5
Crustaceans	1	6.9	6.9	1	1.50	1.50
Wildfowl	NI	NI	NI	4	116	116
Infant (0 - 5 years old)						
Fish	4	4.6	4.2	1	31.2	31.2
Crustaceans	2	0.7	0.6	1	2	2

9.2.3 Phase 1 – Adult Intertidal/Aquatic Occupancy – External exposure

In contrast to the 2011 survey, external exposure was divided into five distinct groups: intertidal activities, aquatic in water activities, aquatic on water activities, the handling of equipment and the handling of sediment - all of which are discussed in further detail in Section 4.12.

In 2016 the highest intertidal occupancy was 1 829 h y^{-1}. There is no comparison in 2011. The highest occupancy on water for an adult was 5 864 h y^{-1} in 2016 which increased from 2 300 h y^{-1} in 2011. The highest occupancy in the water for an adult was 1 372 h y^{-1} in 2016 which increased from 940 h y^{-1} in 2011.

Mean occupancy rates and 97.5th percentile rates were determined in 2016 but there are no comparisons for these with the 2011 data.

9.2.4 Phase 1 – Children and Infants Intertidal/Aquatic Occupancy – External Exposure

As with the adult intertidal/aquatic occupancy, in contrast to the 2011 survey external exposure was divided into five distinct groups: intertidal activities, aquatic in water activities, aquatic on water activities, the handling of equipment and the handling of sediment - all of which are discussed in further detail in Section 4.12.

In 2016 the intertidal occupancy for children and infants was determined. The intertidal occupancy was highest 811 h y^{-1} for a child and 313.6 h y^{-1} for an infant. There is no comparison with the 2011 survey.

The highest occupancy on the water for a child and infant was 547.5 h y^{-1} and 65 h y^{-1} respectively. This increased from 160 h y^{-1} for children and decreased from 160 h y^{-1} for infants in 2011.

The highest occupancy in the water for a child and infant was 228.1 h y^{-1} (for both age groups). This increased from 52 h y^{-1} for children in 2011. There is no comparison for infants as no infants were identified in 2011 spending time in the water.

Mean occupancy rates and 97.5th percentile rates were determined in 2016 but there are no comparisons for these with the 2011 data.

9.2.5 Phase 1 – Handling Equipment and Handling Sediment

In 2011, the mean rate for the adult high-rate group for handling fishing gear is observed to be substantially lower than 2016. Handling fishing gear, however, is a sub-category of the handling of equipment in 2016 which may account for the increase. These figures were checked and confirmed with the individual. The mean rate for the adult high-rate group for handling sediment increased slightly in 2016 compared to 2011 (Table 9.3).

Table 9.3 Comparison of the 2011 and 2016 handling equipment and handling sediment exposure pathways for adults.

Activity	2011			2016		
	Number of people in the high-rate group	Observed maximum for the rate group (h y^{-1})	Observed mean for the high-rate group (h y^{-1})	Number of people in the high-rate group	Observed maximum for the rate group (h y^{-1})	Observed mean for the high-rate group (h y^{-1})
Handling equipment	17	2 250	1 452	3	5 960	3 945
Handling sediment	6	1 092	695	14	1 829	1 061.3

Two children were found to handle equipment in 2016 compared to no children in 2011. No infants were found to handle equipment in 2011 or 2016. Handling of sediment was determined with children and infants during exposure through intertidal activities – which is discussed and presented in further detail in Section 5.10. There is no comparison with the 2011 survey.

9.3 Terrestrial Survey

9.3.1 Phase 1 - Adult Consumption Rates – Internal Exposure

Consumption rates of locally produced food items has increased in the 2016 survey in comparison to 2011 the following food groups: vegetables (green), vegetables (potatoes), fruit (domestic), fruit (wild), fungi (wild), beef, game, poultry, eggs and honey. The large increase in fruit (wild) in the 2016 survey may be attributed to the individual reporting they had not taken part in the previous habits survey in 2011.

Consumption rates decreased in the 2016 survey in comparison to 2011 in the following food groups: vegetables (other), vegetable (root) and sheep.

A comparison between the 2011 and 2016 mean consumption rates for adult consumption of the terrestrial food groups is presented in Table 9.4.

No consumption of locally produced milk (cow, sheep or goat) and water was identified in 2011 or 2016.

Table 9.4 Comparison between 2011 and 2016 mean consumption rates of local terrestrial food groups for adults (kg y^{-1} or l y^{-1}).
NC – Not Consumed

Food group	2011 Mean consumption rate for the high-rate group (kg y^{-1} or l y^{-1})	2016 Mean consumption rate for the high-rate group (kg y^{-1} or l y^{-1})
Vegetables – Green	14.7	24.1
Vegetables – Other	26.2	5.08
Vegetables – Root	25.8	23.5
Vegetables - Potatoes	78.8	84
Fruit - Domestic	41.2	72.9
Fruit - Wild	3.4	93.2
Fungi - Wild	1.8	4
Meat – Beef	19.9	47
Game – Rabbit and hare	1.7	13
Game - Birds	NC	11.6
Game - Venison	6.3	26
Meat - Poultry	6.8	9
Meat – Sheep	9.4	4.5
Eggs	9.4	14.8
Honey	4.3	4.5

9.3.2 Phase 1 – Children and infants consumption rates - Internal exposure

Children were found to consume fruit (wild and domestic), game, poultry and eggs in 2016. There is no comparison with 2011 as there was no consumption was identified.

No infants in 2011 or 2016 were found to consume terrestrial foods.

9.4 Direct Radiation Survey

The time spent indoors and outdoors of their home and for those who work and spend time indoors and outdoors within 1 km of the Torness site was determined. Table 9.5 presents the comparisons between the 2011 and 2016 survey occupancy rates within the direct radiation survey area (h y^{-1}).

Table 9.5. Comparison between 2011 and 2016 occupancy rates for people living and working within the direct radiation area (h y^{-1}).

	2011	**2016**
Highest total	8 604	8 395
Highest indoor at home	8 500	6 935
Highest outdoor at home	1 840	3 370
Highest indoor at work	-	2 295
Highest outdoor at work	-	2 240

In 2016 the highest total occupancy decreased from 2011.

In 2016 the highest indoor occupancy decreased from 2011.

In 2016 the highest outdoor occupancy increased from 2011.

There is no comparison for individuals working within 1 km of the Torness site.

10 Dose Assessment

10.1 Dose Assessment for Phase 1 Survey

10.1.1 Aquatic radiation pathways

The retrospective dose arising from internal exposure (via food sources from the aquatic environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 8.6E-3 mSv y^{-1}. The dose to the representative person (97.5%) is 8.4E-3 mSv y^{-1}. In the case of the most exposed person the dose arises from the consumption of locally obtained fish (110 kg y^{-1}) and crustaceans (47.5 kg y^{-1}).

The retrospective dose arising from external exposure (via people's habit activities in and on the aquatic environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 6.44E-3 mSv y^{-1}. The dose to the representative person (97.5%) is 6.28E-3 mSv y^{-1}. In the case of the most exposed person the dose arises from the handling of fishing gear (5 960 h y^{-1}).

10.1.2 Terrestrial radiation pathways

The retrospective dose arising from internal exposure (via food sources from the terrestrial environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 7.6E-3 mSv y^{-1}. The dose to the representative person (97.5%) is 7.41E-3 mSv y^{-1}. In the case of the most exposed person the dose arises from the consumption of green leafy vegetables (38 kg y^{-1}), root vegetables (39 kg y^{-1}), potato (19 kg y^{-1}), fruit (133 kg y^{-1}), wild foods (93 kg y^{-1}), game (venison (26 kg y^{-1}), game birds (6 kg y^{-1}), wildfowl (1.75 kg y^{-1}), rabbits and hares (13 kg y^{-1})) and wild fungi (4 kg y^{-1}).

The retrospective dose arising from external exposure (via people's habit activities in the terrestrial environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 9.86E-3 mSv y^{-1}. The dose to the representative person (97.5%) is 9.62E-3 mSv y^{-1}. The most exposed person's external terrestrial dose was dominated from direct shine (7.4 h y^{-1}).

10.1.3 Overall combined radiation exposure for Phase 1 survey

The retrospective dose arising from all exposure pathways (e.g. via people's habit activities in and on the aquatic, intertidal or terrestrial environments and the consumption of all foodstuffs derived locally from the aquatic or terrestrial environments) has been used to determine the representative person. The dose rate to the most exposed person from all exposure pathways is 1.21 E-2 mSv y^{-1}. The retrospective dose to the representative person (97.5%) is 1.18E-2 mSv y^{-1}. In the case of the most exposed person, the dose was dominated by the direct shine (7.4 h y^{-1}) but they also consume green leafy vegetables (44.7 kg y^{-1}), other vegetables (2.75 kg y^{-1}), root vegetables (18 kg y^{-1}), fruit (74 kg y^{-1}) and eggs (6 kg y^{-1}). These doses are all very small in comparison with the 1 mSv public dose limit.

Table 10.1 contains some summarised dose information based on the average doses to different people based on age profile.

All the activity concentrations and the external doses were input into a spreadsheet dose assessment tool that summarised the dose based on the habits data for each person. It should be noted that while the individual dose calculations are based on the habits information collected during the surveys, the way the data have been used and the assumptions made mean that the doses are calculated to a stylised person. Similarly, the internal doses were estimated by multiplying the individual habit consumption rates by the activity concentrations in the food type as measured within the RIFE programme (see Environment Agency *et al,* 2015).

Table 10.1 Average dose estimates (mSv y^{-1}) to stylised people averaged by age (Phase 1).

Age Category	Dose (mSv y^{-1})
Infant	3.46E-4
Child	5.01E-4
Adult	1.35E-3
Any	8.55E-4

10.2 Dose Assessment for Phase 2 Survey

The Phase 2 surveys were undertaken in the winter of 2016 and were re-analysed to determine the dose from each radiation exposure pathway using the same approach and data groups as for the Phase 1 survey to allow comparisons to be drawn between the two survey periods. The results are described below.

10.2.1 Aquatic radiation pathways

The retrospective dose arising from internal exposure (via food sources from the aquatic environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 1.4E-3 mSv y^{-1}. The dose to the representative person (97.5%) is 1.36E-3 mSv y^{-1}. In the case of the most exposed person, the dose arises from the consumption of locally obtained fish (116 kg y^{-1}).

The retrospective dose arising from external exposure (via people's habit activities in and on the aquatic environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 1.76E-3 mSv y^{-1}. The dose to the representative person (97.5%) is 1.72E-3 mSv y^{-1}. In the case of the most exposed person, the dose arises from the handling of sediment and fishing gear (12 and 1 608 h y^{-1} respectively).

10.2.2 Terrestrial radiation pathways

The retrospective dose arising from internal exposure (via food sources from the terrestrial environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 2.42E-3 mSv y^{-1}. The dose to the representative person (97.5%) is 2.36E-3 mSv y^{-1}. In the case of the most exposed person, the dose arises from the consumption of green leafy vegetables (36 kg y^{-1}), root vegetables (11 kg y^{-1}), other vegetables (2.8 kg y^{-1}), domestic fruit (121 kg y^{-1}), eggs (6 kg y^{-1}) and venison (3 kg y^{-1}).

The retrospective dose arising from external exposure (via people's habit activities in the terrestrial environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure

pathway is 9.96E-3 mSv y^{-1}. The dose to the representative person (97.5%) is 9.71E-3 mSv y^{-1}. The most exposed person's external terrestrial dose was dominated by direct shine from the site.

10.2.3 Overall combined radiation exposure for Phase 2 survey

The retrospective dose arising from all exposure pathways (e.g. via people's habit activities in and on the aquatic, intertidal or terrestrial environments, direct shine and the consumption of all foodstuffs derived locally from the aquatic or terrestrial environments) has been used to determine the representative person. The dose rate to the most exposed person from all exposure pathways is 1.38E-2 mSv y^{-1}. The retrospective dose to the representative person (97.5%) is 1.34E-2 mSv y^{-1}. In the case of the most exposed person, the dose arises from the consumption of green leafy vegetables (36 kg y^{-1}), root vegetables (11 kg y^{-1}), other vegetables (2.8 kg y^{-1}), domestic fruit (121 kg y^{-1}), eggs (6 kg y^{-1}, venison (3 kg y^{-1}), handling sediment (553 h y^{-1}), handling fishing gear (26 h y^{-1}) and direct shine from the site.

These doses are all very small in comparison with the 1 mSv public dose limit.

10.2.4 Dose comparison of the Phase 1 and Phase 2 survey

The doses calculated for the different exposure pathways from data in the Phase 1 (during May and August) and Phase 2 (during November) surveys are provided in Table 10.2. For pathways except external terrestrial and the total from all pathways, the doses for the Phase 1 survey are higher than or the same order of magnitude as those for Phase 2. The external terrestrial and the total pathways in the Phase 2 survey are slightly higher than the Phase 1 survey but within the same order of magnitude. All doses are still well within the 1 mSv public dose limit.

Table 10.2 Comparison of doses calculated from the Phase 1 (May and August) and Phase 2 (November) survey data

	Phase 1 survey		Phase 2 survey	
Pathway	**Maximum dose mSv y^{-1}**	**97.5 percentile dose mSv y^{-1}**	**Maximum dose mSv y^{-1}**	**97.5 percentile dose mSv y^{-1}**
Internal Aquatic	8.6E-3	8.4E-3	1.4E-3	1.36E-3
External Aquatic	6.44E-3	6.28E-3	1.76E-3	1.72E-3
Internal Terrestrial	7.6E-3	7.41E-3	2.42E-3	2.36E-3
External Terrestrial	9.86E-3	9.62E-3	9.96E-3	9.71E-3
All pathways	1.21E-2	1.18E-2	1.38E-2	1.34E-2

The Phase 2 surveys provide significant added value in either validating or refining dose estimates attributable to more extreme habits and any changes in the individual's habits following the initial survey.

11 Recommendations and Suggestions for Monitoring Programme Changes.

11.1 Introduction

The Habits Survey presents results for occupancy, activity and food consumption from three main sources of community engagement: (i) Postal questionnaire (n = 83); (ii) face-to-face surveys (n = 375); and (iii) a number of meetings and informal contacts. These data have been supplemented with radiometric surveys including: (i) a car-borne gamma spectrometry survey (n = 20 335) and back-pack (n = 16 448) were performed within the survey area; (ii) *in situ* gamma dose rate (n = 41 intertidal; n = 16 inland); (iii) additional produce sampling with laboratory based gamma spectrometry (n = 10); and (iv) Beta skin dose assessments (n = 28).

