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

# Radiological Habits Survey Rosyth 2015

## Public Report

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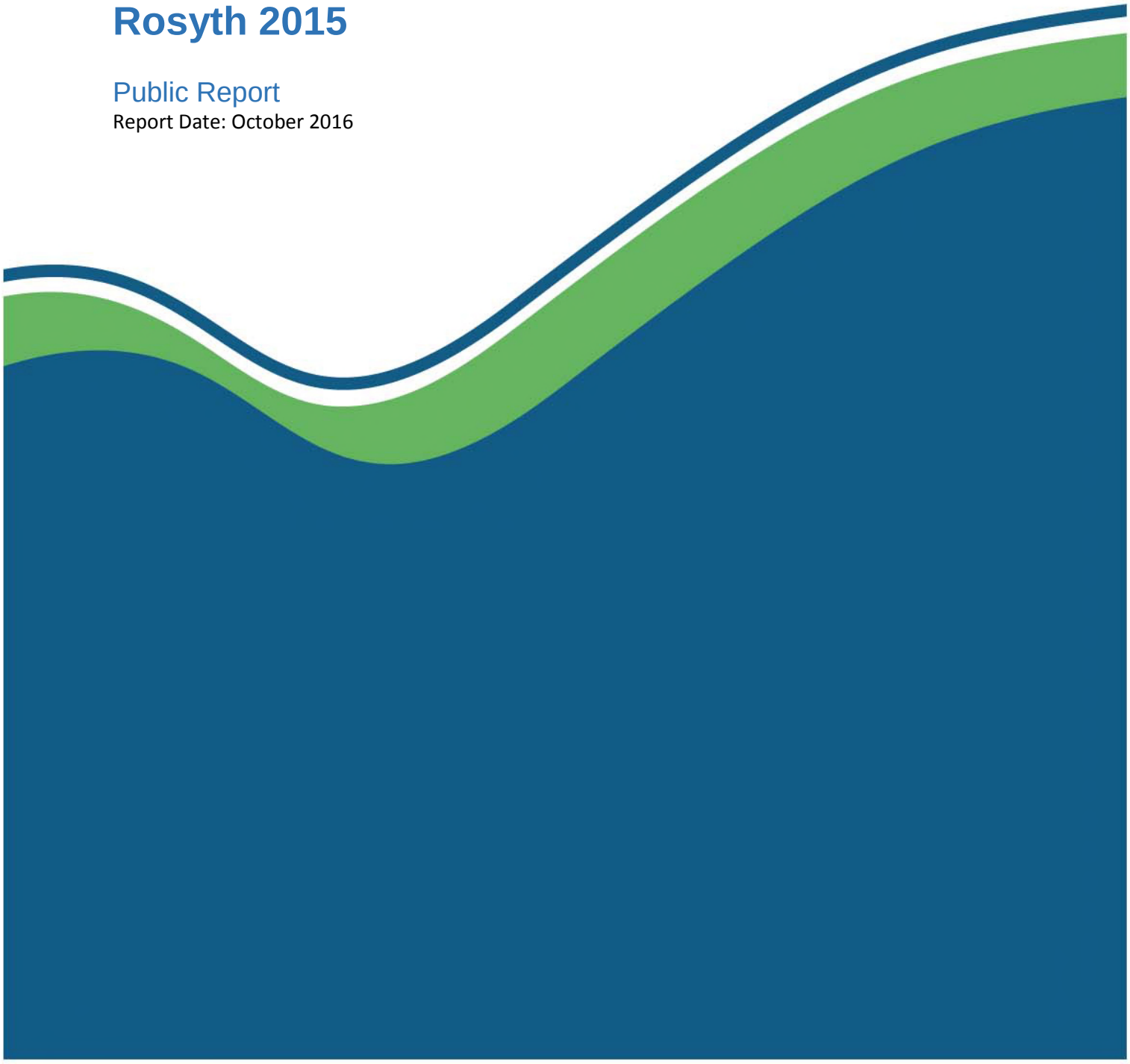

# Radiological Habits Survey: Rosyth 2015

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# Summary

This report presents the results of the 2015 survey to determine the habits and consumption patterns of people living and undertaking recreational activities in the vicinity of the Babcock Rosyth Site (BRS). The site is authorised to discharge gaseous radioactive waste in addition to the discharge of liquid radioactive waste through an outfall into the Firth of Forth. Sources of direct radiation are also found at this site.

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

- The aquatic survey area; covering the Firth of Forth from Kincardine Bridge in the west to Kinghorn in the east
- The terrestrial survey area; extending 5 km from the centre of the Active Waste Accumulation Facility
- The direct radiation survey area; extending 1 km from the centre of the Active Waste Accumulation Facility

During the survey, a number of potential exposure pathways were investigated through postal and face-to-face surveys; the consumption of foods produced within the terrestrial survey area; occupancy of terrestrial areas and within the direct radiation survey area; consumption of aquatic food from within the aquatic survey area; occupancy of aquatic and intertidal areas; handling of equipment used within the aquatic survey area.

Interviews with members of the public were carried out over a period of 14 days and data for 528 individuals are presented and discussed. Those high-rate individuals are identified using established methods comprising a 'cut-off' to define the high-rate group and 97.5$^{th}$ percentiles for dose assessment analysis.

***The aquatic survey area***

Two commercial fishing boats within the survey area fished for brown and velvet crabs and also lobster.

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

- 109 kg y$^{-1}$ for fish (bass, cod, mackerel, salmon)
- 31 kg y$^{-1}$ for crustaceans (common lobster)
- 16 kg y$^{-1}$ for molluscs (mussel)
- 26 kg y$^{-1}$ for wildfowl (sourced out with survey area)

One child was found to consume 1 kg $y^{-1}$ of fish and one infant was found to consume 7.8 kg $y^{-1}$ of fish and 15.6 kg $y^{-1}$ of molluscs.

No consumption of marine plants or algae was identified.

Aquatic activities included sea angling, freshwater angling, boat maintenance, being on a dive boat, canoeing, commercial fishing, commute via boat, diving, jet skiing, paddling, rowing, safety boat duties, sailing, sports fishing, sub-aqua diving, swimming, power boating, water skiing, and working on a boat and the Forth Road Bridge.

Intertidal activities included bait digging, beachcombing, boat maintenance, collecting mussels, razor clams, seaweed or winkles, crabbing, handling creels, dog walking, fixing moorings, horse riding, paddling, playing, research/educational purposes, rock pooling and wildfowling. The activities found for adults involving the handling or maintenance of equipment included boats and boating equipment, clothes and overalls, diving gear, fishing gear, swimming gear.

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

- 2664 h $y^{-1}$ for intertidal activities
- 106 h $y^{-1}$ for activities in the water
- 2969 h $y^{-1}$ activities on the water
- 1460 h $y^{-1}$ handling equipment

A total of 37 in-situ gamma dose rate measurements were made over intertidal surfaces. Also, beta dosimetry of skin dose was measured over objects and clothing immersed within the Firth of Forth.

***The terrestrial survey area***

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

- 68.3 kg $y^{-1}$ green vegetables
- 38.7 kg $y^{-1}$ root vegetables
- 46 kg $y^{-1}$ potatoes
- 38.7 kg $y^{-1}$ domestic fruit
- 20.8 kg $y^{-1}$ beef
- 10.6 kg $y^{-1}$ poultry

No consumption of locally produced milk, eggs, game, sheep meat, wild fruit or honey was identified. A total of 46 gamma dose rate measurements were taken in terrestrial environments.

***The direct radiation survey area***

The highest occupancy rates in the direct radiation area were as follows:

- 5110 h $y^{-1}$ for the total occupancy rate (for a resident)
- 3650 h $y^{-1}$ for the indoor occupancy rate (for a resident)
- 1460 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.

***Comparisons with previous surveys***

The results of the 2015 Rosyth habits survey were compared with the last habits survey carried out at Rosyth in 2010.

In the aquatic survey area, the overall mean consumption rate for the adult high-rate group for fish, crustaceans, molluscs and wildfowl increased in 2015 compared to 2010. The main species of fish consumed by adults were mackerel and cod in 2010 compared with mackerel, salmon and cod in 2015. The main crustaceans consumed by adults in 2010 were brown crab and common lobster, this remained the same in 2015. In 2010 the only molluscs consumed by adults were winkles compared with mussels in 2015.

The only fish species consumed by children was mackerel (self-caught in the Forth) in 2015 and fish consumed by infants were cod and salmon. The same infant also consumed mussels in 2015.

The handling of aquatic equipment was found to be lower in 2015 compared to 2010 and activities included boat maintenance, handling clothes and overalls, diving gear, fishing gear and outdoor swimming gear.

Consumption rates increased in the 2015 survey in the vegetables (green) food group in comparison to the 2010 survey. Consumption rates decreased in the 2015 survey in the following food groups: vegetables (root), vegetables (potatoes), fruit (domestic), meat (beef) and meat (poultry) in comparison to the 2010 survey. Eggs, rabbit/hare and wild fungi were not identified in 2010 or 2015. Locally produced milk, pig meat or fresh water fish were not identified as being consumed in 2010 compared to one person identified in 2015 who consumed fresh water brown trout from within the survey area.

In 2015 the total occupancy, highest indoor occupancy and highest outdoor occupancy decreased from 2010.

***Suggestions for changes to the monitoring programme***

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

- Gamma dose rates should be reported as terrestrial gamma dose rates.
- Include mussels within routine monitoring especially from North Queensferry Harbour.

# List of abbreviations

AWAF- Active Waste Accumulation Facility

BRS - Babcock Rosyth Site

BSS - Basic Safety Standards

CEFAS – Centre for Environment, Fisheries and Aquaculture

DCC - Dose conversion coefficient

FCYC - Forth Corinthians Yacht Club

GPS - Global positioning system

HP laundry – Health Physics Laundry

HSE - Health and Safety Executive

ICRP - International Commission on Radiological Protection

ILW – Intermediate Level Waste

MoD - Ministry of Defence

NDAWG – National Dose Assessment Working Group

ONR - Office for Nuclear Regulation

QE - Queen Elizabeth

RIFE - Radioactivity in Food and the Environment

RSA - Radioactive Substances Act 1993

SCAPE - Scottish Coastal Archaeology and the Problem of Erosion

SEPA - Scottish Environment Protection Agency

SMoGSS – Mobile Gamma Spectrometry System

# Units

Bq - becquerel

Gy - gray

$kg^{-1}$ - per kilogram

µSv - microsievert

$y^{-1}$ - per year

g - gram

$h^{-1}$ - per hour

$l^{-1}$ - per litre

mSv - millisievert

MBq - mega becquerel

# 1 Introduction

## 1.1 Regulatory Context

The Babcock Rosyth Site (BRS) holds an extant authorisation under the Radioactive Substances Act 1993 (RSA '93) to dispose of radioactive waste. The impact of these disposals needs to be monitored under the requirements of Article 35 of the Basic Safety Standards (BSS) 96/29 Euratom and to ensure that the doses to the representative person are within the 1 mSv whole body dose limit and 50 mSv skin dose limit. There are three primary pathways that may result in the exposure of the public: discharges to the aquatic environment; discharges to the atmosphere; and direct exposure from the site. Thus, members of the public may be exposed directly from radiation shine from the licensed site or through inhalation, and/or indirectly due to exposure to contaminated materials, 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 technological 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 site ensuring the public is appropriately protected. Exposure to direct shine from nuclear, radiation or waste facilities from the nuclear licensed site at Rosyth is the responsibility of the Office for Nuclear Regulation (ONR) and the Health and Safety Executive (HSE) where any direct exposure impacts on facility workers.

## 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 (to determine occupancy and local food consumption rates) and an environmental monitoring programme (to determine ambient dose rates and concentrations in foodstuffs). The actual dose received by an individual is dependent upon age, size, sex and metabolism in addition to the various interactions they may have with sources of exposure. Thus, the accepted approach is to identify and consider these sources of variability in appropriate groups. The concept of the representative person was introduced by ICRP (2006) and recommended to replace the previously used concept of the *critical group* in 2007 (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 considered to be protected.

## 1.3 Dose Limits and Constraints

The system of dose limitation recommended by the International Commission on Radiological Protection (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 the 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 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 are not exceeded for all authorised discharges of ionising radiation to the environment.

## 1.4 Survey Aim

The aim of the survey is to collect data to allow a bespoke assessment to be made, identifying the *representative individual(s)* in combination with data from SEPA's routine environmental monitoring programme. The survey may identify any habits which the routine programme does not currently adequately cover and may also recommend removal of monitoring that is no longer required. The survey does this by:

(i) Collecting data on a range of habits/activities by the general public across Rosyth 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 Rosyth.

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

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

This report presents the findings for the 2015 habits survey of the BRS on the Firth of Forth. The previous survey was undertaken during the period 26th July and 3rd August 2010 (Romney *et al*., 2013) and comparisons are made in Chapter 9.

As SEPA is bound by the Data Protection Act, information which may allow the identification of specific individuals is not presented in this report.

# 2 Rosyth Survey Area

## 2.1 Rosyth Site Location and History

The BRS is located on the north bank of the River Forth in Fife, 3 km west of the Forth Road Bridge and some 50 km from the mouth of the Firth of Forth. It is sited on reclaimed land, with reclamation completed in 1916. From 1916 the Site was known as HM Dockyard Rosyth and activities conducted there included refitting and maintaining warships.

The Royal Dockyard and HM Naval Base Rosyth were co-located until 1996 when the Naval Base closed and operational ships were withdrawn.

In February 1997, MoD sold the Rosyth Dockyard Site to Babcock International Group plc. The BRS, a wholly owned subsidiary of Babcock International Group Marine Division, holds a Nuclear Site Licence from ONR and a RSA 93 Authorisation from SEPA to dispose of Radioactive Waste from the Authorised Premises. The BRS was set up in 1997 to be responsible for the decommissioning of the Authorised Premises and the management of radioactive waste that has arisen from the re-fitting and the dismantling of nuclear submarines berthed on the Authorised premises.

Historically, refitting or de-equipping nuclear submarines has been the prime nuclear activities carried out at the BRS. However, these activities ended in 2003.

### 2.1.1 Current Activity

Since 2003, until now, the prime nuclear activities being carried out have been the safe management of legacy radioactive wastes from submarine refitting operations such as radioactively contaminated ion exchange resins, and the management of radioactive wastes from site decommissioning works. The MoD contracts the BRS to carry out these activities with the Ministry of Defence as the radioactive waste owner performing an assurance function.

The Queen Elizabeth (QE) Class aircraft carriers are currently being assembled at the BRS. The site also includes the Rosyth Business Park with a range of buildings used by commercial companies and educational organisations.

Radioactive waste at Rosyth primarily takes the form of solid waste with an associated liquid waste discharge. Some parts of the Authorised Premises are also licensed by ONR under the Nuclear Installations Act 1965 (as amended). Currently, this includes Dry Dock Number

2 and Dry Dock Number 3 and the Active Waste Accumulation Facility (AWAF). The ONR is currently assessing an application from the BRS to delicense the Dock 3 area of the site.

Disposal of radioactive waste from the AWAF is regulated by SEPA under the current BRS RSA93 Authorisation. Other parts of the site are not subject to licensing under the Nuclear Installations Act 1965, but disposals of radioactive waste from those parts of the site are regulated by SEPA under the current RSA 93 Authorisation granted to the BRS.

The BRS is authorised by SEPA under RSA 93 to dispose of solid, aqueous and gaseous radioactive wastes arising from site decommissioning operations and the management of legacy radioactive wastes from former submarine refitting operations at the BRS. The BRS was the first nuclear site operator to have a SEPA multi-media authorisation which was first granted in 2004 and the conditions and limitations were substantially amended in the notice of variation, VN01, issued by SEPA to the BRS in 2008. The site is authorised to discharge cobalt-60 ($^{60}$Co), tritium ($^{3}$H) liquid radioactive waste and other beta-emitting radionuclides (at an annual limit of 300 MBq) through an outfall into the Firth of Forth. Carbon-14 ($^{14}$C) and $^{3}$H gaseous radioactive waste, and beta associated with particulate (with an annual limit of 0.1 MBq), are authorised to discharge to the atmosphere. Whilst there is a potential for atmospheric discharge, none has been detected and filters are installed to prevent particulate atmospheric discharges. Radiographic material testing is undertaken on site which can lead to locally elevated direct radiation exposure during the duration of a test, however the effect on the public from the use of such sources within the site and the resultant shine outwith the site is controlled by the ONR and the Health and Safety Executive (HSE).

The main facilities which deal with the radioactivity and radioactive waste at Rosyth are:

(i) The AWAF with resin catch tank storage, ventilation plant, ILW Storage pits, Drum store, compaction and shredding and non-compactable low level waste storage area. This facility currently stores the radium-226 ($^{226}$Ra) particles from Dalgety Bay.

(ii) The Radiochemistry Laboratory that produces solid waste, in the form of soft waste (papers, gloves) and smaller amounts of non-compactable waste such as glassware, and liquid waste that is treated and discharged into the River Forth from the Low Active Effluent Discharge Line at high tide.

(iii) The effluent from the Health Physics (HP) laundry flows into an underground detention tank located outside the HP laundry. The contents are mixed and

sampled and analysed for radioactive content prior to discharge via the Low Active Effluent Discharge Line.

(iv) The High Intensity Calibration Centre.

On site, the dockyard has approximately 2,300 core employees, supplemented with around 4,000 additional agency/subcontract workers. Core employees are deployed across a variety of projects covering Marine, Nuclear, Oil & Gas and Renewables. The additional workers predominantly support the construction of the two new Aircraft Carriers – HMS Queen Elizabeth and HMS Prince of Wales.

There is a cycle to work scheme at the BRS but little evidence for cycling identified. The site is also served by bus, which travels through the site and there is also a bus scheme, associated with a Park and Ride from the M90 Motorway.

New housing developments have taken place in the area along Admiralty Road.

Rosyth port has a waterfront and land adjacent to it capable of accommodating a diverse range of energy, renewables, tourism and financial and business services. Since the last survey in 2010, the Lexmark factory on Admiralty Road has closed and has recently re-opened as a fish factory (Meridian Salmon Group). The Fife Coastal Path was extended to start in Kincardine in 2011 and runs along the coast of the survey area. This is a change from the previous survey in 2010 with a possible increase of people walking the full length.

### 2.1.2 Changes since 2010

In 2014, the Office for Nuclear Regulation granted its consent for a project to decommission and dismantle seven out-of-service nuclear submarines, following an application by the licensee, the BRS. The application was made under the Nuclear Reactors (Environmental Impact for Decommissioning Regulations 1999). Submarine dismantling is not planned to commence until at least 2016 but before starting, the BRS will need a new RSA 93 Authorisation granted by SEPA to allow disposals of low-level radioactive waste arising from submarine dismantling operations. SEPA is currently determining an application from the BRS for such a new RSA 93 Authorisation.

A staged approach will be applied to submarine dismantling until MoD announces its decision where to locate an interim store for the Intermediate Level Waste (ILW) produced from submarine dismantling operations at the BRS. During Stage 1 dismantling (Initial Dismantling), only Low Level Waste will be removed from the submarines at the BRS, after which they will return to storage afloat. When planning permission for the interim ILW store is

granted, Stage 2 dismantling will commence, (expected to begin 2020) during which ILW and any remaining radioactive waste will be removed. The interim ILW store will be used to store items such as the reactor pressure vessels removed from the submarines.

During decommissioning of the submarines these pressure vessels will be temporarily stored in the AWAF. Final disposal is likely to be by deep geological disposal at an undetermined site.

In October 2014, Fife Council produced a development plan which included a proposal for a biomass plant together with a bypass for Rosyth. The plan identified the wider area around Rosyth, Inverkeithing and Dalgety Bay up to the Forth Bridgehead as attractive for business, tourism and residential investment. The plan identified Rosyth port as a strategic employment and economic activity location and the preferred location for additional freight capacity and noted possibilities for further development in Rosyth Europark 1, 2 and 3.

In 2015, the Forth (Rail) Bridge was awarded World Heritage site status and a large visitor centre is now proposed in North Queensferry to cater for those wishing to visit the World Heritage site.

## 2.2 Estimated Activity Concentrations from Licensed Discharges from Rosyth.

Actual licensed discharges of $^{3}H$ (5.91E+07 Bq $y^{-1}$) and $^{60}Co$ (1.48E+06 Bq $y^{-1}$) from the BRS reported in 2013 were used to calculate aquatic activity concentrations in water using the DORIS model within PC CREAM (Public Health England, 2008). Assuming a 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 Rosyth on PC CREAM were used.

Activity concentration values reported at 50 years for aquatic activities were 1.5E-8 Bq $l^{-1}$ for $^{3}H$ and 4.2E-7 Bq $l^{-1}$ for $^{60}Co$. Activity concentrations in fish ($^{60}Co$ 1.28E-04 Bq $kg^{-1}$ and $^{3}H$ 1.49E-08 Bq $kg^{-1}$), crustaceans ($^{3}H$ 1.49E-08 Bq $kg^{-1}$ and $^{60}Co$ 1.40E-03 Bq $kg^{-1}$) and molluscs ($^{3}H$ 1.49E-04 Bq $kg^{-1}$ and $^{60}Co$ 6.97E-04 Bq $kg^{-1}$).

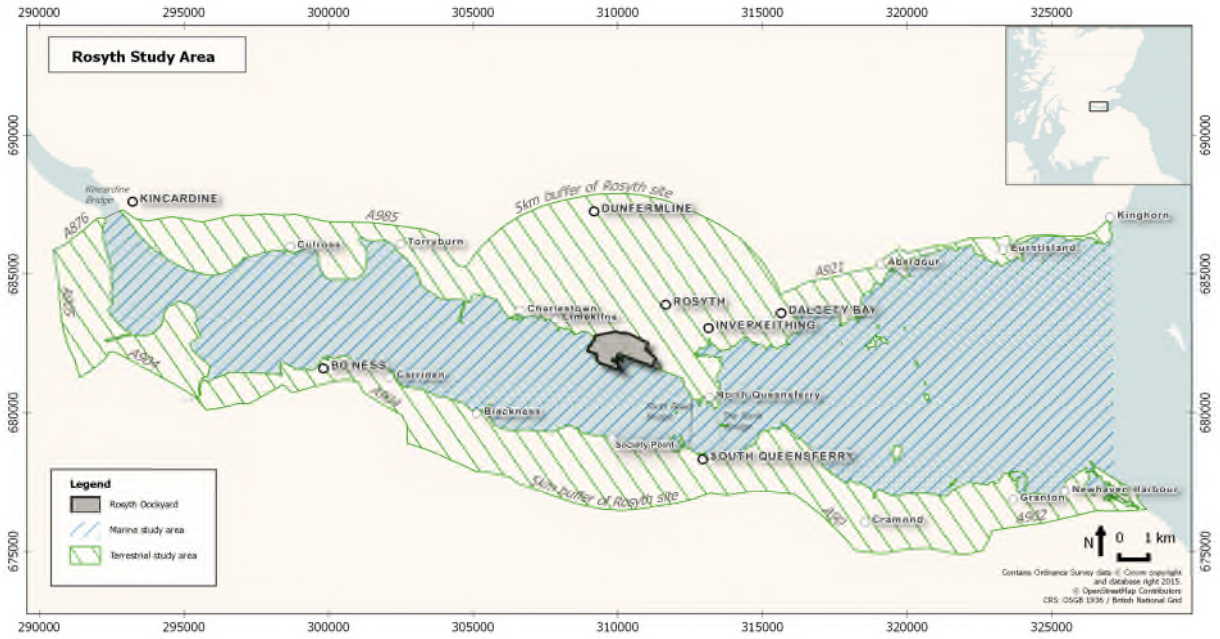


**Figure 2.1** The Rosyth survey area covering the Firth of Forth from Kincardine to Kinghorn on the northern shore and from Bo'ness to Newhaven on the southern shore.

