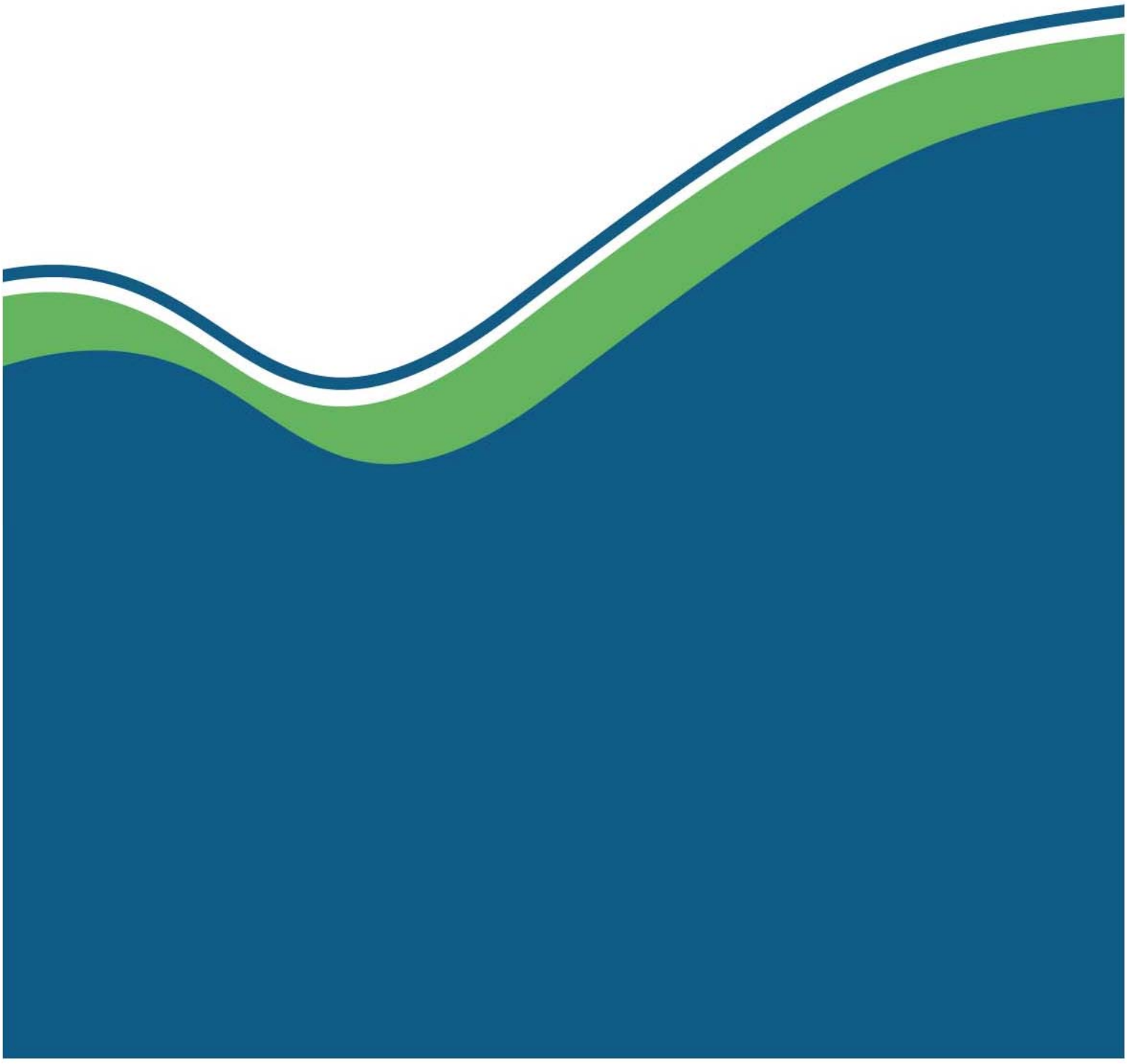
# Radiological Habits Survey: Dounreay, 2008



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# Radiological Habits Survey: Dounreay, 2008

**Final report**

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**SUMMARY**

This report presents the results of a survey conducted in 2008 to determine the habits and consumption patterns of people living, working and undertaking recreational activities in the vicinity of the Dounreay nuclear site in Caithness. The site is undergoing decommissioning of plant including its research reactors and is authorised to discharge gaseous radioactive waste via stacks to the atmosphere and liquid radioactive waste via an outfall to the Pentland Firth. The site also contains sources of direct radiation. The discharges include a minor contribution from the adjoining Vulcan Nuclear Reactor Test Establishment.

The following potential exposure pathways were investigated during the survey: the consumption of locally sourced terrestrial and aquatic foods; occupancy of intertidal areas; handling of fishing gear and sediment; and occupancy within 1 km of the licensed site boundary. Particular attention was paid to the following activities at the request of the Scottish Environment Protection Agency (SEPA):

- Activities undertaken at Sandside Bay which could give rise to contact with fuel fragments, how people undertaking these activities are dressed and where people spend time in the bay
- Long-lining from the shore at Sandside Bay
- The relative proportion of commercial fishing catches taken from two zones within 20 km of the Dounreay pipeline outfall

Three survey areas, which were likely to be most affected by the discharges and sources of radiation, were defined as:

- The aquatic survey area; covering the Caithness coastline from Armadale Bay to Dunnet Head and extending offshore to a radius of 20 km from the Dounreay site outfall pipe
- The terrestrial survey area; extending 5 km from the Dounreay site centre (National Grid Reference NC 986 671)
- The direct radiation survey area; extending 1 km from the licensed site boundary

Interviews were conducted with members of the public and the data collected for 358 individuals are presented and discussed. High rates of consumption, intertidal occupancy and handling are identified using established methods comprising a ‘cut off’ to define the high-rate group and 97.5 percentiles. The rates so identified can be used in dose assessments.

***Aquatic survey area***

The main commercial fishery was identified as creeling for lobsters and brown crabs close to the rocky coast in the summer and further offshore during the winter. Commercial winkle collection was reported to occur on a small scale at Murkle Bay and to the west of Strathy Point, although no commercial winkle collectors were encountered during the survey. Fishermen were operating three

salmon bag-net stations in the summer months at Port a' Chinn, Portskerra and Dunnet Bay. Although salmon was the target species, they were also catching sea trout and bass.

Aquatic foods were consumed from the following food groups: fish, crustaceans and molluscs. The mean consumption rates for the adult high-rate groups for each of these food groups were:

- 18 kg $y^{-1}$ for fish (comprising cod, bass, sea trout, mackerel and other species, caught by boat anglers and shore anglers)
- 21 kg $y^{-1}$ for crustaceans (comprising brown crabs, lobsters and velvet swimming crabs, caught in creels by commercial and hobby fishermen)
- 2.1 kg $y^{-1}$ for molluscs (comprising quahog clams collected from Dunnet Bay and winkles collected from the shore between Melvich Bay and Sandside Bay)

No consumption of wildfowl or marine plants/algae was identified.

The relative contribution of the component species within each food group for the adult high-rate groups were:

- For fish, 31% cod, 20% bass, 17% sea trout, 7% mackerel, 6% haddock and 19% other species
- For crustaceans, 51% brown crab, 38% lobster and 11% velvet swimming crab
- For molluscs, 71% winkles and 29% quahog clams

Two individuals were identified who collected significant amounts of seaweed, which was used as a fertiliser on their vegetable gardens. One individual collected *Fucus vesiculosus* from Crosskirk Bay and one individual collected a single unidentified species from Dunnet Bay. Consumption rates of vegetables fertilised using seaweed collected from Crosskirk Bay were obtained. The use of seaweed as animal feed was not identified.

Intertidal activities identified for adults or children included angling, bait digging, mollusc collection, dog walking, walking, sunbathing, playing on the beach, rock pooling, picnicking, coastal ranger duties and horse riding.