11.2 Ongoing Monitoring

The RIFE report demonstrates a comprehensive set of monitoring undertaken annually around the Torness site encompassing a range of food types and environmental substrates. The gamma dose rates reported by RIFE are generally higher than those reported here because the RIFE data include the cosmic contribution to dose. This assessment reports the terrestrial gamma dose rate only. When taking this into account, the results are similar. Terrestrial food samples taken and reported in the RIFE/SEPA Report 2014 (published 2015:pp141-2) covered milk, apples, cabbages, beef, carrots, cauliflower, geese, honey, leeks, rosehips, potatoes and wheat. The RIFE report additionally provided grass and soil radiation concentration as well as data on seafood taken in the area.

11.3 Conclusions and Recommendations

Of all the pathways identified and considered, the highest retrospective dose for all exposure pathways was 1.21E-2 mSv y^{-1} from the Phase 1 survey data. The highest retrospective dose for all exposure pathways from the Phase 2 survey data was fractionally higher at 1.38E-2 mSv y^{-1}. The doses from the Phase 2 survey were generally fractionally higher than those from the Phase 1 survey.

For the Phase 1 survey, the highest dose from internal exposure associated with the terrestrial food pathway was 7.6E-3 mSv y^{-1} arising from the consumption of green leafy vegetables, root vegetables, potato, fruit, wild foods, game (venison, game birds, wildfowl, rabbits and hares) and wild fungi. The highest dose from external exposure was from doses received by people spending time in direct shine from the site (9.9E-3 mSv y^{-1}). The highest dose from internal exposure associated with the aquatic food pathway was 8.6E-3 mSv y^{-1} arising from the consumption of fish and crustaceans. The highest dose from external exposure in the aquatic environment was from doses received by people handling fishing gear (6.4E-3 mSv y^{-1}).

These are very small compared with the 1 mSv annual public dose limit.

In future surveys, consideration could be given to the following areas:

(i) The sampling of milk could be removed due to there being no dairy farms identified or locally produced milk consumption within the terrestrial survey area (as previously noted in the 2011 survey).

(ii) Consideration should be given to sampling mussels at Torness spillway annually within the routine monitoring programme due to the identification of mussels being collected and consumed at this area and within 10 km of the power station.

(iii) It was identified that lobsters landed at Seacliff and North Berwick are sold to a local restaurant in North Berwick and it is suggested to undertake a one off sample of lobster in addition to samples already being obtained at Torness during the routine monitoring programme.

(iv) It is suggested that apples be sampled annually within the routine monitoring programme at Crowhill and/or Thorntonloch as it was noted during the survey that high quantities of apples were consumed and exchanged at Thistly Cross Cider near Dunbar (500 kg of apples being exchanged by one individual). It may also be prudent to sample the apples grown in the Thistly Cross Cider orchard.

(v) Consideration should be given to sampling elderflower and elderberry around Torness Power Station and Crowhill instead of rosehips as the latter was not identified during the survey, as previously noted in the 2011 survey.

(vi) Consideration should be given to sampling sloe berries at Thorntonloch as they were identified to be the most highly consumed fruit after blackberries and elderflower.

(vii) It is suggested that the marine waste from the Torness site consisting of jellyfish and seaweed, which is composted and sold, be sampled annually.

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Appendices

Appendix A1 Raw Data

Table 1. Adult fish consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
278	Bass	0.66
133	Bass	1
151	Bass	6.5
152	Bass	6.5
180	Bass	5.2
181	Bass	18
226	Bass	1.5
127	Bass	3
264	Bass	0.2
280	Bass	0.66
279	Bass	0.66
299	Bass	1.6
353	Bass	0.25
369	Bass	20.0
376	Bass	59
3	Bass	1
263	Bass	0.2
59	Bass	5
342	Bass	0.25
124	Bass	35
4	Bass	1
9	Bass	1.5
58	Bass	2.5
60	Bass	3
78	Bass	2
81	Bass	2
122	Bass	35
95	Bass	104
104	Bass	4.5
107	Bass	0.4
119	Bass	0.8
121	Bass	35
90	Bass	26
123	Bass	35

Unique ID	Food type	Consumption rate (kg y^{-1})
185	Cod	46.8
184	Cod	6
183	Cod	57.6
182	Cod	60
177	Cod	61.2
176	Cod	15
152	Cod	8
156	Cod	5
226	Cod	1.5
371	Cod	12
151	Cod	8
162	Cod	2.4
272	Cod	1.25
278	Cod	1
279	Cod	1
280	Cod	1
350	Cod	2.2
351	Cod	2.2
356	Cod	1.2
366	Cod	21.6
376	Cod	22
138	Cod	1.25
85	Cod	3
358	Cod	1.2
34	Cod	4
1	Cod	36
2	Cod	36
9	Cod	1
23	Cod	7
95	Cod	104
33	Cod	4
124	Cod	10
36	Cod	4
40	Cod	2
41	Cod	2
66	Cod	0.75
116	Cod	4
24	Cod	7
84	Cod	3

Unique ID	Food type	Consumption rate (kg y^{-1})
122	Cod	10
119	Cod	15
107	Cod	0.4
99	Cod	34.3
97	Cod	31.2
93	Cod	12
123	Cod	10
121	Cod	10
46	Kipper (herring)	3
32	Mackerel	0.25
40	Mackerel	10
36	Mackerel	6
34	Mackerel	6
33	Mackerel	6
31	Mackerel	0.25
30	Mackerel	0.25
9	Mackerel	1
5	Mackerel	2
3	Mackerel	1.5
46	Mackerel	1
50	Mackerel	2
4	Mackerel	1.5
262	Mackerel	2
155	Mackerel	2.4
156	Mackerel	1.5
165	Mackerel	3.3
166	Mackerel	1.35
167	Mackerel	8
176	Mackerel	0.2
177	Mackerel	2.4
182	Mackerel	50
186	Mackerel	12
188	Mackerel	0.4
226	Mackerel	13
154	Mackerel	0.25
253	Mackerel	18.2
351	Mackerel	11
272	Mackerel	3.5
299	Mackerel	17.5

Unique ID	Food type	Consumption rate (kg y^{-1})
350	Mackerel	11
342	Mackerel	0.7
41	Mackerel	10
356	Mackerel	6
358	Mackerel	6
359	Mackerel	3.6
367	Mackerel	12.3
371	Mackerel	12
376	Mackerel	17
252	Mackerel	18.2
84	Mackerel	1.5
353	Mackerel	0.7
153	Mackerel	0.25
51	Mackerel	2
58	Mackerel	1
60	Mackerel	3
66	Mackerel	1
74	Mackerel	0.1
81	Mackerel	2
85	Mackerel	1.5
90	Mackerel	26
97	Mackerel	31.2
99	Mackerel	15.6
107	Mackerel	1
124	Mackerel	25
141	Mackerel	1
78	Mackerel	2
112	Mackerel	2
133	Mackerel	1.5
138	Mackerel	0.5
127	Mackerel	1
134	Mackerel	0.2
123	Mackerel	25
122	Mackerel	25
121	Mackerel	25
119	Mackerel	1
115	Mackerel	4
130	Mackerel	2.5
151	Pollock	2

Unique ID	Food type	Consumption rate (kg y^{-1})
130	Pollock	1
124	Pollock	9
152	Pollock	2
278	Pollock	1
279	Pollock	1
280	Pollock	1
299	Pollock	4
342	Pollock	0.5
367	Pollock	8.86
123	Pollock	9
78	Pollock	2.5
376	Pollock	13.6
353	Pollock	0.5
121	Pollock	9
115	Pollock	2
99	Pollock	31.2
97	Pollock	31.2
93	Pollock	12
81	Pollock	2.5
60	Pollock	1
41	Pollock	1
40	Pollock	1
30	Pollock	1
9	Pollock	0.3
122	Pollock	9
83	Pollock	24
97	Salmon	31.2
226	Salmon	6
119	Salmon	1.2
99	Salmon	15.6
112	Dogfish	1
1	Haddock	36
2	Haddock	36
138	Haddock	12.5
240	Haddock	1.2
269	Haddock	5.2
84	Plaice	1
85	Plaice	1
272	Plaice	1.25

Table 2. Adult crustacean consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
226	Brown crab	3
165	Brown crab	3.24
167	Brown crab	6
171	Brown crab	25
179	Brown crab	26
182	Brown crab	21.6
183	Brown crab	36
156	Brown crab	4.8
188	Brown crab	1.5
166	Brown crab	0.6
252	Brown crab	1.5
253	Brown crab	1.5
262	Brown crab	3
272	Brown crab	2.25
370	Brown crab	6.5
3	Brown crab	1.2
186	Brown crab	0.25
107	Brown crab	1
4	Brown crab	1.2
53	Brown crab	0.5
54	Brown crab	0.5
84	Brown crab	5
85	Brown crab	5
168	Brown crab	9
94	Brown crab	2
134	Brown crab	0.2
117	Brown crab	0.4
118	Brown crab	0.4
119	Brown crab	12
121	Brown crab	8
122	Brown crab	8
123	Brown crab	8
124	Brown crab	8
133	Brown crab	3
93	Brown crab	12
40	Common lobster	1
41	Common lobster	1
1	Common lobster	0.5

Unique ID	Food type	Consumption rate (kg y^{-1})
2	Common lobster	0.5
3	Common lobster	3
4	Common lobster	0.25
5	Common lobster	1
183	Common lobster	0.5
151	Common lobster	9
153	Common lobster	0.25
9	Common lobster	2
166	Common lobster	2.5
167	Common lobster	13.2
168	Common lobster	1
133	Common lobster	0.5
182	Common lobster	25.92
152	Common lobster	9
186	Common lobster	0.2
188	Common lobster	0.5
191	Common lobster	1.1
299	Common lobster	3.6
363	Common lobster	1.2
370	Common lobster	10.9
177	Common lobster	2
94	Common lobster	3
53	Common lobster	1
54	Common lobster	1
84	Common lobster	10
85	Common lobster	10
154	Common lobster	0.25
94	Common lobster	2
127	Common lobster	2.4
97	Common lobster	4
123	Common lobster	20
93	Common lobster	12
124	Common lobster	20
99	Common lobster	0.66
122	Common lobster	20
121	Common lobster	20
119	Common lobster	0.8
118	Common lobster	0.2
117	Common lobster	0.2

Unique ID	Food type	Consumption rate (kg y^{-1})
93	Prawns (langoustines)	12
94	Prawns (langoustines)	1
95	Prawns (langoustines)	26
299	Prawns (langoustines)	2
46	Prawns (langoustines)	0.5
156	squat lobster	6
226	Velvet crab	3

Table 3. Adult mollusc consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
376	Mussels	22.7
299	Mussels	2
133	Mussels	0.3
124	Mussels	0.2
123	Mussels	0.2
122	Mussels	0.2
121	Mussels	0.2
119	Mussels	2
90	Mussels	24
299	Razor clams	0.15
376	Winkles	22.7
133	Winkles	0.3
131	Winkles	0.1

Table 4. Adult wildfowl consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
41	Mallard	1.5
263	Mallard	1
264	Mallard	1
369	Mallard	39.6
40	Mallard	1.5
369	Pink-Footed Goose	48
263	Pink-Footed Goose	0.4
264	Pink-Footed Goose	0.4
41	Teal	0.25
263	Teal	0.4
264	Teal	0.4

Unique ID	Food type	Consumption rate (kg y^{-1})
369	Teal	3.96
40	Teal	0.25
263	Widgeon	1
264	Widgeon	1
369	Widgeon	24
264	Greylag goose	1
263	Greylag goose	1

Table 5. Child fish consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
80	Bass	2
81	Bass	2
265	Bass	0.2
266	Bass	0.2
267	Bass	0.2
281	Bass	0.66
282	Bass	0.66
283	Bass	0.66
375	Bass	20.04
79	Bass	2
283	Cod	1
37	Cod	4
38	Cod	3
39	Cod	3
282	Cod	1
281	Cod	1
37	Mackerel	6
38	Mackerel	4
39	Mackerel	4
79	Mackerel	2
80	Mackerel	2
81	Mackerel	2
135	Mackerel	0.2
254	Mackerel	18.2
283	Pollock	1
79	Pollock	2.5
80	Pollock	2.5
81	Pollock	2.5
281	Pollock	1

Unique ID	Food type	Consumption rate (kg y^{-1})
282	Pollock	1

Table 6. Child crustacean consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
254	Brown crab	1.5
135	Brown crab	0.2

Table 7. Child wildfowl consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
266	Mallard	1
267	Mallard	1
375	Mallard	39.6
265	Mallard	1
265	Pink-Footed Goose	0.4
266	Pink-Footed Goose	0.4
267	Pink-Footed Goose	0.4
375	Pink-Footed Goose	48
267	Teal	0.4
266	Teal	0.4
375	Teal	3.96
265	Teal	0.4
265	Widgeon	1
266	Widgeon	1
267	Widgeon	1
375	Widgeon	24
267	Greylag goose	1
265	Greylag goose	1
266	Greylag goose	1

Table 8. Infant fish consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
357	Cod	1.2
352	Cod	0.1
98	Cod	7.81
35	Cod	2

Unique ID	Food type	Consumption rate (kg y^{-1})
357	Mackerel	6
352	Mackerel	0.25
98	Mackerel	7.81
35	Mackerel	4
98	Pollock	7.81
98	Salmon	7.81
270	Haddock	2.6

Table 9. Infant crustacean consumption rate from aquatic survey area

Unique ID	Food type	Consumption rate (kg y^{-1})
98	Common lobster	2

Table 10. Adult intertidal occupancy rates from aquatic survey area

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
66	Bait digging	12
120	Bait digging	26
356	Bait digging	24
166	Beachcombing	2
269	Beachcombing	105
257	Beachcombing	130
228	Beachcombing	26
227	Beachcombing	26
204	Beachcombing	7
192	Beachcombing	25
180	Beachcombing	52
179	Beachcombing	18
175	Beachcombing	78
173	Beachcombing	144
323	Beachcombing	2
171	Beachcombing	500
169	Beachcombing	5
163	Beachcombing	5
159	Beachcombing	4.9
158	Beachcombing	91.3
95	Beachcombing	117
71	Beachcombing	4
70	Beachcombing	4