Atmospheric activity concentrations were also modelled using the Plume model in PC CREAM. As no actual discharges occurred, the authorised limits in 2014 for the BRS were modelled with PC CREAM. These included $^{14}C$ (5.00E+8 Bq $y^{-1}$) and $^{3}H$ (2.00E+08 Bq $y^{-1}$). DORIS was set to calculate activity concentrations released at three different stack heights (10, 15 and 20 metres) and at a distance of 500, 1,000, 2,000, 3,000 and 5,000 metres. As the default deposition velocity settings for $^{14}C$ and $^{3}H$ in PC CREAM have a value of zero, no activity concentration was reported by our model. PC CREAM was exclusively used to model activity concentrations and not to calculate doses.

Where present, the modelled activity concentrations were used in the dose assessment tool to calculate doses through internal pathways such as ingestion of water, fish, crustaceans and molluscs, and external pathways for aquatic and intertidal activities. These are reported in Section 3.9. However, it should be noted that in reality if $^{3}H$ discharge did occur some washout would occur resulting in deposition

## 2.3 Survey Area

Despite the very low radionuclide concentrations modelled by PC CREAM (Public Health England, 2008) within the Firth of Forth, to remain consistent with previous Rosyth Habits surveys, the 2015 survey area was defined by three main factors:

(i) to cover all potential pathways of exposure,

(ii) to extend beyond the 2010 survey area to reflect the survey areas covered by Babcock International and encompass more of the locally caught fish,

(iii) to cover the same areas used in previous habits surveys conducted in the Rosyth area for direct comparison and identify any changes since the last survey.

Since there are no current gaseous releases from the site (RIFE 20), the main pathway of public exposure from the BRS is the aquatic pathway from discharges of $^{60}Co$ and $^{3}H$ into the Firth of Forth. The survey area for the marine pathway covered the Firth of Forth and its intertidal areas from Kincardine Bridge in the west to Kinghorn in the east on the northern shore of the estuary, and from Bo'ness in the west to Newhaven in the east on the south shore (Figure 2.1).

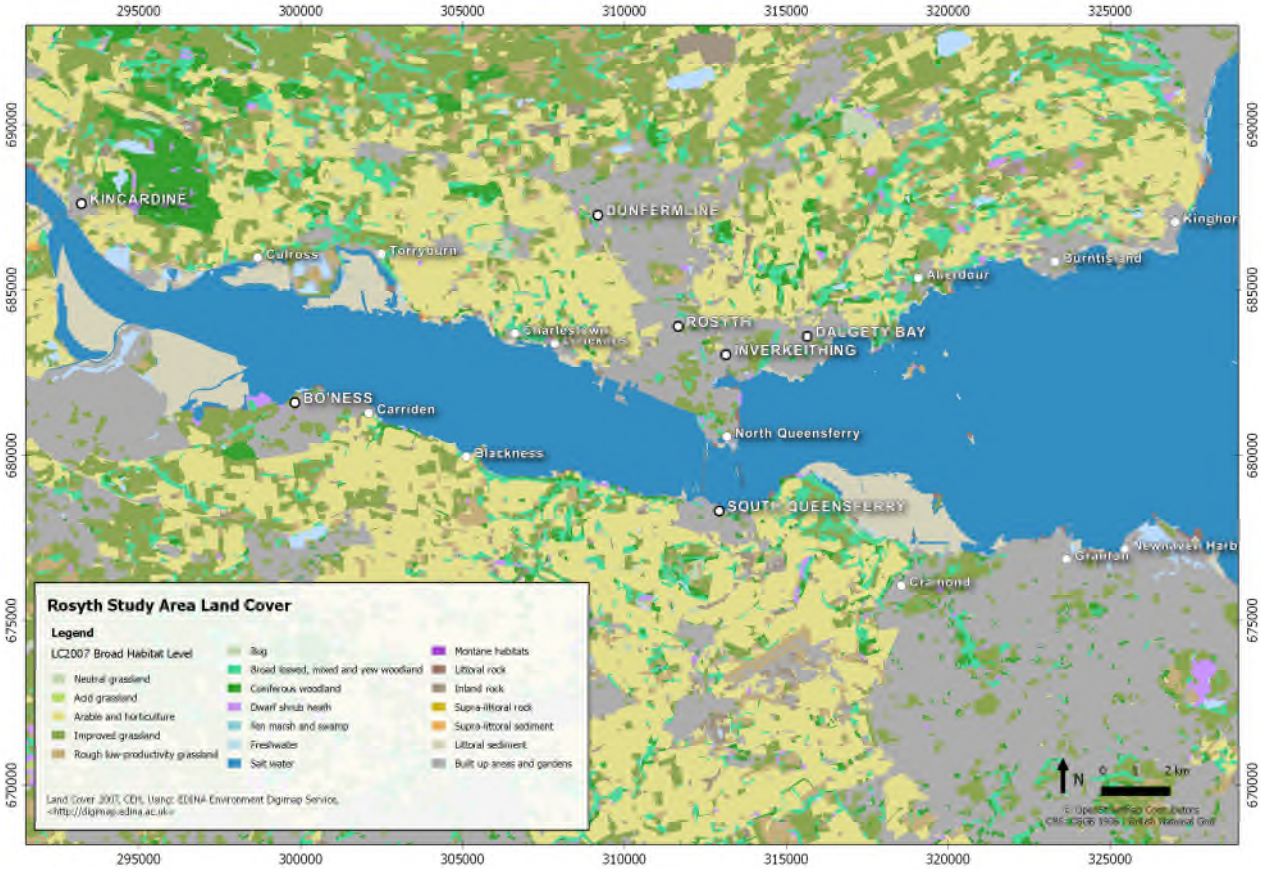


**Figure 2.2** Land cover data for the Rosyth, Firth of Forth area (EDINA online 2007).

To address potential atmospheric discharges of $^{14}C$ and $^{3}H$ the survey area was defined as a 5km radius from the Active Waste Accumulation Facility (AWAF). Any possible atmospheric releases are likely to have minimal impact on the terrestrial survey area. The direct radiation survey area was represented by the immediate public areas around the AWAF inside the BRS and up to 1 km around its boundaries. Outside the 5 km area used to model

atmospheric discharges, the terrestrial survey area was bounded by the coastal roads on the northern and southern shorelines (Figure 2.1).

## 2.4 Land Cover Data

The land cover data for the survey area is shown in Figure 2.2 (EDINA online 2007) and shows that the area is dominated by *built up areas and gardens* and *arable and horticultural* land capable of producing moderate to good crop yields and moderate grassland is the third most dominant land cover type outside the aquatic environment. This is summarised in Table 2.1, which provides a summary of the land cover types within the 1 km, 3 km and 5 km areas surrounding the BRS.

**Table 2.1** Area of land cover in hectare with buffer zones surrounding the BRS

| **Land Cover 2007 Broad Habitats** | **Within 1 km (hectares)** | **Within 3 km (hectares)** | **Within 5 km (hectares)** |
|---|---|---|---|
| Arable and Horticulture | 164 | 84 | 2,827 |
| Broad Leaved, Mixed and Yew Woodland | 14.8 | 160 | 509 |
| Built up Areas and Gardens | 335 | 1,058 | 2,218 |
| Coniferous Woodland | 4.38 | 73.3 | 278 |
| Dwarf Shrub Heath | 0.00 | 26.1 | 48.7 |
| Freshwater | 0.00 | 10.7 | 20.4 |
| Improved Grassland | 81.8 | 318 | 756 |
| Inland Rock | 12.67 | 21.6 | 96.9 |
| Littoral Rock | 0.00 | 13.3 | 20.6 |
| Littoral Sediment | 16.4 | 47.6 | 95.7 |
| Neutral Grassland | 0.00 | 2.14 | 66.1 |
| Rough Low-Productivity Grassland | 0.83 | 43.5 | 175 |
| Salt Water | 518 | 2,254 | 3,986 |
| Supra-littoral Sediment | 2.81 | 2.81 | 5.29 |
| **Grand Total** | **1,151** | **4,871** | **11102** |

Table 2.1 shows the increasing importance of arable and horticultural land within increasing buffer size around the site increasing from 14% in the 1 km zone to 25.5 % in the 5 km zone, largely at the expense of built up areas and gardens.

## 2.5 Soil Data

The soil data for the study area surrounding the BRS is presented in Figure 2.3 and reproduced from data provided by the Macaulay Land Use Research Institute. The soils are dominated by *brown earths* and *non-calcareous gleys* with minor amounts of *alluvial soils* and *peaty gleys* and *podsols* towards the west of the study area.

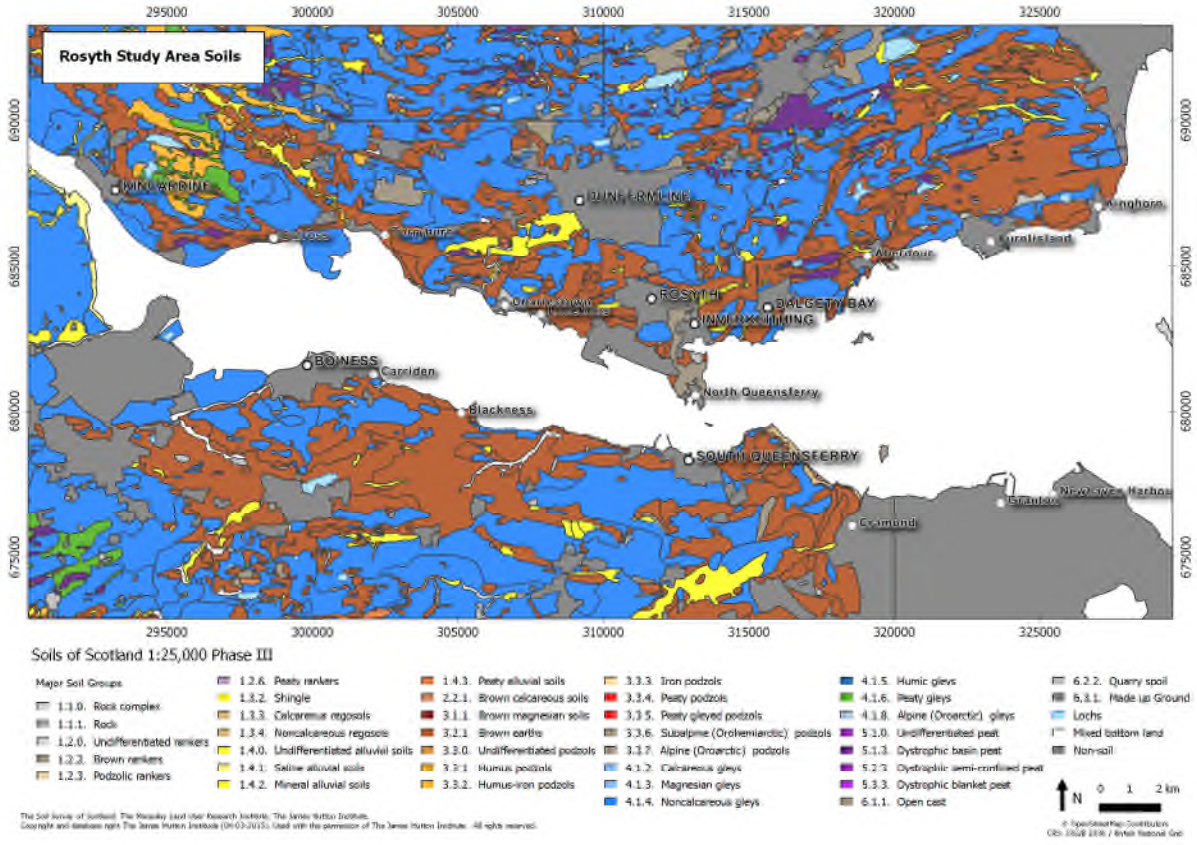


**Figure 2.3** Soil types surrounding the BRS (Macaulay Land Use Research Institute)

## 2.6 Crop Production

Whilst Rosyth itself is largely urban, the survey area either side of the Firth of Forth has a significant amount of agriculture land. The Scottish Agricultural Census data for the parishes (defined by postcodes as used by the Scottish Government) surrounding the BRS has been summarised in Table 2.2. The data were kindly supplied by the Environment and Forestry Directorate of the Scottish Government, including Dalgety, Dunfermline, Inverkeithing on the north side of the Firth of Forth, and Abercorn and Dalmeny to the south. A total of 13,489 hectares of land are available for production in these parishes. Cereal production is dominated by wheat and barley production for crops, and Table 2.2 summarises the number of holdings, the area under production for crops and the estimated yield.

In addition, potatoes, peas, beans and other vegetables are produced in these parishes. Soft

**Table 2.2** Summary of commercial crop production in the Rosyth area (2014), summarised from the Scottish Agricultural Census

| Crops and Fallow Land | Number of Holdings | Area (hectares) | Estimated Yield (tonnes) |
|---|---|---|---|
| Wheat | 24 | 1,175 | 11,363 |
| Winter Barley | 16 | 680 | 5,648 |
| Spring Barley | 23 | 904 | 5,566 |
| Total Barley | 27 | 1,584 | 10,327 |
| Oats, Triticale and Mixed Grain | 10 | 156 | 1,090 |
| Rape for Oilseed and Linseed | 12 | 597 | 2,519 |
| All Other Crops | 14 | 48 | |
| Fallow Land < 5 Years | 26 | 242 | |
| Fallow Land > 5 Years | 9 | 23 | |
| **Total Crops, Fallow and Set-side** | **43** | **3,980** | |

fruit and orchard fruit are also grown. Table 2.3 summarises the remaining use of the agricultural land usage in the parishes surrounding Rosyth.

**Table 2.3** Summary of other agricultural land in the Rosyth area (2014), summarised from the Scottish Agricultural Census

| Grazing and other | Holdings | Hectares |
|---|---|---|
| Grass under 5 years old | 34 | 356 |
| Grass 5 years and older | 104 | 2,758 |
| Rough grazing | 41 | 2,969 |
| Total grass and rough grazing | 129 | 6,083 |
| **Utilised agricultural area (crops, grass and grazing land)** | **139** | **10,062** |
| Woodland | 41 | 2,898 |
| Other land | 60 | 479 |
| **Total** | **152** | **13,439** |

# 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 survey in 2010 provided a useful frame of reference for undertaking this survey of the BRS site. Chapter 2 described the desktop study undertaken to characterise and define the Habits Survey, including:

(i) a review of site activities
(ii) the modelling of the atmospheric and marine discharges from the site to define the survey area boundary
(iii) an assessment of the land cover and agricultural activity

The 2015 Habits Survey of Rosyth covers activities and food consumption. Following discussion with SEPA, the survey introduces the following new methods to try and capture a full range of relevant habits, validate methods and characterise the radiological environment:

(i) an initial postal survey to help target the subsequent face-to-face survey
(ii) a mobile radiometric survey to characterise the heterogeneity of radiation in the environment surrounding the Rosyth site
(iii) GPS tracking on a number of volunteers to better understand the time spent by individuals as they interact with the environment (although due to the limited number of individuals tracked and resultant specific personal data obtained the results are not directly reported in this report)
(iv) Information and focus groups 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 after ethical approval, distributed to 1000 households selected using stratified random sampling methods, based on the areas defined in Figure 3.1. The survey included a map for identifying the range of activities undertaken by household members. The sample included populations living in the following geographical areas (see Figure 3.1):

(i) Within 1 km from the site boundary (zone 1B)

(ii) Between 1 km and 3 km from the site (zone 2B)

(iii) Between 3 km and 5 km from the site (zone 3B)

(iv) Zones 1-3 repeated within the plume area. This was governed by the prevailing wind direction (zones 1A to 3A)

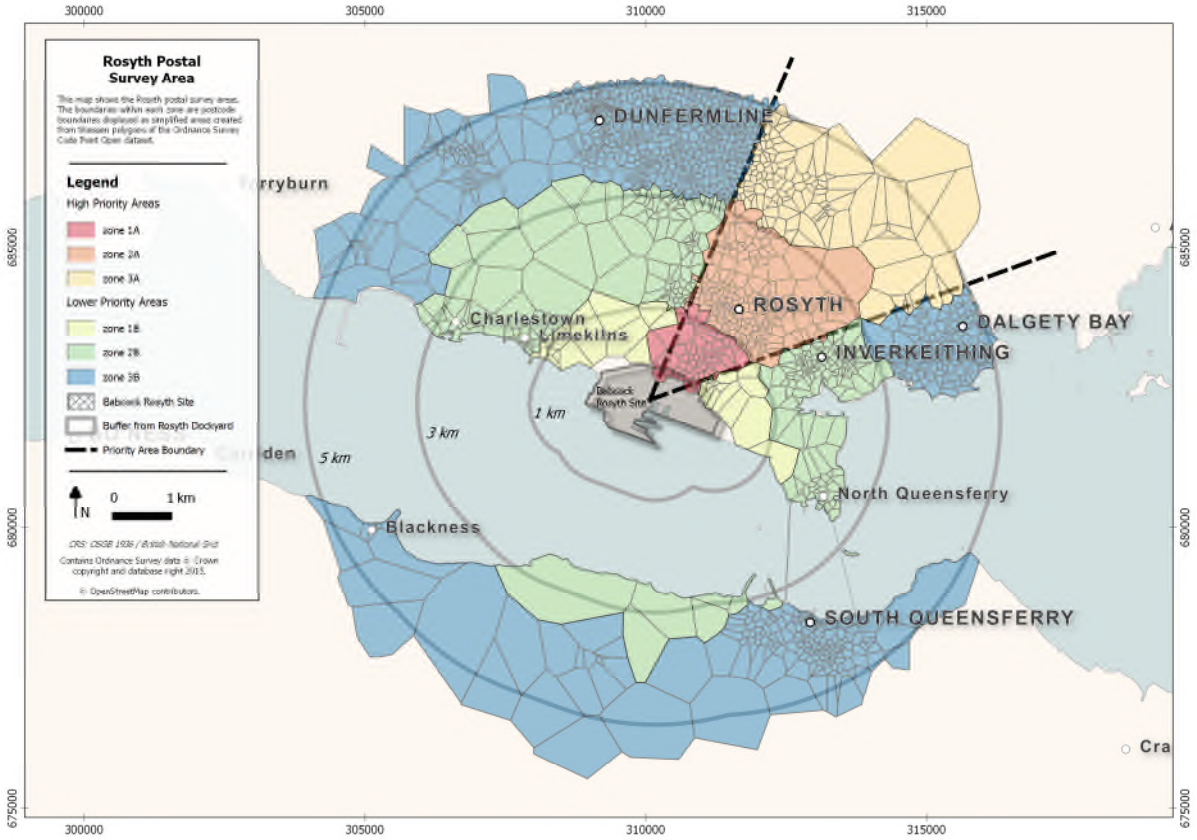


**Figure 3.1** The postal survey zones for the Rosyth area centred from the site boundary

Postcodes for all the geographical areas described above, and shown in Figure 3.1, were generated. The electoral register was grouped according to the zones shown in Figure 3.1. Contact details of people living within these postcode areas were randomly selected to provide a demographic cross-section of individuals. An assessment was made of the deposition areas from the plume using the prevailing wind direction. Under the area of the potential plume, 50% of the surveys were posted to people living north west of the BRS. Considering the weighting factor under the plume, the number of surveys were equally divided on each zone, with zones 1 to 3 under the plume receiving 167 surveys each and Zones 1, 2 and 3 outside of the plume receiving 167, 166 and 166 respectively. Sampling and surveying at different distances from the site enabled the relationship between distance and habits to be explored and provided a means of producing additional potentially useful

data. The postal survey produced an independent data set from a broader cross section of the population living in the area again 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 information groups.

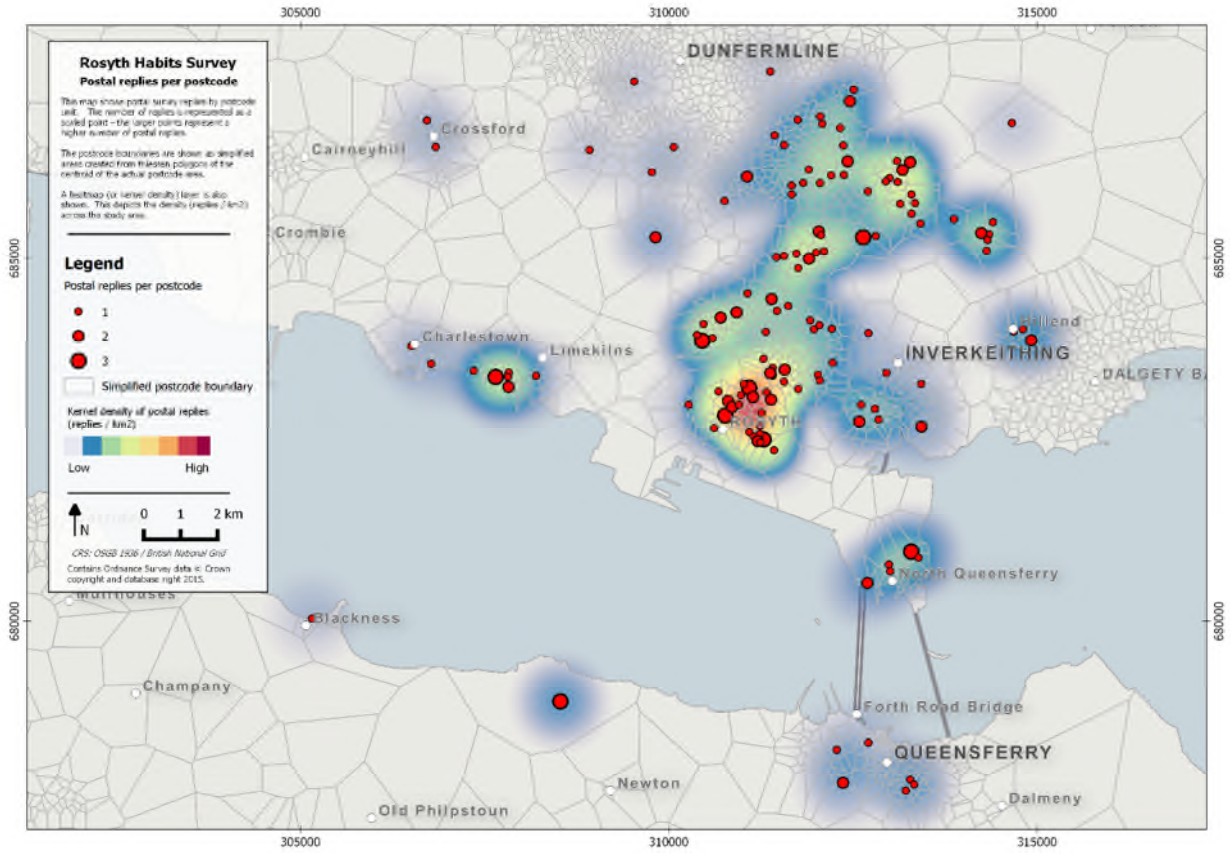


**Figure 3.2** Postal Survey Responses for the Rosyth Area

The survey and information was mailed out and a reminder was sent out after 2 weeks to people who had not returned the survey. The distribution of the questionnaire responses, by postcode, is shown in Figure 3.2. The percentage response received per head of estimated population in each postcode area is presented in Figure 3.3. It is important to note that postcodes with very small populations can result in 100 % response when surveys are returned.