The mean rates for the high-rate group for occupancy over intertidal substrates were:

- 330 h $y^{-1}$ over rock (for one angler at Castletown and Thurso East Mains)
- 470h $y^{-1}$ over sand (for dog walkers at Thurso, Scrabster, Sandside Bay, Strathy Bay, Melvich Bay and Dunnet Bay; and for a person who was collecting winkles for their own consumption from the shore between Melvich Bay and Sandside Bay, and who was also angling at Melvich Bay)

Gamma dose rate measurements were taken over substrates in the aquatic survey area where people were spending time.

Fishermen were identified handling fishing gear including creels and bag-nets. Bait diggers and shellfish collectors were identified handling sediment. The mean rates for the high-rate groups for handling were:

- 1700 h $y^{-1}$ for handling fishing gear (for commercial creel fishermen who generally, but not always, wore gloves when fishing and who did not wear gloves when mending the creels)
- 30 h $y^{-1}$ for handling sediment (for bait diggers at Castletown, Dunnet Bay and Murkle Bay, who generally did not wear gloves)

Activities taking place in the survey area in the water around Dounreay were swimming, surfing, snorkelling, scuba diving, kayaking and lying in tidal pools. Activities on the water in the survey area were commercial fishing, boating, sailing, angling and paddling. The maximum occupancy rate in water was 610 h $y^{-1}$ for a person who was snorkelling near Thurso and surfing near Thurso East Mains and Sandside Bay. The maximum occupancy rate on water was 2000 h $y^{-1}$ for two commercial creel fishermen.

The results of the investigations requested by SEPA into activities in the aquatic survey area were:

- The main activity occurring at Sandside Bay was dog walking. Other activities included walking, sunbathing, picnicking, angling, horse riding, lying in tidal pools, surfing, snorkelling, swimming, paddling and boating. There was no evidence of salmon fishing at this location. The local dog walkers, anglers and most of the walkers generally had less skin exposed since they were wearing tops, ranging from t-shirts to jackets, long trousers and shoes. People that were sunbathing, paddling and swimming on warm days had far more skin exposed as they were wearing t-shirt and shorts or swimwear, sandals or flip flops, and were sometimes barefoot. The western section of the beach was most frequently used as the main access points to the beach were in this area.
- No evidence of long-lining from the shore at Sandside Bay was found.
- For commercial fishing catches, it was estimated that 50% of the crustaceans were caught from the 2-10 km zone and 50% from the 10-20 km zone; 33% of the salmon were caught from the 2-10 km zone and 67% from the 10-20 km zone; 20% of the demersal fish were caught from the 2-10 km zone and 80% from the 10-20 km zone; and 100% of the scallops and winkles were caught from the 10-20 km zone.

***The terrestrial survey area***

Farmers in the area predominantly produced beef and lamb. Arable crops for animal feed were also produced. Four beekeepers were identified who kept hives within the survey area. Farmers and residents grew fruit and vegetables on a small scale and one household was self sufficient in fruit and vegetables. Several households kept chickens for eggs and one household kept goats and consumed goats' milk and goats' cheese. A limited amount of wild foods grew in the survey area. However, small quantities of rosehips were collected from farmland, and elderberries, hazel nuts and

rowanberries were collected from land near Isauld. Wild fungi was collected from farm fields and consumed. Game, including venison, rabbits, pheasants, grouse and pigeons, was shot on private game shoots and on farmland.

In the terrestrial area, foods were identified being consumed from 15 food groups. The mean consumption rates for the high-rate groups for terrestrial foods were:

- 62 kg $y^{-1}$ green vegetables
- 74 kg $y^{-1}$ other vegetables
- 78 kg $y^{-1}$ root vegetables
- 71 kg $y^{-1}$ potatoes
- 41 kg $y^{-1}$ domestic fruit
- 170 l $y^{-1}$ milk (goats')
- 7.9 kg $y^{-1}$ cheese (goats')
- 18 kg $y^{-1}$ sheep meat
- 6.1 kg $y^{-1}$ poultry
- 14 kg $y^{-1}$ eggs
- 3.7 kg $y^{-1}$ wild/free foods
- 4.2 kg $y^{-1}$ rabbits/hares
- 4.2 kg $y^{-1}$ honey
- 3.0 kg $y^{-1}$ wild fungi
- 56 kg $y^{-1}$ venison

No consumption of cattle meat, pig meat, freshwater fish or cereals from the survey area was identified.

***The direct radiation survey area***

The direct radiation survey area was sparsely populated. Occupancy rates were obtained at seven residences, five of which were also commercial premises.

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

- 8500 h $y^{-1}$ for the total occupancy rate (for a resident who also worked in the area)
- 2600 h $y^{-1}$ for the outdoor occupancy rate (for the same resident with the highest total occupancy rate)
- 7100 h $y^{-1}$ for the indoor occupancy rate (for two residents)

Gamma dose rate measurements were taken indoors and outdoors at properties where interviews were conducted. For comparison, background gamma dose rate measurements were taken at distances further than 5 km from the Dounreay site centre.

***Comparison with the previous survey***

The results of the 2008 Dounreay habits survey were compared with the last habits survey undertaken at Dounreay in 2003. In the aquatic survey area, the mean consumption rate for fish decreased and the mean consumption rates for crustaceans and molluscs increased significantly in 2008 compared to 2003. The mean occupancy rate for the high-rate group over intertidal substrates decreased for rock and increased for sand in 2008. The mean handling rates for the high-rate group for fishing gear increased slightly and for sediment decreased significantly in 2008. In the terrestrial survey area, the food groups showing significant increases in consumption rates in 2008 were cheese (goats'), wild/free foods and wild fungi. The most significant decreases in consumption rates were for domestic fruit, cattle meat, poultry and freshwater fish. In the direct radiation survey in 2008, the highest total occupancy rate remained the same as in 2003, and the highest indoor occupancy rate and outdoor occupancy rate decreased.

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

Based on the findings of this survey, the following suggestions to changes to the current environmental monitoring programme are provided for consideration:

- Adding a quarterly sample of cod
- Adding an annual sample of honey
- Replacing red berries with an annual sample of rowanberries

# 1 INTRODUCTION

## 1.1 Regulation of radioactive waste discharges

There are generally three main sources of radiation exposure to members of the public from nuclear sites in routine operations: discharges of liquid radioactive waste to the aquatic environment, discharges of gaseous radioactive waste to the atmosphere, and direct radiation emanating from the site. Regulation of waste discharges in Scotland is carried out under the Radioactive Substances Act 1993, (RSA93) (UK Parliament, 1993). Authorisations granted under RSA93 set limits on the quantities and types of radioactivity that are permitted to be released from the site. For discharges in Scotland, the Scottish Environment Protection Agency (SEPA) is the regulatory authority under RSA93. Sources of direct radiation from sites are regulated by the Nuclear Installations Inspectorate (NII) of the Health and Safety Executive (HSE).

## 1.2 The representative person

Radiological protection of the public is based on the concept of a 'representative person'. This notional individual is defined as being representative of the more highly exposed members of the population. It follows that, if the dose to the representative person is acceptable when compared to relevant dose limits and constraints, members of the public generally will receive lower doses, and overall protection of the public is provided from the effects of radiation. The term 'representative person' is equivalent to, and replaces, the term 'average member of the critical group' as recommended by the International Commission on Radiological Protection (ICRP) (ICRP, 2007).

The representative person can only be established once a dose assessment using environmental monitoring data and habits survey data has been undertaken. This survey provides information to assist SEPA in determining the representative person in the Dounreay area.

## 1.3 Dose limits and constraints

Doses to the representative person can be compared to nationally and internationally recommended dose limits and constraints. The Radioactive Substances (Basic Safety Standards) (Scotland) Direction 2000 (Scottish Executive, 2000) directs SEPA to ensure that the sum of doses of ionising radiation to the public do not exceed the limits set out in Article 13 of Council Directive 96/29/Euratom (CEC, 1996) and that doses should be as low as reasonably achievable (ALARA), economic and social factors being taken into account.

In connection with this, SEPA is directed to have regard to the following maximum doses which may result from a defined source, for use at the planning stage in radiation protection:

a) 0.3 millisieverts per year from any source from which radioactive discharges are first made on, or after 13 May, 2000: or
b) 0.5 millisieverts per year from the discharges from any single site.