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
51	Beachcombing	104
50	Beachcombing	52
9	Beachcombing	156
5	Beachcombing	156
172	Beachcombing	100
162	Beachcombing	180
356	Beachcombing	41.8
359	Beachcombing	1.5
23	Boat maintenance	16
6	Boat maintenance	6
226	Collecting mussels	0.25
376	Collecting mussels	3
299	Collecting mussels	2
90	Collecting mussels	12
138	Collecting mussels	10
299	Collecting razor clams	2
152	Collecting seaweed	0.1
132	Collecting seaweed	48
58	Collecting seaweed	24
301	Collecting seaweed	10.5
302	Collecting seaweed	10.5
9	Collecting seaweed	3
134	Collecting seaweed	4
2	Collecting winkles	208
1	Collecting winkles	208
356	Collecting winkles	23.8
365	Collecting winkles	390
376	Collecting winkles	3
226	Collecting winkles	0.25
90	Collecting winkles	730
162	Crabbing	1
159	Crabbing	24
158	Crabbing	26
176	Crabbing	15
190	Crabbing	20
10	Crabbing	3
6	Crabbing	1.5
133	Dog walking	365
134	Dog walking	1 825

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
150	Dog walking	150
143	Dog walking	40
139	Dog walking	200
138	Dog walking	360
151	Dog walking	100
179	Dog walking	144
202	Dog walking	183
201	Dog walking	1 460
355	Dog walking	23.8
186	Dog walking	365
185	Dog walking	62
184	Dog walking	30
170	Dog walking	52
181	Dog walking	48
162	Dog walking	360
175	Dog walking	21
174	Dog walking	540
173	Dog walking	365
104	Dog walking	365
172	Dog walking	365
168	Dog walking	60
167	Dog walking	50
183	Dog walking	350
21	Dog walking	40
114	Dog walking	200
371	Dog walking	183
46	Dog walking	183
41	Dog walking	156
40	Dog walking	39
34	Dog walking	104
33	Dog walking	104
26	Dog walking	365
54	Dog walking	1 095
22	Dog walking	40
57	Dog walking	124
20	Dog walking	1 095
19	Dog walking	1 095
18	Dog walking	365
14	Dog walking	365

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
13	Dog walking	365
5	Dog walking	156
4	Dog walking	547.5
3	Dog walking	547.5
25	Dog walking	365
92	Dog walking	9
128	Dog walking	104
127	Dog walking	530
118	Dog walking	90
117	Dog walking	90
116	Dog walking	120
354	Dog walking	23.76
112	Dog walking	10
152	Dog walking	100
53	Dog walking	1095
93	Dog walking	361
129	Dog walking	30
91	Dog walking	1095
89	Dog walking	208
81	Dog walking	156
78	Dog walking	156
77	Dog walking	234
74	Dog walking	52
369	Dog walking	482
65	Dog walking	10
94	Dog walking	1095
342	Dog walking	16.5
304	Dog walking	365
335	Dog walking	312
334	Dog walking	21
295	Dog walking	365
277	Dog walking	156
338	Dog walking	19.5
353	Dog walking	16.5
300	Dog walking	54
341	Dog walking	912.5
263	Dog walking	102.9
305	Dog walking	365
276	Dog walking	1095

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
278	Dog walking	234
274	Dog walking	137
299	Dog walking	548
227	Dog walking	78
190	Fixing moorings	120
6	Fixing moorings	2
171	Handling creels	100
23	Handling creels	780
6	Handling creels	60
102	Horse riding	104
296	Paddling	24
360	Paddling	3.84
173	Paddling	300
236	Paddling	34.8
237	Paddling	34.8
251	Paddling	10
25	Paddling	3.25
241	Paddling	4.29
356	Paddling	72
150	Paddling	2.6
26	Paddling	3.25
250	Paddling	10
117	Paddling	12
62	Paddling	6
118	Paddling	12
351	Paddling	5
309	Paddling	8.58
61	Paddling	6
129	Paddling	3
128	Paddling	12
165	Paddling	15
350	Paddling	5
91	Paddling	45.6
305	Paddling	2
10	Paddling	3
179	Paddling	130
9	Paddling	1.5
75	Paddling	1.5
88	Paddling	52

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
304	Paddling	2
46	Playing	78
53	Playing	8
346	Playing	9
6	Playing	4.5
284	Playing	26
62	Playing	6
287	Playing	13
351	Playing	45
313	Playing	1.32
288	Playing	13
192	Playing	25
78	Playing	312
77	Playing	312
67	Playing	104
269	Playing	105
305	Playing	2
56	Playing	8
347	Playing	9
130	Playing	3
309	Playing	8.58
61	Playing	6
81	Playing	351
207	Playing	3
304	Playing	2
128	Playing	12
54	Playing	8
187	Playing	52
296	Playing	24
237	Playing	34.8
325	Playing	6
330	Playing	8
356	Playing	72
75	Playing	3
331	Playing	8
88	Playing	365
186	Playing	51
111	Playing	18
165	Playing	20

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
108	Playing	52
324	Playing	6
111	Playing	18
236	Playing	34.8
350	Playing	45
36	Playing	104
70	Playing	4
71	Playing	4
319	Playing	12
241	Playing	4.29
165	Research/education	4
71	Rock pooling	4
75	Rock pooling	3
67	Rock pooling	104
95	Rock pooling	78
81	Rock pooling	156
296	Rock pooling	24
70	Rock pooling	4
180	Rock pooling	26
26	Rock pooling	3.25
128	Rock pooling	7
364	Rock pooling	11.9
350	Rock pooling	10
324	Rock pooling	6
237	Rock pooling	34.8
236	Rock pooling	34.8
351	Rock pooling	10
33	Rock pooling	19.5
179	Rock pooling	60
25	Rock pooling	3.25
184	Rock pooling	144
186	Rock pooling	21
190	Rock pooling	10
6	Rock pooling	4.5
346	Rock pooling	3
347	Rock pooling	3
207	Rock pooling	2
3	Rock pooling	6
325	Rock pooling	6

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
42	Rock pooling	2
129	Rock pooling	2
241	Rock pooling	4.29
34	Rock pooling	19.5
36	Rock pooling	19.5
269	Rock pooling	105
309	Rock pooling	8.58
319	Rock pooling	12
43	Rock pooling	2
263	Wildfowling	51.5
369	Wildfowling	234
49	Walking	1.5
308	Walking	4
313	Walking	8
3	Walking	156
372	Walking	65
4	Walking	36
11	Walking	52
48	Walking	2.5
12	Walking	52
47	Walking	2.5
21	Walking	156
107	Walking	25
317	Walking	104
307	Walking	4
318	Walking	104
13	Walking	156
211	Walking	15
137	Walking	18
225	Walking	6
199	Walking	2.5
200	Walking	2.5
136	Walking	24
240	Walking	26
224	Walking	6
246	Walking	26
130	Walking	5
155	Walking	200
204	Walking	7

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
105	Walking	30
142	Walking	9
244	Walking	0.5
245	Walking	0.5
208	Walking	365
209	Walking	1
210	Walking	1
108	Jogging	26
85	Litter picking	52
50	Litter picking	52
84	Litter picking	52
51	Litter picking	52
52	Litter picking	36
34	BBQ/Picnicking/Sitting	32.5
36	BBQ/Picnicking/Sitting	32.5
316	BBQ/Picnicking/Sitting	2
153	BBQ/Picnicking/Sitting	180
42	BBQ/Picnicking/Sitting	3
105	BBQ/Picnicking/Sitting	120
33	BBQ/Picnicking/Sitting	32.5
43	BBQ/Picnicking/Sitting	3
220	BBQ/Picnicking/Sitting	12
154	BBQ/Picnicking/Sitting	180
217	BBQ/Picnicking/Sitting	273
195	BBQ/Picnicking/Sitting	3
196	BBQ/Picnicking/Sitting	3
214	BBQ/Picnicking/Sitting	273
6	BBQ/Picnicking/Sitting	1.5
213	BBQ/Picnicking/Sitting	6
5	BBQ/Picnicking/Sitting	48
212	BBQ/Picnicking/Sitting	6
205	BBQ/Picnicking/Sitting	5
206	BBQ/Picnicking/Sitting	5
221	BBQ/Picnicking/Sitting	12
264	BBQ/Picnicking/Sitting	2
46	BBQ/Picnicking/Sitting	72
263	BBQ/Picnicking/Sitting	2
129	BBQ/Picnicking/Sitting	12
116	BBQ/Picnicking/Sitting	27

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
155	Beach Clean	8
179	Fishing	520
255	Fishing	416
226	Fishing	3
59	Fishing	416
60	Fishing	312
191	Fishing	26
366	Fishing	72
192	Fishing	18
177	Fishing	6
279	Fishing	60
180	Fishing	48
112	Fishing	9
66	Fishing	24
5	Fishing	4
369	Fishing	120
367	Fishing	104
94	Fishing	72
90	Fishing	234
81	Fishing	70
120	Fishing	1 800
50	Fishing	4
256	Fishing	416
141	Fishing	3
40	Fishing	54
81	Fishing	78
139	Fishing	8
263	Fishing	4.5
130	Fishing	8
249	Fishing	15
176	Fishing	20
131	Fishing	240
171	Fishing	8
58	Fishing	104
376	Fishing	1560
170	Fishing	234
167	Fishing	4
364	Fishing	624
30	Bird/Nature watching	312

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
84	Week end visit to harbour	48
85	Week end visit to harbour	48
110	Life Guard	720
108	Life Guard	720
109	Life Guard	720
165	Life Guard	50
136	Power Kiting	12
202	Other	183
218	Other	7
168	Coastguard	204
312	Preparation and deconstruction of paddle board	48
336	Camping	24
337	Camping	24
366	Metal detecting	312

Table 11. Child intertidal occupancy rates from aquatic survey area

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
72	Beachcombing	4
259	Beachcombing	130
194	Beachcombing	25
160	Beachcombing	4.9
230	Beachcombing	26
258	Beachcombing	130
229	Beachcombing	26
160	Crabbing	2
275	Dog walking	45.6
145	Dog walking	75
82	Dog walking	156
79	Dog walking	156
80	Dog walking	156
140	Dog walking	20
306	Horse riding	6
215	Paddling	78
197	Paddling	0.1
243	Paddling	4.29

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
306	Paddling	2
219	Paddling	1
198	Paddling	0.1
216	Paddling	78
145	Paddling	15
242	Paddling	4.29
222	Paddling	1.5
223	Paddling	1.5
239	Paddling	34.8
343	Paddling	20
238	Paddling	34.8
29	Paddling	3.25
28	Paddling	3.25
27	Paddling	3.25
219	Playing	6
223	Playing	10.5
222	Playing	10.5
349	Playing	9
216	Playing	78
215	Playing	78
198	Playing	1
194	Playing	25
82	Playing	351
80	Playing	351
79	Playing	351
72	Playing	4
55	Playing	8
39	Playing	104
38	Playing	104
37	Playing	104
197	Playing	1
326	Playing	6
348	Playing	9
343	Playing	20
333	Playing	8
332	Playing	8
329	Playing	6
328	Playing	6
327	Playing	6

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
321	Playing	12
320	Playing	12
315	Playing	1.32
314	Playing	1.32
306	Playing	2
291	Playing	13
289	Playing	13
238	Playing	34.8
243	Playing	4.29
239	Playing	34.8
242	Playing	4.29
290	Playing	13
39	Rock pooling	19.5
328	Rock pooling	6
327	Rock pooling	6
243	Rock pooling	4.29
242	Rock pooling	4.29
72	Rock pooling	4
329	Rock pooling	6
69	Rock pooling	208
45	Rock pooling	2
239	Rock pooling	34.8
79	Rock pooling	156
38	Rock pooling	19.5
37	Rock pooling	19.5
343	Rock pooling	20
29	Rock pooling	3.25
348	Rock pooling	3
28	Rock pooling	3.25
349	Rock pooling	3
44	Rock pooling	2
215	Rock pooling	26
197	Rock pooling	1
27	Rock pooling	3.25
321	Rock pooling	12
320	Rock pooling	12
82	Rock pooling	156
326	Rock pooling	6
238	Rock pooling	34.8

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
216	Rock pooling	26
198	Rock pooling	1
80	Rock pooling	156
315	Walking	8
314	Walking	8
198	BBQ/Picnicking/Sitting	0.4
197	BBQ/Picnicking/Sitting	0.4
37	BBQ/Picnicking/Sitting	32.5
267	BBQ/Picnicking/Sitting	2
38	BBQ/Picnicking/Sitting	32.5
266	BBQ/Picnicking/Sitting	2
265	BBQ/Picnicking/Sitting	2
44	BBQ/Picnicking/Sitting	3
45	BBQ/Picnicking/Sitting	3
106	BBQ/Picnicking/Sitting	120
39	BBQ/Picnicking/Sitting	32.5
79	Fishing	70
79	Fishing	78
80	Fishing	70
80	Fishing	78

Table 12. Infant intertidal occupancy rates from aquatic survey area

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
193	Beachcombing	25
73	Beachcombing	4
96	Beachcombing	117
161	Beachcombing	4.9
357	Beachcombing	41.8
260	Beachcombing	130
270	Beachcombing	105
7	Crabbing	1.5
8	Crabbing	4.5
161	Crabbing	2
357	Paddling	72
63	Paddling	6
64	Paddling	6
310	Paddling	8.58
298	Paddling	24

Unique ID	Intertidal Activity	Occupancy (h y^{-1})
352	Paddling	5
311	Paddling	8.58
344	Paddling	20
297	Paddling	24
35	Playing	104
352	Playing	45
193	Playing	25
270	Playing	105
73	Playing	4
68	Playing	104
64	Playing	6
63	Playing	6
344	Playing	2
8	Playing	4.5
357	Playing	72
297	Playing	24
298	Playing	24
7	Playing	4.5
310	Playing	8.58
311	Playing	8.58
96	Rock pooling	78
7	Rock pooling	4.5
63	Rock pooling	6
35	Rock pooling	19.5
64	Rock pooling	6
68	Rock pooling	104
73	Rock pooling	4
344	Rock pooling	20
270	Rock pooling	105
311	Rock pooling	8.58
297	Rock pooling	24
298	Rock pooling	24
310	Rock pooling	8.58
352	Rock pooling	10
7	BBQ/Picnicking/Sitting	1.5
35	BBQ/Picnicking/Sitting	32.5
8	BBQ/Picnicking/Sitting	1.5