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 information on sites for the collection of observation data and indicated at what times the areas might be busy and supplied additional information and contacts with regard to both individuals and a wider range of activities that might merit further investigation in the later survey work.

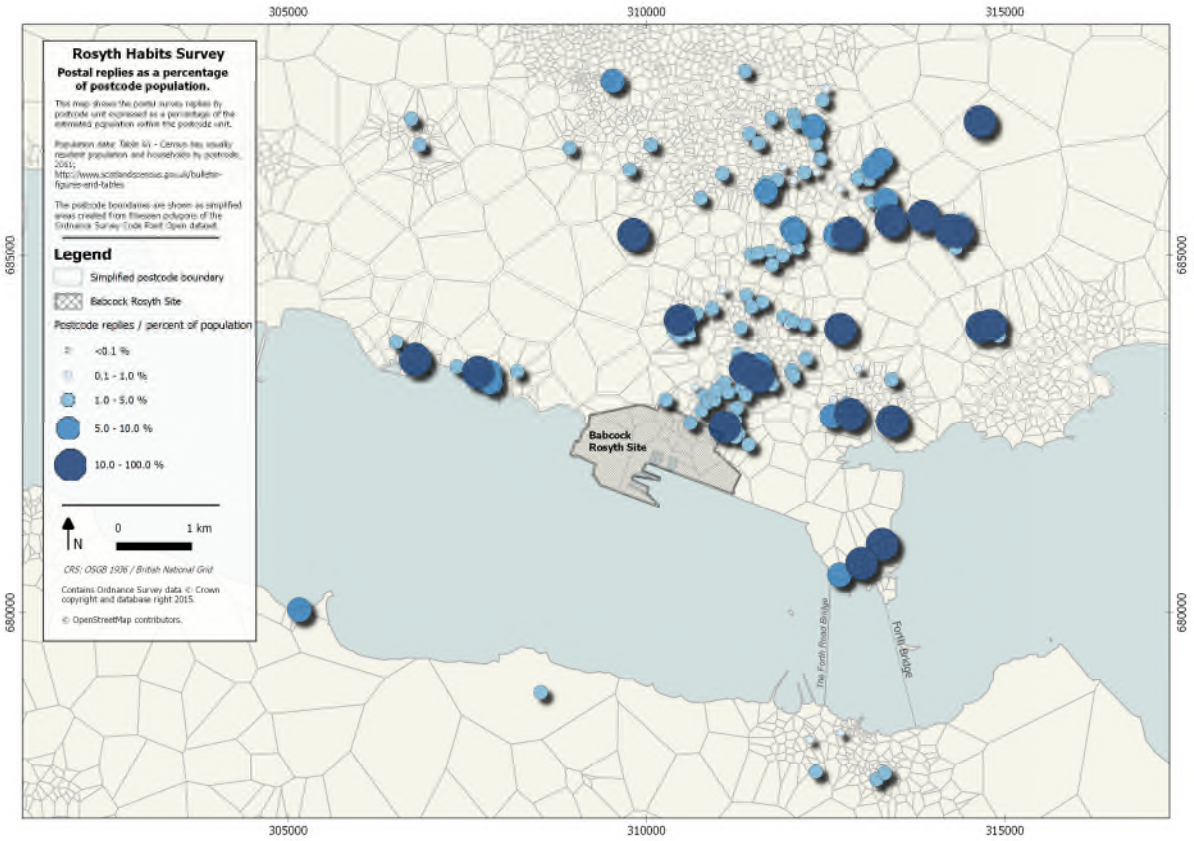


**Figure 3.3.** Showing the percentage response per size of local population (local population from postcode headcounts 2011)

## 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 A.

### 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 (air kerma), using ISO 17025:2005 accredited (UKAS) accredited 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 can be found in Appendix B.

### 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 used to monitor items that were used in the Firth of Forth and potentially exposed to the higher radioactivity concentrations, i.e. close to licensed discharge points. Items monitored included: wetsuits, waterproof clothing, fishing tackle and nets. Further details of the Beta skin dosimetry can be found in Appendix C.

### 3.3.3 Sampling

Where unusual foodstuffs or areas of possible contamination were identified and not included within the SEPA's monitoring programme, samples were collected and analysed by gamma spectrometry in accordance with ISO17025 protocols.

## 3.3 GPS Tracking

A number of methods of tracking user location were investigated, from using Google Location histories in mobile phones to custom mobile application development. However, to ensure consistency in data a wearable GPS tracking device was considered the most suitable device for the Rosyth Habits Survey. Further details of the system deployed are described in Appendix D.

## 3.4 Conduct of the Survey

Preparatory work undertaken before the fieldwork survey entailed discussions with SEPA, meetings and telephone calls with the BRS staff, on site visits and exploratory observations around the survey area prior to the commencement of the survey itself. The approach to the face-to-face surveys is described in more detail in Appendix E. Past survey reports were reviewed and web-based searches were conducted to ensure as many relevant groups were identified and captured along with a range of maps to planning for the survey. A large directory of key groups involved in activities, occupancy and food production and sale in the area was compiled and used (see Chapter 5 for additional detail) to contact key groups and individuals in the locality. This included sailing, yachting, motor powered sailing, wild swimming, rowing, walking, cycling and running groups, social clubs, youth groups and playgroups within and outwith the area where necessary because some of their members used the area for recreation and other activities.

The team also approached both the Fife local authority, a number of community councils in the area and employers such as those involved in the construction of the new Forth Bridge. Some focus groups and informal meetings were arranged prior to the surveys and also during and after the surveys to gain additional information and fill in any critical gaps that might emerge in the face-to-face interviews

The nature and timing of the fieldwork survey was discussed with SEPA prior to the start of the work. The fieldwork was conducted primarily between 29th June 2015 and 12th July 2015. A number of follow-up visits were also undertaken in the area.

The survey team that conducted the face-to-face interviews, observations and measurements totalled 9 people all of whom had received appropriate training and several had experience from conducting previous surveys. The team were provided with site specific field manuals developed for the survey.

From the preliminary survey visits and planning, the team of 9 were able to cover multiple sites at multiple times over the survey period. They interviewed those engaged in a wide range of activities, some living in close proximity to the BRS and some who consumed local produce from land or sea. Adults with children and infants were included. Those surveyed included wild swimmers, kayakers, rowers, yachts people, boat repairers, bridge builders, emergency workers, café owners, postal staff, community gardeners, allotment keepers, walkers, professional dog walkers, runners, cyclists and people fishing.

## 3.5 Meetings, Informal Contacts and Focus Groups

In the 2015 survey, a variety of data were gathered by a variety of approaches. This included holding a range of meetings with relevant parties and individuals as well as a ‘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 by householders, allotment owners, horticulturalists and farmers and consumption of particular types of local food such as honey and game. The information gathered also facilitated some snowballing of the survey because the individual meetings and focus groups provided additional contacts to follow-up on. These groups were approached prior to, during and after the face-to-face interviews by telephone and email.

Additionally, prior to and during 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.

Focus groups and various related informal meetings were also held with groups such as rowing clubs, community councils, community groups and centres, social clubs, youth groups and other local organisations and business groups. The information gathered helped to ensure the face-to-face interviews were relevant, relatively comprehensive and covered all the key topics necessary. The meetings also supplemented information from the postal survey and the face-to-face interviews and provided an opportunity to probe in more detail information or address omissions relating to the face-to-face surveys. Information gleaned for example related to type of activity or food consumption. This included provision of information on new developments and location of activities and increase in activities.

## 3.6 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. 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 typically yields 700g (Garden Forum Horticulture, 2009; Hessayon, 2014) so that all consumption figures were reported in kilograms per year.

## 3.7 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 reports but focussed on the most common food items. Respondents were given the option to add any additional food items in ‘Other’ food category.

**Table 3.1** Food Groups used in the Habits Survey

| Food Group | Example of Foods within this Group |
|---|---|
| Green Vegetables | asparagus, broccoli, brussel sprouts, cabbage, calabrese, cauliflower, chard, courgettes, herbs, kale, lettuce, marrow, spinach, broad bean, french bean, pea, kohi rabi, pepper, runner bean, sweetcorn |
| Root Vegetables | beetroot, carrot, celery, fennel, garlic, jerusalem artichoke, leek, onion, parsnip, radish, shallot, spring onion, swede, turnip |
| Potato | potato |
| Domestic Fruit | apple, blackberry, blackcurrant, blueberries, cucumber, gooseberry, grape, pear, plum, raspberry, redcurrant, strawberry, tayberry, tomato |
| Milk | milk, yoghurt, cheese |
| Cattle Meat | beef, buffalo |
| Pig Meat | pork |
| Sheep Meat | lamb, mutton |
| Poultry | chicken, turkey, goose |
| Eggs | hens' eggs |
| Wild/Free Foods | apple, blackberry, garlic, elderflower, cherries, meddlers, mushrooms, raspberry, sloe berries |
| Honey | honey |
| Game | pheasant, wild venison |
| Fish | bass, cod, mackerel, pollock, salmon |
| Crustaceans | brown crab, common lobster |
| Molluscs | winkle, mussels |
| Wild fowl | mallard, pink-footed goose, teal, wigeon |

The time respondents spent carrying out activities was calculated by multiplying frequency (occasions per year) and duration (hours) taking into account seasonality where appropriate. 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 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 | 0-5 year old |
| Group 2 | 6-15 year old |
| Group 3 | 16 year old and over |

## 3.8 Qualitative and Quantitative Observation

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 of habits at different times and within and outwith the period of the local school holidays.

## 3.9 Dose Assessment Tool

The Habits Dose Assessment Spreadsheet Tool collates the data from the face-to-face survey in Rosyth 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. Dose assessment was carried out following the guidance in NDAWG and ICRP for the Representative Person.

Activity concentration values came from modelling Rosyth discharges for 2013 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 3.7, data for the 2015 Rosyth Habits Survey were collected in three age groups (Table 3.2). The dose conversion coefficients (DCCs) for each age group were taken from ICRP: Group 1 - infants; Group 2 - 10 year olds; and Group 3 - 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 ingestion of fish, crustaceans, molluscs and inadvertent consumption 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.* (2014), McBride (2012) and Stone *et al.* (2008); and
(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 in publically accessible areas to on-site activities was included in the analysis using in-situ measurements.

The representative person was calculated independently for the total exposure and then by each exposure pathway. To identify the representative person, the 97.5 percentile rate cut off method was applied (see 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. In cases when the representative person (i.e. between the 93 and 97.5 percentile) was not found by the survey, the tool calculated a hypothetical representative person. The report therefore details both the hypothetical representative person and the most exposed person(s) found for that pathway during the survey.

# 4 Survey Site Introduction

## 4.1 Introduction

The survey locations were established from the analysis presented in Chapter 2 and to provide consistency with the previous Rosyth Habits Survey undertaken in 2010. The sites were visited throughout the survey period and selected where possible to be revisited before and during the local school holiday period. 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 BRS.

## 4.2 Survey Area Descriptions

The terrestrial/aquatic survey area (shown in Figure 2.1) covered a stretch of the Firth of Forth and its intertidal areas - the northern shore stretched from Kincardine to Kinghorn and the southern shore stretched from Bo'ness to Newhaven. The survey site was extended to accommodate areas outwith the concentrated survey area from the BRS. Preliminary visits showed little commercial or hobby fishing. The survey is reported from west to east starting on the northern shore with the most western area visited being Kincardine. The southern shore is also reported from west to east with the most western area visited being Bo'ness. Many sites reported the presence of mudflats and bait diggers which would be expected given the estuary's SSSI designation and classification under the NATURA 2000 regulations. On the northern shore the entire survey reported the extensive use of the Fife Coastal Path which runs along the coast of the survey area. This was extended to start in Kincardine in 2011 therefore a change from the previous survey in 2010 with a possible increase of people walking the full length. The region is well served by the East Coast Railway from Inverkeithing to Dundee.

For both the northern shoreline and southern shoreline, the observation descriptions are described in survey locations starting from the west to east.

## 4.3 Site Descriptions for the Firth of Forth Northern Shore

### 4.3.1 Kincardine

The most western point on the northern shore of the survey area was Kincardine (Figure 4.1). Observations were made at this site but no face-to-face interviews were undertaken. The area observed was by the shore with the coastal path running alongside and scrub woodland behind to the north. The Fife Coastal Path was extended to Kincardine with the

development of the new Kincardine Bridge in 2011 and now connects Kincardine to Culross without the need for extensive use of the road network. The coastal path moves away from the coast as it passes the Longannet coal fired power station before returning to the coast at Culross. No onshore habits were observed other than the occasional walker. Offshore there were three boats moored, one fishing boat and five paddleboats to the west of the Kincardine Bridge.

**Figure 4.1** View to the south towards Kincardine Bridge from Kincardine

### 4.3.2 Culross

Culross is a popular tourist area with a number of attractions. On the sea front (Figure 4.2) access to the beach and jetty is available to foot traffic via the level crossing with the stone railway embankment forming the sea wall. The railway line from Inverkeithing lies between the shore and Culross itself. There are two large car parks both east and west to the main

village area. There was a range of onshore activities which included dog walking, walking, cycling, jogging, tourists, families' with children playing at the park, children playing football in the green park space and people walking along the beach and beach combing. Tourists from outwith the survey area made up the majority of people with numbers visiting the area approximately in excess of 20, 60 and 100 per day when visited during the survey period. The onshore activities noted were all during the local school holiday period, no activities were noted outwith (Appendix H). Two sailing boats and a rowing boat were moored offshore and at some distance offshore a commercial ship, a leisure boat and a sail boat were observed during the survey period. The lower shore substrate was that of mud and stone. A disused jetty was also noted.

**Figure 4.2** View to the East along the coast at Culross from Culross

### 4.3.3 Preston Island, Torry Bay and Crombie Point

Torry Bay is a small village overlooking the Firth of Forth and to the west is Preston Island which forms a promontory between Culross and Torry Bay. A children's playground area is situated directly behind the shore separated only by the coastal path (Figure 4.3). A new

housing development overlooks the bay with building plots for sale. A public car parking area is situated by Torry Burn.

During the survey period this site reported relatively low occupancy with three dog walkers, one cyclist, one walker and two families playing in the playground by the shore observed when visited during the survey period. No children or families were playing in the playground outwith the local school holidays (Appendix H). As would be expected from villages close to Edinburgh a steady stream of commuting traffic was noted. On the south side of the Forth one boat was observed with two people on it and two boats were moored. The shore area at low tide reveals a large area of mud and large boulders. Torry Bay forms part of the designated nature reserve which has areas of salt marsh formed from artificial lagoons built from ash from the Longannet Power Station. The reserve forms part of the larger area between Longannet Point and Crombie Point and has an intertidal substrate of mud flats. This area is home to overwintering birds. Torry Bay is an area where wildfowling is permitted but no wildfowlers were identified during the survey period.

**Figure 4.3** View towards the east at Torry Bay from Torry Bay

Eastwards from Torry Bay there is access to the shore at Crombie Point. Although the area is largely woodland there are around ten residential houses looking south over the Firth of

Forth with cycle paths and agricultural land noted in the surrounding area. The beach area was mainly sand and mud and the people observed included five dog walkers, one walker, one person jogging and several people paddling. There were in excess of 60 people playing on the beach noted during the local school holiday period in contrast to solely dog walkers, cyclists and walkers outwith the school holiday period. Access eastwards along the shore is prevented by the MoD base, RNAD Crombie, with the Fife Coastal Path re-joining the coast at Charlestown.

### 4.3.4 Charlestown

Along the coastline eastwards, between Charlestown to Limekilns, there were several small bays made up of sand, mud and pebbles. Rocky outcrops were also noted. There is a small harbour in Charlestown (Figure 4.4) with over 30 boats and three sail boats moored within the harbour. No activities offshore with boats were noted either outwith or during the local school holiday period (Appendix H). At the time of survey he was working on his boat and continued to spend a large amount of time there. The boats moored were all observed to sit on the mud substrate when the tide went out. Onshore beside the harbour one person was observed undertaking boat maintenance. Other onshore activities consisted of dog walking, walking and people working in their gardens in the nearby residential area. During the school holiday period several children were observed playing and walkers and dog walker numbers increased from four outwith the holiday period to 10 within the holiday period.

**Figure 4.4** Charlestown Harbour

### 4.3.5 Limekilns

Limekilns is a small coastal town with several shops, pubs and restaurant/bistro. There is a small marina with a boat club, The Forth Cruising Club, which has around 90 members whose aquatic activity is predominantly sailing. The Forth Cruising Club has approximately 60 boats which are mainly 17 to 35 feet in length together with a few sailing dinghies. The majority of the boats are moored at Brucehaven Harbour (Figure 4.5) and Limekilns Pier during the sailing season but some are moored outwith Limekilns in other clubs on the Forth.

Activities observed on the beach were a mixture of families playing and paddling, dog walkers, people sitting on the beach, picnickers and a family playing football. Numbers of individuals varied with these activities during and outwith the local school holiday period with walking and dog walking attributing to the most popular activity (Appendix H). The substrate was sand and rocks with one person observed to be bait digging.

Offshore there were more than 10 sail boats moored with only one boat under sail.


**Figure 4.5** Brucehaven Harbour, Limekilns

### 4.3.6 Rosyth

The BRS was part of the survey area. A large part of the surrounding area of shore was occupied by the BRS preventing access by the public to this area of the shore. Adjacent to the BRS is a commercial port which houses a ferry terminal.

Activities noted at the entrance to the BRS were cars and delivery vehicles travelling in and out of the site, people walking, security men checking cars and people walking to and from work.

Rosyth itself is part of a waterfront regeneration scheme. A recent proposal, which is currently out to public consultation, aims to provide both residential and commercial development in the area.

Further detail of the BRS is discussed in Section 2.1.

### 4.3.7 North Queensferry

North Queensferry (Figure 4.6) is a small town situated beneath the Forth Bridge and is the most southerly site on the northern shore of the survey area. The shoreline along this area from the slipway in the town to the North Queensferry Harbour is mainly large boulders on the upper shore and rocks, mud and seaweed towards the lower shore. The slipway in town provided public access to boats giving adventure trips together with the possibility of launching and recovery of small vessels. Within the shore area of the town the activities noted were two people dog walking, in excess of 20 people sightseeing, two photographers, walkers and a family of five picnicking on the slipway. There is an active community garden in North Queensferry and this is discussed in Section 6.7.1. Two sailboats and a sea kayak were noted offshore.

West of the main town is the harbour in which the North Queensferry Boat Club is located. It has approximately 100 members with moorings available to boats with keels that can sit on the mud at low tide. A small pontoon is also available. Boats affiliated with the club are mainly sailing yachts. Several boats were moored but a large number of boats were observed to be in the boat yard. Several people used the shoreline just on the west side of the entrance into the harbour for dog walking. One person was observed fishing from the pier within the harbour and six people were working on their boats. Offshore activities noted from the harbour were sailing yachts, kayaks and a leisure boat.

Extensive construction operations are underway due to the building of the new Forth Road Bridge (with lottery funding being approved to develop a Forth Bridge Visitors Centre) which is due to open in 2016. Further details of the Forth Road Bridge are discussed in Chapter 2.

Deep Sea World in North Queensferry is a visitor centre that attracts many people to the area.

No observations were undertaken for this site outwith the local school holiday period (Appendix H).

**Figure 4.6** View towards the South towards the Forth Bridge at North Queensferry

### 4.3.8 Inverkeithing

Inverkeithing is a developing town and attracts visitors due to its historical interest. It is bypassed by the M90 which links Fife, south of the Firth of Forth, via the Forth Road Bridge. There is also a rail link to Edinburgh and Dundee. Many people that work at the nearby the BRS find accommodation here resulting in the town population being that of locals and transient workers.

The town has a well organised community garden with some core workers identified and other volunteers. Further information is discussed in Section 6.7.1. Activities noted in town were mainly that of people shopping and socialising. Inverkeithing has a small inlet revealing a mud substrate at low tide. This particular area appeared relatively run down with a large derelict expanse to the west of the inlet area. One person was observed fishing from the inlet during the survey period. In April this year several members of the Inverkeithing Boat Club attended a community council meeting with Fife Council. Fife Council proposed the club formally register as a community boat club. The club is in the process of cleaning up the area and plan to provide ‘member’ details and to register as a club. A large green space

west of the inlet was popular with approximately 20 people dog walking, in excess of 15 families playing at the park, three people cycling, five people jogging and in excess of 40 people walking. Limited intertidal access was noted from here via a steep embankment. No observations were noted at this site outwith the local school holiday period (Appendix H).

Offshore activities observed were a large cruise liner towards North Queensferry, a gravel cargo ship resting on the mud and some sail boats were moored along with three rowing boats.

### 4.3.9 St David's Harbour and Dalgety Bay

Access to St David's Bay is via a coastal path and there are also large sea defence boulders along the shoreline which people were observed climbing over too, gaining access to the bay. The bay itself is sandy. This bay was to the west of St David's Harbour which appeared to be disused.

Onshore observations at St David's Bay were 10 people dog walking along the coastal paths and the steep embankment, one family (two adults and one child) playing and digging in the sand on the beach and two people sitting in their car eating lunch and enjoying the view. Offshore activities were one windsurfer and six sailing boats some distance offshore. Observations were made within the local school holiday period (Appendix H).

Dalgety Bay lies on the north shore of the Firth of Forth eastwards from St Davids Bay. The bay itself lies to the south east of Dalgety Bay town. The town was developed in the 1960's and 1970's. Prior to the creation of the new town the area hosted a MoD airbase, RNAS Donibristle, which closed in 1959. The current Donibristile Industrial Park was developed over much of the runway of the former air base.

On the beach (Figure 4.7) at Dalgety Bay, since 1990, radioactive items which contain radium-226 and associated daughter products have been detected. The historical disposal of radioactive wastes together with other wastes from the Royal Naval Air Station, Donibristle, is the cause of this contamination. It has been reported by SEPA that during the operation of the site and clearance the coastline advanced in a southerly direction, such advancement was caused by the disposal of incinerated waste and resultant ash and clinker onto the foreshore. Coastal erosion of this site has now exposed the contamination on and adjacent to the foreshore. Due to the magnitude of the contamination found and its potential effects on public health, if encountered, public protection measures have been established and people are advised not to remove material from the beach and to avoid one area of the beach entirely. Currently the area is monitored on a monthly basis by a contractor working

for the MoD. The contractor was observed to be undertaking this monitoring during the survey.

Dalgety Bay has an active sailing club with direct access to the foreshore with two slipways and a jetty. The main craft are sail dinghies and keel boats. Safety Boats are also used. The sailing club operates a Royal Yachting Association Recognised Teaching Establishment which house 27 dinghies for this purpose. To the west is a sandy harbour with one boat moored on the sand. In contrast to this sand, the area in front of the Sailing Club and to the east of the Club (forming part of the contaminated area) is rock and shingle with obvious artefacts from site clearance (crockery, brick, etc.). The lower shore substrate was mud. Warning signs are visible indicating the presence of radioactive contamination both on approach to the club and to the east and west. A Food and Environment Protection Act ban is also in place for Dalgety Bay preventing the commercial harvesting of fish and shellfish due to the radioactive contamination in the sediment. The area behind the foreshore forms part of the coastal path and is wooded and grassy. Activities noted on the coastal path area were predominantly dog walking (in excess of 20) and walking (in excess of 20) with some people picnicking, cycling and jogging. Three tents were set up in front of the sailing club lodge. No people were noted to be engaged in any intertidal activities. One individual interviewed collected and consumed whelks along the foreshore of Dalgety Bay. Offshore one oil tanker was noted at the Forth Bridge Terminal, one tanker off the terminal port at Braefoot Bay, one tanker off of Hound Point and a further one oil tanker with support vessels. Three cruise liners, three tug boats, small boats ferrying passengers to and from shore and 19 sailing yachts along with three power boats were moored to buoys.