Additionally, the Government accepts that, in general it should be possible to operate existing facilities within the 0.3 mSv per year constraint. The ICRP recommends a dose limit of 1 mSv per year to members of the public from all anthropogenic sources.

## 2 THE SURVEY

### 2.1 Survey aims

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook the survey on behalf of SEPA (Cefas contract C2448 and SEPA contract R40067/PUR). The aim of the survey was to obtain information on the habits of the public that might lead them to be exposed to liquid discharges, atmospheric discharges and direct radiation arising from the routine activities undertaken at the Dounreay nuclear site. The survey provided comprehensive information to ensure that all potential pathways were identified.

Specifically, investigations were carried out to ascertain the following:

- The consumption of food from the aquatic survey area
- Activities and occupancy over intertidal areas
- The handling of fishing gear and sediment
- Activities and occupancy in and on water
- The use of seaweed as human or animal food or use as a fertiliser
- The consumption of food from the terrestrial survey area
- The production, use and destination of local produce
- The consumption and use of groundwater and surface water in the terrestrial survey area
- The transfer of contamination off-site by wildlife
- Occupancy within 1 km of the licensed site boundary
- Any new or unusual exposure pathways

Particular attention was paid to the following activities at the request of the Scottish Environment Protection Agency (SEPA):

- Activities undertaken at Sandside Bay, which could give rise to contact with fuel fragments originating from the Dounreay site. Also identifying how people are dressed when undertaking these activities and if there are specific areas of the bay where people spend time.
- Fishing using long-lines from the shore at Sandside Bay
- The relative proportion of commercially caught fish and shellfish taken from two zones within 20 km of the Dounreay site outfall pipe.

### 2.2 Site activity

The Dounreay site is a nuclear establishment which opened in 1955 to develop reactor technology. Three reactors were built on the site, all of which are now closed and are undergoing decommissioning. The main operations currently taking place on the site are decommissioning, waste management and building of new facilities for use in restoration activities. The site is

authorised to discharge gaseous radioactive waste via stacks to the atmosphere and liquid radioactive waste via an outfall to the Pentland Firth. The site also contains sources of direct radiation. The Dounreay site was formally transferred to the Nuclear Decommissioning Authority (NDA), with effect from the 1st April 2005. Since 1st April 2008, the management company, operator and licence holder, on behalf of the NDA, has been Dounreay Site Restoration Ltd (DSRL).

The adjoining Vulcan Nuclear Reactor Test Establishment is operated by the MoD and is a separate entity to the DSRL site. The Vulcan site discharges gaseous radioactive waste via stacks to the atmosphere and routes liquid radioactive waste via DSRL into the Pentland Firth. For the purpose of this report, the DSRL and Vulcan sites are considered together as one site.

### 2.3 Survey areas

Three survey areas were defined to encompass the main areas potentially affected by the discharges from the site and sources of radioactivity. These were an aquatic area relating to liquid discharges, a terrestrial area relating to the deposition of gaseous discharges, and a direct radiation area relating to ionising radiation emanating directly from the site.

The aquatic survey area (Figure 1) extended along the Caithness coastline from Armadale Bay in the west to Dunnet Head in the east and offshore to a radius of 20 km from the Dounreay site outfall. A fishing exclusion zone of 2 km radius from the site outfall and associated shoreline was in place.

The terrestrial survey area (Figure 2) was defined as the circle to a radius of 5 km from the centre of the Dounreay site (National Grid Reference NC 986 671).

The direct radiation survey area (Figure 2) was defined as the area within 1 km of the licensed site boundary. For habits surveys undertaken on behalf of SEPA, the direct radiation survey area is usually defined as the area within 1 km of the site centre. However, this was extended because, owing to the large area of the site, there was relatively little land outside the site boundary within this area.

The aquatic and terrestrial survey areas used in this survey were the same as those used in the previous habits survey conducted by Cefas in the Dounreay area in 2003 (Tipple, McTaggart and Clyne, 2004). Also, in both 2003 and 2008, the properties included in the direct radiation survey areas were the same.

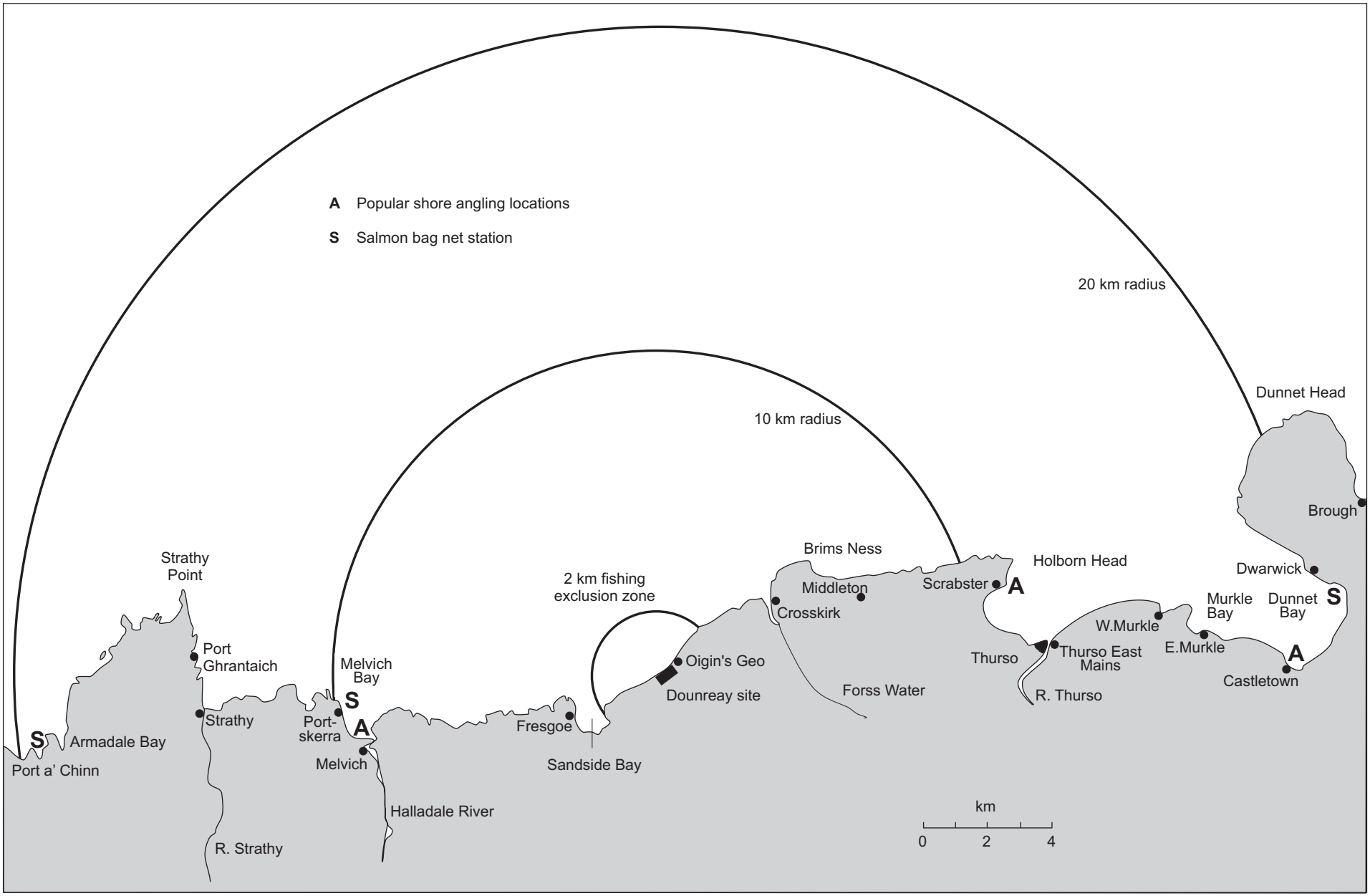


Figure 1. The Dounreay aquatic survey area.


Figure 2. The Dounreay terrestrial (outer ring) and direct radiation (inner ring) survey areas.