Table 13. Adult aquatic occupancy rates from aquatic survey area

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
252	Angling - Sea	270
181	Angling - Sea	180
299	Angling - Sea	156
272	Angling - Sea	72
60	Angling - Sea	36
115	Angling - Sea	30
22	Angling - Sea	30
9	Angling - Sea	24
107	Angling - Sea	23
40	Angling - Sea	18
30	Angling - Sea	8
249	Angling - Sea	2.5
271	Boat maintenance	1 460
262	Boat maintenance	365
261	Boat maintenance	312
370	Boat maintenance	183
6	Boat maintenance	98
360	Boat maintenance	52
190	Boat maintenance	40
226	Boat maintenance	30
17	Boat maintenance	9
107	Boat maintenance	8
101	Canoeing	1 040
369	Canoeing	96
149	Canoeing	60
148	Canoeing	60
144	Canoeing	60
147	Canoeing	60
167	Canoeing	20
102	Canoeing	18
168	Canoeing	15
6	Canoeing	12
46	Canoeing	9.75
361	Canoeing	8
104	Canoeing	6
118	Canoeing	6
41	Canoeing	6
40	Canoeing	6
117	Canoeing	6

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
91	Canoeing	1.5
271	Commercial fishing/creeling	4 380
6	Commercial fishing/creeling	3 120
262	Commercial fishing/creeling	1 095
370	Commercial fishing/creeling	821
90	Commercial fishing/creeling	312
191	Commercial fishing/creeling	300
182	Commercial fishing/creeling	300
370	Commercial fishing/creeling	126
363	Commercial fishing/creeling	36
176	Commercial fishing/creeling	20
272	Commercial fishing/creeling	4.5
166	Diving	40
167	Diving	15
113	Diving	9
226	Rowing	156
369	Rowing	52
127	Rowing	50
190	Rowing	48
261	Safety boat duties	30
271	Safety boat duties	24
17	Safety boat duties	9
360	Safety boat duties	0.5
17	Sailing	468
23	Sailing	208
190	Sailing	96
360	Sailing	48
217	Sailing	18
226	Sailing	1.25
87	Sub-aqua diving	58.5
86	Sub-aqua diving	58.5
268	Sub-aqua diving	26.3
249	Sub-aqua diving	26.3
83	Sub-aqua diving	24
248	Sub-aqua diving	1.5
203	Outdoor swimming	1 369
81	Outdoor swimming	140
159	Outdoor swimming	91.3
158	Outdoor swimming	91.3

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
369	Outdoor swimming	48
183	Outdoor swimming	39
5	Outdoor swimming	39
173	Outdoor swimming	36
155	Outdoor swimming	30
169	Outdoor swimming	20
163	Outdoor swimming	20
46	Outdoor swimming	13.5
3	Outdoor swimming	13
88	Outdoor swimming	13
325	Outdoor swimming	12
127	Outdoor swimming	12
139	Outdoor swimming	12
324	Outdoor swimming	12
293	Outdoor swimming	8
167	Outdoor swimming	8
292	Outdoor swimming	8
347	Outdoor swimming	6
346	Outdoor swimming	6
54	Outdoor swimming	5
56	Outdoor swimming	5
26	Outdoor swimming	4
25	Outdoor swimming	4
109	Outdoor swimming	4
203	Outdoor swimming	3
40	Outdoor swimming	2
41	Outdoor swimming	2
89	Outdoor swimming	1
190	Outdoor swimming	1
296	Outdoor swimming	0.66
319	Outdoor swimming	0.58
211	Outdoor swimming	0.33
48	Outdoor swimming	0.25
47	Outdoor swimming	0.25
237	Outdoor swimming	0.249
236	Outdoor swimming	0.249
261	Power boating	156
360	Power boating	48
113	Power boating	18

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
107	Power boating	8
141	Power boating	3
191	Working on a boat	300
183	Surfing	200
167	Surfing	200
110	Surfing	150
149	Surfing	120
148	Surfing	120
147	Surfing	120
154	Surfing	100
153	Surfing	100
151	Surfing	60
152	Surfing	60
10	Surfing	52
109	Surfing	48
83	Surfing	36
350	Surfing	20
168	Surfing	20
130	Surfing	18
192	Surfing	18
134	Surfing	16
127	Surfing	12
56	Surfing	6
54	Surfing	6
293	Surfing	6
292	Surfing	6
268	Body boarding	16
33	Body boarding	13
34	Body boarding	13
36	Body boarding	13
346	Body boarding	12
322	Body boarding	12
347	Body boarding	12
350	Stand-up paddle boarding	40
312	Stand-up paddle boarding	36
351	Stand-up paddle boarding	20
46	Stand-up paddle boarding	13.5
110	Life Guard	200
108	Life Guard	180

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
109	Life Guard	180
165	Life Guard	180
108	Cliff/Rock Jumping	15
109	Cliff/Rock Jumping	4.5
151	Spear Fishermen	192
152	Underwater camerawoman	192
257	Surfing	1 040
257	Surfing	420
268	Snorkelling	8
295	Kayaking	2
299	Creel fishing/handling creels (not commercial)	5
350	Kite surfing	10
101	Other	6
101	Other	6
153	Other	1
154	Other	1

Table 14. Child aquatic occupancy rates from aquatic survey area

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
145	Canoeing	60
146	Canoeing	60
140	Canoeing	24
275	Sailing	548
160	Outdoor swimming	228
79	Outdoor swimming	140
82	Outdoor swimming	140
80	Outdoor swimming	140
69	Outdoor swimming	52
103	Outdoor swimming	18
329	Outdoor swimming	12
326	Outdoor swimming	12
327	Outdoor swimming	12
328	Outdoor swimming	12
140	Outdoor swimming	12
294	Outdoor swimming	8
349	Outdoor swimming	6
348	Outdoor swimming	6

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
55	Outdoor swimming	5
29	Outdoor swimming	4
28	Outdoor swimming	4
27	Outdoor swimming	4
321	Outdoor swimming	0.58
320	Outdoor swimming	0.58
238	Outdoor swimming	0.249
239	Outdoor swimming	0.249
198	Outdoor swimming	0.1
197	Outdoor swimming	0.1
140	Power boating	24
135	Surfing	150
145	Surfing	120
146	Surfing	120
282	Surfing	91
103	Surfing	18
194	Surfing	18
294	Surfing	6
55	Surfing	6
106	Body boarding	15
38	Body boarding	13
37	Body boarding	13
39	Body boarding	13
349	Body boarding	12
348	Body boarding	12
29	Body boarding	2
28	Body boarding	2
27	Body boarding	2
258	surfing	156
259	surfing	65
258	surfing	26

Table 15. Infant aquatic occupancy rates from aquatic survey area

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
161	Outdoor swimming	228
68	Outdoor swimming	52
96	Outdoor swimming	6

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
298	Outdoor swimming	0.66
297	Outdoor swimming	0.66
35	Body boarding	13
260	surfing	65

Table 16. Adult handling rates for equipment from aquatic survey area

Unique ID	Handling rate (h y^{-1})
94	72.0
99	52.0
226	85.0
249	25.5
252	278
255	433
256	433
261	312
262	1 460
263	4.5
271	5 960
272	76.5
279	60.0
299	161
363	36.0
364	624
366	72.0
367	104
376	1 560
369	120
370	2 590
360	52.0
17	25.0
22	33.0
23	796
30	10.0
40	73.5
41	0.58
46	18.5
5	4.00
50	4.25
58	104

Unique ID	Handling rate (h y^{-1})
59	442
6	3 286
60	96.0
66	25.5
81	148
83	6.00
9	24.8
90	585
91	0.75
107	39.0
112	9.00
115	30.0
120	1800
127	24.0
130	8.00
131	240
139	8.00
141	3.00
151	192
167	4.00
170	234
171	108
176	40.0
177	7.00
179	520
180	65.2
181	180
182	300
190	161
191	626
192	18.0

Table 17. Child handling rates for equipment from aquatic survey area

Unique ID	Handling rate (h y^{-1})
79	148
80	148

Table 18. Infant handling rates for equipment from aquatic survey area

Unique ID	Handling rate (h y^{-1})
35	1
68	0.3

Table 19. Adult green vegetable consumption rate from terrestrial survey area

Unique ID	**Sum of consumption rate (kg y^{-1})**
231	15.3
232	15.3
301	6.80
302	6.80
233	15.3
316	16.9
11	1.00
12	1.00
15	0.22
16	0.45
21	16.4
22	16.4
3	23.0
4	23.0
40	38.2
41	33.2
58	44.7
74	5.70
84	1.00
85	1.00
120	25.0
121	22.0
122	17.0
123	11.0
124	11.0
125	11.0
126	11.0
132	40.0
133	2.00
138	9.50
141	2.75

Unique ID	Sum of consumption rate (kg y^{-1})
156	2.10

Table 20. Adult other vegetable consumption rate from terrestrial survey area

Unique ID	Sum of consumption rate (kg y^{-1})
377	5.00
378	5.00
231	1.66
232	1.66
301	1.38
302	1.38
233	1.66
354	0.36
355	0.36
15	3.68
16	3.68
21	0.25
22	0.25
3	8.25
4	8.25
40	1.25
41	1.25
58	2.75
74	0.08
132	0.30
138	4.00

Table 21. Adult root vegetable consumption rate from terrestrial survey area

Unique ID	Sum of consumption rate (kg y^{-1})
377	11.5
378	11.5
231	17.3
232	17.3
301	30.7
302	30.7
233	17.3
316	1.80
354	0.25

Unique ID	Sum of consumption rate (kg y^{-1})
355	0.25
15	0.40
16	0.40
21	10.0
22	10.0
3	3.10
4	1.80
40	39.4
41	26.1
58	17.9
120	10.0
121	10.0
122	5.00
123	5.00
124	5.00
125	5.00
126	5.00
132	10.0
133	4.50
138	14.5
156	0.01

Table 22. Adult potato consumption rate from terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
377	25
378	25
277	2.7
231	21.7
232	21.7
301	118
302	118
233	21.7
316	10.9
354	7.5
355	7.5

Unique ID	Consumption rate (kg y^{-1})
15	50
16	50
21	7.7
22	7.7
40	19.3
41	19.3
120	30
121	30
122	15
123	15
124	15
125	15
126	15
138	7.5

Table 23. Adult domestic fruit consumption rate from terrestrial survey area

Unique ID	Sum of consumption rate (kg y^{-1})
102	24.3
278	49.6
279	49.6
280	49.6
231	30.5
232	22.5
301	49.9
302	49.9
303	3.00
233	22.5
316	29.0
354	34.4
355	34.4
15	30.4
16	31.8
19	0.75
20	0.75
21	63.3
22	63.3
3	85.9
4	85.9

Unique ID	Sum of consumption rate (kg y^{-1})
40	133.
41	121
58	74.1
74	11.0
132	38.0
133	2.00
138	11.0
141	0.50
156	6.00

Table 24. Adult wild foods consumption rate from terrestrial survey area

Unique ID	Wild food	Consumption rate (kg y^{-1})
40	Blackberry	2
156	Blackberry	3.5
133	Blackberry	0.5
93	Blackberry	0.5
85	Blackberry	1.5
372	Blackberry	5.45
168	Blackberry	1
41	Blackberry	2
84	Blackberry	1.5
22	Blackberry	1
21	Blackberry	1
20	Blackberry	0.75
19	Blackberry	0.75
16	Blackberry	0.25
15	Blackberry	0.25
74	Blackberry	2
355	Blackberry	0.9
316	Blackberry	1.4
241	Blackberry	0.9
277	Blackberry	2.72
354	Blackberry	0.9
172	Elderberry	4
40	Elderberry	1.2
19	Elderflower	0.2
20	Elderflower	0.2
21	Elderflower	0.2

Unique ID	Wild food	Consumption rate (kg y^{-1})
22	Elderflower	0.2
41	Elderflower	1.2
280	Elderflower	0.1
278	Elderflower	0.1
279	Elderflower	0.1
172	Elderflower	1
156	Elderflower	0.04
4	Raspberry	1
3	Raspberry	1
280	Sloe	3
156	Sloe	0.1
279	Sloe	3
278	Sloe	3
132	Sloe	5
15	Sloe	0.1
172	Sloe	1
16	Sloe	0.1
85	Sloe	0.5
84	Sloe	0.5
41	Mushrooms	4
16	Mushrooms	0.2
40	Mushrooms	4
15	Mushrooms	0.2
3	Wild Garlic	1
4	Wild Garlic	1
4	Apple	5
40	Apple	90
41	Apple	10
3	Apple	5
172	Apple	6
21	Gooseberry	0.25
22	Gooseberry	0.25
84	Wild herbs	0.05
85	Wild herbs	0.05
279	Cherries	0.58
278	Cherries	0.58
280	Cherries	0.58

Table 25. Adult wild fungi consumption rate from terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
15	0.2
16	0.2
40	4
41	4

Table 26. Adult beef meat consumption rate from terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
373	47
374	47

Table 27. Adult all game consumption rate from terrestrial survey area

Unique ID	Consumption Rate (kg y^{-1})
259	7.3
261	7.3
272	6
278	0.16
279	0.16
280	0.16
355	1.2
3	7
4	7
40	50.6
41	50.6
120	3.2
122	3.2
123	3.2
124	3.2
125	3.2
126	3.2
130	3

Table 28. Adult poultry consumption rate from terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
379	4.5
380	4.5
278	1

Unique ID	Consumption rate (kg y^{-1})
279	1
280	1

Table 29. Adult sheep meat consumption rate from terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
377	9
378	9

Table 30. Adult eggs consumption rate from terrestrial survey area

Unique ID	Sum of consumption rate (kg y^{-1})
373	18.1
374	18.1
377	26.3
378	26.3
379	0.35
381	0.35
241	6.03
277	9.05
278	13.9
279	13.9
280	13.9
301	9.05
302	9.05
303	12.1
316	0.35
354	18.1
355	18.1
361	9.05
362	9.05
15	9.05
16	9.05
19	18.1
20	18.1
3	18.1
4	18.1
58	6.03
74	12.1

Unique ID	Sum of consumption rate (kg y^{-1})
132	3.02

Table 31. Adult honey consumption rate from terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
301	4.5
302	4.5