No evidence of significant land use change was noted in the area. It was noted that there was a proposal for a further housing development to the east of the town.

**Figure 4.7** View towards the East at Dalgety Bay

### 4.3.10 Aberdour

Aberdour is a small village on the south coast of Fife looking south to the island of Inchcolm which is a popular tourist attraction. It is a village that attracts visitors with one coach noted and several visitor attractions including a Castle with in excess of 50 visitors at the time of the survey and local shops. During the time of the survey together with five people were noted walking and five people cycling on the nearby cycle route. There is a railway station which connects the village eastward towards Dundee and west towards Inverkeithing. Aberdour is situated between the larger conurbations of Burntisland to the east and Dalgety Bay to the west.

Aberdour is home to the Aberdour Boat Club and is situated on the northern shore of the Firth of Forth. Founded in 1930 it provides a range of boating activities including canoes, rowing, power boats and sailing. An active racing and cruising programme is also available. The club has a current membership of over 100 members and the club is affiliated to both the Royal Yachting Association and the Forth Yacht Clubs Association. The harbour has a stone pier and large rocks on the upper shore with a small sandy beach.

### 4.3.11 Silversands

Silversands is a small sandy leisure beach situated to the east of Aberdour on the northern shore of the Firth of Forth. It has a rocky promontory to the west separating Aberdour Harbour from Silversands beach. It is a very popular beach with lifeguards patrolling the beach during the peak summer season. Silversands is a Blue Flag beach and has a Green Coast Award. The sandy bay is approximately 600 metres long with the beach sloping gently towards the water. Fife Council maintains the site.

The Fife Coastal Path and the Millenium Cycleways Network pass by this beach and the surrounding area. Tourist and visitor facilities observed during the survey were a beachfront café, toilets and outdoor shower area, a first aid point, children's play park and crazy golf. A slipway allows the launching and recovery of small craft.

Activities observed during the survey period were families playing and paddling at the beach, families with children digging in the sand, one person jogging, dog walking, dogs paddling, beachcombing, three families having a barbeque and families playing at the park and crazy golf. Silversands beach is a dog friendly beach and only has dog restrictions on the main sandy area during the summer season.

On one particular day at Silversands approximately 500 people were observed at the beach along with 20 people swimming and paddling, one fishing boat, one leisure boat and one commercial boat some distance from the shore. Body boarding and sailboarding were also observed. Open water swimming has increased in popularity at Silversands and swimmers are reported to swim daily in the sea for pleasure as a leisure pursuit and also for training for open water competitions. The bay itself provides some safety from the currents. Despite this reported increase of the open water-swimming hobby, no open water swimmers were observed during the survey period.

The beach backs onto woodland with a very large green space behind the café area providing ample space for parking.

All observations for this site were undertaken during the local school holiday period (Appendix H).

### 4.3.12 Burntisland

Burntisland is a coastal resort on the Firth of Forth to the east of Silversands. The town has a popular 18 hole golf course, bowling green and leisure centre with swimming pool. Behind the beach promenade on a large grassy expanse a fair ground is set up for the summer period which attracts many visitors and locals. Burntisland beach (Figure 4.8) is a sandy Blue Flag beach with a promenade providing benches for sitting, a large car park, leisure centre and swimming pool, café and restaurant, dive boat centre, slipway and lifeguard station. The slipway can be used by the public for small leisure crafts and dive boats. The beach is fine sand with patches of black coal dust, which is present from layers of coal outcropping from the sea bed being washed onshore (SNH, Beaches of Fife, 1978).

**Figure 4.8** View towards the north towards Burntisland

Aquatic activities observed were five people paddling and swimming, one open water swimmer, five leisure sail boats, four dive boats landing and one bait digger. Twelve people (mainly children) were observed walking out onto the mud near the rocky promontory to the east. At low tide mud and sand flats are visible on the lower part of the beach.

Onshore activities observed within the survey period were mainly people at the funfair, families sitting on benches and playing on the beach and rocks, building sandcastles, beach combing, dog walking, people out walking, one photographer, cycling and fishing. Persons were also observed to be excercising other animals on the beach. No observations were made outwith the local school holidays (Appendix H).

Continuing eastwards from Burntisland beach the rocky stretch of shore extends to the Burntisland docks. The Port of Burntisland is made up of two inner basins – the east dock with an adjoining west dock. The dockyard has experienced a revival from coastal shipping and also opportunities within the offshore renewable sector with the west dock housing two major employers. Creeling is still undertaken at Burntisland. The outer harbour is occupied by the Burntisland Sailing Club on the Firth of Forth. The club has 25 moorings accessible in all tides and is situated within the south eastern corner of the outer harbour (Figure 4.9). It holds a compound for winter storage for boats and boating equipment.

Burntisland railway station is situated beside the harbour.

**Figure 4.9** Burntisland Harbour

### 4.3.13 Kinghorn Harbour Beach and Pettycur

Kinghorn Harbour beach is a small sandy beach with large rocky outcrops to the east and west of the sandy area. It was a very popular small beach and activities noted were dog walking, walking and playing on the beach, one person fishing from beach, one photographer, and two people bait digging. Offshore Habits noted were two people paddle boarding, sailing, fishing, maintenance supply oilrigs, commercial shipping and container ships. There is a small parking area beside the harbour and several boats were seen to be moored.

The residential area consisted of houses, a small café and shop and the Kinghorn Lifeboat Station which is an RNLI funded and operated rescue station. One person and a child were fishing from the rocks at the west side of the beach. A steep embankment to the eastern promontory had benches and two people were bird/nature watching.

To the east from Kinghorn Harbour is Pettycur beach (Figure 4.10) which is a sandy beach between high rocky promontories to both the east and the west. This little harbour was very popular with fishermen with approximately 14 huts (Figure 4.11) present to store fishing equipment, seven fishing boats and six rowing boats moored. Several people were interviewed at this site who fished and creeling was also undertaken. The lobster and crab caught were sold outwith the survey area. One person was observed bait digging for lug worms, rag worms and white sand worms. Several people were seen fishing from the shore and indicated that this was a regular activity. Other onshore activities observed were five dog walkers, several families out walking and three people were observed kite boarding at low tide to the east of the eastern rocky promontory.


**Figure 4.11** Fishing hut, Pettycur

One person was particularly interested in the local history of Pettycur and had noticed for some time that as a result of the tides and weather some rocky outcrops have become apparent in the centre of the beach towards the beach wall. It was reported that this slow erosion was thought to be uncovering the old Pettycur Harbour and is currently under investigation by the Scottish Coastal Archaeology and the Problem of Erosion (SCAPE).

A road runs alongside the beach with its high beach wall and a small café and shop are situated towards the eastern end.

**Figure 4.10** View towards the west at Pettycur

## 4.4 Site Descriptions for the Firth of Forth Southern Shore

### 4.4.1 Bo'ness

Bo'ness lies on the south bank of the River Forth and the beach tidal area, easily accessed from several locations, is composed of sand, pebbles and mud. Onshore habit observations throughout the survey period included people on pathed areas and at designated benched areas. The onshore habits behind the shoreline included people out for walks, dog walking, sitting picnicking, sitting reading, cycling and jogging. Outwith the school holidays approximately four dog walkers were observed and this number increased significantly within the school holidays on one day to 12 dog walkers, 15 walkers and two cyclists. It was generally noted that the number of individuals increased with onshore activities during the school holiday period (Appendix H). No habits were noted on the intertidal area (Figure 4.11). Four people were observed fishing from the wall of the harbour. Four sailing boats were the only offshore habits observed.

The Bo'ness and Kinneil Railway runs alongside the Firth of Forth and is a very popular tourist attraction to the area.

The Upper Forth Boat Club is based in the Grangepans area of Bo'ness with the bay having swinging moorings being the property of individual members. Hard standing provides storage for approximately 30 boats. Shore-side facilities consist of a launching system, de-masting derrick, gantry and work shop.

**Figure 4.11** View towards the north from Bo'ness

### 4.4.2 Carriden

Carriden beach is a mud, sand and pebble beach which has two small boat yards and sewage treatment works to the rear. The coastal path, which forms part of the John Muir Way passes by the beach with a children's play park nearby. Carriden Boat Yard is primarily a storage facility for boats situated on the south bank of the Forth Estuary.

There were a number of children observed playing in the park outwith the school holiday period and this increased for families and individuals to 10 walkers, five dog walkers, seven cyclists and four picnickers during the local school holiday period (Appendix H). Several scrambling bikes were observed in the woods behind the sewage works. Potential offshore

habits were indicated with the presence of three boats moored but unattended together with seven launch and motor boats on the water. Locals reported that people fish for their own consumption from this area off the pier although none were identified during the survey period.

The coastal path leads from here eastwards towards Blackness. Some of this coastal path is currently being repaired and a new path being made due to coastal erosion.

### 4.4.3 Blackness

Blackness village (Figure 4.12) is close to Blackness Castle. There is a large grassy expanse and the John Muir Way provides ready access for walkers and cyclists. Onshore, people were observed to be dog walking, walking, cycling, picnicking, playing on the beach, having a barbeque, people sitting on boats onshore and beach combing. Numbers of individuals undertaking onshore activities were generally similar outwith and during the school holidays (Appendix H). Habits noted offshore were people on boats, 17 sail boats under sail and five boats in the harbour. This was within the local school holidays in contrast with only one boat sailing observed outwith the local school holidays. The substrate was mainly of mud flats on the lower shore with a mixture of stone, sand and mud in the upper shore. It was reported that people undertake metal detecting, bait digging and collecting sea coal within the intertidal area.

**Figure 4.12** View towards the west at Blackness

Blackness Boat Club is affiliated to both the Royal Yachting Association and the Forth Yacht Clubs Association and has a membership of over 60. The club caters for canoes, rowing, power boats and sailing. Members tend to be mainly interested in day sailing and cruising and occasionally club races. Swinging moorings are used for boats out in the bay and a pier is available to be used for short stay. Winter storage is also available.

### 4.4.4 Society Point

Society Point was visited during the survey period and was observed to have a beach area with Hopetoun House to the West. Close to Hopetoun House cars were parked and on the nearby beach area one family were observed to be playing. Four people were playing on the beach, two people were beach combing, two dog walkers and one photographer was observed. Several cyclists were also observed to pass by the beach.

Offshore habits observed were a cargo ship passing by the BRS to the north over the Firth of Forth, a bridge support vessel and two speedboats. A Marine Conservation Society beach and litter clean-up had been undertaken over the summer.

### 4.4.5 Port Edgar and South Queensferry

Port Edgar is primarily a large marina with business being dominated with boating services, sales, supplies and training for the Royal Yacht Association. Restaurants, pubs, cruise/ferry stop and lifeboat services were also present. The marina is located between the Forth Road Bridge and the Rail Bridge and is host to a slipway with approximately 300 berths with sail and motor boats moored. The marina (Figure 4.13) is the base for a rowing club, a yacht club and a paddlers club that was established in 2011. Port Edgar Marina is also home to organisations such as the Sea Cadets, HMS coastguard and Port Edgar Watersports Activity School which provide a wide range of watersports including dinghy sailing, powerboating, sea kayaking and canoeing. There is evidence of creeling being undertaken.

Onshore, the immediate town of Port Edgar, South Queensferry, was extremely busy and very popular with tourists. Tourist buses were present waiting for ferries. A high proportion of visitors were families and tourists with well in excess of 1000 people on three occasions during the survey period, dominated by tourists from cruise ships and coaches using the car parks as drop off points. Photographers and a bagpipe band were also observed.

Offshore activities observed consisted of sail boats, speed boat, ferry cruise boats, a large cruise ship docked, small tug boats, tourist boats, sailing dinghies, sailing boats, sail boards, yachts, boats working on the Forth Bridge crossing. South Queensferry also has a Lifeboat Station.

**Figure 4.13** Port Edgar Marina

### 4.4.6 Hound Point

Hound Point is a headland on the Dalmeny Estate which gives public access (there is no formal right of way) to the shore. The area of beach surveyed at Hound Point was part of the coastal walk which provided a pier and a boat house. It was a relatively popular area with onshore activities and seven cyclists, 11 dog walkers, 49 walkers and three people picnicking were observed. Numbers of individuals present daily were relatively similar during and outwith the local school holiday period. Three people had a campfire and several people were sitting on the beach. Four people were observed to be fishing from the pier.

Offshore activities included commercial ships and tug boats, work boats operating, cruise ship, four jet skis and seven sail boats. Eight sailing boats and dinghies were moored. All these offshore activities took place during the local school holiday period (Appendix H).

Hound Point also has an offshore tanker berth and oil handling facility which is operated by BP in conjunction with Forth Ports Plc.

### 4.4.7 Cramond

Cramond village is located towards the east of the River Almond with a sandy beach and coastal path. A small café was nearby with restaurant and pubs in the village

Cramond Island is a small tidal island on the Firth of Forth approximately 1.6 km offshore with a rocky shoreline. It is connected to the mainland at low tide across the Drum Sands. The causeway between Cramond Island and Cramond village exposes a paved path at low tide. On the southern shore of the Firth of Forth Drum Sands is an extensive tidal area of sand. Drum Sands extends from Hound Point to Granton in the east. The sandflats within this area are of international importance and host to thousands of breeding and roosting waders and winter wildfowl.

**Figure 4.14** View north towards Cramond Island

The main onshore activities within Cramond and Cramond Island (Figure 4.14) were dog walkers, cyclists and joggers but one person fishing off the rocks and one person beachcombing were also observed. Two people were also camping on the island. The beach area has a slipway which was being jet washed by boat club members during the survey period. During the school holidays it was noted that the number of families with children

walking increased from none observed outwith to approximately 60 individuals (including children) on one day within the school holidays. The numbers of dog walkers, cyclist and joggers remained similar during and outwith the holidays showing approximately eight, two and two individuals respectively (Appendix H).

Public shellfish consumption notices were visible warning people not to consume the shellfish as they are unfit for human consumption due to the possible bacterial contamination.

The majority of activities took place on the causeway but one family was observed to be walking east of the causeway.

Offshore habits observed were three boats moored and unattended, small numbers of yachts, sailing dinghies and one safety boat. Two container ships were within the Firth of Forth. There was no significant difference during and outwith the school holidays.

The Cramond Boat Club has its moorings at the mouth of the River Almond for 40 keel boats and space in an enclosed dinghy park for a further 40 boats.

### 4.4.8 Granton

From Drum Sands eastwards towards Granton Harbour there was a sand and pebble shore but no activities were observed. Granton Harbour has been in a stage of re-development for both residential and commercial use and a further revised proposal has recently been submitted to the council. The Royal Eastern Yacht Club and the Almond Yacht Club, (incorporated by the Royal Forth Yacht Club) are based at Granton Harbour and they share the harbour with The Forth Corinthians Yacht Club (FCYC) who have 80 boats moored at Granton or stored in their own boat yard on the pier. The FCYC club is primarily a cruising club, with a membership of around 140 and growing, although there is a keen racing group within the club racing fin keeled boats. A rowing group is also housed within the club, the Newhaven Coastal Rowers.

The sandy beach area of Granton was large with a coastal path. A large expanse of green space with benches was situated for visitors. The beach was relatively popular with many people and the activities observed included 10 dog walkers, 12 people walking along the beach and two people sitting on the beach. Seven people were fishing off the beach and a further two people were fishing off the jetty during the school holiday period. None were observed outwith the local school holiday period (Appendix H). Dog walkers, cyclist and joggers were also observed along the coastal path. Three people were painting boats.

Public shellfish consumption notices were visible warning people not to consume the shellfish as they are unfit for human consumption due to the possible bacterial contamination.

### 4.4.9 Newhaven

Newhaven is situated east from Granton and has areas identified for residential development land. Recently Forth Ports have unveiled plans for a new cruise liner terminal in a bid to attract the 'super liners' of the future. Plans for dredging and reviews of local infrastructure are all reportedly well advanced. If proposals are developed, ships would anchor around 1.5 miles offshore with passengers brought to Newhaven Harbour (Figure 4.15) on tender vessels.

Current onshore activities observed were mainly dog walking, jogging and walking. Numbers of individuals for these activities were fairly low with the exception of walking when in excess of 30 adults and children were observed on one day. Offshore activity was considerable with ships noted in ports both to the east and west, commercial boat traffic and people on board a power boat and sailing yacht in the harbour. There is evidence of creeling being undertaken based on boats moored at Newhaven Harbour.


**Figure 4.15** Newhaven Harbour

# 5 Aquatic Radiation Pathways

## 5.1 Introduction

This section describes the relevant pathways for aquatic exposure to radioactivity and radiation for both internal and external routes as a result of authorised discharges to the Firth of Forth. The chapter describes the results from the postal survey returns, exposure pathways from commercial and private fishing, wildfowling, use of pleasure craft in the Firth of Forth along with other sources of exposure include wild swimming. The final section of this chapter details consumption rates for food sourced from the Firth of Forth and environmental occupancy rates for external exposure.

## 5.2 Postal Survey Results

Of the 1000 postal surveys that were sent out to households in the survey area 177 households returned their surveys, 24 of the surveys were returned incomplete and the remaining 153 postal returns were used in analysis along with extra information obtained on behalf of other household members. The postal survey proved very useful for identifying popular activities (Figure 5.1) along with where households take part in certain activities, as

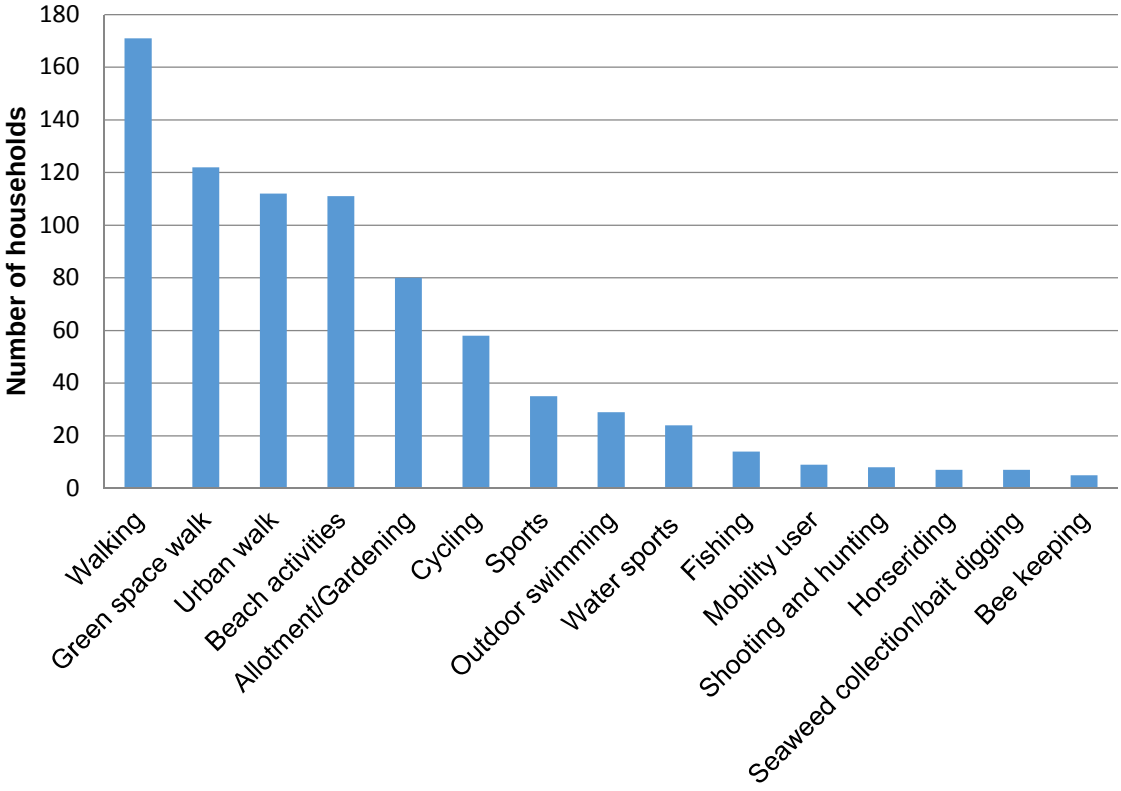


**Figure 5.1** Overview of the number of household participating in activities within the survey area.

respondents were asked to mark down where they carry out their activities on a map of the survey area. This information was mapped onto a heat map (a map showing the density of responses) to identify popular areas and activities around the BRS (Figure 5.2). These areas were later factored into the schedule for the face-to-face surveys. In addition to location, households were asked to indicate how often they participate in certain activities which was converted into number of days per year; most days (260 days per year), once or twice a week (104 days per year), once or twice a month (24 days per year), once or twice a year (2

days per year) or never (0 days per year). No information on how long individuals spent doing these activities was captured. The results of the aquatic radiation pathway can be found in Sections 5.2.1, 5.2.2 and terrestrial radiation pathways in Sections, 6.2.1 and 6.2.2.

### 5.2.1 Internal exposure

Each household was asked to indicate how often members of their household consume local fresh or frozen fish/crustaceans/molluscs. The 153 household postal returns showed that 61 individuals from within the households consume crab, lobster, mussels and 153 consume fish such as cod, salmon, haddock and mackerel each varying in frequency. A summary of

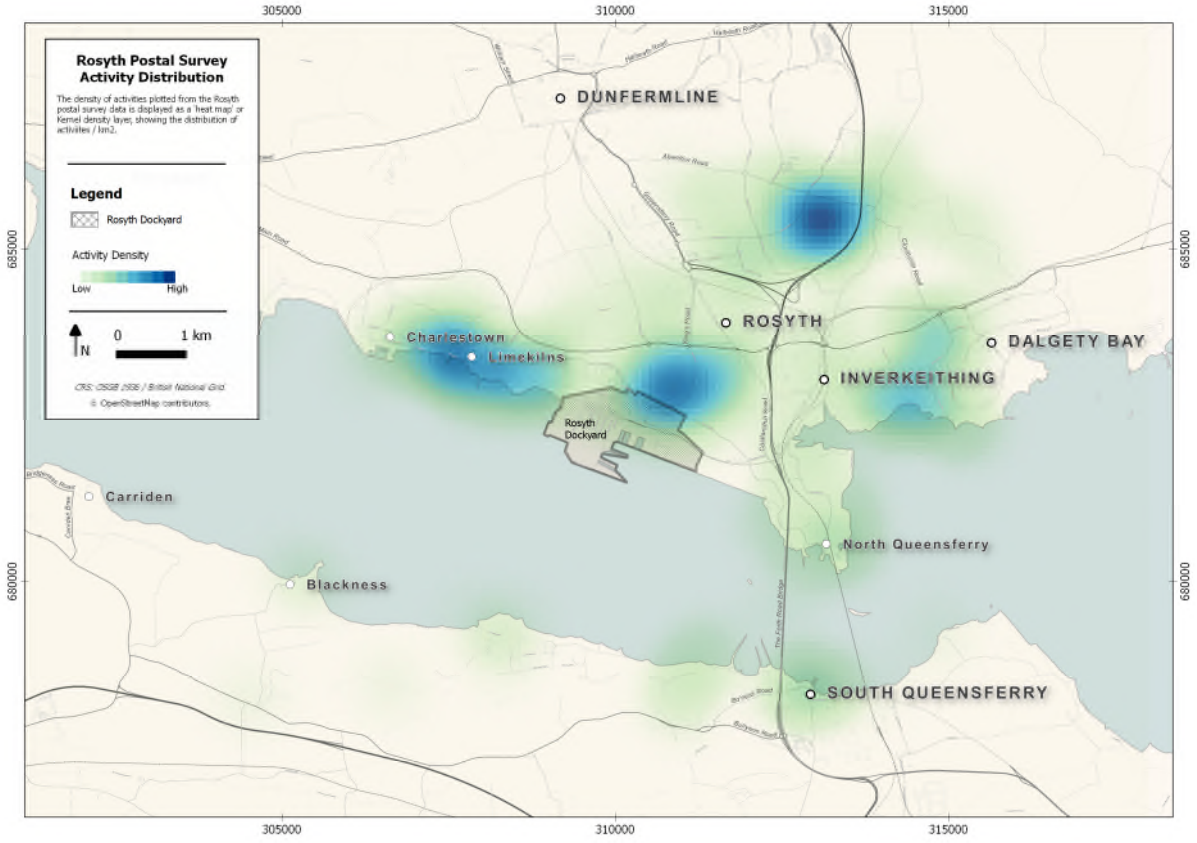


**Figure 5.2** Heat map showing where respondents carry out activities within the survey area.

results from the postal survey shows that respondents consume fish (71.5%) more frequently than they consume crustaceans and molluscs (28.5%). The highest number of individuals (45.4%) consume fish more than 24 days per year. For crustaceans the highest number of respondents consume crustaceans/molluscs twice a year (18.2%). There was no follow-up with those higher rate individuals.