## 2.4 Conduct of the survey

As part of the pre-survey preparation, SEPA was contacted to identify any additional requirements. Information relating to the activities of people in the aquatic and terrestrial survey areas was obtained from internet searches, Ordnance Survey maps and from previous habits surveys undertaken at Dounreay. People with local knowledge of the survey area were contacted for information on any aspects relevant to the exposure pathways. These included the fisheries officer at Scrabster, individuals connected with the local inshore fishing industry and a local beekeeping organisation. Prior to the fieldwork a proposed fieldwork programme was distributed to SEPA for their comment.

The fieldwork component of the survey was carried out during the period 7$^{th}$ - 17$^{th}$ August, 2008 by three members of staff from the Cefas laboratory at Lowestoft, according to techniques described by Leonard *et al* (1982). At the start of the fieldwork, a meeting was held between the survey team and Dounreay site representatives. These discussions provided details about current site activities, local information, potential pathways and activities in the area, and the transfer of contamination off-site by wildlife.

Interviews were conducted with individuals who were identified from the pre-survey preparation, or encountered during the fieldwork, that had the potential to be exposed to radioactivity from the site. These included commercial fishermen, boat and shore anglers, bait diggers, gardeners, beekeepers, farmers and individuals living close to the site. Interviews were used to establish individuals' consumption, occupancy and handling rates relevant to the aquatic, terrestrial and direct radiation areas. Any general information of use to the survey was also obtained. Gamma dose rate measurements were taken over intertidal substrates in the aquatic area and were taken indoors and outdoors at all properties visited within the direct radiation area. Measurements of background gamma dose rates were taken at locations beyond 5 km from the site centre.

# 3 METHODS FOR DATA ANALYSIS

## 3.1 Data recording and presentation

Data collected during the fieldwork were recorded in logbooks. On return to the laboratory, the data were examined and any notably high rates were double-checked, where possible, by way of a follow-up phone call. In rare cases where follow-up phone calls were not possible (e.g. interviewees who wished to remain anonymous), the data were accepted at face value. The raw data were entered into a purpose-built database where each individual for whom information was obtained was given a unique identifier (the observation number) to assist in maintaining data quality.

The results of the individuals' consumption, occupancy and handling rates collected during the survey were grouped and presented in tables with the high-rate group members indicated in bold. The consumption rates, occupancy rates and handling rates for all groups are presented in Annexes 1 and 2 for adults and children respectively, with the high-rate group members indicated in bold.

## 3.2 Data conversion

During the interviews, people could not always provide consumption rates in kilograms per year for food or litres per year for milk. In these circumstances, interviewees were asked to provide the information in a different format. For example, some estimated the size and number of items (e.g. eggs) consumed per year, whereas others gave the number of plants in a crop or the length and number of rows in which the crop was grown per year. These data were converted into consumption rates by the database using a variety of standard conversion factors. These factors included produce weights (Hessayon 1997 and Good Housekeeping, 1994), edible fraction data researched by Cefas, and information supplied by the Meat and Livestock Commission.

## 3.3 Rounding and grouping of data

The consumption and occupancy data in the text of this report are rounded to two significant figures, except for values less than 1.0, which are rounded to one decimal place. This method of presentation reflects the authors' judgement on the accuracy of the methods used. In the tables and annexes, the consumption rate data are usually presented to one decimal place. Occasionally, this rounding process causes the computed values (row totals, mean rates and 97.5 percentiles), which are based on un-rounded data, to appear slightly erroneous. Consumption rates less than 0.05 kg $y^{-1}$ are presented to two decimal places in order to avoid the value of 0.0 kg $y^{-1}$. External exposure data are quoted as integer numbers of hours per year.

The habits data are structured into groups of food items or substrate types with similar attributes. For example, when considering terrestrial food consumption, all types of root vegetables are grouped

together in a food group called 'root vegetables'. Similarly, for aquatic food consumption, all crustacean species are grouped as 'crustaceans'. For external exposure over intertidal sediments, occupancies over the same substrate, such as sand, are grouped together. The typical food groups used in habits surveys are shown in Table 1.

***Table 1. Typical food groups used in habits surveys***

| **Food group** | **Typical foods within the food groups** |
|---|---|
| Green vegetables | Globe artichoke, asparagus, broccoli, Brussels sprout, cabbage, calabrese, cauliflower, chard, courgettes, cucumber, gherkin, herbs, kale, leaf beet, lettuce, marrow, spinach |
| Other vegetables | Aubergine, broad bean, chilli pepper, French bean, mange tout, pea, pepper, runner bean, sweet corn, tomato |
| Root vegetables | Jerusalem artichoke, beetroot, carrot, celeriac, celery, chicory, fennel, garlic, kohl rabi, leek, onion, parsnip, radish, shallot, spring onion, swede, turnip |
| Potato | Potato |
| Domestic fruit | Apple, apricot, blackberry, blackcurrant, boysenberry, cherry, damson, fig, gooseberry, grapes, greengages, huckleberry, loganberry, melon, nectarines, peach, pear, plum, pumpkin, raspberry, redcurrants, rhubarb, rowanberry, strawberry, tayberry, whitecurrant |
| Milk | Milk, cream, yoghurt, goats' milk |
| Solid milk products | Butter, cheese |
| Cattle meat[a] | Beef |
| Pig meat[a] | Pork |
| Sheep meat[a] | Lamb, mutton |
| Poultry | Chicken, duck, goose, grouse, guinea fowl, partridge, pheasant, pigeon, turkey, woodcock |
| Eggs | Chicken egg, duck egg, goose egg |
| Wild/free foods | Blackberry, blackcurrant, chestnut, crab apple, damson, dandelion root, elderberry, nettle, raspberry, rowanberry, sloe and watercress |
| Honey | Honey, honey comb |
| Wild fungi | Mushrooms |
| Rabbits/hares | Hare, rabbit |
| Venison[a] | Red deer, roe deer, fallow deer |
| Sea fish | Bass, brill, cod, ling, dab, Dover sole, flounder, gurnard, haddock, hake, herring, lemon sole, mackerel, monkfish, mullet, plaice, pollack, saithe, salmon, sea trout, squid[b], cuttlefish[b], rays, turbot, whitebait, whiting |
| Freshwater fish | Brown trout, rainbow trout, perch, pike, salmon (river), eels |
| Crustaceans | Brown crab, spider crab, velvet crab, crawfish, lobster, *Nephrops*, squat lobster, prawn, shrimp |
| Molluscs | Cockles, limpets, mussels, oysters, scallops, razor shell, whelks, winkles |

**Notes**

[a] Including offal

[b] Although squid and cuttlefish are molluscs, radiologically they are more akin to fish

Data are structured into age groups because different dose coefficients (i.e. the factors which convert intakes of radioactivity into dose) can apply to different ages. The age groups and their relevant age ranges are based on the recommendations in ICRP 72 (ICRP, 1996), and are listed below:

| Age group | Age range in group |
|---|---|
| 3-month-old | Under 1-year-old |
| 1-year-old | 1-year-old |
| 5-year-old | 2-year-old to 6-year-old |
| 10-year-old | 7-year-old to 11-year-old |
| 15-year-old | 12-year-old to 16-year-old |
| Adult | 17-year-old and over |

### 3.4 Approaches for the identification of high rates

The habits data have been analysed to indicate high rates of consumption, occupancy and handling, prior to a formal assessment being undertaken. Two approaches have been used:

Firstly, the 'cut-off' method described by Hunt *et al.* (1982) was used. With the cut-off method, the appropriate high rate was calculated by taking the arithmetic mean of the maximum observed rate and all observed rates within a factor of three of the maximum value (termed the lower threshold value). In this report, the term 'high-rate group' is used to represent the individuals derived by the cut-off method. The mean of the high-rate group was calculated for each food group, intertidal substrate and handling pathway identified in the survey. In certain cases, using the cut-off method can result in a high-rate group of just a single person. In these cases, expert judgement was used to decide whether the high-rate group should remain as one individual or whether others should be included. If it was appropriate to include others, the second highest rate was divided by three to give a new cut-off value and all observations above this were included in the high-rate group.