Table 32. Child domestic fruit consumption rate from terrestrial survey area

Unique ID	Sum of consumption rate (kg y^{-1})
103	20.3
281	49.6
282	49.6
283	49.6

Table 33. Child wild fruit consumption rate from terrestrial survey area

Unique ID	Wild food	Consumption rate (kg y^{-1})
243	Blackberry	0.9
242	Blackberry	0.9
283	Elderflower	0.1
282	Elderflower	0.1
281	Elderflower	0.1
283	Cherries	0.58
282	Cherries	0.58
281	Cherries	0.58

Table 34. Child all game consumption rate from terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
281	0.16
282	0.16
283	0.16

Table 35. Child poultry meat consumption rate from terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
278	1
279	1
280	1

Table 36. Child egg consumption rate from terrestrial survey area

Unique ID	Sum of consumption rate (kg y^{-1})
242	6.03
243	6.03
281	13.9
282	13.9
283	13.9

Table 37. Adult Terrestrial activities in terrestrial survey area

Unique ID	Terrestrial Activity	Occupancy (h y^{-1})
301	Bee keeping	90
301	Bee keeping	90
58	Bird/nature watching	365
271	Bird/nature watching	1.92
3	Bird/nature watching	48
368	Bird/nature watching	36
30	Bird/nature watching	78
300	Bird/nature watching	241
226	Bird/nature watching	1
156	Bird/nature watching	1 460
4	Bird/nature watching	48
226	Bird/nature watching	1
303	Bird/nature watching	183
9	Bird/nature watching	104
241	Cycling	274
244	Cycling	104
247	Cycling	26
257	Cycling	104
271	Cycling	52
246	Cycling	312
168	Cycling	1
191	Cycling	100
162	Cycling	60

Unique ID	Terrestrial Activity	Occupancy (h y^{-1})
142	Cycling	45
136	Cycling	36
13	Cycling	58.5
81	Cycling	9
78	Cycling	9
41	Cycling	104
40	Cycling	12
22	Cycling	97.5
16	Cycling	208
21	Cycling	234
190	Cycling	20
301	Cycling	364
353	Cycling	24.8
362	Cycling	183
361	Cycling	183
342	Cycling	24.8
157	Dog walking	639
11	Dog walking	183
354	Dog walking	365
168	Dog walking	15
171	Dog walking	45
141	Dog walking	350
181	Dog walking	500
133	Dog walking	365
341	Dog walking	548
338	Dog walking	156
234	Dog walking	390
172	Dog walking	24
235	Dog walking	390
12	Dog walking	26
15	Dog walking	365
132	Dog walking	365
22	Dog walking	274
102	Dog walking	104
369	Dog walking	1 095
355	Dog walking	365
13	Dog walking	365
3	Dog walking	274
74	Dog walking	548

Unique ID	Terrestrial Activity	Occupancy (h y^{-1})
14	Dog walking	104
58	Dog walking	1 095
40	Dog walking	365
21	Dog walking	274
162	Dog walking	48
301	Dog walking	548
301	Dog walking	548
271	Dog walking	365
278	Dog walking	365
241	Dog walking	234
295	Dog walking	24
300	Dog walking	23.8
277	Dog walking	312
354	Gardening	365
75	Gardening	274
301	Gardening	90
21	Gardening	1 095
102	Gardening	156
76	Gardening	624
355	Gardening	365
19	Gardening	78
141	Gardening	350
278	Gardening	156
279	Gardening	156
13	Gardening	351
273	Gardening	1 248
277	Gardening	68.4
285	Gardening	183
22	Gardening	26
20	Gardening	78
132	Gardening	365
12	Gardening	26
104	Gardening	365
245	Gardening	104
241	Gardening	702
316	Gardening	260
301	Gardening	1 065
240	Gardening	13
235	Gardening	52

Unique ID	Terrestrial Activity	Occupancy (h y^{-1})
15	Gardening	104
40	Gardening	365
41	Gardening	365
234	Gardening	52
244	Gardening	104
156	Gardening	104
342	Gardening	49.5
301	Gardening	90
16	Gardening	52
58	Gardening	365
11	Gardening	52
246	Gardening	13
4	Gardening	260
353	Gardening	49.5
301	Gardening	1 065
74	Gardening	130
133	Gardening	365
286	Gardening	183
102	Horse riding	1 460
61	Playing	12
62	Playing	12
132	Playing	365
133	Playing	365
247	Rambling/walking	52
40	Rambling/walking	156
240	Rambling/walking	39
316	Rambling/walking	156
235	Rambling/walking	26
363	Rambling/walking	365
368	Rambling/walking	24
41	Rambling/walking	208
234	Rambling/walking	104
316	Rambling/walking	260
191	Rambling/walking	150
3	Rambling/walking	104
177	Rambling/walking	10
102	Rambling/walking	260
30	Rambling/walking	48
11	Rambling/walking	52

Unique ID	Terrestrial Activity	Occupancy (h y^{-1})
190	Rambling/walking	40
142	Rambling/walking	100
4	Rambling/walking	104
13	Rambling/walking	156
12	Rambling/walking	52
168	Running	10
257	Running	104
244	Running	78
271	Running	52
245	Running	26
100	Sitting/picnicking	365
132	Sitting/picnicking	52
12	Sitting/picnicking	365
133	Sitting/picnicking	52
139	Sitting/picnicking	300
11	Sitting/picnicking	365
4	Sitting/picnicking	52
3	Sitting/picnicking	52
111	Sports	75
15	Collecting wild produce	0.5
15	Collecting wild produce	26
3	Collecting wild produce	65
4	Collecting wild produce	65
133	Collecting wild produce	0.5
372	Collecting wild produce	4
316	Collecting wild produce	0.5
278	Collecting wild produce	7
277	Collecting wild produce	0.375
241	Collecting wild produce	0.25
172	Collecting wild produce	3
168	Collecting wild produce	0.25
139	Collecting wild produce	1.5
16	Collecting wild produce	0.5
132	Collecting wild produce	0.75
93	Collecting wild produce	0.25
40	Collecting wild produce	2.25
19	Collecting wild produce	1.5
21	Collecting wild produce	1
156	Collecting wild produce	0.5

Unique ID	Terrestrial Activity	Occupancy (h y^{-1})
22	Collecting wild produce	52
41	Collecting wild produce	2.25
74	Collecting wild produce	1
84	Collecting wild produce	3
85	Collecting wild produce	3
355	Jogging	52
40	Shooting	416
87	At caravan	390
86	At caravan	390
156	community woodland	52
260	Farming	2 080
284	Farming	730
285	Farming	730
257	Farming	2 190
257	Farming	4 380

Table 38. Child Terrestrial activities in terrestrial survey area

Unique ID	Terrestrial Activity	Occupancy (h y^{-1})
283	Cycling	241
80	Cycling	9
282	Cycling	241
82	Cycling	9
281	Cycling	241
243	Cycling	24.8
79	Cycling	9
103	Dog walking	104
243	Playing	821
242	Playing	821
140	Sitting/picnicking	300
140	Sports	150
281	Sports	365
282	Sports	365
283	Sports	365
140	Collecting wild produce	1.5

Table 39. Infant Terrestrial activities in terrestrial survey area

Unique ID	Terrestrial Activity	Occupancy (h yr^{-1})
344	Cycling	24.8

Unique ID	Terrestrial Activity	Occupancy (h yr^{-1})
64	Playing	12
63	Playing	12

Table 40. Adult occupancy rates (including partial annual occupancy) in the direct shine radiation survey area

Unique ID	Indoors at home (h y^{-1})	Outdoors at home (h y^{-1})	Indoors at work (h y^{-1})	Outdoors at work (h y^{-1})
20				1 840
21	5 012	2 148		
22	2 506	1 074	2 295	765
40				2 000
41	2 106	1 404		
58	2 696	3 370		
61	288	144		
62	288	144		
75	3 036	2 024		1 792
76	2 530	2 530		2 240
77	700	700		
78	700	700		
81	700	700		
132	6 935	1 460		
133	6 204	1 825		
234			1 920	720
271				480
273	5 110	1 825		
284	2 856	714		
285	3 570	714		
286	5 712	357		
342	2 380	1 428		

Table 41. Child occupancy rates (including partial annual occupancy) in the direct shine radiation survey area

Unique ID	Indoors at home (h y^{-1})	Outdoors at home (h y^{-1})	Indoors at work (h y^{-1})	Outdoors at work (h y^{-1})
79	700	700		
80	700	700		
82	700	700		

Table 42. Infant occupancy rates (including partial annual occupancy) in the direct shine radiation survey area

Unique ID	Indoors at home (h y^{-1})	Outdoors at home (h y^{-1})	Indoors at work (h y^{-1})	Outdoors at work (h y^{-1})
63	288	144		
64	288	144		

Table 43. Phase 2 surveys of Adult consumption rates of fish from the aquatic survey

Unique ID	Food type	Consumption rate (kg y^{-1})
376	Bass	60
58	Bass	2.5
171	Cod	5
376	Cod	22
171	Mackerel	1
376	Mackerel	20
58	Mackerel	2
376	Pollock	14
262	Haddock	2
171	Haddock	5

Table 44. Phase 2 surveys of Adult consumption rates of crustaceans from the aquatic survey

Unique ID	Food type	Consumption rate (kg y^{-1})
262	Brown crab	3
171	Brown crab	6
171	Common lobster	1

Table 45. Phase 2 surveys of Adult intertidal occupancy rate in the survey area

Unique ID	Intertidal Activity	Total hours (h y^{-1})
171	Beachcombing	156
376	Collecting mussels	6
132	Collecting seaweed	48
58	Collecting seaweed	6
376	Collecting winkles	6
171	Dog walking	156
277	Dog walking	365
58	Dog walking	548
22	Dog walking	40
21	Dog walking	40
171	Handling creels	360
21	Walking	156
132	BBQ/Picnicking/Sitting	13
376	Fishing	1 560
58	Fishing	26

Table 46. Phase 2 surveys of Adult aquatic occupancy rates in the survey area

Unique ID	Aquatic Activity	Occupancy (h y^{-1})
376	Angling - Sea	36
22	Angling - Sea	30
171	Angling - Sea	24
17	Boat maintenance	9
262	Commercial fishing/creeling	480
17	Safety boat duties	4.5
17	Sailing	468

Table 47. Phase 2 surveys of Adult handling rates in the survey area

Unique ID	Handling Activity	Occupancy (h y^{-1})
262	Commercial fishing/creeling	480
376	Angling – sea	36.0
376	Fishing gear	12.0
376	Fishing	1 560
17	Boat maintenance	9.00
17	Boats and boating equipment	2.50
17	Cloths and overalls	13.5
22	Angling - sea	30.0
22	Boats and boating equipment	2.00

Unique ID	Handling Activity	Occupancy (h y^{-1})
22	Cloths and overalls	1.00
22	Fishing gear	0.75
58	Fishing	26.0
171	Angling – sea	24.0
171	Handling creels	360

Table 48 Phase 2 surveys of Adult consumption rates of green vegetables from the terrestrial survey area the survey area

Unique ID	Sum of consumption rate (kg y^{-1})
21	8.60
22	8.60
58	35.9
132	17.5

Table 49. Phase 2 surveys of Adult consumption rates of other vegetables from the terrestrial survey area the survey area

Unique ID	Sum of consumption rate (kg y^{-1})
21	0.25
22	0.25
58	2.75
132	2.50

Table 50. Phase 2 surveys of Adult consumption rates of root vegetables from the terrestrial survey area the survey area

Unique ID	Sum of consumption rate (kg y^{-1})
21	11.94
22	11.94
58	11.3
132	10.00

Table 51. Phase 2 surveys of Adult consumption rates of potatoes from the terrestrial survey area the survey area

Unique ID	Sum of consumption rate (kg y^{-1})
277	3.6
21	7.7
22	7.7

Table 52. Phase 2 surveys of Adult consumption rates of domestic fruit from the terrestrial survey area the survey area

Unique ID	Sum of consumption rate (kg y^{-1})
21	53.8
22	53.8
58	121
132	55.0

Table 53. Phase 2 surveys of Adult consumption rates of wild foods from the terrestrial survey area

Unique ID	Wild food	Consumption rate (kg y^{-1})
277	Blackberry	3.4
22	Blackberry	1
21	Blackberry	1
22	Elderberry	0.2
21	Elderflower	0.2
132	Sloe	5
22	Gooseberry	0.25
21	Gooseberry	0.25

Table 54. Phase 2 surveys of Adult consumption rates of eggs from the terrestrial survey area

Unique ID	Consumption rate (kg y^{-1})
58	6.03
132	3.02

Table 55. Phase 2 surveys of Adult terrestrial occupancy rates of in the terrestrial area site

Unique ID	Terrestrial Activity	Occupancy (h y^{-1})
22	Cycling	130
21	Cycling	234
21	Dog walking	274
22	Dog walking	274
58	Dog walking	548
132	Dog walking	365
277	Dog walking	365
58	Gardening	365
132	Gardening	365
22	Gardening	52
21	Gardening	1 095
277	Gardening	137
277	Collecting wild produce	1.5
132	Collecting wild produce	3
21	Collecting wild produce	2
22	Collecting wild produce	2

Table 56. Phase 2 surveys of Adult occupancy (including partial annual occupancy) rates in the direct shine radiation survey area

Unique ID	Indoors at home (h y^{-1})	Outdoors at home (h y^{-1})	Indoors at work (h y^{-1})	Outdoors at work (h y^{-1})
21	5 012	2 148		
22	2 506	1 074		
58	2 696	3 370		
132	6 802	1 432		

Appendix A2 Postal Survey

The postal survey produced an independent data set from a broader cross section of the population living in the area potentially providing the means to identify new or

missed habits that might provide useful focus to target some of the face-to-face surveys or meetings with local groups.

The postal survey helped refine and revise the face-to-face survey tools and identify the optimal areas to target the face-to-face surveys. It also provided additional information on sites to be identified for the collection of observation data and indicated the optimum timings to visit each site. Further information and contacts were obtained with regard to both individuals and a wider range of activities that might merit further investigation in the later survey work.