**Table 5.1. Summary of how often members of a household consume aquatic food types.**

| Food Type | Frequency (days per year) >24 | 24 | 2 | Total |
|---|---|---|---|---|
| Crustaceans/molluscs (crab, lobster, mussels) | 5 (2.4%) | 17 (7.9%) | 39 (18.2%) | 61 (28.5%) |
| Fish (cod, salmon, haddock, mackerel) | 97 (45.4%) | 47 (22.0%) | 9 (4.2%) | 153 (71.5%) |

Participants were also asked to provide information on where their household sourced aquatic food (supermarket, local shop or local market) and how often they purchase these on a scale of 0-5 (0=never, 5=always). A total of 195 out of 214 (including responses from

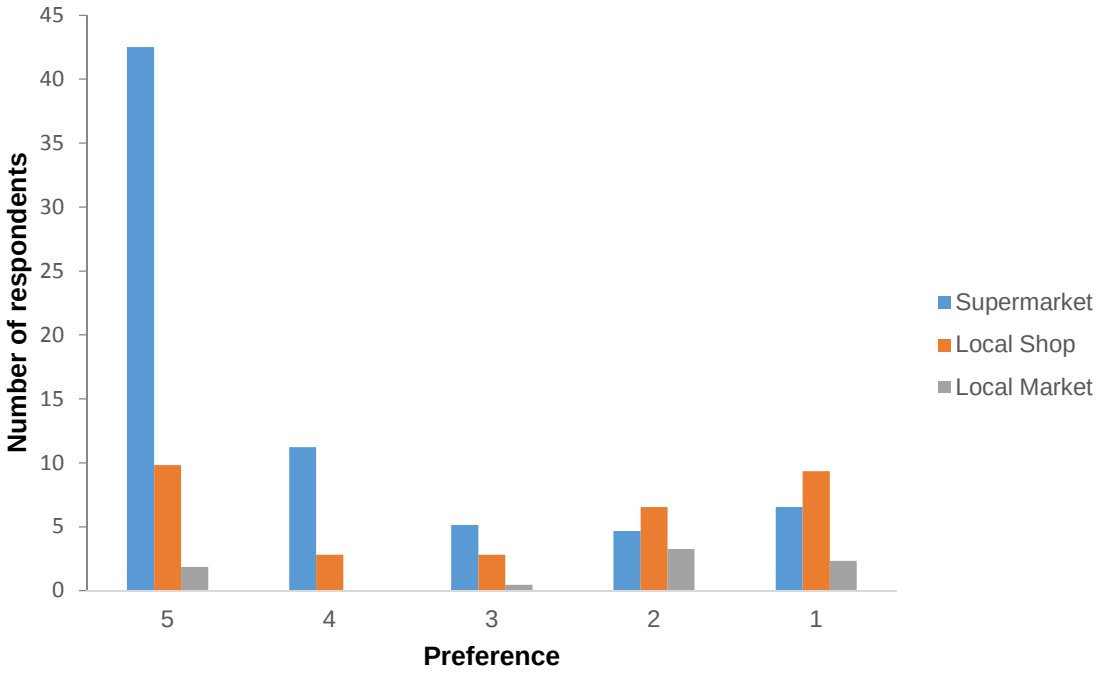


**Figure 5.3** Summary of how often respondents obtain fish/crustaceans/molluscs from supermarkets/local shops or local markets. Scale: 5 (always) to 1 (occasional).

multiple household members) individuals provided information on where they source their fish. The results of where and how often people sourced aquatic food is displayed in figure 5.3. Results show that over 40% of the 195 individuals that consume aquatic food always source it from a supermarket, 10% local shop and 2% local market.

### 5.2.2 External Exposure

A number of households carry out aquatic or intertidal activities within the survey area. The frequency and total number of visits are presented in Table 5.2 with the highest number of

respondents taking part in beach activities (e.g. walking, paddling, beachcombing) followed by outdoor swimming and water sports.

**Table 5.2**. Total number of individuals participating in aquatic activities within the survey area.

| | Frequency (days per year) | | | |
|---|---|---|---|---|
| **Activity** | **>24** | **24** | **2** | **Total** |
| Beach activity | 15 | 30 | 66 | 111 |
| Fishing | 3 | 4 | 8 | 15 |
| Outdoor swim | 3 | 5 | 21 | 29 |
| Seaweed collection | 0 | 0 | 7 | 6 |
| Water sports | 7 | 3 | 12 | 22 |

## 5.3 Commercial fisheries

There has been no increase in commercial fishing activity in the survey area since 2010. Two creel fishing boats were identified to operate within the survey area. One boat's catch of brown and velvet crab and lobster goes outwith the survey area and the other boat's catch supplies fishmongers within the survey area. Crab and lobster also go through the Edinburgh market worldwide. Mackerel, sprats, crab, lobsters and whelks are all caught within the River Forth survey area and may be sold locally. One north east Scotland company took crab and lobster throughout the year for export to Europe and beyond from fishing vessels in the Forth. Sprats caught at Newhaven are sold within the survey area. Mackerel sold in the survey area is supplied from outwith the survey area.

One shop in the area was able to confirm that they sold crab, lobster and whelks from the Firth of Forth area provided by a fishing boat based within the survey area. It also supplied locally caught mackerel in the shop landed by a fishing boat based within the survey area. Another shop in the area took fish from outwith the survey area and one fish van that traded in the survey area did not supply any locally caught fish.

In 2004 the Scottish Executive granted a Special Nature Conservation Order (SNCO) to Scottish Natural Heritage (SNH) to protect the Firth of Forth cockles as a source of food for important bird populations. The Nature Conservation Order (Firth of Forth NCO 2006) was reviewed and retained in 2011.

## 5.4 Seafood operations

Rosyth now has a salmon processing plant but the salmon do not come from the Forth area.

## 5.5 Fishing and Angling

Hobby fishing continues in the survey area and relates to fish and crabs caught for non-commercial consumption from boats across the survey area (Table 5.3).

Angling from the shore was identified at South Queensferry, Burntisland, Cramond Island, Newhaven and Inverkeithing. Angling occurs all year but primarily in the summer. Cod, mackerel and pollock were caught around Newhaven. Mackerel, pollock and wrasse were caught at Burntisland in the summer and cod and whiting in the winter.

In one week in the early autumn, one individual caught 100 mackerel in the Rosyth area for their own and their family and friends consumption. Follow-up was attempted on several occasions but was unsuccessful.

**Table 5.3** Locations associated with hobby fishing activities

| Bait Digging | Fishing from shore/rocks/pier | Small fishing boats (non-commercial) |
|---|---|---|
| Burntisland<br>Pettycur – lug worm, rag worm and white sand worm<br>Kinghorn | Burntisland<br>Cramond Island off rocks<br>Kinghorn off rocks – mackerel<br>Kinghorn off beach – plaice, dab, flounder<br>Granton off jetty - mackerel<br>Hound Point from pier<br>Port Edgar with rods – mackerel<br>Pettycur off beach - mackerel | Carriden – none observed but advised that people go out to fish from here<br>Crombie Point – one fishing boat observed offshore<br>North Queensferry – many go out fishing from boats here<br>Preston Island – fishing boats moored<br>Pettycur – lobster, crab,<br>Pettycur – mackerel, cod and lobster<br>Kinghorn – mackerel and flounder |

## 5.6 Wildfowling

No wildfowling was noted either during the survey period or in the survey area. However, mallard, teal and wigeon are all present in the survey area and may be shot by wildfowlers as are pink footed geese and possibly grey lag geese. The *East of Scotland Association for Wildfowling and Conservation* was approached on several occasions for more information about wild fowling in the area, but no response was forthcoming.

## 5.7 Pleasure Craft using the Firth of Forth

A member of the *Forth Corinthian Yacht Club* was approached to summarise the boating activity within the Firth of Forth to supplement the survey results. It was highlighted that there is a lack of information on usage of the Forth but is being rectified by work by the *Forth Estuary Forum* and by an ongoing survey of recreational use of the coast and sea areas around Scotland for *Marine Scotland*.

A wide variety of pleasure craft use the Forth ranging from cruise liners that moor just east of the Forth Bridge, to yachts, small motor boats, kayaks, canoes and rowing boats. Tour and charter boats operate from North Queensferry, Hawes Pier at South Queensferry. The Inchcolm ferry operates from Hawes Pier offering 1.5 h cruises upto 4 times per day during the summer and three hour landing trips to Inchcolm two times per day. Port Edgar has about 300 boats for recreational use and additional boat moorings are available in South Queensferry Harbour and North Queensferry. Cruise ships moored east of the Forth Bridge use multiple landing craft to ferry passengers to and from tourist coaches at Hawes Pier in South Queensferry. Increasingly, cruise liners anchor in Leith Roads (a stretch of water 3 km from the town of Leith) and passengers are then ferried to Newhaven. Plans have also been proposed to land passengers in North Queensferry in the future.

### Smaller Craft

Dinghy racing activities are focussed in three main centres, Port Edgar, Dalgety Bay and North Berwick. Racing activities take place throughout the year on weekends and holidays and scheduled around the tide times. Races can involve tens of boats largely from within clubs and include adults and children orientated activities. Windsurfing activities take place largely in the outer Estuary in East Lothian although a limited amount is known to take place from Cramond. One face-to-face survey respondent indicated that kite surfing also takes place to a limited extent off Burntisland, although none was observed during the survey.

There are a small number of sailing craft under 6 metres long used for day sailing and local dinghy cruising, for example at Portobello.

Kayaking activity is currently being surveyed by the *Firth of Clyde Forum* and will be reported in February 2016. Kayaking activities take place within and independent of organised groups. Coastal rowing is a competitive and recreational sport that started at Anstruther. There are currently ten clubs on the Forth with 16 St Ayles skiffs between them and more being built and new clubs being formed. Although there are few large competitive events on the Forth all the boats are heavily used for training and there are many local events.

The main boating station of the Northern Area of the Sea Cadets is at Port Edgar and the units at Grangemouth, Port Edgar, Rosyth, Granton, Leith, Musselburgh and Methil all row and sail on the Forth. The Port Edgar Sea Cadets Centre, which is also the National Sea Cadets Centre, has 40 cadets who spend around 40 h $y^{-1}$ on the water in the area. The Sea Scouts based at Limekilns have over 80 members aged from 6 to 16, most live locally, and 11 leaders and six instructors spend three hours per week on average in a boat on the Forth with four out of six instructors also on the water for that time (typically 150 h $y^{-1}$). The boat is hauled across the mud depending on tides. The Sea Scouts sail from Long Craig just east of South Queensferry.

Sea angling is dominated by small 5 m powerboats that are out in all weathers and focus in the area east of the bridges and around the islands. They routinely creel for lobster and catch fish such as mackerel. No consumption rates were obtained.

#### Larger Craft

Forth Yacht Clubs Association has 23 member clubs although there are a few clubs that do not belong to it. These clubs total approximately 800 cruising boats based on the Forth. There are several hundred visiting boats on the Forth over the summer period, generally on passage to the north or south or transiting the Forth and Clyde canal (about 100 h $y^{-1}$) although these figures are all estimates. Most visitors berth at Anstruther, Granton or Port Edgar, all of which have marina facilities. Most clubs have a programme of races. The most intense racing area is from Blackness in the west to Inchkeith in the east with races run by six clubs. Port Edgar is particularly important for racing with fleets of more than 50 racing yachts having been recorded. Most racing takes place between May and October although there is winter racing from Port Edgar. There are perhaps 50 boats that race regularly with more than 50 that take part occasionally. These craft will have crews of at least four people.

Most sailing on the Forth is day sailing although many boats sail to the annual Anstruther Muster and some boats cruise through to the west coast, the Northern Isles or further afield. Fife Council in particular is well aware of the potential for encouraging water-borne recreation and tourism and the use of the Forth for cruising is expected to increase.

## 5.8 Other Pathways

### 5.8.1 Wild Swimmers

Wild swimmers swam in the Forth at various times without wet suits and, locally, could spend 100 hours a year in the water. Discussions with the Wild Swimmers Club members from the area indicated that in the summer, club members spent around 40 hours in the

water, in spring 20 hours, in winter 20 hours and in autumn, 20 hours. Daily swims were taken by some of 30-40 minutes adding up to 3.5 hours a week for some. In winter swims were 15-20 minutes long. One swimmer spent 104 hours over the year in the water in the survey area (Kinghorn, Burntisland, Inverkeithing and Limekilns).

### 5.8.2 Rowing

North Queensferry Boat (Rowing) Club identified that rowers spent on average around three hours a week rowing in the area in the summer – June to September. Occasionally more time would be spent rowing at weekends but not all rowing was local. The group estimates that for the other eight months of the year, they spent on average an hour a week rowing in the area. When rowing locally, they spent around 40 minutes in and around their boatyard. This involved putting boats in the water and taking them out again. Boats were washed down with freshwater and the group remarked that there was little sand or mud on the boats. When rowing, because of the design of the boats, there was little spray and the rowers were rarely wet from 'sea water'. Most club members lived within the survey area although one came from Kirkcaldy.

### 5.8.3 Professional Dog Walkers

Professional dog walkers now operate within the survey area. These groups will be active along the coastal strip for much longer periods in comparison to the 2010 survey. As dogs can go into the sea and along muddy and sandy areas, the group may potentially have greater exposure to intertidal substrates.

### 5.8.4 Ramblers

The South Queensferry Ramblers confirmed that each year they do 10 walks in the area of between six to eight miles in length. Each walk is around four to five hours. Most walks are usually circular but some are linear. They consist of coastal and woodland walks. Annually these would total 40 to 50 hours walking in the survey area including around 25 hours along coastal paths and roads.

### 5.8.5 Animals Grazing

No animals were observed feeding on seaweed anywhere in the study area.

### 5.8.6 Bridge Building

A new bridge across the Forth began in 2011 and is planned to be complete in 2016. In 2015, 1200 employees were working on the bridge. In 2015, work was divided between those working on the land and those on the bridge itself. Those bridge builders not on the land side commute to the bridge six times a week and spend six hours a week on a boat with a 60 hour working week on occasions.

## 5.9 Internal Exposure

### 5.9.1 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 97.5$^{th}$ percentile rates, the high-rate group was determined using a cut off method and the top 20% of the sample were included in this group. The Table also includes mean consumption rates and 97.5$^{th}$ percentile rates based on the full dataset, in addition to the hypothetically derived 95.7$^{th}$ percentile, generic mean and generic 97.5$^{th}$ percentile rates based on National Habit Data (Smith and Jones, 2003).

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

| 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 – Hypothetical 97.5$^{th}$ percentile (kg $y^{-1}$) | National Data mean (kg $y^{-1}$) | National data 97.5$^{th}$ percentile (kg $y^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fish** | 42 | 1 | 109 | 109 | 109 | NA | 13 | 106 | 15 | 40 |
| **Crustaceans** | 16 | 1 | 31 | 31 | 31 | NA | 7 | 30 | 3.5 | 10 |
| **Molluscs** | 4 | 1 | 16 | 16 | 16 | NA | 8 | 15 | 3.5 | 10 |
| **Wildfowl** | 1 | 1 | 26 | 26 | 26 | NA | 26 | 25 | ND | ND |

Adults consumed mackerel (30 individuals), salmon (19 individuals), cod (16 individuals), and a small number consumed sea bass (8 individuals) from the aquatic survey area. On average, these respondents consumed mackerel 35 times a year, salmon 38 times a year, cod 37 times a year and sea bass 35 times a year. The observed maximum consumption (portion size * frequency per person) of fish was 109.2 kg $y^{-1}$ and this individual consumed bass (13.7 kg $y^{-1}$) cod (13.7 kg $y^{-1}$), mackerel (68.3 kg $y^{-1}$) and salmon (13.7 kg $y^{-1}$) all obtained from a fish delivery van within the survey area.

Crustacean consumption consisted of mainly brown crab and common lobster. Of the crustaceans consumed, 11 individuals consumed brown crab 22 times a year on average and 5.3 kg $y^{-1}$. Also, 12 individuals consumed common lobster 15 times a year on average and 4.6 kg $y^{-1}$. The highest consumption was 31.2 kg $y^{-1}$, this individual consumed freshly caught common lobster (13 kg $y^{-1}$) and brown crab (18.2 kg $y^{-1}$) sourced from within the survey area. Mussel was the only species of mollusc consumed by adults (4 individuals), the observed maximum consumption was 15.6 kg $y^{-1}$ and sourced from fish van within the survey area. Only one individual was found to consume wildfowl (26 kg $y^{-1}$) sourced from outwith the survey area.

All respondents sourced aquatic produce from local friends/fishermen that fished off Burntisland, Kinghorn, North Queensferry or Kirkcaldy. Also, respondents used a local fishmonger or fish van from within survey area.

### 5.9.2 Children and Infant Consumption Rates

Table 5.5 presents a summary of children's 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 97.5$^{th}$ percentile rates are included in Table 5.5. The high-rate group was determined using a cut off method, those found at 80% and over were included in the high-rate group. The Table also includes mean consumption rates and 97.5$^{th}$ percentile rates based on the full dataset. For both the child and infant age group, no consumption of crustaceans or wildfowl was identified.

For the child age group, mackerel was the only fish species to be consumed by children. The observed maximum consumption provided from the parent was 1 kg y$^{-1}$, all of which was self-caught within the survey area. Fish species consumed by infants were cod (3.9 kg y$^{-1}$) and salmon (3.9 kg y$^{-1}$) with maximum consumption being 7.8 (kg y$^{-1}$). The same infant also consumed mussels (15.6 kg y$^{-1}$) all of which came from a fish van that delivers within survey area, whose fish is sourced outwith the survey area.

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

| 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 95.7$^{th}$ percentile (kg y$^{-1}$) | Full dataset – Observed mean (kg y$^{-1}$) | Full dataset – Hypothetical 97.5$^{th}$ percentile (kg y$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **Child age group (6 - 15 years old)** | | | | | | | | |
| **Fish** | 2 | 1 | 1 | 1 | 1 | NA | 1 | 0.99 |
| **Crustaceans** | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 |
| **Molluscs** | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 |
| **Wildfowl** | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 |
| **Infant age group (0 - 5 years old)** | | | | | | | | |
| **Fish** | 1 | 1 | 7.8 | 7.8 | 7.8 | NA | 4.17 | 7.6 |
| **Crustaceans** | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 |
| **Molluscs** | 1 | 1 | 15.6 | 15.6 | 15.6 | NA | 15.6 | 15.2 |
| **Wildfowl** | 0 | 0 | 0 | 0 | 0 | NA | 0 | 0 |

## 5.10 External Exposure

Occupancy rates for adults in intertidal, aquatic (in water), aquatic (on water) and handling rates of equipment can be found in Table 5.6. Intertidal activities for adults included bait digging, beachcombing, boat maintenance, collecting mussels, razor clams, seaweed and winkles, crabbing, dog walking, and fixing moorings, handling creels, horse-riding, paddling, playing, research/educational purposes and rock pooling. The highest intertidal occupancy rate was 2,930 h $y^{-1}$ for a respondent who spent time beachcombing, professional dog walking and rock pooling within the survey area. Given the high occupancy a follow-up interview was undertaken and confirmed these values were correct.

Activities in the water included swimming, diving, sub-aqua diving and paddling**.** The highest occupancy rate for adults in the water was 106 h $y^{-1}$ for a respondent who goes paddling (100 h $y^{-1}$) and outdoor swimming (6 h $y^{-1}$) within the survey area**.** Activities on the water included angling, boat maintenance, being on a dive boat, canoeing, commercial fishing, commute via boat, jet skiing, rowing, safety boat duties, sailing, power boating, water skiing, and working on a boat**.** The highest occupancy rate for adults on the water was 3,416 h $y^{-1}$ for a respondent who works full-time on a boat (2,920 h $y^{-1}$) and also owns his own boat so carries out boat maintenance (416 h $y^{-1}$) within the survey area. Adults were also found to handle equipment within the survey area, the activities for adults involving handling equipment included boat maintenance, handling clothes and overalls, diving gear, fishing gear and outdoor swimming gear. The highest level of handling equipment was 1,460 h $y^{-1}$ this respondent spent time handling boating equipment, fishing gear, clothes and overalls on a daily basis within the survey area.

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

| 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 95.7$^{th}$ percentile (h $y^{-1}$) | Hypothetical 95.7$^{th}$ percentile (h $y^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Intertidal** | 199 | 2 | 2930 | 2398 | 2664 | ND | 2856.8 |
| **Aquatic (in water)** | 43 | 1 | 106 | 106 | 106 | ND | 103 |
| **Aquatic (on water)** | 94 | 5 | 3416 | 2768 | 2969 | ND | 3331 |
| **Handling Equipment** | 56 | 1 | 1460 | 1460 | 1460 | ND | 1424 |

Table 5.7 presents a summary of the children and infants' intertidal, aquatic (in water), aquatic (on water) occupancy rates and handling rates of equipment. Intertidal activities for children and infants included beachcombing, boat maintenance, collecting mussels, collecting seaweed, dog walking, paddling, and playing on the intertidal area and rock pooling. The highest occupancy rate for children on the intertidal zone was 1,556 h $y^{-1}$ for a respondent who spent time beachcombing and dog walking. For infants, the highest occupancy was 1,248 h $y^{-1}$ for an infant who spends time playing (624 h $y^{-1}$), rock pooling (208 h $y^{-1}$), paddling (104 h $y^{-1}$) and dog walking (312 h $y^{-1}$) on the intertidal area. It is recognised that these values may be an overestimate but no contact details are available to follow up.

Activities in the water included paddling, swimming and diving. The highest occupancy rate for children in the water was 104 h $y^{-1}$ for a respondent who practiced outdoor swimming at various locations within the survey area. For infants, the highest occupancy was 52 h $y^{-1}$ for an individual spending time paddling within the survey area.