Secondly, 97.5 percentile rates were calculated using the Excel mathematical function for calculating percentiles. The use of percentiles accords with precedents used in risk assessment of the safety of food consumption.

Mean and 97.5 percentile rates based on national statistics have been derived by the Ministry of Agriculture, Fisheries and Food (MAFF) (now part of Defra) and the Food Standards Agency (Byrom *et al.,* 1995 and FSA, 2002), and these are referred to as generic rates in this report. The generic rates are used as a baseline for comparison with the observed rates.

For the direct radiation pathway, mean occupancy rates and 97.5 percentile rates have not been calculated. Such an analysis is of limited value without a detailed knowledge of the spatial extent of dose rates due to direct radiation.

### 3.5 Child ratios for use in dose assessments

For ingestion pathways, mean rates for the high-rate groups for children have been calculated from the survey data. However, because few child observations were identified, the rates should be viewed with caution. For assessment purposes, an alternative approach may be taken which involves scaling the mean rates for the adult high-rate groups by ratios. These ratios are given in Table 2 and have been calculated using generic 97.5 percentile consumption rates. Note that the age ranges within the 1-year-old and 10-year-old age groups in Table 2 do not correspond exactly with the age ranges within these age groups used throughout the rest of this report.

***Table 2. Ratios for determining consumption and occupancy rates for children***

| Food group | Ratio child/adult[a] | |
|---|---|---|
| | 1-year-old | 10-year-old |
| Fish[b] | 0.050 | 0.200 |
| Crustaceans[b] | 0.050 | 0.250 |
| Molluscs[b] | 0.050 | 0.250 |
| Green vegetables | 0.222 | 0.444 |
| Other vegetables | 0.200 | 0.500 |
| Root vegetables | 0.375 | 0.500 |
| Potatoes | 0.292 | 0.708 |
| Domestic fruit | 0.467 | 0.667 |
| Milk | 1.333 | 1.000 |
| Cattle meat | 0.222 | 0.667 |
| Pig meat | 0.138 | 0.625 |
| Sheep meat | 0.120 | 0.400 |
| Poultry | 0.183 | 0.500 |
| Eggs | 0.600 | 0.800 |
| Wild/free foods[c] | 0.110 | 0.490 |
| Game[d] | 0.140 | 0.500 |
| Honey | 0.789 | 0.789 |
| Wild fungi | 0.150 | 0.450 |
| Freshwater fish[b] | 0.050 | 0.250 |
| Direct radiation | 1.000 | 1.000 |
| External exposure | 0.030 | 0.500 |
| Plume | 1.000 | 1.000 |

**Notes**

[a] Excepting notes b and c, consumption ratios were derived from Byrom et al., (1995) which presented data for infants aged 6 to 12 months (classified here as 1-year-old) and children aged 10 to 11 years (classified here as 10-year-old).

[b] Ratios were derived from Smith and Jones, (2003) which presented data for infants and children.

[c] Ratios were derived from FSA, (2002) data for wild fruit and nuts for infants and 10 year old children.

[d] Game includes rabbits/hares and venison.

# 4 AQUATIC RADIATION PATHWAYS

## 4.1 Aquatic survey area

***Overview***

The aquatic survey area, as shown in Figure 1, covered the Caithness coastline from Armadale Bay in the west to Dunnet Head in the east and extended offshore to a radius of 20 km from the Dounreay site outfall.

The coastline was predominantly rocky with high cliffs in places, most notably at Strathy Point, Holborn Head and Dunnet Head. Several bays with sandy beaches were interspersed along the coast including, Armadale Bay, Strathy Bay, Melvich Bay, Sandside Bay, Thurso Bay, Murkle Bay and Dunnet Bay. The main A836 road ran parallel to the coast between one and two kilometres inland. Side roads led to the shore in several places but there were large stretches of the coast with no vehicular access. The main coastal town was Thurso; with Scrabster being the main fishing port, where the majority of fishing boats were berthed. A few small fishing and angling boats operated from Port a' Chinn near Armadale Bay, Port Ghrantaich near Strathy Point, Portskerra, Sandside Harbour, the river at Thurso, Castletown Harbour and Dwarwick Pier in Dunnet Bay. In recent years the number of salmon bag-net stations in the survey area had declined, but salmon bag-nets were still operated at Port a' Chinn, Portskerra and Dunnet Bay.

Four rivers flowed into the sea along the coast: the River Strathy, Halladale River, Forss Water and the River Thurso. Angling, mainly for salmon, occurred along the length of all these rivers.

***Armadale Bay to Portskerra***

The rocky shore around Armadale Bay was difficult to access but there was a large sandy beach at the head of the bay, which was accessed by a footpath from the main road. The beach was infrequently used as the footpath was not visible from the road and was not marked on Ordnance Survey maps. There was a small sand and stone beach at Port a' Chinn, on the west side of Armadale Bay, and a boat was launched from here to service a bag-net station located just offshore. From Armadale Bay the rocky shore continued eastwards around Strathy Point. The shore in this area could only be accessed by a difficult descent from the top of a cliff, but despite this, it was reported that anglers occasionally fished in this area. A few small fishing boats were observed pulled up onto a slipway at the foot of a steep gully to the east of Strathy Point called Port Ghrantaich. A salmon bag-net station had once been in operation in this area but it was now closed. There was road access and parking at Strathy Bay although it required a demanding walk across steep sand dunes to reach the beach. The beach was used by people who were angling, walking, dog walking, picnicking, playing, paddling, swimming, kayaking and boating, with up to 20 visitors observed on the

beach on fine summer days. Members of a scuba diving club occasionally dived from the beach and it was reported that it was a popular surfing area, especially in the winter. The River Strathy entered the sea to the west of Strathy Bay.

***Portskerra to Sandside Bay***

Portskerra was a small natural harbour with a slipway. A few small fishing boats were based there and it was reported that kayaking and diving sometimes took place from the rocky shore. A salmon bag-net station was situated just offshore.

The beach at Melvich Bay was predominantly sand with patches of stones. The area was popular with anglers and other activities recorded here included, walking, dog walking, playing and picnicking. One individual was observed collecting winkles for their own consumption from the stones on the beach. The River Halladale flowed into the sea to the east of Melvich Bay. Paddling and swimming took place both in the river and the sea.

Access to the coastline between Melvich Bay and Sandside Head, a distance of approximately 7 km, was difficult, with no vehicular access and steep cliffs leading down to boulders and rocks on the shore. No activities were reported to occur in this area.

***Sandside Bay to Crosskirk Bay***

Sandside Harbour was located on the west side of Sandside Bay, in the hamlet of Fresgoe. One commercial creel boat and one hobby/angling boat were based there at the time of the survey. There was a 1 km long sandy beach at Sandside Bay, which had patches of stones on the mid-shore and was backed by sand dunes. Activities included angling, walking, dog walking, horse riding, sunbathing, picnicking, surfing, snorkelling, swimming, paddling and boating. There was an official public information sign at Sandside beach stating that radioactive particles had been found on the shore and advising the public not to remove objects or materials from the beach. There was also a notice board that gave information about the DSRL beach monitoring programme for the detection of fuel fragments. The habits of people using the beach did not appear to be affected by this information. Further information on Sandside Bay is given in Section 4.6.

Due to the lack of public roads and footpaths, the 7 km stretch of rocky shoreline between Sandside Bay and Crosskirk Bay could only be accessed by crossing fields and barbed wire fences. The Dounreay nuclear site extended along approximately 2 km of this coastline. There were several deep clefts in the rocky coastline, known as geos, where spume entrained with organic particulate material of potential radiological significance could accumulate. One local individual reported that they spent a few hours per year walking on the rocks in and around Oigin's Geo.

***Crosskirk Bay to Holborn Head***

The river known as Forss Water entered the sea at Crosskirk Bay, where the shore substrate was mainly boulders and stones. One individual was recorded swimming in the bay and was wearing swimwear rather than a wet suit or a dry suit while swimming. Dog walking took place on the shore of Crosskirk Bay.