Appendix A3 The Mobile Gamma Spectrometry System

The Mobile Gamma Spectrometry System (MoGSS) deploys 76 mm x 76 mm and large volume (4 or 8 litre) NaI(Tl) detectors for real time data acquisition gamma ray spectra. One second spectra were acquired whilst driving with the detector mounted in the roof box of the survey vehicle to characterise the heterogeneity in the radiation environment around the Torness Site and further afield to identify exposure pathways that might otherwise be missed through conventional point measurements. Acquisition rate is limited by road and traffic conditions, but aims to achieve better than one measurement per 20 m. MoGSS comprises a real time differential GPS system providing < 0.6 m positional accuracy, controlled by bespoke software through a tablet computer. Spectra were collected with 1 second integration times and data are presented as counts per second (gross counts or counts in the window >350 keV). MoGSS was deployed to identify anomalies in the radiation field to help target follow-up *in situ* dosimetry surveys and identify the likely source of the radioactive anomaly and spatially extrapolate any anomalous observations identified.

This approach provided a better understanding of the underlying natural background and any anthropogenic contribution to the radiation environment. The MoGSS system was deployed in vehicular mode to undertake a carborne survey along the road network and in hand held mode to map the site perimeter and the spillway.

To measure such an extensive area, a Mobile Gamma-ray Spectrometry System (MoGSS) was deployed to measure the differential dose estimations for the natural radioelements (^{40}K and the ^{238}U and ^{232}Th series) alongside estimates for anthropogenic ^{137}Cs. This type of capability is not possible using conventional gamma dosimetry measurements. However, the measurement of ^{3}H, known to be released from the Torness site, is not possible through this approach.

Survey Area

Two MoGSS were deployed during the survey period, producing gamma-ray spectra data recorded at 1 second integration times alongside high accuracy (<0.6 m) differential GPS readings. Firstly, two large volume sodium iodide detectors were mounted in a box on top of the field vehicle and was driven along all the major roads within the area of interest. The system whilst highly efficient is bulky and therefore only allowing data to be collected from roads. To target smaller areas not accessible by vehicle, and crucially to cover the coast line and measure the dose at relevant access points, two separate backpack systems were used. To encompass many of the access points, a large section of the John Muir way was walked using the backpack systems stretching from Tyningham to Cove Bay (Figure A3i). Each backpack system comprised of a 76 × 76 mm sodium iodide detector.

Conversion of detector count rate (counts s^{-1}) to activity (Bq kq^{-1}) was performed using Monte Carlo calibrations and a conventional window stripping routine. Cosmic background was measured on Loch Lomond (2016) and stripped from all spectral data. Prior to stripping, window counts were smoothed using spatial Gaussian kernel filter. Finally, dose (nGy hr^{-1}) was calculated using ICRU conversion factors (ICRU, 1994).

Figure A3i MoGSS coverage of Torness survey area. Red points demonstrate the area walked using the backpack system and the blue points represent roads covered by the carborne system.

Appendix A4 In-Situ Gamma Dose Rate Measurements

The protocol requires the detector to be maintained at 1 m above the surface (Figure 3.1) and counts acquired over a 600 second integration time and the cosmic and intrinsic component to the measurement subtracted. The protocol also requires no persons operating the detector to be within 5 m of the probe during the count. Both instruments are calibrated with ^{226}Ra and ^{137}Cs. Here, gamma dose rates were dominated by the natural background so all results are reported with the ^{226}Ra calibration and reported as µGy h^{-1}.

For the dose assessment tool, gamma dose rates were converted to Effective Dose (µSv hr^{-1}) using a conversion factor of 0.85, which assumes an individual is standing and exposed to terrestrial derived gamma radiation. This conversion factor is used

for most statutory monitoring programmes (Punt *et al*., 2011). All survey measurements are reported as terrestrial gamma dose measurements and have had the cosmic and intrinsic component subtracted.

Appendix A5 Beta Skin Dosimetry Measurements

The instrument was calibrated under UKAS accreditation against: strontium-90 (^{90}Sr) and yttrium-90 (^{90}Y); chlorine-36 (^{36}Cl) and carbon^{-1}4 (^{14}C) (and put inside a file poly-pocket to protect the system from the weather). A 12 mm Perspex shield was used to shield out any beta emissions and so enable the gamma contribution to the instrument to be established. All measurements were made with a 20 second integration time and in duplicate, with and without the 12 mm Perspex shield, enabling the net beta contribution to skin dose rate to be estimated (effective dose, or ambient dose equivalent) and reported in μSv h^{-1}. The system is estimated to have a detection limit of around 0.2 μSv h^{-1}.

Appendix A6 GPS Tracker Device

To ensure consistency in data a wearable GPS tracking device was considered the most suitable device for the Torness Habits Survey.

The devices used were iGOTU GT600 trackers (Figure A6i), which have a capacity to record 262 000 waypoints, at user defined intervals. The battery life varies depending on the sampling rate which was set to record once every 6 seconds, giving 30 hours of use on a single charge. This battery life could be extended by enabling motion detection, whereby the device sleeps until an on-board accelerometer detects motion and then enables the GPS tracking (which has a bigger battery cost). However initial tests showed that the device would not wake from its sleep mode if used on certain modes of transport, such as trains, where the motion was not severe enough to be detected. For this reason the motion detection was disabled so that the tracker logged continuously.

Figure A6i iGOTU GPS tracker

The devices require specialist software to download the trajectory data, and all units were password protected to maintain data security and privacy. The participants were

informed that the tracker worked best when positioned on their wrist, or on a bag/belt strap, where they had a clear line of sight to the sky. The participants were asked to take the device with them whenever they left their home and instructions were given regarding use and recharging of the device.

With the 6 second sample rate, the device was able to store the last 16 days of position data on board. Participants were asked to stop charging the unit on the last day of use before collection, to ensure it would run out of power and stop logging position data.

Appendix A7 Postal Survey Results

A7.1 Terrestrial – External Exposure

The postal survey showed rambling/walking, gardening, dog walking and sitting/picnicking were the most frequently reported terrestrial activities (Figure A7i). Zone 1 was the least visited by 20 respondents totalling 3 088 hours annually, Zone 2 was visited by 34 respondents totalling 10 682 hours annually and Zone 3 was visited by 60 respondents totalling 20 785 hours annually.

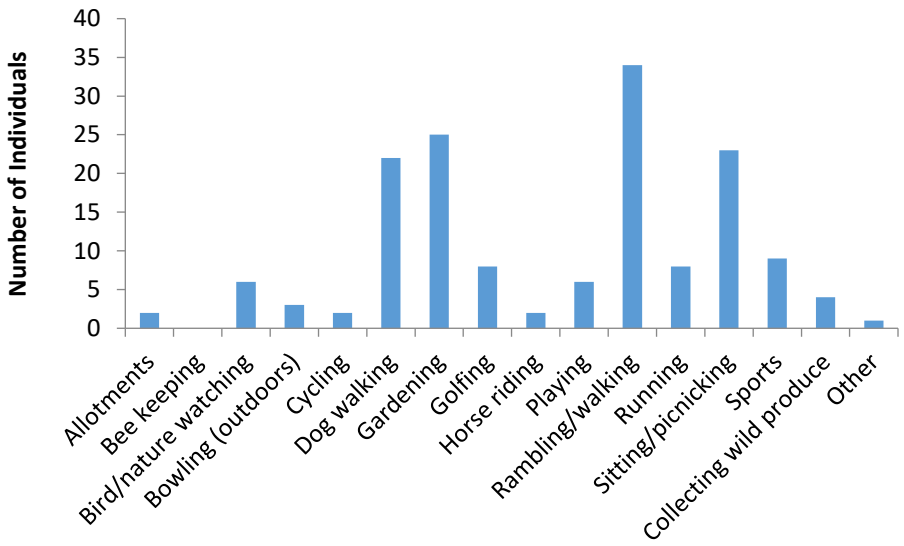

Figure A7i Terrestrial activities undertaken by respondents to the postal survey.

The individual with the highest occupancy in Zone 1 spent a total of 936 hours annually undertook gardening (312 hours) and numerous other activities (624 hours). The individual with the highest occupancy in Zone 2 spent a total of 4 086 hours annually undertook dog walking (730 hours), gardening (548 hours), horse riding (936 hours), playing (936) and rambling/walking (730 hours). The individual with the highest occupancy in Zone 3 spent a total of 2 045 hours annually cycling (208 hours), gardening (156 hours), running (1 664 hours) and sitting/picnicking (17 hours). The individual with the combined highest occupancy for all zones totalled 4 086 hours annually (and has the highest occupancy for Zone 2). See Table A7i for a statistical summary of terrestrial occupancy per zone based on actual replies.

Table A7i Terrestrial occupancy within Zones 1, 2 and 3.

	Zone 1 (h y^{-1})	**Zone 2 (h y^{-1})**	**Zone 3 (h y^{-1})**	**Total all zones (h y^{-1})**
Maximum	936	4 086	2 045	4 086
Minimum	4	1	2	1
Mean	154	314	346	473
Median	82	104	156	272
97.5th percentile	765	1 468	1 742	2 340

A7.2 Aquatic – External Exposure

The aquatic activities were also segregated into the same three zones as shown in Figure 4.1, delineated by the points where the zones intersect the coast.

The postal survey showed that few people were exposed via aquatic external exposure with outdoor swimming being the highest reported aquatic activity (Figure A7ii). Zone 1 was visited by one respondent for a total of four hours annually, Zone 2 was visited by three respondents for a total of 169 hours annually and Zone 3 was visited by five respondents for a total of 175 hours annually.

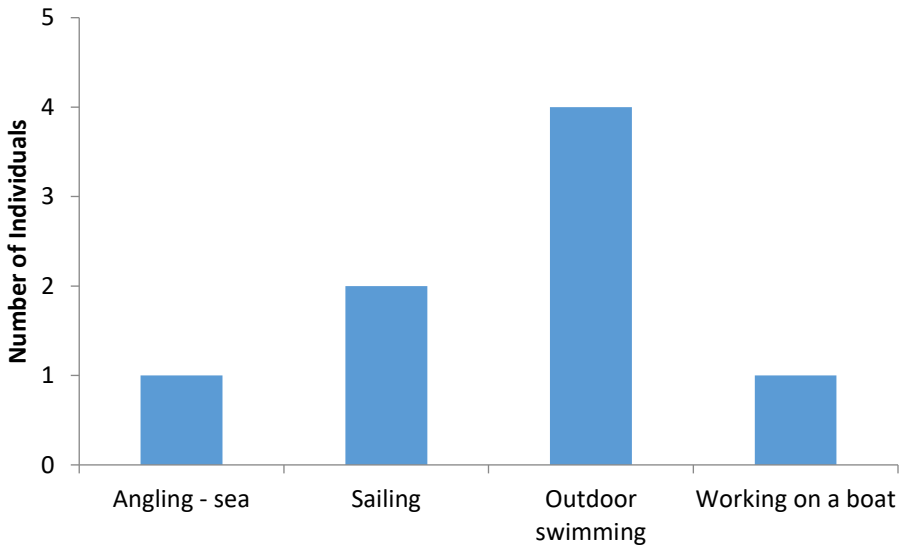

Figure A7ii Aquatic external exposure activities undertaken.

The individual with the highest occupancy in Zone 1 spent a total of 4 hours annually sailing (4 hours). The highest occupancy in Zone 2 and Zone 3, was reported by the same individual, who spent 156 hours annually in each zone sailing (78 hours) and working on a boat (78 hours) The individual with the combined highest occupancy for all zones totalled 312 hours annually (and had the highest occupancy for Zone 2 and 3). See Table A7ii for a statistical summary of terrestrial occupancy per zone based on actual replies.

Table A7ii Aquatic occupancy within Zones 1, 2 and 3.

	Zone 1 (h y^{-1})	**Zone 2 (h y^{-1})**	**Zone 3 (h y^{-1})**	**Total all zones (h y^{-1})**
Maximum	4	156	156	312
Minimum	4	2	1.5	1.5
Mean	4	56	35	60
Median	4	11	3	3
97.5th percentile	4	149	142	276

A7.3 Intertidal – External Exposure

The postal survey showed that dog walking and paddling was the highest reported intertidal activities (Figure A7iii). Zone 1 was visited by seven respondents for a total of 603 hours annually, Zone 2 was visited by 11 respondents for a total of 819 hours annually and Zone 3 was visited by 20 respondents for a total of 4 856 hours annually.

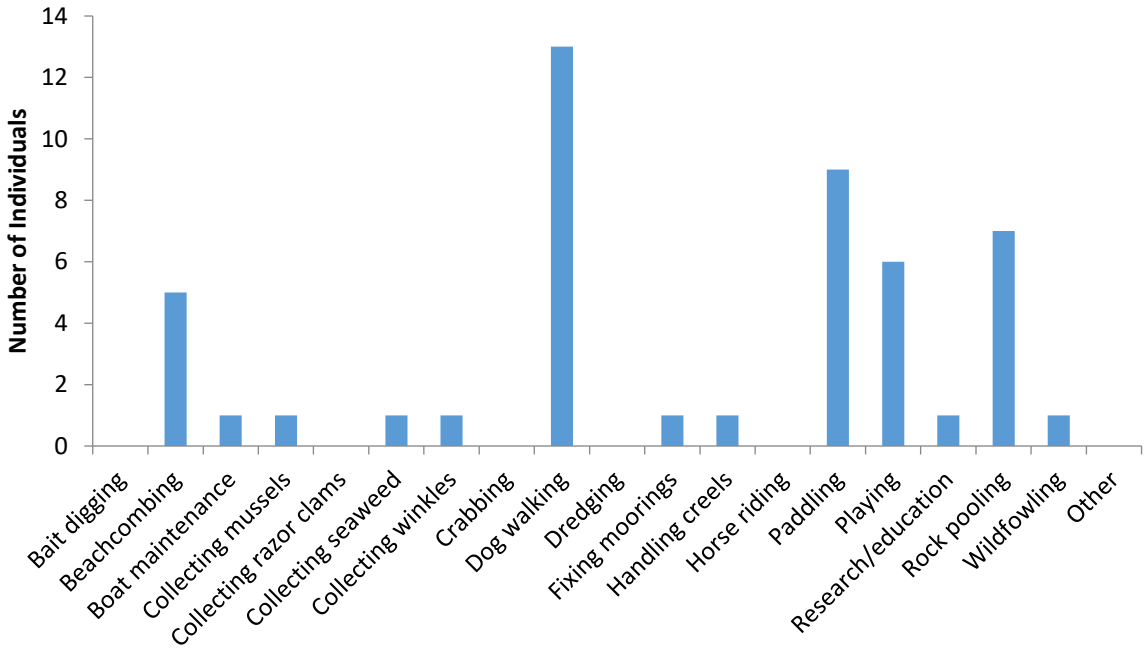

Figure A7iii Intertidal activities undertaken by survey respondents.