Activities on the water included sea angling, boat maintenance, canoeing, rowing, safety boat duties, sailing, sports fishing and working on a boat. The highest occupancy rate for children carrying out activities on the water was 1,267 h $y^{-1}$. This respondent helped his parents who were working on a boat (1,095 h $y^{-1}$) in addition to, canoeing (24 h $y^{-1}$), rowing (4 h $y^{-1}$)' safety boat duties (24 h $y^{-1}$), sailing (24 h $y^{-1}$) and sports fishing (96 h $y^{-1}$), further information on the work this respondent conducted was not obtained and it's recognised that this value may be an overestimate but no contact details are available to follow up. All of these activities were recorded within the survey area. For infants, the highest occupancy was 72 h $y^{-1}$ carrying out fishing activities with a parent. Children also handled equipment within the survey area, this equipment included boating equipment, diving gear, fishing gear and swimming gear. The highest occupancy for a child handling equipment was 1,095 h $y^{-1}$, this respondent spent time maintaining boat equipment and fishing gear with a parent. No individuals in the infant age group were identified handling equipment during the survey period.

**Table 5.7** Summary of children's and infants' external exposure for intertidal, aquatic and handling of equipment

| 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 95.7$^{th}$ percentile (h $y^{-1}$) | Hypothetical 95.7$^{th}$ percentile (h $y^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Child age group (6 - 15 years old)** | | | | | | | |
| **Intertidal** | 35 | 6 | 1556 | 1378 | 1462 | ND | 1517 |
| **Aquatic (in water)** | 10 | 1 | 104 | 104 | 104 | ND | 101 |
| **Aquatic (on water)** | 8 | 1 | 1267 | 1267 | 1267 | ND | 1235 |
| **Handling Equipment** | 4 | 1 | 1095 | 1095 | 1095 | ND | 1068 |
| **Infant age group (0 - 5 years old)** | | | | | | | |
| **Intertidal** | 25 | 2 | 1248 | 1248 | 1248 | ND | 1217 |
| **Aquatic (in water)** | 10 | 1 | 52 | 52 | 52 | ND | 50.7 |
| **Aquatic (on water)** | 1 | 1 | 72 | 72 | 72 | ND | 70.2 |
| **Handling Equipment** | 0 | 0 | 0 | 0 | 0 | ND | 0 |

Gamma dose rate measurements over different substrates within the survey area can be found in Section 7.3.

# 6 Terrestrial Radiation Pathways

## 6.1 Introduction

Chapter 6 deals with all inland routes of exposure immediately adjacent to the Firth of Forth coastal and intertidal areas (Figure 2.1). The observations made at each site have been presented in Chapter 4. The results from the postal survey reports are presented to provide an overview of the habits within the 5 km study area immediately around the Rosyth perimeter. The experimental results from the GPS tracker devices are also presented to provide some temporal and spatial resolution in the habits of individuals. Private food production details are provided and the results from the face-to-face consumption levels for privately produced food stuffs are presented. It is noted that there is subjectivity on individuals reporting on masses, volumes and frequency. Information is reported as provided.

## 6.2 Postal Survey Results

### 6.2.1 Internal Exposure

A list of terrestrial food items used in the postal survey is shown in Table 6.1. The results show that dairy products such as milk, cheese and yoghurt are the most frequently consumed food type with 126 respondents consuming it daily as well as the most popular with 169 respondents consuming dairy products. Wild meat, such as rabbit and game, was the least selected food type with only 24 respondents consuming it and 16 of these only consume it twice a year. No eggs were identified as being sourced within the study area.

For terrestrial food types respondents were asked to estimate where they sourced fresh or frozen terrestrial food from (supermarket, local shop, allotment/garden or a local market). On using the full dataset respondents selected terrestrial food items from the supermarket on a daily basis (1,115 selections). Figures 6.1-6.3 show how frequently respondents use supermarkts to source meat, vegetables and potatoes.

**Table 6.1** Summary of terrestrial food types and how frequently each food type is consumed.

| | Frequency (days per year) | | | | |
|---|---|---|---|---|---|
| **Food type** | **260** | **104** | **24** | **2** | **Total** |
| beef, lamb, pork | 15 | 98 | 31 | 6 | 150 |
| green vegetables | 32 | 89 | 30 | 6 | 157 |
| chicken,(duck, goose, wildfowl) | 30 | 102 | 17 | 0 | 149 |
| cow and goats' milk, cheese and/or yoghurt | 126 | 37 | 5 | 1 | 169 |
| honey | 20 | 26 | 42 | 18 | 106 |
| leeks or onions | 53 | 75 | 19 | 4 | 151 |
| lettuce, tomatoes, cucumber | 49 | 78 | 25 | 6 | 158 |
| pies, burgers, sausages, haggis made from local meat | 7 | 46 | 70 | 10 | 133 |
| potatoes | 65 | 75 | 10 | 0 | 150 |
| root vegetables | 42 | 86 | 22 | 2 | 152 |
| shop bought apples, pears and/or berries | 83 | 53 | 16 | 7 | 159 |
| wild meat such as rabbit or game | 0 | 2 | 6 | 16 | 24 |
| wild/ free food including berries, apples, pears, mushrooms in season | 18 | 21 | 14 | 25 | 78 |

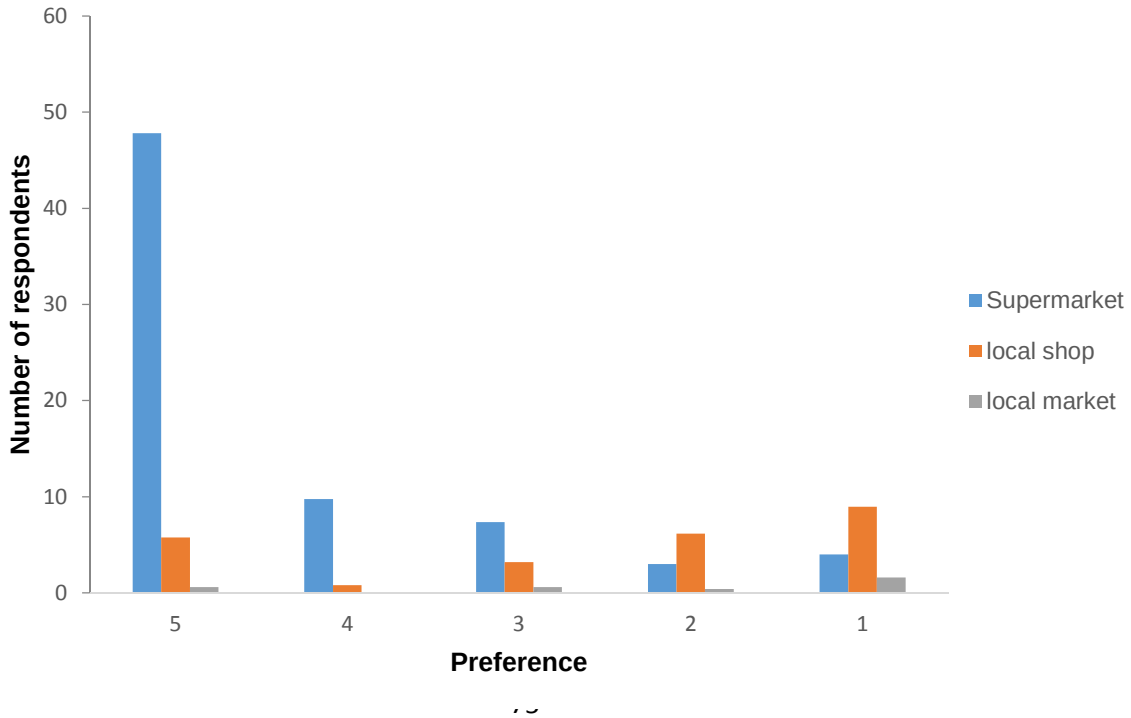


**Figure 6.1** Summary of how often respondents obtain meat from supermarkets/local shops or local markets. Scale: 5 (always) to 1 (occasional).

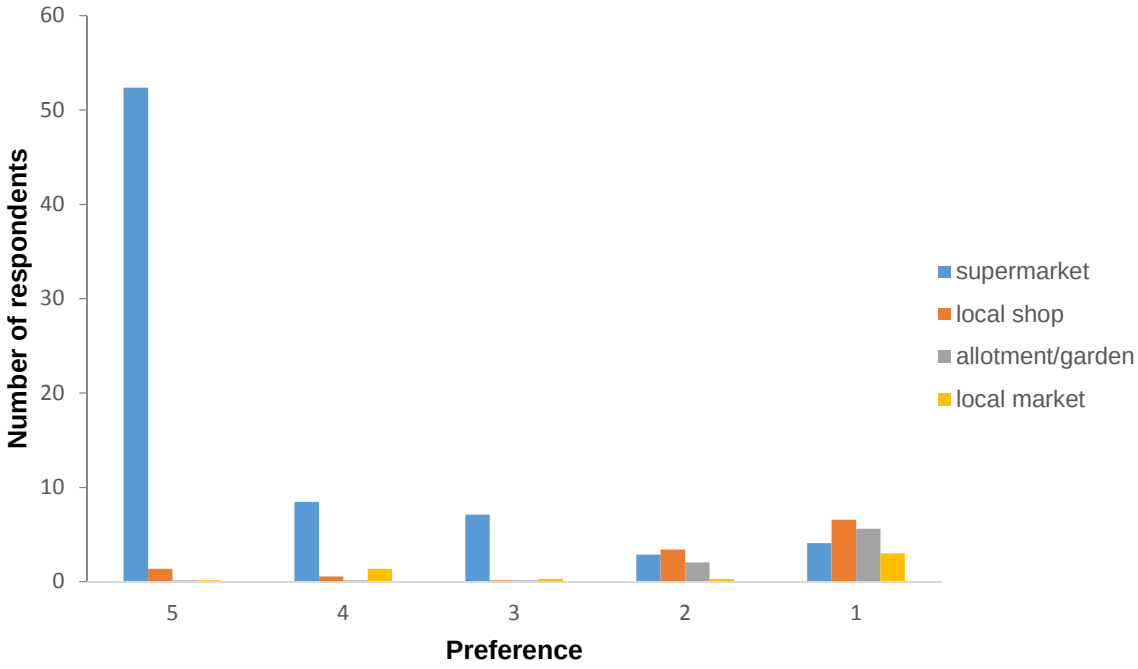


**Figure 6.2** Summary of how often respondents obtain vegetables from supermarkets/local shops or local markets. Scale: 5 (always) to 1 (occasional).

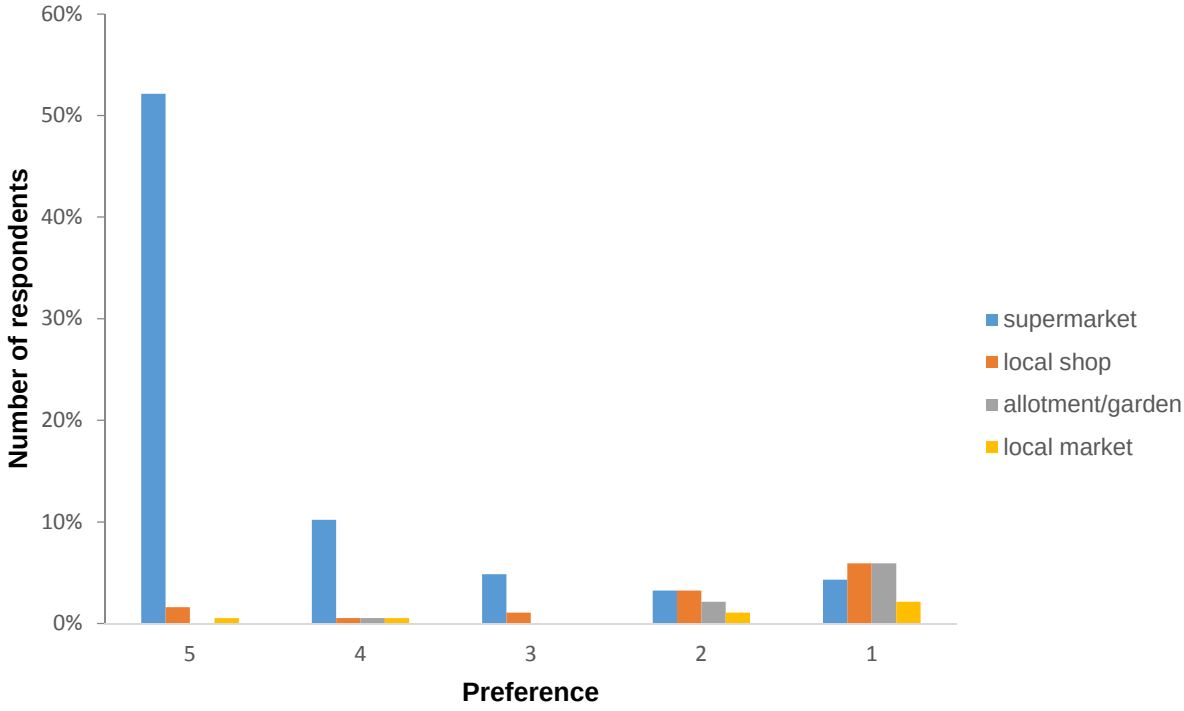


**Figure 6.3** Summary of how often respondents obtain potatoes from supermarkets/local shops or local markets. Scale: 5 (always) to 1 (occasional).

### 6.2.2 Outdoor Activities

The postal survey showed that greenspace walking, urban walking and allotment/gardening activities were the highest selected terrestrial activities. Allotments and gardening were selected by 80 households with 34% participating on a daily basis and a further 345 participating twice per week (Table 6.2). Outdoor walking was selected 163 times with 61% participating daily.

**Table 6.2** Summary of how often respondents participate in outdoor terrestrial activities.

| | Frequency (days per year) | | | | |
|---|---|---|---|---|---|
| **Activity** | **260** | **104** | **24** | **2** | **Total** |
| Allotment/Gardening | 27 | 27 | 21 | 5 | 80 |
| Bee keeping | 2 | 1 | 1 | 1 | 5 |
| Cycling | 9 | 19 | 15 | 16 | 59 |
| Green Space Walking | 30 | 46 | 35 | 8 | 119 |
| Horse-Riding | 1 | 5 | 0 | 2 | 8 |
| Mobility User | 1 | 6 | 1 | 2 | 10 |
| Shooting and Hunting | 0 | 2 | 4 | 4 | 10 |
| Sports | 0 | 15 | 6 | 5 | 26 |
| Urban Walking | 35 | 37 | 26 | 9 | 107 |
| Walking | 100 | 49 | 14 | 0 | 163 |

## 6.3 GPS Survey Results

To provide more details on the use of the environment around the BRS, 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 one week. Three were given to Rosyth site employees and two were given to two residents of North Queensferry who were identified from the face-to-face survey as spending a lot of their time in the North Queensferry area. Details of the GPS tracker results are presented in Appendix F.

## 6.4 Private Food Production

### 6.4.1 Allotments and Community Gardens

Five allotments were identified within the 5 km radius of the BRS. Two were based in Rosyth: (i) *Admiralty Road* allotments (Figure 6.4), which is run by a private committee; and (ii) *Wemyss Road* allotments, which is run by the council. Two further allotments were identified in Dunfermline: (i) *Calais View* allotments; and (ii) *Whirlbut* allotments, both run by the council. Additional allotments identified included: (i) one in Inverkeithing, *Hope Street*

allotments, which is run by a committee. One allotment in *Dalgety Bay*, which is run by a committee, was identified but is just outwith the 5 km radius.

The allotments varied in size from a small allotment of approximately five plots at the *Calais*

**Figure 6.4** View looking west over the *Admiralty Road* Allotments, Rosyth

*View* allotments in Dunfermline to approximately 50 at the Admiralty Road allotments in Rosyth. The *Admiralty Road* allotments were by far the most active site at the time of the interviews, resulting in the majority of the successful face-to-face interviews. It was however difficult to access the site due to the locked gates, required for site security. The *Wemyss Road* allotments were situated beside the railway station and appeared fairly small with approximately 20 well-maintained plots. The *Calais View* allotments, with only about five plots, were less well maintained and there appeared to be only one plot being worked. No interviews were undertaken at this allotment. The *Whirlbut* allotments were a fairly small site with approximately 15 plots, all of which were relatively well maintained. As with *Admiralty Road*, access to *Whirlbut* was difficult due to the presence of locked gates.

The individual interviewed at this allotment indicated that the council were developing plans to expand the *Whirlbut* site to the adjacent land to provide more plots.

The allotments produced a wide variety of vegetables and fruit and the majority of allotment holders interviewed provided detailed data on the yield of their products, many of which had a record of the amount of each vegetable and fruit planted and the yield. Face-to-face interviews at the *Admiralty Road* allotments indicated that all the produce on the survey list were produced to varying degrees by one or more allotment owners. The food grown at the allotments were consumed by their families and friends within the survey area.

Two community gardens and one community "free food" project were identified within the survey area. The community garden in Inverkeithing is well organised. Members manage the garden together and consume the vegetables and fruit. Visitors are welcome to wander around the garden and there is an opportunity to purchase produce available. A second active community garden was identified at North Queensferry, behind Ferryhills Road, within an old walled garden. The community garden produces food primarily for those that tend to the garden, although an open-day was being planned by the organising committee at the time of visiting. A school within the survey area also has a garden, tended by volunteers and school children. Seaweed is extensively used as a soil conditioner on the school garden within the survey area. No other community gardens within the survey area were identified.

The community "free food" in Rosyth – Edible and Tasty Spaces (EATS) - was set up by the Rosyth Community Council as a project and there are the three sites situated at the library, The Anchor Bed and Queensferry Road. The Rosyth Community Council is hoping to establish a community garden and a centenary orchard which they are currently trying to secure land for from Fife Council. Other EATS sites are present elsewhere in Fife but no others were identified within the survey area.

Within the community gardens a variety of green leafy vegetables, root vegetables and alliums were grown. Some soft fruits were also grown. Within the free foods available it was mainly cabbage, purple sprouting, chard, crab apples and fruit shrubs.

Over the survey period, 120 people were interviewed who grew their own food either within their own home gardens or community gardens. However, fully quantitative information was difficult to acquire or interpret from all interviews. Of these interviews, 26 individuals yielded data of sufficient quality for quantitative estimates of food quantities grown and consumed.

### 6.4.2 Use of Seaweed as a soil conditioner

Seaweed as a soil conditioner is used in the area, and of the 26 individuals questioned in the face-to-face survey, five confirmed that they used seaweed routinely for this purpose and this is presented in Table 6.3. Quantities were usually reported in terms of trailer, wheel barrow or sack loads. These were converted during the face-to-face interviews with the

respondents to approximate mass assuming the seaweed was wet. The seaweed was applied either as compost or directly to the soil surface and allowed to decompose. Two additional respondents identified that they used a commercial liquid seaweed application, this has been excluded from any further analysis.

**Table 6.3** Use of Seaweed as a soil conditioner in the Rosyth Area

| Survey ID | Used where | Collected From | Application | Estimated Annual Quantity (kg) |
|---|---|---|---|---|
| R/S/AT/015 | Community Garden and School | Firth of Forth, Northern Shore | Directly to the soil surface | 3000 |
| R/A/LE/71 | Admiralty Road Allotment | Limekilns | Composted | 180 |
| R/A/AT/052a | Admiralty Road Allotment | Limekilns | Composted | 200 |
| R/A/AT/052c | Admiralty Road Allotment | Limekilns | Composted | 200 |
| R/A/AT/053a | Admiralty Road Allotment | Limekilns and Crombie Point | Composted | 150 |

## 6.5 Other Pathways

### 6.5.1 Production of Honey

The production of honey is very much weather-dependent as wet cold weather reduces the bees' ability to come out of the hive. In 2015 during the wet cool summer the bees have not been able to leave the hive as often as previous years. Coupled with this, the cool wet weather has also affected the growth of flowers. These two factors meant that in 2015 honey production was significantly lower than that for 2014 (Dunfermline and West Fife Beekeepers Association - DWFBA). Beekeepers around Rosyth have confirmed that production of honey has been low with beekeepers having to feed the bees sugar for most of the summer.

Although 2015 appears to have been a poor year for honey production around Fife, Fife beekeepers reported an increase in the number of beekeepers over the last few years. However, as beekeepers are not required to be a member of a bee keeping association or be registered the precise numbers in the Roysth area are unknown. Information from a member of Fife Beekeepers Association estimates that there may be around 100 bee keepers between Burntisland and Culross of which 30 – 40 are known to the Association. The majority of these are thought to be hobby beekeepers consuming their own honey and gifting it to friends and family. West Fife Beekeepers has around 60 members. Hives are

estimated to produce 14 kg of honey but may produce as much as 32 kg. However, as noted above for 2015, and reported from Dunfermline and West Fife Beekeepers Association (DWFBA), significantly lower quantities of honey appear to have been produced.

Two commercial beekeepers were identified in the 2015 survey. Both of the commercial beekeepers identified sell honey locally within the survey area. As noted, honey production is weather dependent and one of the beekeepers stated they would 'normally' expect to yield 18 – 22 kg of honey from one hive. A third beekeeper was identified within the survey area however, during the survey period contact with this person was unsuccessful.

## 6.6 Internal Exposure

### 6.6.1 Internal Exposure Adult Consumption Rate

Consumption data for locally produced foodstuffs potentially affected by atmospheric releases from Rosyth are presented in Table 6.4 for adults and Table 6.5 for children. No consumption of locally produced foodstuffs were identified by infants in 2015.

Table 6.4 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 (or hypothetically derived) 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 Rosyth. The Table also provides the mean and 97.5% consumption rates from national data (Smith and Jones, 2003) for comparison.

**Table 6.4** Summary of adult consumption rate of foods from the terrestrial survey area

| Food type | 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 97.5$^{th}$ percentile (kg $y^{-1}$) | Full dataset – Observed mean (kg $y^{-1}$) | Full dataset – Hypothetical 97.5$^{th}$ percentile (kg $y^{-1}$) | National Mean (kg $y^{-1}$) | National 97.5$^{th}$ percentile (kg $y^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Vegetables-Green** | 22 | 3 | 74.2 | 62.1 | 68.3 | NA | 21.8 | 72.4 | 15 | 45 |
| **Vegetables - Root** | 21 | 6 | 43.0 | 36.3 | 38.7 | 27.3 | 22.2 | 41.9 | 10 | 40 |
| **Vegetables - Potatoes** | 14 | 4 | 50.0 | 42.0 | 46.0 | NA | 24.6 | 48.8 | 50 | 120 |
| **Fruit - Domestic** | 19 | 2 | 39.0 | 39.0 | 38.7 | NA | 13.5 | 38.0 | 20 | 75 |
| **Fruit - Wild** | | | | | | | | | 7 | 25 |
| **Meat - Beef** | 1 | 1 | 20.8 | 20.8 | 20.8 | NA | 20.8 | 20.3 | 15 | 45 |
| **Meat - Game** | | | | | | | | | NA | NA |
| **Meat - Poultry** | 1 | 1 | 10.6 | 10.6 | 10.6 | NA | 10.6 | 10.3 | 10 | 30 |
| **Meat - Sheep** | | | | | | | | | 8 | 25 |
| **Honey** | | | | | | | | | 2.5 | 9.5 |

Consumption of locally produced foods were identified for green and root vegetables, potatoes, domestic fruit, beef and poultry. No consumption of locally produced lamb or mutton, honey, venison, milk, pig products, eggs, rabbits/hares, wild mushrooms or freshwater fish were observed.

Three observed mean consumption rates for the high-rate consumer group were found to be greater than the 97.5% value for the full 2015 dataset. These were for fruit, beef and poultry products. Only one of the observed mean consumption rates for the high-rate consumer group was found to exceed the national 97.5% consumption rate. This was for green vegetables. The remaining five groups for which data was collected in the 2015 survey were

all found to have lower mean consumption rates for the high-rate consumer group than the national 97.5% consumption rate.