Crosskirk Bay to Holborn Head covered approximately 8 km of rocky coastline and, with the exception of a farm track leading to Brims Ness, access to the shore involved long walks across private land. At Brims Ness the rocks formed flat shelves and stray cattle were observed on the rocks of the upper shore. A family were playing on the rocks and swimming in a small sheltered bay to the east of Brims Ness, called Port of Brims.

***Holborn Head to Thurso***

Holborn Head had towering vertical cliffs and there was no access to the shore. The cliffs diminished southwards and just north of Scrabster lighthouse there was a stretch of stepped rocks that was a very popular angling venue.

South of the lighthouse was the ferry terminal and major fishing port of Scrabster Harbour. Most of the catches landed were from large offshore vessels that fished well outside the survey area but it was also the main base for the local fishing fleet. A few yachts and other pleasure craft also used the harbour and a lifeboat was based here. Anglers occasionally fished from some of the piers.

Immediately south of the harbour, the sandy Scrabster beach was popular with dog walkers and a child was observed paddling in the sea. A dinghy sailing club with 70 members was located at the north end of the beach and the boats were launched across the sand and sailed in Thurso Bay.

Further towards Thurso the shore substrate changed to rocks and stones and no activities were observed there at the time of the survey.

***Thurso to Castletown***

The sandy beach at Thurso was close to residential areas. It was extremely popular with dog walkers. However, it was reported that it was not very popular for family days out on the beach since there were often piles of rotting seaweed. Horses were exercised on the beach and a kayak club had a hut at the western end. One individual regularly went snorkelling in the area. Four surfers were seen offshore and it was reported that the southeast corner of Thurso Bay, from Thurso beach to the rocks of Thurso East Mains, was a very popular surfing area in the winter when the swells were higher.

The River Thurso entered the sea to the east of the beach. Interviewees reported that they had seen individuals collecting winkles from the rocks and boulders either side of the river mouth, but due to the limited information available, it was not possible to identify typical consumption rates of winkles collected from this location. A few pleasure and angling boats were kept moored in the river and the Sea Cadets had a base on the quay.

East of the river towards Thurso East Mains there were patches of shell sand on the upper shore that were used by dog walkers, while rocks and boulders covered the lower shore. A net–and-coble fishery for salmon had once operated in this area but was now closed. Anglers were identified fishing from the rocky shore at Thurso East Mains.

The stretch of shoreline between Thurso East Mains and Castletown was approximately 9 km in extent and was mainly rocky with a small sandy beach at Murkle Bay. Access to the shoreline was only possible via farm tracks. The beach at Murkle Bay was used by a few dog walkers who lived close by, and occasional anglers and bait diggers. It was reported that a limited amount of commercial winkle collecting took place on the rocks at either side of the bay.

***Castletown to Dunnet Head***

The small harbour at Castletown was the base for one commercial creel fishing boat and a few angling boats. The rocky shore either side of the harbour was a very popular angling venue and a small sand beach in amongst the rocks to the south of the harbour was used regularly by bait diggers. One family of holidaymakers was observed paddling there.

The 3 km long sandy Dunnet beach extended northwards from Castletown and was backed by sand dunes. It was a popular venue for both tourists and local residents who used it for walking, dog walking, beachcombing, playing, swimming, paddling, surfing, kayaking, boating, angling and bait digging. A caravan and camping site, and visitor's centre, were located at the north end of the beach. The rangers at the visitor's centre organised various events on the beach including nature surveys and sandcastle competitions. They reported that they had observed up to 250 people on the beach at one time, but that such numbers were only seen on about 10 days per year. Litter was collected on Dunnet beach by a team of contractors.

North of Dunnet beach the shore became rocky and the cliffs started to rise towards Dunnet Head. A salmon bag-net station was situated just off the rocks. One kilometre further north the pier and slipway at Dwarwick was the base for a few small hobby and angling boats. Further north, access to the shore was only possible at a small sandy bay known locally as Peedie beach, before the cliffs rose sharply towards the towering vertical faces of Dunnet Head.

## 4.2 Commercial fisheries

Fishing was prohibited within a 2 km zone around the Dounreay site pipe outfall, which was located at 58º 35' 03''N, 3º 45' 21''E.

### *Crustaceans*

The main commercial fishery in the survey area was fishing for brown crabs (*Cancer pagurus*) and lobsters (*Homarus gammarus*), using creels from small inshore fishing vessels. Velvet swimming crabs (*Liocarcinus puber*) were also caught in the creels, but in lesser amounts. About 12 inshore commercial creel boats were operating from Scrabster at the time of the survey with another one based at Sandside Harbour and one more at Castletown Harbour. Creels were set along the rocky areas of coast throughout the aquatic survey area. Most fishermen set their creels close inshore during the summer but moved them further offshore in the winter to avoid storm damage. The more substantial inshore vessels sometimes fished out to 20 km offshore. While some fishermen worked all through the year, others only operated from April to September. In addition to the inshore fleet, Scrabster was also used by larger offshore creeling vessels, which usually fished much further afield, around Orkney and Shetland. However, it was reported that these vessels, together with offshore creelers based in Orkney and Shetland, might occasionally fish within the outer northeastern limit of the 20 km area.

One Scrabster creeling boat was periodically chartered by DSRL to fish within the 2 km fishing exclusion zone to provide crustacean samples for analysis.

The bigger offshore vessels working outside the survey area caught a large proportion of the crustacean catch landed at Scrabster. It was estimated that the inshore boats working within the survey area caught approximately 10% - 15% of the total landings of crab, and possibly a slightly higher percentage of the lobsters.

### *Fish*

Very little commercial fishing for finfish took place within the survey area. The most notable fishery was the three salmon bag-net stations based at Port a' Chinn, Portskerra and Dunnet Bay. These caught small quantities of sea trout (*Salmo trutta*) and bass (*Dicentrarchus labrax*), as well as salmon (*Salmo salar*). The commercial salmon and sea trout fishing season was from 11$^{th}$ February to 26$^{th}$ August. However the nets were not usually deployed until April or May due to unpredictable weather conditions. No fishing was allowed during weekends in order to allow the migrating salmonids to enter the rivers unobstructed.

Two Scottish fly-seine vessels working out of Scrabster very occasionally fished in the western section of the survey area for haddock, (*Melanogrammus aeglefinus*), plaice (*Pleuronectes platessa*) and spurdog (*Squalus acanthias*). These vessels also fished periodically within the survey area under charter to DSRL, specifically to collect samples for analysis.

It was reported that offshore trawlers from other ports occasionally fished for haddock, plaice and spurdog off Strathy Point. There has been a periodic long-line fishery for spurdog in the Strathy Point area but a new regulation has been introduced limiting a vessels catch of spurdog to 5% of the total catch, so this will probably bring the directed spurdog fishery to an end.

***Molluscs***

The commercial collection of winkles (*Littorina littorea*) from the shore was reported to take place at a low level but was not observed at the time of the survey. The main winkle wholesaler at Scrabster estimated that approximately 5 tonnes per year were harvested from the survey area, mainly from around Murkle Bay and to the west of Strathy Point.

Whelks (*Buccinum undatum*) were caught incidentally in crustacean creels but the fishermen usually did not land them as the whelks caught in the survey area had a low meat yield and consequently low value.

It was also reported that nomadic scallop dredging vessels sometimes had a tow to the west of Strathy Point as they passed by on their way between other fishing grounds.

### 4.3 Marketing of fish and shellfish

Most of the crustacean catch from within the survey area was exported to Portugal, France and Spain, although some crabs and lobsters were sold to local restaurants and hotels. The majority of the salmon and sea trout caught were sent to Aberdeen and Billingsgate for sale, although a small percentage was sold locally to individuals and hotels. Most of the other finfish landed at Scrabster was taken to Aberdeen or Peterhead for sale and practically none of this was caught within the survey area. Winkles were exported to France and Spain.