The individual with the highest occupancy in Zone 1 spent a total of 338 hours annually undertaking beachcombing (104 hours), paddling (39 hours), playing (91 hours) and rock pooling (104 hours). The individual with the highest occupancy in Zone 2 spent a total of 365 hours annually undertaking dog walking (365 hours). The individual with the highest occupancy in Zone 3 spent a total of 2 190 hours annually undertaking boat maintenance (730 hours), fixing moorings (365 hours) and handling creels (1 095 hours). The combined highest occupancy for all zones was the same individual with the highest occupancy for Zone 3 and totalled 2 190 hours annually. See Table A7iii for a statistical summary of terrestrial occupancy per zone based on actual replies.

Table A7iii Intertidal occupancy within Zones 1, 2 and 3.

	Zone 1 (h y^{-1})	Zone 2 (h y^{-1})	Zone 3 (h y^{-1})	Total all zones (h y^{-1})
Maximum	338	365	2 190	2 190
Minimum	1	1	1	1
Mean	86	74	243	233
Median	6	6	22	18
97.5th percentile	324	333	1 896	1 787

A7.4 Internal exposure

Household respondents were asked to provide information on where they sourced their food. A summary of the results (Figure A7iv) shows the origins of where respondents sourced their food. Results show that the respondents sourced most of their food from outwith the zoned areas. This was consistent across all food groups.

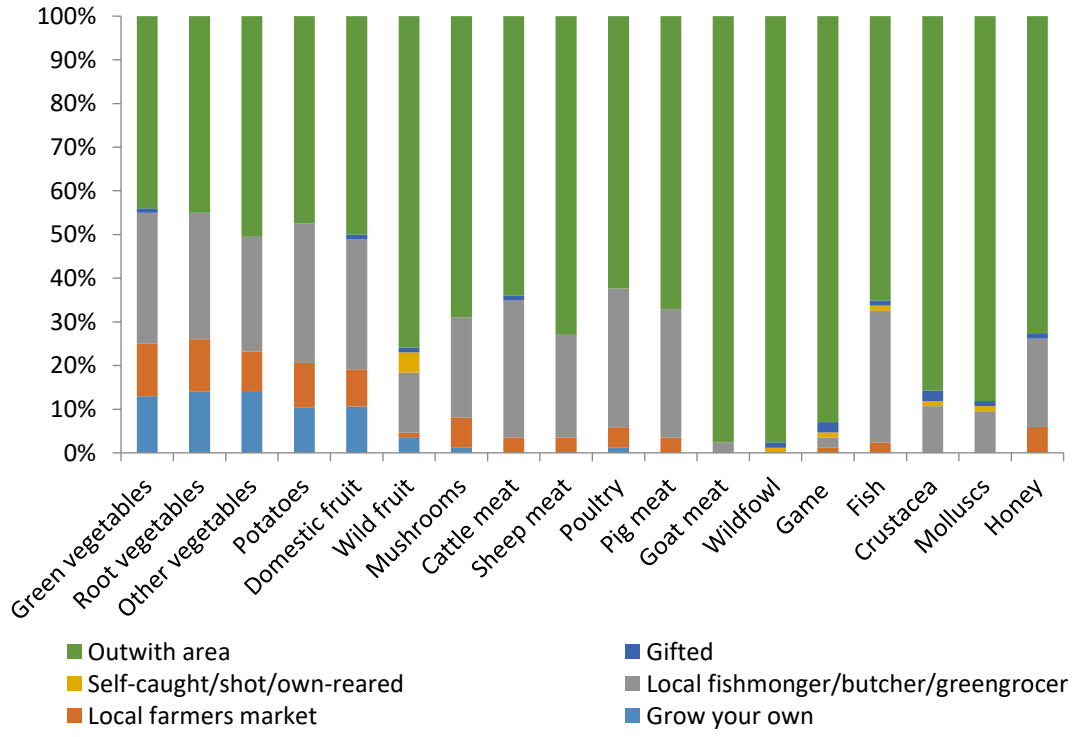

Figure A7iv Sources of food consumed by the surveyed households.

The survey showed respondents most frequently consumed locally sourced green vegetables, root vegetables, other vegetables, potatoes, domestic fruit and mushrooms obtained mostly from local greengrocers. All meat was mostly sourced from a local butcher and all fish, crustaceans and molluscs was mostly sourced from a local fishmonger. See Table A7iv for the percentage of respondents sourcing food locally from various sources. It should be noted that some respondents consumed produce from more than one source in the same food group.

Table A7iv Percentage of respondents sourcing food locally.

	Total individuals	Grow your own (%)	Local farmers market (%)	Local fishmonger/butcher/greengrocer (%)	Self-caught/shot/own-reared (%)	Gifted (%)
Green vegetables	39	33	31	77	0	3
Root vegetables	38	37	32	76	0	0
Other vegetables	33	42	27	79	0	0
Potatoes	37	27	12	37	0	0
Domestic fruit	36	12	10	34	0	1
Wild fruit	17	18	6	71	24	6
Mushrooms	23	4	26	87	0	0
Cattle meat	28	0	11	96	0	4
Sheep meat	21	0	14	95	0	0
Poultry	30	3	13	90	0	0
Pig meat	26	0	12	96	0	0
Goat meat	2	0	0	100	0	0
Wildfowl	1	0	0	0	100	100
Game	4	0	25	50	25	50
Fish	27	0	7	96	4	4
Crustaceans	11	0	0	82	9	18
Molluscs	9	0	0	89	11	11
Honey	22	0	23	77	0	5

Appendix A8 Aquatic site descriptions and observations

A8.1 North Berwick, Milsey Bay and Seacliff

North Berwick is the most northerly site within the survey area and is a busy tourist town with a working harbour. The harbour has four creelers (only one of which is full time) that fish for lobster, mackerel and occasionally velvet crabs that launch out of North Berwick. It is also home to the East Lothian Yacht Club and the North Berwick Rowing Club. There are catamaran trips and two Rigid Inflatable Boats (RIB) that provide bird watching, sightseeing and visits to the Isle of May and Bass Rock which are popular with tourists and bird watchers. Kayak hire is available. East Lothian Yacht Club (ELYC), based at the harbour, has approximately 408 members with a children's sea cadet section. The ELYC attracts regattas to the local area. North Berwick Coastal Rowing Club is also situated at the harbour. During the summer there is a Fringe Festival attracting many visitors and locals. A lobster hatchery is situated here, a tourist attraction, with its aim to improve the sustainability of lobster populations rearing lobster eggs until they are 12 weeks old then releasing them back into the sea. There are plans submitted to make this facility permanent. There is a cafe situated in the harbour where all lobster sold is sourced within the survey area. West of the harbour is a sandy beach where several walkers and dog walkers were observed. To the east of the harbour is Milsey Bay, a sandy beach with many rocky outcrops throughout its length and a tidal swimming pool. A large amount of seaweed is washed up and deposited along the strand line. Outwith the school holiday period over 20 people were noted on one occasion beachcombing, picnicking and dog walking. Five campervans were parked at the east of the beach in off-road parking with individuals picnicking. There is a rocky promontory at the east end of Milsey Bay. The rocky coastline continues towards Seacliff but is inaccessible due to the steep cliffs. Seacliff is a long sandy beach (Figure A8i) with the steep rocky cliff-side continuing on the western end of the beach, only accessible via a private road which requires payment for a coin-operated barrier. A small harbour situated west of the beach had one fishing boat moored. Two commercial creel boats operate out of this harbour with two individuals working them together. Outwith the school holiday period two horse riders were observed on the beach.

During the school holiday period North Berwick was very popular with visitors and locals due to the Sea Fringe Festival (8th – 14th August) and a national children's sailing club competition taking place. It was reported that approximately 120 yachts took part in the sailing competition over the survey weekend. The west beach was well populated with walkers (adults and children > 200), playing/digging (adults and children 44), dog walking (adults and children 59), sitting (adults and children 44), three adults and three children kite flying, two joggers, one cyclist on the sand, two children rock pooling, 11 individuals paddling, nine individuals having a barbeque and two tractors being driven on the beach during the school holiday survey period. Aquatic activities observed were two RIBs, three rowing boats (each with 4 or 5 individuals rowing), nine kayakers or sit-on kayakers, one stand up paddle boarder and five sail boats. Milsey Bay to the east of the harbour was also well populated during the school holiday period with >150 individuals playing on the beach, 37 individuals walking/climbing on the rocks and rock pooling, 70 individuals walking, 16 dog walkers, 48 individuals sitting on the beach, one kite flyer, one photographer, one jogger and four children having a donkey ride (donkey rides were available daily on the beach during the school holiday period). Aquatic activity observed comprised 11 individuals swimming, 29 paddling, and two kayakers. Six campervans were also parked up in the parking bay at the east end of the beach.

Seacliff was a popular beach and well populated with individuals undertaking a variety of beach and aquatic activities. One winkle picker and two creel fishermen were identified at Seacliff. Two university researchers had been out with the creel fishermen undertaking gannet tracking research. During the school holiday survey period the intertidal activity included six dog walkers, 13 walkers, 15 individuals horse riding, one individual flying a kite, 14 individuals rock pooling, six individuals digging in the sand, a group of three adults and one child fishing off the rocks to the west of the beach, three individuals practising archery and in excess of 150 individuals sitting and/or playing on the sand. Aquatic activities observed were 22 swimmers, two body boarders, two stand-up paddle boarders, two dinghies in the water, one RIB, one yacht and 16 kayakers.

Figure A8i Seacliff looking out to Bass Rock (May 2016).

No spume was noted at any of these sites during the survey outwith the school holiday period. Within the school holiday survey period the beach to the west of North Berwick harbour and Seacliff was noted to have a small amount of spume visible.

A8.2 Peffer Sands, Ravensheugh Sands and Bathan's Strand

South from Seacliff is a wide and long sandy expanse comprising Peffer Sands, Ravensheugh Sands and Bathan's Strand (Figure A8ii). During the school holiday time this area was relatively quiet, with only six dog walkers, four walkers, one jogger and two individuals picnicking while sitting beside a fire observed during the survey.

Access is possible from a public car park and walking through a wooded area to the coast. This provided access by foot along the beach to Peffer Sands, though access time is limited because it is cut off at high tide. Public access to the shore of Peffer Sands is difficult from the north. Continuing south from Bathan's Strand there is a rocky headland which separates this continuous sandy expanse from Belhaven Bay.

Figure A8ii Looking to Peffer Sands from Ravensheugh Bay (2016).

During the school holiday survey period Peffer Sands, Ravensheugh Bay and Bathan's Strand were popular mainly with tourists but also some local residents. The activities observed on this stretch of beach were 38 dog walkers, 23 walkers and 17 individuals sitting/picnicking in the sand. Other activities along this stretch included families playing, paddling and rock pooling, sand boarding on the dunes, birdwatching, flying kites, kite boarding, sunbathing, jogging, collecting firewood, horse riding and two cyclists. One group of five individuals were camping on the sand beside the rocky outcrop between Ravensheugh Bay and Bathan's Strand. Aquatic activities observed consisted of swimming, surfing, kayaking, one yacht and six fishing boats.

No spume was observed at these sites outwith or within the school holiday period.

A8.3 Belhaven Bay

Belhaven Bay is accessible via the John Muir Country Park and has a large sandy beach and a caravan park (Figure A8iii). During the survey period outwith the school holiday period, approximately ten surfers, four dog walkers, and several walkers were observed. Wildfowling is permitted by license in areas of the John Muir Country Park and evidence of horse riding was also noted.

Within the school holiday period observed activities included 24 dog walkers, 24 walkers, paddling, a large group of 17 individuals having a campfire on the sandy/grassy area behind the foreshore by the Tyne River, families playing and sitting in the sand, joggers and one cyclist. Aquatic activities observed included 13 surfers, six adults and children body boarding, five individuals swimming, one power boat, one fishing boat and one sail boat. The northern section of Belhaven Bay was inaccessible via Tyne Sands during the school holiday survey period due to this section being fenced off (fencing is usually erected in April and removed by September) to protect tern nesting during the breeding season (May to end of August).

It was reported that on a good day, which would combine good weather with a good swell, around 150 surfers may be surfing at any one time at Belhaven Bay.

Figure A8iii Belhaven Bay (2016).

The River Tyne flows through the saltmarsh area in the northern end of the John Muir Country Park and then out through the sand to the sea. At the southern end of the beach the Biel Water flows beside rocky outcrops and into the sea.

Between Belhaven Bay and Dunbar, the coastline is backed by steep rocky cliffs and the shore is largely inaccessible.

No spume was observed outwith the school holiday period but spume was visible along the shoreline in a small section of Belhaven Bay nearest Dunbar during the school holiday period.

A8.4 Dunbar

Dunbar is home to Dunbar Harbour which consists of an outer harbour where approximately 18 sailboats and five fishing boats were moored and with an interconnecting harbour where boats rested on the mud at low tide. The substrate is predominately mud with stone and seaweed present. A slipway allows access for

boats and individuals. Access at low tide is also possible via rocks. There are 29 fishing boats (full-time and part-time) based at Dunbar with lobster, crab and prawn landed. There are plans to land mackerel but at the time of this survey these were not being actively caught.

The Royal National Lifeboat Institute (RNLI) has an office at Dunbar Harbour with a small inshore lifeboat moored at the harbour. Outwith the school holiday period several tourists were observed, in addition to four individuals undertaking boat maintenance and several fishermen working with nets and creels on the harbour side and in boats. During the school holiday survey period many individuals were observed visiting the harbour, including six individuals fishing off the harbour wall, a group of four Scouts and one adult, and ten children observed jumping into the water from the cliffs at the harbour. Six rowing boats (five persons to each rowing boat, operated by the Dunbar Coastal Rowing Club; Figure A8iv), seven adults paddle boarding in the harbour, in excess of ten leisure craft, in excess of 15 sailing boats and nine fishing boats were also observed.

To the east of the harbour is Dunbar's East Beach, which is a long sandy stretch with adults and children playing outwith the school holiday period. During the school holiday survey period, individuals observed at East Beach included dog walkers, several walkers, children playing, two individuals sitting on the beach and two children swimming.

No spume was observed outwith or within the school holiday period.

Figure A8iv Dunbar Harbour (August 2016).