### 6.6.2 Children and Infant's Consumption Rates

Table 6.5 presents a summary of the children 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 (or hypothetically derived) 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 Rosyth. No data on children's consumption rate are available at a national level. No information on infants' consumption rates of foods from the local survey area could be identified.

Child consumption of locally produced foods were identified for four groups green and root vegetables, potatoes and domestic fruit. No consumption of locally produced lamb or mutton, honey, venison, milk, pig products, eggs, rabbits/hares, wild mushrooms, beef, poultry or freshwater fish were observed. The two observed mean consumption rates for the high-rate consumer group were found to be greater than the 97.5% value than the full 2015 dataset.

**Table 6.5** 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 $y^{-1}$) | Observed minimum for the high-rate group (kg $y^{-1}$) | Observed mean for the high-rate group (kg $y^{-1}$) | Observed 95.7$^{th}$ percentile (kg $y^{-1}$) | Full dataset – observed mean (kg $y^{-1}$) | Full dataset – Hypothetical 97.5$^{th}$ percentile (kg $y^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **Vegetables- Green** | 2 | 2 | 9.1 | 9.1 | 9.1 | NA | 9.1 | 8.9 |
| **Vegetables - Root** | 2 | 2 | 2.6 | 2.6 | 2.6 | NA | 2.6 | 2.5 |
| **Vegetables - Potatoes** | 2 | 2 | 12.5 | 12.5 | 12.5 | NA | 12.5 | 12.2 |
| **Fruit - Domestic** | 2 | 2 | 39 | 39 | 39 | NA | 39 | 38 |
| **Fruit - Wild** | 0 | | | | | | | |
| **Meat – Beef** | 0 | | | | | | | |
| **Meat – Game** | 0 | | | | | | | |
| **Meat – Poultry** | 0 | | | | | | | |
| **Meat – Sheep** | 0 | | | | | | | |
| **Honey** | 0 | | | | | | | |

# 7 Direct Radiation Exposure

## 7.1 Introduction

Direct radiation exposure was assessed in the first instance by a mobile gamma spectrometry survey, including the main routes around the survey area, the majority of roads within the 1 km area (Chapter 2) and a more detailed survey of all publically accessible areas within the BRS.

These data were used to help target follow-up in-situ terrestrial air kerma measurements, which were undertaken at any location where an apparent anomaly was observed and at all face-to-face survey locations concurrently with the face-to-face surveys. Estimates of doses derived from discharges from site are very small and described in Section 2.2.

## 7.2 Mobile Gamma Spectrometry Survey

### 7.2.1 Survey Area

A significant portion of the study area was surveyed by car-borne gamma spectrometry. The main focus was the areas surrounding the BRS, however, additional data was also captured on route to other survey locations as shown in Figure 7.1 for the broad area and Figure 7.2 for the area surrounding Rosyth. The survey was acquired on two separate occasions on the 15$^{th}$ May and 18$^{th}$ June.

Figure 7.1 shows the results from the survey. A number of increased counts are illustrated across the survey area and reflect the change in the gamma radiation environment largely due to bridges, concrete and other road related support structures. Bridges increase the amount of natural radiation by changing the geometry from a flat plain underneath the detector to one that fully surrounds the detector. Anomalies are noted in South Queensferry. The spectra indicate that these are features resulting from the increase in the natural abundance of potassium-40, uranium and thorium and is attributed to changes in road material, for example the change from tarmac to cobbles.

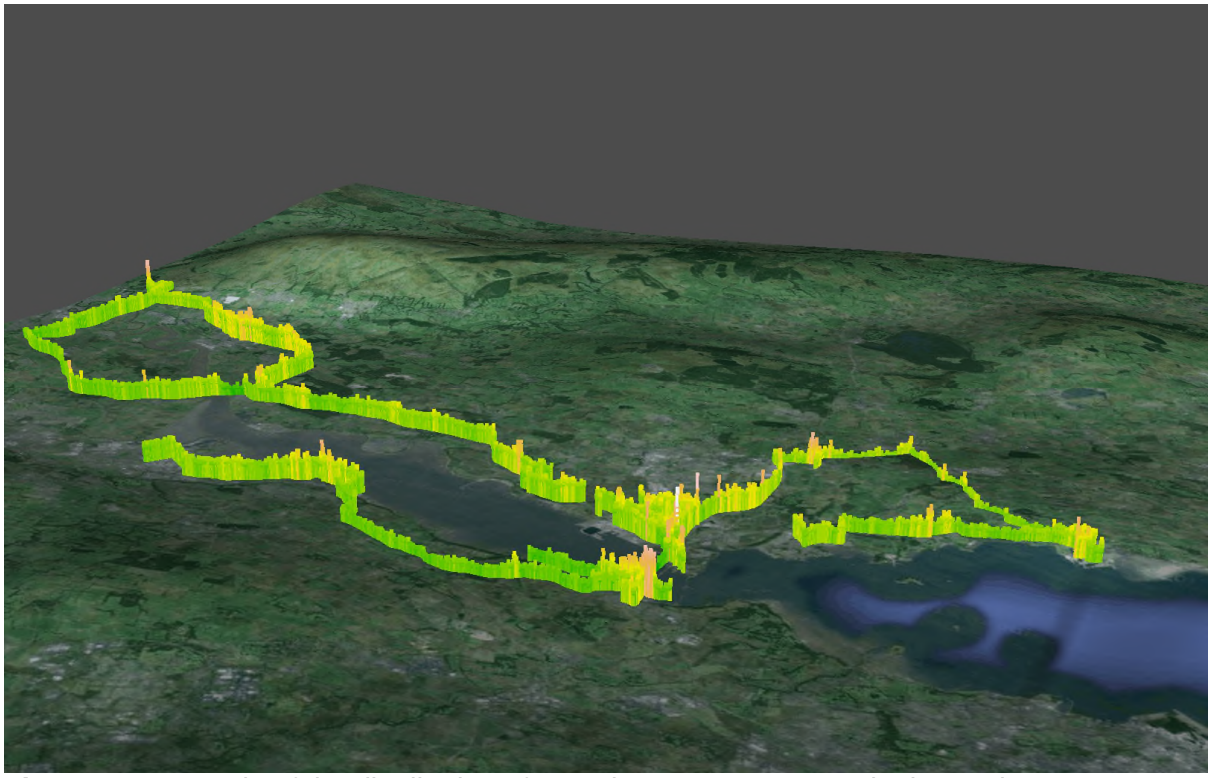

**Figure 7.1** Example of the distribution of >350 keV gamma counts in the study area

## 7.3 In-Situ Gamma Dosimetry

### 7.3.1 Terrestrial Areas

A total of 46 gamma dose rate measurements were taken in terrestrial environments, excluding intertidal areas. The distribution in terrestrial gamma dose rates are mapped in Figure 7.2. The map shows that whilst there is no systematic distribution of terrestrial gamma dose rate, the highest values are identified on site, discussed in Section 7.2.3, and one site to the south of the estuary in Carriden. Table 7.1 provides a summary of the gamma dose rate measurements made.

The slightly elevated measurement at Carriden Boat Club was made at a central location within the boatyard.

**Table 7.1** Summary of Gamma Dose rate measurements collected across the terrestrial environments. Where n=1, the range is based on the 2**σ** measurement uncertainty.

| Location | Surface | n | Mean (μGy $h^{-1}$) | Range Minimum (μGy $h^{-1}$) | Range Maximum (μGy $h^{-1}$) |
|---|---|---|---|---|---|
| Bo'ness | grass bank close to intertidal area | 1 | 0.0331 | 0.0291 | 0.0370 |
| Carriden | coastal path | 1 | 0.0243 | 0.0206 | 0.0279 |
| Carriden | boat club | 1 | 0.0442 | 0.0399 | 0.0485 |
| Charlestown | grass area close to harbour | 4 | 0.0186 | 0.0159 | 0.0246 |
| Cramond Island | causeway on concrete surface | 1 | 0.0265 | 0.0228 | 0.0303 |
| Cramond Island | grass bank close to beach | 1 | 0.0155 | 0.0120 | 0.0190 |
| Crombie Houses | on road close to shoreline | 1 | 0.0242 | 0.0206 | 0.0279 |
| Culross | grass/tarmac in car park | 2 | 0.0328 | 0.0316 | 0.0341 |
| Culross | grass on seafront | 1 | 0.0282 | 0.0244 | 0.0320 |
| Culross | grass in West Park | 7 | 0.0285 | 0.0236 | 0.0332 |
| Dalgety Bay | grass bank | 1 | 0.0196 | 0.0160 | 0.0232 |
| Granton | grass bank on coastal path | 1 | 0.0242 | 0.0206 | 0.0279 |
| Hound Point | grass on seafront | 1 | 0.0137 | 0.0103 | 0.0171 |
| Kincardine | concrete/coastal path | 2 | 0.0340 | 0.0299 | 0.0380 |
| Kincardine | grass bank | 3 | 0.0283 | 0.0228 | 0.0338 |
| Limekilns | grass bank | 1 | 0.0236 | 0.0200 | 0.0273 |
| North Queensferry | garden where boating equipment is washed | 1 | 0.0240 | 0.0204 | 0.0277 |
| BRS | concrete surface on perimeter fence of radiography buildings | 7 | 0.0280 | 0.0245 | 0.0309 |
| BRS | road outside AWAF | 1 | 0.0315 | 0.0276 | 0.0354 |
| BRS | junction between Wood Road. and Bell Road | 1 | 0.0538 | 0.0491 | 0.0584 |
| Rosyth Park | grass | 3 | 0.0347 | 0.0275 | 0.0392 |
| Torryburn | coastal path | 1 | 0.0237 | 0.0200 | 0.0273 |

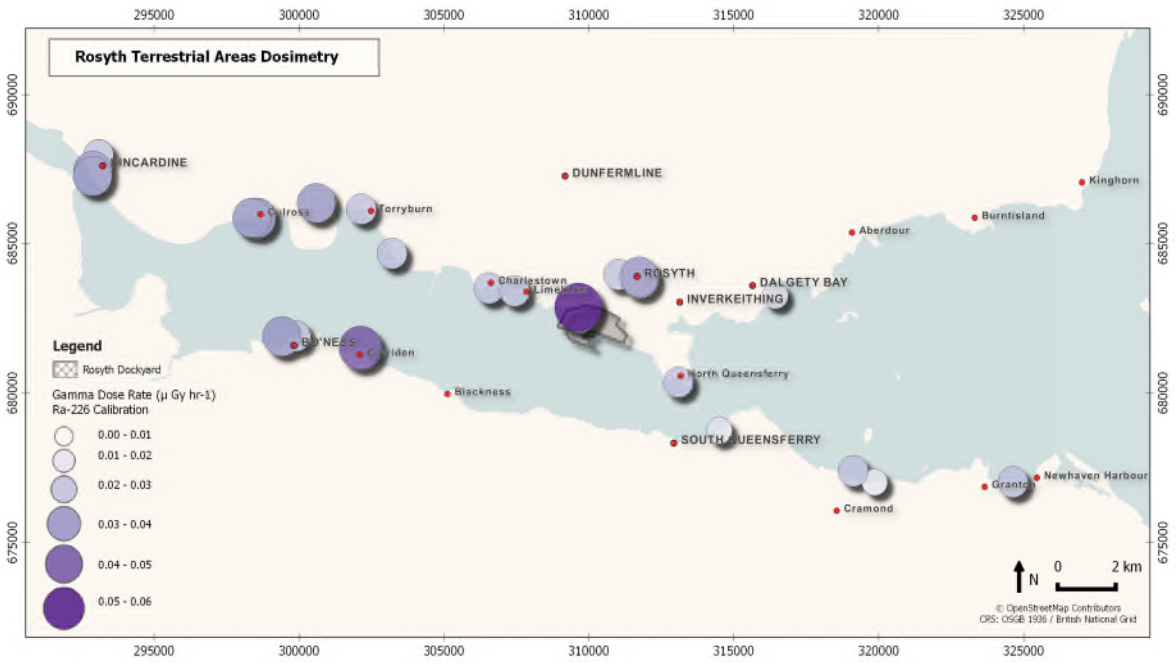


**Figure 7.2** Map showing the distribution of gamma dose rates observed at the study site locations in the terrestrial environment. Note at Rosyth radiography sources were known to be in use.

### 7.3.2 Intertidal areas

A total of 37 in-situ terrestrial gamma dose rate measurements were made over intertidal surfaces. At each site, gamma dose rate measurements were made over the dominant intertidal surfaces observed. Figure 7.3 provides a summary of the intertidal gamma dose rates measured. Geological influences in addition to sediment moisture strongly control the observed terrestrial gamma dose rate. The lowest values were very close to 0 µGy $h^{-1}$ (with intrinsic and cosmic component removed) over wet sand with standing water at Burntisland and as a result of the purity of the quartz sand Silversands. The maximum values recorded for each site are reported in Table 7.2.

**Table 7.2** Terrestrial gamma dose rate recorded over different intertidal substrates

| | Gamma Dose Rate over Substrate type (µGy $h^{-1}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **Mud / silt** | **2 σ** | **Sand** | **2 σ** | **Shingle** | **2 σ** | **Pebbles / Rock** | **2 σ** |
| Blackness | | | 0.0126 | 0.0034 | | | | |
| Bo'ness | 0.0258 | 0.0037 | 0.0343 | 0.0423 | 0.0423 | 0.0042 | | |
| Burntisland | 0.0129 | 0.0034 | 0.0188 | 0.0067 | | | 0.0193 | 0.0035 |
| Carriden | 0.0223 | 0.0036 | | | 0.0346 | 0.0040 | | |
| Charlestown | | | 0.0183 | 0.0035 | | | | |
| Cramond Island | 0.0215 | 0.0036 | 0.0170 | 0.0035 | | | | |
| Dalgety Bay | 0.0260 | 0.0037 | 0.0239 | 0.0037 | 0.0284 | 0.0038 | 0.0093 | 0.0033 |
| Inverkeithing | 0.0242 | 0.0037 | | | | | | |
| Kincardine | 0.0265 | 0.0037 | | | | | | |
| Limekilns | 0.0202 | 0.0035 | | | | | | |
| North Queensferry | 0.0194 | 0.0035 | 0.0248 | 0.0037 | 0.0277 | 0.0038 | | |
| Silver Sands | | | 0.0200 | 0.0035 | | | | |
| Society Point | | | 0.0141 | 0.0034 | | | | |
| South Queensferry | | | 0.0126 | 0.0034 | | | | |
| Torryburn | 0.0246 | 0.0037 | 0.0276 | 0.0038 | 0.0254 | 0.0037 | | |
| Mean | 0.0224 | | 0.0204 | | 0.0317 | | 0.0143 | |
| Maximum | 0.0265 | | 0.0343 | | 0.0423 | | 0.0193 | |

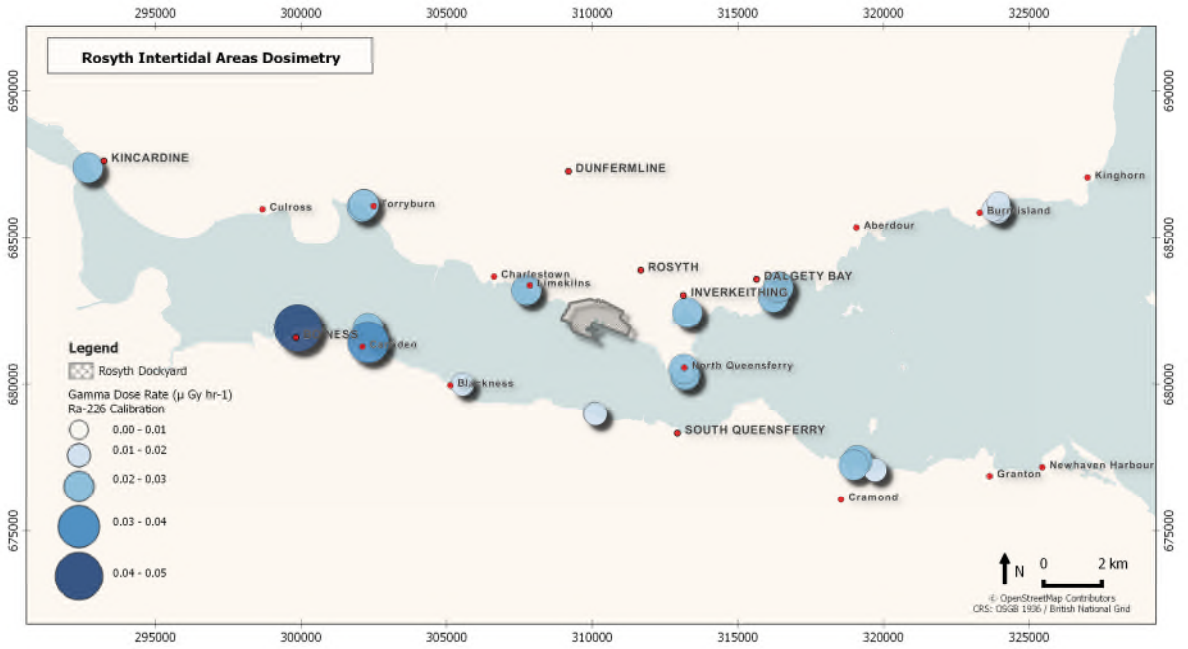


**Figure 7.3** Map showing the distribution of gamma dose rates observed at the study site locations in the intertidal environment

The highest values were recorded at Bo'ness and are associated with historical pottery manufacturing, and has been observed previously (CEFAS, 2010). This historical legacy may also explain the slightly elevated values at Carriden.

## 7.4 In-Situ Beta Dosimetry

Beta dosimetry of skin dose [H'(0.07)] was measured over objects and clothing frequently immersed within the Firth of Forth. A kayak, wet suit, wet suit boots and fishing equipment were measured within the northern shore survey area and wet suit clothing from dinghy sailors were measured within the southern shore survey area. All measurements were below the detection limits of 0.2 µSv $h^{-1}$ per $cm^{-2}$.

## 7.5 Sample Analyses

During the survey period samples were collected at locations thought to represent possible pathways of radioactivity into the food chain or external exposure. Samples of soil and vegetables were collected from a Community garden in Rosyth where it is known that seaweed has been used as a soil conditioner. Similarly, samples of sediment were collected from the west bay at North Queensferry. The results are presented in Table 7.3. The $^{137}Cs$ activities are consistent with environmental levels of 1960's nuclear weapons testing fallout.

**Table 7.3** Summary of the radio-analytical results from the samples collected in and around North Queensferry and community garden

| | $^{60}Co$ | | $^{137}Cs$ | | |
|---|---|---|---|---|---|
| **Sample** | **Quality** | **Activity Bq $kg^{-1}$** | **Quality** | **Activity Bq $kg^{-1}$** | **2 σ** |
| Soil Community Garden Plot 1 | < | 8.36E-02 | | 5.43E+00 | 5.71E-02 |
| Soil Community Garden Plot 2 | < | 5.62E-02 | | 5.36E+00 | 5.55E-02 |
| Soil Community Garden Plot 3 | < | 3.21E-01 | | 6.54E+00 | 8.30E-02 |
| Intertidal Mud | < | 3.93E-02 | | 3.51E+00 | 8.16E-02 |
| Green Leaf from Radish | < | 1.66E-01 | < | 3.83E-01 | |
| Radish | < | 4.13E-01 | < | 2.60E-01 | |
| White Chard | < | 4.29E-01 | < | 4.31E-01 | |
| Red Spinach | < | 4.23E-01 | | 2.75E+00 | 3.29E-01 |

## 7.6 Occupancy levels

### 7.6.1 Occupancy data for the survey area

A summary of the types of activities that respondents participate in within the survey area can be found in Table 7.4. The face-to-face interviews revealed that individuals to take part in a range of terrestrial, aquatic and intertidal activities within the survey area (Table 7.4) with the highest number of individuals taking part in rambling/walking (232 respondents) with the most frequent walker spending 2,190 hours a year rambling/walking in Hound Point. For the aquatic activities, sailing was the most popular (39 respondents) and dog walking was the most popular intertidal activity (121 respondents).

**Table 7.4** Summary of the activities and total number of respondents that take part in the activities. The location of the maximum occupancy is also given.

| Activity type | Activity | Number of respondents | Maximum occupancy (h $y^{-1}$) | Location (if provided) |
|---|---|---|---|---|
| Terrestrial | Allotment | 39 | 1825 | Rosyth Allotments |
| Terrestrial | Bee Keeping | 6 | 91.25 | Limekilns |
| Terrestrial | Bird/Nature Watching | 69 | 730 | Charlestown, Limekilns |
| Terrestrial | Bowling | 23 | 312 | Aberdour |
| Terrestrial | Cycling | 171 | 730 | |
| Terrestrial | Dog Walking | 185 | 1825 | Silversands |
| Terrestrial | Gardening | 209 | 730 | Rosyth |
| Terrestrial | Golfing | 43 | 1460 | Blackness |
| Terrestrial | Horse Riding | 10 | 208 | Burntisland |
| Terrestrial | Playing | 102 | 1825 | Inverkeithing |
| Terrestrial | Rambling/Walking | 232 | 2190 | Hound Point |
| Terrestrial | Running | 117 | 912.5 | |
| Terrestrial | Sitting/Picnicking | 132 | 728 | |
| Terrestrial | Sports | 42 | 730 | Dalgety Bay |
| Terrestrial | Collecting Wild Produce | 28 | 104 | Limekilns |
| Aquatic | Angling – Sea | 33 | 832 | North Queensferry |
| Aquatic | Angling - Freshwater | 13 | 832 | Kinghorn |
| Aquatic | Boat Maintenance | 29 | 2920 | |
| Aquatic | Being on a Dive Boat | 3 | 480 | |
| Aquatic | Canoeing | 14 | 730 | North Queensferry |
| Aquatic | Commercial Fishing/Creeling | 1 | 24 | |
| Aquatic | Commute via Boat | 2 | 300 | |
| Aquatic | Diving | 5 | 24 | Burntisland |
| Aquatic | Jet Skiing | 1 | 624 | |
| Aquatic | Paddling | 41 | 100 | South Queensferry to Society Point |
| Aquatic | Rowing | 10 | 208 | North Queensferry |

| | | | | |
|---|---|---|---|---|
| Aquatic | Safety Boat Duties | 13 | 200 | |
| Aquatic | Sailing | 39 | 520 | Dalgety Bay |
| Aquatic | Sports Fishing | 3 | 416 | Rosyth |
| Aquatic | Sub-aqua Diving | 1 | 4 | Around Forth |
| Aquatic | Swimming | 28 | 104 | Around Forth |
| Aquatic | Power Boating | 6 | 208 | Granton |
| Aquatic | Water Skiing | 0 | 0 | |
| Aquatic | Working on a Boat | 7 | 2920 | BRS |
| Aquatic | Forth Road Bridge Work | 1 | 2700 | Forth Road Bridge |
| Intertidal | Bait Digging | 11 | 52 | Pettycur Beach, Kinghorn |
| Intertidal | Beachcombing | 75 | 1440 | North Queensferry |
| Intertidal | Boat Maintenance | 16 | 900 | Charlestown Harbour |
| Intertidal | Collecting Mussels | 8 | 52 | North Queensferry |
| Intertidal | Collecting Razor Clams | 2 | 208 | North Queensferry |
| Intertidal | Collecting Seaweed | 6 | 52 | North Queensferry |
| Intertidal | Collecting Winkles | 1 | 6 | |
| Intertidal | Crabbing | 36 | 208 | North Queensferry |
| Intertidal | Handling Creels | 1 | 1095 | |
| Intertidal | Dog Walking | 121 | 2190 | Cramond |
| Intertidal | Fixing Moorings | 7 | 208 | Limekilns |
| Intertidal | Horse Riding | 2 | 52 | Limekilns |
| Intertidal | Paddling | 74 | 160 | Kinghorn |
| Intertidal | Playing | 56 | 1248 | |
| Intertidal | Research/Educational Purposes | 4 | 24 | Kinghorn/Aberdour |
| Intertidal | Rock Pooling | 50 | 730 | Forth – various |
| Intertidal | Wildfowling | 0 | 0 | |
| Maintaining equipment | Boats and Boating Equipment | 32 | 730 | North Queensferry |
| Maintaining equipment | Clothes and Overalls | 29 | 365 | Blackness |
| Maintaining equipment | Diving Gear | 7 | 12 | |
| Maintaining equipment | Fishing Gear | 19 | 365 | North Queensferry |
| Maintaining equipment | Swimming Gear | 5 | 84 | |

### 7.6.2 Occupancy rates within 1km of Babcock Rosyth Site (inside/outside work or home)

Individuals living or working within 1km of BRS were asked to estimate how much time they spend inside and outside their home or workplace. The results presented in Table 7.5 show the time spent indoors and outdoors on an annual basis. Three individuals interviewed lived

within 1km of the BRS, the highest amount of time spent indoors was 3,650 h $y^{-1}$ and 1,460 h $y^{-1}$ outdoors, individual spent the rest of the time outwith the survey area.