### 4.4 Angling and hobby fishing

The most popular places for shore angling were at Melvich, Scrabster and Castletown but angling took place at many other venues in the survey area and along the rivers flowing into it. The rivers were fished mainly for salmon (*Salmo salar*) and sea trout (*Salmo trutta*). The main species caught from the shore were mackerel (*Scomber scombrus*), bass (*Dicentrarchus labrax*), cod (*Gadus*

*morhua*), saithe (*Pollachius virens*) and sea trout. Species caught in smaller quantities included dab (*Limanda limanda*) and flounder (*Platichthys flesus*).

Several keen boat anglers fished within the survey area. They caught haddock (*Melanogrammus aeglefinus*), pollack (*Pollachius pollachius*), ling (*Molva molva*), spurdog (*Squalus acanthias*), lemon sole (*Microstomus kitt*), plaice (*Pleuronectes platessa*), turbot (*Scopthalmus maximus*) and monkfish (*Lophius piscatorius*) in addition to the species caught from the shore. Three charter angling boats, which took parties of local and visiting anglers, operated out of Scrabster Harbour.

In addition to boat angling, several individuals were hobby fishing with a few creels offshore of Sandside Bay, Scrabster and Dunnet Bay to catch brown crabs and lobsters for their own consumption.

One individual caught bass for his own consumption by spear fishing while snorkelling offshore of Thurso.

One individual collected winkles from the rocks between Melvich and Sandside Bay for their own consumption and another collected quahog clams *(Arctica islandica*) and winkles from Dunnet Bay for their own consumption. Quahog clams do not live on the shore and they had been washed up from deeper water following winter storms.

### 4.5 Other pathways

The use of seaweed as a fertiliser on fruit and vegetables was identified during the survey. One individual collected approximately 150 kg $y^{-1}$ of seaweed (*Fucus vesiculosus*) from Crosskirk and another individual collected several sacks per year of what was believed to be a seaweed fruiting body (unknown species) from Dunnet beach. The use of seaweed as animal feed was not identified during the survey. However, stray cattle were observed on the foreshore at Brims Ness although there was little vegetation or seaweed growing on the rocks in this area.

It was reported that people were occasionally observed extracting lorry loads of sand from Dunnet beach. This was not observed during the habits survey and no one was identified undertaking this activity.

### 4.6 Specific activities investigated at the request of SEPA

***Activities which could give rise to contact with fuel fragments at Sandside Bay***

Sandside Bay, shown in Figure 3, was visited daily during the survey and on many of these visits no one was observed on the beach, even on sunny days. On one occasion, 10 people were observed on the beach and this was the maximum number of people seen at one time. In fine weather, the sand on the upper shore of the bay above the strandline was dry. Large areas of sand on the mid and lower shore remained wet on falling tides and in certain areas the sand remained wet because water from several burns drained onto the beach.

The main activity that occurred on the beach was dog walking. Many local people from the nearby village of Reay reported that they walked their dogs on Sandside beach daily. Other activities noted at Sandside Bay were walking, picnicking, sunbathing, angling, lying in tidal pools, paddling, swimming, snorkelling, surfing and boating. Horse riders were observed on the beach but were not interviewed. Two commercial fishermen and one hobby fisherman were setting creels close to the rocky shore on the east side of Sandside Bay near the fishing exclusion zone.

The weather conditions and the activities being undertaken had a direct bearing on how people were dressed. The local dog walkers, anglers and most of the walkers routinely wore long trousers, shoes and tops, ranging from t-shirts to jackets, depending on the weather. It was observed that on the warm sunny days some of the people that were walking and picnicking, and most of the people that were sunbathing and paddling, wore swimwear or t-shirts and shorts. They usually wore sandals or flip flops, or were sometimes barefooted. Surfers wore wet suits, gloves and booties and reported that they changed into and out of their wet suits at their vehicles in the car park. It was noted that people had sand on their clothing and dogs had sand on their fur as they left the beach.

The western side of Sandside Bay was used most frequently since the beach in this area could be accessed from two small parking areas via footpaths through the sand dunes. These parking areas were located at National Grid Reference NC 957 655 and NC 960 652. There was also a larger car park near Sandside Harbour but it was difficult to access the sandy beach from this location as the shore was rocky. Most of the local dog walkers followed regular routes on the western section of the beach that included walking along either the waterline or the strandline. Tourists and visitors mostly used the western and central areas of the beach and some people walked the length of the beach to the eastern side. People were sunbathing at the western side of the bay on the upper shore near the sand dunes and they occasionally walked down to the water's edge to go swimming or paddling. People who were paddling, lying in the tidal pools, surfing and swimming mainly used the western and central parts of the bay. One local person only walked on the eastern side of the beach since this area was easily accessed from their home.

***Figure 3. Sandside Bay***

***Long-lining at Sandside Bay***

No evidence of long-lining taking place either from boats or directly from the shore of Sandside Bay was found. None of the local fishermen or residents that were interviewed had seen or heard of anyone long-lining from the shore and members of the Cefas survey team did not observe anyone long-lining during their visits to Sandside Bay.

***Commercial fishing catches taken from two zones within 20 km of the Dounreay pipe outfall***

Estimates of the relative proportion of commercial fishery catches taken from two zones within 20 km of the Dounreay pipe outfall were made based on information from fishermen and fisheries officers. The zones were 2–10 km and >10–20 km from the pipe outfall and included seafood collected from the shore. The estimates are provided in Table 3. Fishing was not permitted within 2 km of the pipe outfall.

***Table 3. Estimates of the relative proportion of the commercial fishery catches taken from the 2-10 km zone and the >10-20 km zone***

| Fishery | Main species caught | Percentage of the catch from within the 2-10 km zone | Percentage of the catch from within the >10-20 km zone | Comments |
|---|---|---|---|---|
| Creels | Brown crabs, lobster and velvet swimming crabs | 50% | 50% | The main fishery in the survey area |
| Salmon bag-net | Salmon | 33% | 67% | |
| Fly-seine and trawl | Haddock, plaice and spurdog | 20% | 80% | Low catch |
| Scallop dredge | Scallops | 0% | 100% | Very low catch from passing vessels |
| Winkle collecting from the shore | Winkles | 0% | 100% | Estimate of 5 tonnes per year taken within the survey area |

### 4.7 Internal exposure

***Adult consumption rates***

The main consumers of seafood from the Dounreay survey area were commercial fishermen, hobby fishermen and anglers, together with their families. No consumption of wildfowl or marine plants/algae by adults was identified during the survey.

Adults' consumption rates of fish are presented in Table 4. The main species of fish consumed by the high-rate group were cod, bass, sea trout and mackerel. A high-rate group of 17 individuals was identified with a maximum consumption rate of 30 kg $y^{-1}$ and a mean of 18 kg $y^{-1}$. The observed 97.5 percentile rate based on 70 observations was 29 kg $y^{-1}$. This compares with the adult generic mean and 97.5 percentile consumption rates for fish of 15 kg $y^{-1}$ and 40 kg $y^{-1}$ respectively. The percentage breakdown of fish species consumed by the high-rate group was 31% cod, 20% bass, 17% sea trout, 7% mackerel, 6% haddock and 19% other species.

Adults' consumption rates of crustaceans are presented in Table 5. The main species of crustaceans consumed by adults were brown crab and lobster, with a smaller amount of velvet swimming crab. A high-rate group of three individuals was identified with a maximum consumption rate of 37 kg $y^{-1}$ and a mean of 21 kg $y^{-1}$. The observed 97.5 percentile rate based on 25 observations was 23 kg $y^{-1}$. This compares with the adult generic mean and 97.5 percentile consumption rates for crustaceans of 3.5 kg $y^{-1}$ and 10 kg $y^{-1}$ respectively. The percentage breakdown of crustacean species consumed by the high-rate group was 51% brown crab, 38% lobster and 11% velvet swimming crab.

Adults' consumption rates of molluscs are presented in Table 6. The species of molluscs consumed by adults were quahog clams (*Arctica islandica*) and winkles. A high-rate group of two individuals was identified with a maximum consumption rate of 2.7 kg $y^{-1}$ and a mean of 2.1 kg $y^{-1}$. The observed

97.5 percentile rate based on two observations was 2.7 kg $y^{-1}$. This compares with the adult generic mean and 97.5 percentile consumption rates for molluscs of 3.5 kg $y^{-1}$ and 10 kg $y^{-1}$ respectively. The percentage breakdown of mollusc species consumed by the high-rate group was 71% winkles and 29% quahog clams.