A8.5 Whitesands, Barns Ness and Skateraw Harbour

South of Dunbar the shore is a mixture of pebbles and sand with rocks. Whitesands is a sandy beach with some rock; this stretch of coast to Torness Power Station is accessible by foot along a coastal path and also by road. One jogger, one walker and four children playing in the sand were observed at Whitesands outwith the school holiday period. The substrate at Barns Ness beach consists of sand and pebbles and a rock platform (Figure A8v). Three dog walkers, two tourists and two winkle pickers were observed outwith the school holiday period. Skateraw Harbour (Figure A8vi) has a sandy foreshore with seaweed and pebbles and outwith the school holiday period four dog walkers, one walker, one bird watcher, one photographer and one individual metal detecting were observed. Brambles were growing alongside the carpark area and this site was surrounded by agricultural fields growing Brussels sprouts. The area around Skateraw Harbour forms part of the Scottish Site of Special Scientific Interest,

which attracts bird watchers to the area to observe the intertidal birdlife. Access around the Torness nuclear power station is provided via a coastal path.

Figure A8v View East from Barns Ness across the Rock Platform to Torness Power Station (August 2016)

During the school holiday survey period intertidal activities observed included 15 individuals playing, five people sitting, two dog walkers, six walkers and a group of five adults and three children bait digging at Whitesands. At Barns Ness, intertidal activities observed were nine dog walkers, group of five children undertaking an organised hike, two path wardens, one bird watcher and one individual sitting. A large tent had been discarded on the grassy area behind the beach and it was reported at least four tents had been present for several days. Barns Ness Light House is a popular attraction and six cars were parked here for walkers, dog walkers and picnickers. At Skateraw Harbour, the intertidal activities consisted of five dog walkers, one child paddling and playing in the sand and a group of five children and three adults playing that were camping on the grassy area behind the beach. Winkle picking was not observed at

any of these sites during the school holiday survey period. Aquatic activities observed were seven individuals swimming and one surfer from Whitesands.

No spume was observed at these sites outwith or within the school holiday period.

Figure A8vi Skateraw looking towards Barns Ness (May 2016).

A8.6 Torness Power Station

The spillway from Torness Power Station is bounded by rocky boulders forming a man-made embankment leading down to a sandy beach with flat rocky outcrops both to the east (to Thorntonloch) and west (to Skateraw). The spillway area was found to be popular with fishermen fishing from the rocky boulders and from the beach from shelving rock. It was reported that individuals collect winkles, sand eels, eat limpets raw and fish regularly, often at night with glow lights. It is also reported that many individuals fish and keep large quantities of the catch that are below the recommended size. One individual is reported to lay fishing nets in the area.

Consistent with the 2011 habits survey, winkle picking and bait digging was identified along this stretch of coast. One fisherman stated that the fish are attracted to this area due to the pressure of the spillway water flowing out to and mixing with the sea,

drawing the fish in with the current. Other individuals reported it was due to the warm water near the power station outfall that was the key factor.

No spume was observed at these sites outwith or within the school holiday period.

During the school holiday survey period one walker and ten dog walkers were observed along the shore by Torness and 12 individuals fishing from the spillway area.

The RNLI all-weather life boat is moored at Torness.

Seaweed and jellyfish are regularly removed from the Torness Power Station seawater filters although the quantity varies depending on the weather. Preparation for potential large influxes is aided by weather forecasting. The seaweed is washed off the filters into a collection skip where it is then transferred to a composting station off the Torness site. This separate commercial operation then mixes the seaweed with grass in order to be utilised as compost. This is sold to the public as garden compost.

Spume was observed in two areas to the western side of the spillway outwith the school holiday survey period (Figure A8vii). No spume was observed within the school holiday survey period.

Figure A8vii Spume at the western side of the spillway (May 2016).

A8.7 Thorntonloch, Cove and Pease Bay

South of Torness Power Station is Thorntonloch with a large sandy beach. Thorntonloch Caravan Park is situated by the beach and several visitors were noted during the survey outwith the school holiday period. It appeared to be well populated during the school holiday period. Walkers were observed on the beach as well as two kayakers during this time. It is reported that individuals surf at Thorntonloch however this was not observed during the survey outwith the holiday period. A fishing

competition was underway during the survey period before the school holiday period and ten fishermen from Fife were visiting for the first time. No fish were consumed and those caught were measured and returned. During the school holiday survey period intertidal activities observed were seven dog walkers, one individual fishing, two walkers, one adult sitting in the sand, three children playing in the sand and five individuals swimming. It was reported that kayakers launch from Thorntonloch to fish and also that spear fishermen operate from the beach although none were observed during the survey period.

From Thorntonloch the coastline is rocky with access possible to a rocky beach, west of Cove Bay and its harbour, via a private access road that runs down a steep embankment and rocks. Seaweed was visible at low tide. To the east there is a small, sand and pebble beach, Cove Bay, and a small walled harbour, Cove Harbour (Figure A8viii). Access is via a steep grassy embankment that is thick with gorse. This beach could also be accessed through a tunnel in the landscape leading from the private road. Two creel boats were moored in the harbour and two rowing boats were lying on the grass above the tide line of the bay. Three creel boats are reportedly moored at Cove Harbour with two of them operating full time (all year) and one part time (May to November) for catching lobster and brown crab within the survey area. It was reported that bait digging was undertaken in the western coastal area from the harbour, known as Lidsters Bay and one individual was observed collecting whelks there. One dog walker, one nature watcher, one adult and a child playing on the beach and four fishermen were noted during the survey outwith the school holiday period. During the school holiday survey period the car park and road leading to Cove Bay was relatively busy with the intertidal area occupied by three adults and five children playing. One holiday cottage at the back of the beach was occupied by a family. In the car park three spear fishermen were preparing to go fishing for pollock. Offshore two fishing boats were also noted.

Figure A8viii Cove Harbour and Bay (August 2016).

Continuing south from Cove is Pease Bay (Figure A8ix), which is a sand and pebble beach, accessed via a caravan park located nearby. Several people were observed at the caravan park outwith the school holiday period with one walker on the beach. A stream flows into the bay with wild garlic growing along the bank. During the school holiday survey period intertidal activities observed were 31 dog walkers, nine walkers, six individuals playing, five individuals paddling, 15 swimming and one individual sitting. No other aquatic activities were observed although a number of individuals reported surfing at Pease Bay at different times of the year.

No spume was observed at any of these sites outwith or within the school holiday period.

Figure A8ix View looking West along Pease Bay (August 2016)

A8.8 St Abbs Head, St Abbs, Coldingham Bay and Killiedraught Bay

Continuing south east along the coastline the only access to the coast prior to St Abbs was from a private road (requiring voluntary payment) towards the lighthouse. This part of the coastal cliff area, St Abbs Head, was popular with 15 bird watchers and walkers observed outwith the school holiday period and with two walkers, three individuals sitting and one cyclist during the school holiday survey period. St Abbs Head forms a National Nature Reserve which has the potential to attract many bird watchers and nature enthusiasts. Public access to the small stony beach on the western side of St Abbs Head is provided via a path leading from a private road. One sit-on kayaker was observed to be launching from the stony beach with a fishing rod outwith the school holiday period.

Continuing along the rocky coastline is the village of St Abbs. St Abbs has a small harbour with five fishing boats observed moored outwith the school holiday period. It was reported to the survey team that approximately ten creel fishing boats (both full

time and part time) operate from the harbour landing lobster, brown crab and mackerel (Figure A8x). Part-time fishing boats were reported to go out between June and November. St Abbs was very popular with sub-aqua divers at the time of the first face-to-face surveys with some divers visiting from England to dive for five days each year. The coastal area between St Abbs and Eyemouth is a Voluntary Marine Reserve which covers 1 030 hectares along an 8 km stretch of coast with the aim to conserve marine life and promote sustainable fishing. Divers were interested in underwater photography which included the photography of Guillemot and Nudibranches (sea slugs). Divers from the East Lothian Diving Club were also observed and dive regularly in this area all year. Six fishermen were working on boats in the harbour, two dog walkers and many tourists (20 on one occasion alone) were noted to be visiting the area outwith the school holiday period. A dive centre and a number of dive boats operate out of St Abbs.

Figure A8x St Abbs Harbour (August 2016).

A Marine Research Station (linked to Napier University, Edinburgh) was established at St Abbs Harbour approximately four years ago and officially opened in 2015. A

private lifeboat is to be based at St Abbs, planned for July 2016 (as reported to the survey team outwith the school holiday period and BBC News; 9th September 2016), and money has been both gifted and raised to buy this. It is to arrive in July 2016. In two sections of the harbour, unauthorised crab waste and bait disposal was being undertaken with individuals having reported this but with no resolution at the time of the survey period.

During the school holiday survey period St Abbs Harbour proved to be popular with divers (17 observed on one occasion), families visiting, dog walkers and walkers/ramblers.

The coastal area surrounding St Abbs is predominantly rocky and continuing south is Coldingham Bay (Figure A8xi), a sandy beach which has been awarded blue flag status, with 30 beach huts and a café. Lifeguards are present during the summer season from May 21st to September 4th. Five lifeguards patrol the beach during this period in a shift pattern with three working at any one time seven days of the week. The lifeguards spend approximately 30 minutes each day of their shift in the water training with surf boards and rescue boards. During the time of the face-to-face surveys, outwith the school holiday period, ten lifeguards were undertaking a training session in preparation for the summer season. Coldingham Bay was popular with seven dog walkers, nine ramblers walking the Berwickshire Coastal Path, walkers, six surfers, several individuals swimming and paddling, horse riders and a group of ten individuals taking part in an outdoor fitness club on the beach outwith the school holiday period. During the school holiday survey period Coldingham Bay was very popular and intertidal activities observed consisted of 39 dog walkers, 13 walkers, six individuals sitting, 22 adults and children playing in the sand, three individuals sunbathing, two joggers, one photographer, one child flying a kite, a children's club of 25 children and an annual school trip of five adults and 37 children. Aquatic activities consisted of 19 surfers, one body boarder, four body surfers and six kayakers (who are members of the Lothian Sea Kayak Club and reported to frequently use Coldingham Bay).

Figure A8xi Coldingham Bay.

Access to the rocky cliff side and shore between Coldingham Bay and Killiedraught Bay below is relatively limited due to steep cliffs. Killiedraught Bay is accessible via a cliff path from the nearby caravan park or from a playing field next to the caravan park which lead to the small beach with a substrate of sand and stone. Outwith the school holiday period, one adult and one infant were beach combing and one individual was identified to be winkle picking. During the school holiday survey period this area was relatively quiet with intertidal activities consisting of one dog walker and eight adults and two children fishing from the rocks. Offshore one kayaker, one sailing yacht and six fishing boats were observed.

No spume was observed at any of these sites outwith or within the school holiday survey period.

A8.9 Eyemouth

Continuing south from Killiedraught Bay, Eyemouth was the furthest most point of the aquatic survey. Eyemouth has a harbour with creel fishing boats moored, though this

is reported to have diminished over the years. There are ten prawn and nine creel fishing boats moored at Eyemouth Harbour (Figure A8xii). The Eyemouth Harbour Master reported that of the six remaining trawler boats two have recently been sold, two were in the process of being sold at the time of the survey and two have moved from trawling to prawning. One individual interviewed outwith the school holiday survey period was fishing off the harbour wall at the entrance into the harbour. During the school holiday survey period two individuals were observed fishing from the harbour wall and eight individuals were observed to be going out diving. The Eye Water flows into the eastern side of the harbour. This area of Eyemouth contains some residential housing, commercial businesses, Eyemouth Harbour and fish merchants, a dive centre and a 'feed the seal' station. The beach itself at Eyemouth is predominantly composed of a sandy substrate with some pebbles. To the western side of the beach are rocky outcrops with rock pools and further west a rocky promontory. Thirteen people were observed walking on the beach, seven dog walkers and one child playing in the sand outwith the school holiday period. During the school holiday survey period the beach was more heavily frequented and the activities observed included 50 individuals playing, 17 sitting, 12 dog walkers, two walkers, one individual fishing and two individuals launching kayaks. Aquatic activities observed were six individuals paddling and swimming. Access to the beach is from the eastern end from the harbour and access from the western end is via a caravan park. A high stone beach wall runs the extent of the beach with road access above.

No spume was observed at these sites outwith or within the school holiday period.

A8xii Eyemouth Harbour (2016).

Appendix A9 Terrestrial site descriptions and observations

A9.1 Skateraw, Thorntonloch, Crowhill

Surrounding Torness Power Station are many agricultural fields largely growing wheat and Brussels sprouts, with houses ranging from single isolated houses to small villages. The communities are comprised mainly of locals involved in farming and individuals who work outwith the area.

A9.2 Torness

The Torness site discharges radioactive wastes via stacks to the atmosphere, liquid radioactive wastes via an outfall from a spillway into the North Sea and contains sources for direct radiation. No employees were interviewed at the Torness site and no Torness employees were encountered throughout the face-to-face survey period. Volunteers were approached to provide information on offsite habits and were interviewed during a follow-up survey. Torness Visitor Centre was contacted and reported that for the second year running they had been awarded the Biodiversity Benchmark Award from the Wildlife Trust. Several new species of butterflies and moths to the area have also been identified over the past couple of years. Traditionally, species had a northern limit but have been creeping northwards along the coast from England, tending to appear in the south east coast and the Torness coastline. Annual insect and botany reports along with weekly monitoring are undertaken. Also undertaken is a Tree Sparrow recovery programme of nest box provision and winter feeding and there is an ongoing Rock Rose planting scheme which is specifically to attract the Northern Brown Argus butterfly. In 2015 the Torness Visitor Centre staff set-up a sign posted Nature Trail at Torness thus capitalising on their achievement of securing the Biodiversity Benchmark Award. The Nature Trail was successful, with plants and insects being the main focus, including activities for children and the Visitor Centre hope to run similar events in the future (Hogg G. (2015) Torness, Butterfly, Moth and other Invertebrates Report). It is reported that there are no real pest control issues at the Torness site and that the double fencing around the site is rabbit proof. The Torness Visitor Centre re-opened in 2013 and has received 10 000 visitors since re-opening, of which 4 300 visitors were in 2015. Discussions with locals have indicated that the new car park charging policy (new since the previous survey) has increased visitor numbers, including dog walkers, to those car parks where no charging exists.

Refer to Chapter 2 for further details of the Torness site.