**Table 7.5** Occupancy rates of those individuals working or living within 1km of the BRS.

| Survey Id | Indoors at home (h $y^{-1}$) | Outdoors at home (h $y^{-1}$) | Indoors at work (h $y^{-1}$) | Outdoors at work (h $y^{-1}$) |
|---|---|---|---|---|
| R/A/ID/071 | 3650 | 1460 | 1460 | 85.8 |
| R/A/ID/080 | 2920 | 1095 | NA | NA |
| R/A /BS/004 | 1825 | 730 | NA | NA |
| R/A/AW/23 | NA | NA | 0 | 800 |
| R/A/SB/002 | NA | NA | 630 | 945 |
| R/A/SB/003 | NA | NA | 1125 | 450 |
| R/A/SB/012 | NA | NA | 84 | 0 |
| R/A/SB/038 | NA | NA | 0 | 1820 |
| R/A/SB/043 | NA | NA | 0 | 780 |
| R/A/LE/003 | NA | NA | 0 | 2080 |
| R/A/LE/004 | NA | NA | 0 | 2600 |
| R/A/LE/014 | NA | NA | 8.5 | 260 |
| R/A /BS/005 | NA | NA | 1300 | 780 |
| R/A/DM/019 | NA | NA | 4197.5 | 85.8 |
| R/A/DM/022 | NA | NA | 3650 | 130 |
| R/A/DM/025 | NA | NA | 3285 | 130 |

# 8 Doses to the Representative Person

## 8.1 Introduction

The information collected within the Habits Survey in 2015 has been used to estimate retrospectively the doses to people living around Rosyth and in the surrounding area. The data collected have identified individuals who consume locally producing food and who have activities that may lead them to receiving an exposure to radioactive materials present in the environment. It should be noted that the Rosyth discharges are small and well within permitted discharge limits and that consequently the doses calculated for people are correspondingly small and well within the public dose limit of 1 mSv per year for retrospective assessment and 0.3 mSv for prospective assessment. Here the data are first considered for the aquatic and terrestrial pathways separately for both internal and external exposure and then a combined dose assessment is presented.

## 8.2 Aquatic Radiation Pathways

### 8.2.1 Internal exposure

The retrospective dose arising from internal exposure (via food sources from the aquatic environment) has been used to determine the representative person from this pathway but the doses reported here also include the contributions to the dose from the consumption of food sources in the terrestrial environment and the external activities that people do in both the aquatic and terrestrial environments (e.g. dog walking on intertidal surfaces or swimming in open water etc.).

The retrospective dose to the representative person (97.5%) from internal aquatic exposure is 1.51E-8 mSv with the dose rate to the most exposed person from this same exposure pathway is 1.55E-8 mSv. In the case of those higher rate consumers (of locally produced food only) the dose arises from the consumption of fish and molluscs with no significant contribution from the external activities in either the aquatic or terrestrial environments.

### 8.2.2 External exposure

The retrospective dose arising from external exposure (via people's habit activities in and on the aquatic environment) has been used to determine the representative person from this pathway but the doses reported here also include the consumption of food sources in the aquatic and terrestrial environment and the external activities that people do in the terrestrial environment (e.g. dog walking on intertidal surfaces etc.).

The retrospective dose to the representative person (97.5%) from external aquatic exposure is 6.3E-15 mSv with the dose rate to the most exposed person from this same exposure pathway is 6.1E-15 mSv. It should be noted that the total dose to the individuals in the higher activity habits in the aquatic environment are still dominated by contributions from the internal exposure pathway (the total dose being in the order of 7.9E-13 mSv). In the case of those higher rate activities the dose arises from direct contact with equipment that may be contaminated (96% of the dose), followed by activities on water at 3.6% of the dose and finally activities in water at 0.6% of the dose.

## 8.3 Terrestrial radiation pathways

### 8.3.1 Internal exposure

The retrospective dose arising from internal exposure (via food sources from the terrestrial environment) only has been used to determine the representative person from this pathway. The doses reported also include the contributions to the dose from the consumption of food sources in the aquatic environment and the external activities that people do in both the aquatic and terrestrial environments. However, it should be noted that because of the specific radionuclides released to atmosphere from the Rosyth site (principally $^{14}C$ and $^{3}H$) there is no or only very limited deposition to the terrestrial environment. This means that the terrestrial internal exposure pathway is essentially 0 mSv from the anthropogenic releases from Rosyth.

### 8.3.2 External exposure

#### External exposure (excluding direction shine on site)

The retrospective dose arising from external exposure (via people's habit activities in the terrestrial environment) only has been used to determine the representative person from this pathway. The doses reported also include the contributions to the dose from the consumption of food sources in the aquatic and terrestrial environments and the external activities that people do in the aquatic environment. However, it should be noted that because of the specific radionuclides released to atmosphere from the Rosyth site (principally $^{14}C$ and $^{3}H$) there is no or only very limited deposition to the terrestrial environment. This means that the terrestrial internal exposure pathway is essentially 0 mSv from the anthropogenic releases from Rosyth.

#### External exposure with direct shine including from onsite sources

The retrospective dose arising from external exposure (via people's habit activities in the terrestrial environment) only has been used to determine the representative person from this pathway but the doses reported here also include the contributions to the dose from the consumption of food sources in the aquatic and terrestrial environments and the external activities that people do in the aquatic environment.

The retrospective dose to the representative person (97.5%) from external terrestrial exposure is 7.5E-4 mSv with the dose rate to the most exposed person from this same exposure pathway is 7.7E-4 mSv. In the case of those higher rate activity people the dose arises almost entirely from the direct shine from the Rosyth site itself.

## 8.4 Overall combined radiation exposure

### 8.4.1 Total exposure (excluding direction shine on site)

The retrospective dose arising from all exposure pathways (e.g. via people's habit activities in and on the aquatic 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 retrospective dose to the representative person (97.5%) is 1.51E-8 mSv with the dose rate to the most exposed person from the same exposure pathways being 1.55E-8 mSv. In the case of those higher rate exposed person the dose is dominated by the internal aquatic environment doses from ingestion of molluscs (1.5E-8 mSv) and fish (7.4E-10 mSv).

These doses are very small in comparison with the 1 mSv public dose limit. They are for a retrospective dose assessment using PC CREAM modelled dispersion of the actual reported discharges from Rosyth in RIFE 2013, the consumption of locally produced food and the habit activities in the terrestrial and aquatic environments in the local area around the Rosyth site.

### 8.4.2 With direct shine including from onsite sources

The retrospective dose arising from all exposure pathways (e.g. via people's habit activities in and on the aquatic 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 retrospective dose to the representative person (97.5%) is 7.5E-4 mSv with the dose rate to the most exposed person from the same exposure pathways is 7.7E-4 mSv. In the case of those higher rate exposed people the dose is dominated by the external terrestrial environment doses from the direct shine from the Rosyth site.

These doses are very small in comparison with the 1 mSv public retrospective dose limit. They are for a retrospective dose assessment using PC CREAM modelled dispersion of the actual reported discharges from Rosyth in RIFE 2013, the consumption of locally produced food and the habit activities in the terrestrial and aquatic environments in the local area around the Rosyth site.

In summary, the key point of exposure excluding shine from Rosyth is the aquatic internal pathway. However including shine from Rosyth the external terrestrial pathway becomes the key point of exposure.

# 9 Comparisons with the previous survey

## 9.1 Introduction

The results from this 2015 Rosyth Habits Survey can be compared with results from the last Habits Survey, undertaken in Rosyth in 2010 by CEFAS. The results have been reported in Chapters 5 and 6 for both the postal survey and the face-to-face survey and comparisons are made. No comparisons have been made for the postal survey as a postal survey was not undertaken in 2010.

The aquatic and terrestrial survey area in the 2015 survey area remained unchanged from the 2010 survey. However full face-to-face interviews were completed within Kinghorn and Newhaven area, east of the Kincardine Bridge in the 2015 survey. This was different to the 2010 survey with no full face-to-face surveys being completed within the Kinghorn and Newhaven areas in 2015. In addition, meetings and focus groups were able to provide additional data and validate the findings of the face-to-face surveys.

## 9.2 Aquatic Survey

### 9.2.1 Postal Survey: Internal Exposure

A postal survey was undertaken in the 2015 survey and it was reported that respondents consumed fish (cod, salmon, haddock and mackerel) more frequently than crustaceans (crab and lobster) and molluscs (mussels). The majority of respondents sourced their fish/crustaceans/molluscs from supermarkets (40 %) but fish was sourced from local shops and markets (12 %). This is discussed further in Section 5.2.1. A postal survey was not undertaken in 2010 therefore there are no data for comparison.

### 9.2.2 Postal Survey: External Exposure

It was reported that of the respondents who undertook aquatic activities, the highest number of respondents participated in beach activities (walking, paddling, beach combing) followed by outdoor swimming and water sports. This is discussed further in Section 5.2.2. A postal survey was not undertaken in 2010 so there are no data for comparison.

### 9.2.3 Face-to-Face: Adult Consumption Rates - Internal Exposure

In 2015 the mean consumption rate for the adult high-rate group in the face-to-face interviews is substantially increased for fish, crustaceans, molluscs and wildfowl compared with 2010. The main species of fish consumed by adults were mackerel and cod in 2010

compared with mackerel, salmon and cod in 2015. The main crustaceans consumed by adults in 2010 were brown crab and common lobster, this remained the same in 2015. In 2010 the only mollusc consumed by adults was winkles compared with mussels in 2015. It should be noted that one person interviewed consumed shellfish from Dalgety Bay. In 2010 the main species of wildfowl consumed by adults were wigeon, mallard, pink-footed goose and teal compared with only one person identified who consumed wildfowl from outwith the survey area in 2015. The origins of the wildfowl were not known. The consumption of marine plant/algae by adults remained unchanged with no consumption identified in 2010 and in 2015.

A comparison between 2010 and 2015 adult consumption rates of aquatic foods in the face-to-face interviews is presented in Table 9.1.

**Table 9.1** Comparison between 2010 and 2015 adult consumption rates of aquatic foods

| | 2010 | | | 2015 | | | National/ Generic |
|---|---|---|---|---|---|---|---|
| Food Group | 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** | 8 | 35.0 | 17.0 | 1 | 109.20 | 109.20 | 15.0 |
| **Crustaceans** | 10 | 7.8 | 4.6 | 1 | 31.20 | 31.20 | 3.5 |
| **Molluscs** | 4 | 5.8 | 5.8 | 1 | 15.60 | 15.60 | 3.5 |
| **Wild Fowl** | 3 | 8.3 | 4.8 | 0 | 26.00 | 26.00 | ND |

### 9.2.4 Face-to-Face: Children and Infants' Consumption Rates - Internal Exposure

The consumption rate of fish, crustaceans, molluscs and wild fowl for children and infants was not determined in 2010 therefore there is no data for comparison. There was no consumption of crustaceans or wildfowl identified for children and infants in 2015. The only fish species consumed by children was mackerel (self-caught in the Forth) in 2015 and fish consumed by infants were cod and salmon. The same infant also consumed mussels in 2015.

Refer to Section 4.10.2 for further details.

### 9.2.5 Face-to-Face: Adults Intertidal Occupancy - External Exposure

In contrast to the 2010 survey external exposure was divided into four distinct groups: intertidal activities, aquatic in water activities, aquatic on water activities and the handling of equipment - all of which are discussed in further detail in Section 5.10.

In 2015, handling of equipment by adults within the survey area was reported. These activities included boat maintenance, handling clothes and overalls, diving gear, fishing gear and outdoor swimming gear. In 2010, the handling of fishing gear was determined as a mean occupancy-handling rate for the high rate group (h $y^{-1}$) as 674. This was observed to be substantially lower although the handling of fishing gear is only a sub category of the handling of equipment in 2015 so this may account for the substantial increase.

Activities taking place in or on the water were assessed differently in 2015 with mean occupancy rates and 97.5th percentile rates determined. In 2010 survey these data were not determined.

Handling of sediment for adults was not identified as a significant pathway determined within the 2015 survey as there was no difference in dose on different sediment types.

These data are presented in Table 9.2.

**Table 9.2** The 2015 aquatic external exposure pathways for adults

| Activity | 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 $y^{-1}$) |
|---|---|---|---|
| **Intertidal** | 5 | 2930 | 2664 |
| **Aquatic (in water)** | 1 | 106 | 106 |
| **Aquatic (on water)** | 1 | 3416 | 2968.8 |
| **Handling equipment** | 1 | 1460 | 1460 |

### 9.2.6 Face-to-face: Children and Infants Intertidal Occupancy - External Exposure

As with the adult intertidal occupancy, in contrast to the 2010 survey, external exposure was divided into four distinct groups: intertidal activities, aquatic in water activities, aquatic on water activities and the handling of equipment - all of which are discussed in further detail in Section 5.10.

In 2015 the intertidal occupancy for children and infants was recorded. These data are presented in Table 9.3.

As with the adults, handling of sediment for children and infants was not recorded in the 2015 survey.

Activities taking place in or on the water were assessed differently in 2015 with mean occupancy rates and 97.5th percentile rates determined in comparison to these data not being determined in 2010.

In 2015 one person in the infant age group was identified and none were identified in 2010.

**Table 9.3** The 2015 aquatic external exposure pathways for children and infants

| Activity | Number of people in the high rate group (h $y^{-1}$) | Observed maximum for the high rate group (h $y^{-1}$) | Observed mean for the high rate group (h $y^{-1}$) |
|---|---|---|---|
| ***Child (6 - 15 years old)*** | | | |
| **Intertidal** | 5 | 1556 | 358.59 |
| **Aquatic (in water)** | 1 | 104 | 104 |
| **Aquatic (on water)** | 1 | 1267 | 1267 |
| **Handling equipment** | 1 | 1095 | 1095 |
| ***Infant (0 - 5 years old)*** | | | |
| **Intertidal** | 2 | 1248 | 1248 |
| **Aquatic (in water)** | 1 | 52 | 52 |
| **Aquatic (on water)** | 1 | 72 | 72 |
| **Handling equipment** | 0 | 0 | 0 |

## 9.3 Terrestrial Survey

### 9.3.1 Postal Survey: Internal Exposure

A postal survey was undertaken in 2015 and it was determined that dairy products (milk, cheese and yoghurt) was the most frequently consumed food type. Wild meat (rabbit and game) was the food type least frequently consumed. The supermarket was reported as being where respondents most frequently sourced terrestrial food items although local shops and markets were also used. Refer to Section 5.2.1 for further detail.

No postal survey was undertaken in 2010 therefore there are no data to make comparisons.

### 9.3.2 Postal Survey: External Exposure

The most frequently selected terrestrial activities within the postal survey in 2015 were greenspace walking, urban walking and allotment/gardening. A total of 61 % of respondents participated in outdoor walking daily. Refer to Section 5.2.2 for further detail.

No postal survey was undertaken in 2010 therefore there are no data to make comparisons.

### 9.3.3 Face-to-Face: Adult Consumption Rates - Internal Exposure

Consumption rates increased in the 2015 survey in the vegetables (green) food group in comparison to the 2010 survey.

Consumption rates decreased in the 2015 survey in the following food groups: vegetables (root), vegetables (potatoes), fruit (domestic), meat (beef) and meat (poultry) in comparison to the 2010 survey.

Eggs, rabbit/hare and wild fungi were not identified in 2010. This remained unchanged in 2015.

Locally produced milk, pig meat or fresh water fish were not identified as being consumed in 2010 compared to one person identified in 2015 who kept his own brown trout in his garden in North Queensferry.

A comparison between the 2010 and 2015 mean consumption rates for adult consumption of the terrestrial food groups is presented in Table 9.4. It is noted from Table 9.4 that the total consumption of these food groups (kg $y^{-1}$) has decreased.

**Table 9.4** Comparison between 2010 and 2015 mean consumption rate for adult consumption of terrestrial food groups (kg $y^{-1}$).

| Food group | 2010 | 2015 | National | FSA National diet survey |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Vegetables – Green | 39.2 | 68.3 | 15 | 59 (all veg) |
| Vegetables – Root | 45.6 | 38.7 | 10 | |
| Vegetables - Potatoes | 73.4 | 46.0 | 50 | |
| Fruit - Domestic | 60.6 | 38.7 | 20 | 34 (all fruit) |
| Fruit - Wild | 0.7 | ND | 7 | |
| Meat – Beef | 47.3 | 20.8 | 15 | 40.15 (all meat and fish) |
| Meat - Game | ND | ND | 6 | |
| Meat - Poultry | 1.4 | 10.6 | 10 | |
| Meat - Sheep | 7.9 | ND | 8 | |
| Meat - Honey | 8.8 | ND | 2.5 | |

### 9.3.4 Face-to-Face: Children and Infants Consumption Rates - Internal Exposure

No comparison of consumption rate was made for children as there was no consumption rate identified in 2010. The mean consumption rates for children and infants is presented in table 9.5.

**Table 9.5** The mean consumption rates (kg $y^{-1}$) for children and infants in the 2015 Habits Survey, national values and estimated consumptions rates based on adult data (Table 9.4).

***Values derived from ratio used in RIFE 2014 Table X2.1.

| Food group | 2015 | National* (children) | National* (Infants) | Consumption rates for Children | Consumption rates for Infant |
|---|---|---|---|---|---|
| Vegetables – Green | 9.1 | 6 | 3.5 | 27.3 | 16.0 |
| Vegetables – Root | 2.6 | 6 | 5 | 24.2 | 19.3 |
| Vegetables - Potatoes | 12.5 | 45 | 10 | 41.2 | 9.2 |
| Fruit - Domestic | 39 | 15 | 9 | 29.8 | 17.6 |
| Fruit - Wild | ND | 3 | 1 | ND | ND |
| Meat – Beef | ND | 15 | 3 | 20.8 | 11.6 |
| Meat - Game | ND | 4 | 0.8 | ND | ND |
| Meat - Poultry | ND | 5.5 | 2 | 5.9 | 2.5 |
| Meat - Sheep | ND | 4 | 0.8 | ND | ND |
| Honey | ND | 2 | 2 | ND | ND |

## 9.4 Direct Radiation Survey

**Table 9.6** Comparison between 2010 and 2015 occupancy rates for people living and working within the direct radiation area (h $y^{-1}$)

| | **2010** | **2015** |
|---|---|---|
| Highest Total | 8100 | 5110 |
| Highest Indoor at home | 7800 | 3650 |
| Highest Outdoor at home | 1800 | 1460 |
| Highest indoor at work | ND | 4198 |
| Highest outdoor at work | ND | 2600 |

In 2015 the highest total occupancy rate decreased from 2010.

In 2015 the highest indoor occupancy rate decreased from 2010.

In 2015 the highest outdoor occupancy rate decreased from 2010.

Table 9.6 presents the comparisons between 2010 and 2015 survey occupancy rates for people living and working within the direct radiation area (h $y^{-1}$). In 2010 the highest total occupancy rate and highest indoor occupancy rate were both for one adult resident individual. In 2015, one resident was identified with the highest indoor (3650 h $y^{-1}$) and outdoor occupancy (1460 h $y^{-1}$) with rest of the time spent outwith the survey area. In 2010 the highest outdoor occupancy rate was one adult resident who worked in the area. In 2015, occupancy rates for those working within the direct radiation area were determined. The highest indoor occupancy for one individual at work was 4198 h $y^{-1}$ and a different individual had the highest outdoor occupancy which was 2600 h $y^{-1}$. There is no comparison as this was not looked at during the 2010 survey.

Children and infants were not identified within the high-rate groups in the 2010 survey, this remained unchanged in the 2015 survey.

# 10 Recommendations and Suggestions for Monitoring Programme Changes

## 10.1 Introduction

The Rosyth Habits Survey presents results from three main sources of community engagement: (i) Postal questionnaire (n=156); (ii) face-to-face surveys (n=526); and (iii) a number of meetings, informal contacts and focus group meetings. These data have been supplemented with radiometric surveys including: (i) a car-borne gamma spectrometry survey (n=18,000); (ii) *in situ* gamma dose rate (n=45); (iii) additional sampling with laboratory based gamma spectrometry (n=8); and (iv) Beta skin dose assessments (n=6).

Prior to the survey, there was discussion with the Health Physicists of the Babcock International Group who operate the site. This provided an update on relevant site operations and activities since the previous 2010 Habits Survey and planned changes in site operation over the next five years. As in previous surveys of human habits around the Rosyth site, airborne discharges remain below detection limits although future change in site usage may alter that position.

Routine surveys monitor gamma doses over sediment, fish and shellfish (RIFE Report 2014 for 2013 data) with further monitoring undertaken by the Babcock International Group. The sampling activities reported in this report confirmed that concentrations of radionuclides from the site remain extremely low and below detectable activities for $^{60}$Co. $^{137}$Cs activity concentrations measured were consistent with levels anticipated from historical nuclear weapons testing fallout.

Here the main findings and recommendations are presented.

## 10.2 Conclusions and Recommendations

SEPA's current monitoring programme provides satisfactory coverage to enable assessment to be made of the impact of Rosyth discharges on the public.

Retrospective dose assessments indicate that the doses received by the representative persons and most exposed individual(s) are very small in comparison with the 1 mSv public dose limit for all pathways identified and considered. The highest dose estimated was from direct shine from on-site sources (0.00077 mSv).

In conducting the survey, attention was given as to whether the correct food groups, area and frequency are being monitored. Consideration could be given to the following areas:

(i) Gamma dose rates could be reported as terrestrial gamma dose rates, i.e. with the cosmic and intrinsic component removed. This will provide a better estimate of dose from any contaminated surfaces and provide data that is more consistent with European partners.

(ii) Overall fish consumption rates are higher in 2015 compared with 2010. Mussels appear to be the more popular mollusc collected and consumed in 2015 compared with winkles in 2010. Consideration should be given to the inclusion of mussels within routine monitoring, especially in North Queensferry harbour. This could be considered to be monitored from North Queensferry harbour and analysed by gamma spectrometry.

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