***Table 4. Adults' consumption rates of fish in the Dounreay area (kg $y^{-1}$)***

| Observation number | Bass | Cod | Ling | Dab | Flounder | Haddock | Lemon sole | Mackerel | Mixed fish | Monkfish | Plaice | Pollack | Saithe | Salmon | Sea trout | Spurdog | Turbot | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **252-253** | **-** | **5.0** | **-** | **-** | **-** | **5.0** | **4.5** | **5.0** | **-** | **5.0** | **-** | **5.0** | **-** | **-** | **-** | **-** | **-** | **29.5** |
| **256** | **-** | **28.7** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **28.7** |
| **201-203,205** | **3.1** | **11.4** | **-** | **-** | **-** | **-** | **-** | **2.5** | **-** | **-** | **-** | **-** | **-** | **-** | **0.9** | **-** | **-** | **17.9** |
| **108** | **17.7** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **17.7** |
| **171-172** | **12.8** | **-** | **-** | **0.9** | **-** | **-** | **-** | **1.1** | **-** | **-** | **0.8** | **-** | **-** | **-** | **1.9** | **-** | **-** | **17.5** |
| **357-358** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **5.4** | **10.4** | **-** | **-** | **15.8** |
| **298-299** | **2.9** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **12.2** | **-** | **-** | **15.1** |
| **261-262** | **-** | **5.7** | **-** | **-** | **-** | **4.5** | **4.5** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **14.7** |
| **150** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **9.9** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **9.9** |
| 113-114 | 1.1 | 4.5 | - | - | - | - | - | 2.8 | - | - | 0.8 | - | - | - | - | - | - | 9.1 |
| 186-187 | 8.0 | - | - | - | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | 8.9 |
| 188, 190 | 1.0 | 2.1 | 1.0 | 0.3 | 0.3 | - | - | - | - | - | 0.3 | 1.3 | 1.0 | - | - | 1.0 | 0.6 | 8.8 |
| 10 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 8.5 | - | - | 8.5 |
| 193 | 6.4 | - | - | - | 1.0 | - | - | - | - | - | - | - | - | - | - | - | - | 7.4 |
| 161 | - | 3.7 | 3.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 7.4 |
| 207-208 | - | 7.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 7.4 |
| 247-248 | - | 2.6 | 2.4 | - | - | - | - | - | - | - | - | - | 2.4 | - | - | - | - | 7.4 |
| 354, 356 | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.8 | - | - | - | 5.8 |
| 84 | - | - | - | - | - | - | - | 5.5 | - | - | - | - | - | - | - | - | - | 5.5 |
| 138 | - | 2.4 | - | - | - | - | - | 1.1 | - | - | - | 1.1 | - | - | - | - | - | 4.6 |
| 269,271-272 | - | - | - | - | - | - | - | - | - | - | - | - | - | 4.6 | - | - | - | 4.6 |
| 156-160 | - | 1.1 | 1.1 | - | - | - | - | 1.1 | - | - | - | 1.1 | - | - | - | - | - | 4.5 |
| 59-61 | - | - | - | - | - | - | - | - | 3.7 | - | - | - | - | - | - | - | - | 3.7 |
| 96-97 | - | - | - | - | - | - | - | 3.7 | - | - | - | - | - | - | - | - | - | 3.7 |
| 303 | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.4 | - | - | - | 3.4 |
| 309,352-353 | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.3 | - | - | - | 3.3 |
| 278 | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.1 | - | - | - | 3.1 |
| 169-170 | - | - | - | - | - | - | - | - | - | - | - | 1.4 | - | 1.3 | - | - | - | 2.7 |
| 189 | 0.2 | 0.6 | 0.2 | 0.1 | 0.1 | - | - | - | - | - | 0.1 | 0.3 | 0.2 | - | - | 0.2 | 0.1 | 2.1 |
| 164 | - | - | - | - | - | - | - | 1.1 | - | - | - | - | - | - | 0.8 | - | - | 1.9 |
| 36-37 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.6 | - | - | - | 1.6 |
| 304-305 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.6 | - | - | - | 1.6 |
| 329-330 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.6 | - | - | - | 1.6 |
| 109,111-112 | - | - | - | - | - | - | - | 1.4 | - | - | - | - | - | - | - | - | - | 1.4 |
| 165-166 | - | - | - | - | - | - | - | 1.1 | - | - | - | - | - | - | - | - | - | 1.1 |
| 63 | - | 0.5 | - | - | - | - | - | 0.5 | - | - | - | - | - | - | - | - | - | 0.9 |
| 191-192 | - | 0.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.6 |

**Notes**

Emboldened observations are the high-rate consumers

***Table 5. Adults' consumption rates of crustaceans in the Dounreay area (kg $y^{-1}$)***

| Observation number | Brown crab | Lobster | Velvet swimming crab | Total |
|---|---|---|---|---|
| **251** | **13.7** | **15.8** | **7.1** | **36.6** |
| **247** | **8.9** | **4.1** | - | **13.0** |
| **248** | **8.9** | **4.1** | - | **13.0** |
| 59 | 3.0 | 7.0 | - | 10.0 |
| 60 | 3.0 | 7.0 | - | 10.0 |
| 267 | 7.1 | 0.6 | - | 7.8 |
| 268 | 7.1 | 0.6 | - | 7.8 |
| 78 | 1.4 | 6.3 | - | 7.7 |
| 256 | 1.7 | 3.2 | - | 4.8 |
| 315 | 4.1 | - | - | 4.1 |
| 257 | 2.0 | 2.0 | - | 4.0 |
| 258 | 2.0 | 2.0 | - | 4.0 |
| 208 | 3.6 | - | - | 3.6 |
| 261 | 3.6 | - | - | 3.6 |
| 262 | 3.6 | - | - | 3.6 |
| 263 | 3.6 | - | - | 3.6 |
| 264 | 3.6 | - | - | 3.6 |
| 252 | - | 1.5 | - | 1.5 |
| 253 | - | 1.5 | - | 1.5 |
| 316 | 1.4 | - | - | 1.4 |
| 317 | 1.4 | - | - | 1.4 |
| 265 | 0.8 | - | - | 0.8 |
| 266 | 0.8 | - | - | 0.8 |
| 329 | 0.3 | 0.3 | - | 0.7 |
| 43 | 0.4 | - | - | 0.4 |

**Notes**
Emboldened observations are the high-rate consumers

***Table 6. Adults' consumption rates of molluscs in the Dounreay area (kg $y^{-1}$)***

| Observation number | Quahog clam | Winkle | Total |
|---|---|---|---|
| **10** | **-** | **2.7** | **2.7** |
| **212** | **1.2** | **0.2** | **1.4** |

**Notes**
Emboldened observations are the high-rate consumers

Two individuals were identified using seaweed from Crosskirk Bay and Dunnet Bay as a fertiliser on land where fruit and vegetables were grown. Consumption rates were obtained for vegetables that were grown in soil fertilised with seaweed from Crosskirk Bay and are presented in Table 7.

***Table 7. Adults' consumption rates of vegetables, fruit and plants grown on land where seaweed had been used as fertiliser (kg $y^{-1}$)***

| Observation number | Spinach | Brussels sprout | Broccoli | Rocket | Herbs | Leek | Potato | Raspberry | Dandelion |
|---|---|---|---|---|---|---|---|---|---|
| 303 | 5.1 | 0.9 | 0.7 | 0.1 | 0.5 | 6.8 | 13.7 | 0.7 | 0.5 |

**Notes**
These data are not included in the terrestrial food group tables because the source of exposure is liquid discharge and not gaseous discharge.

A summary of adults' consumption rates of aquatic foods in the Dounreay area is presented in Table 8.

***Table 8. Summary of adults' consumption rates of aquatic foods in the Dounreay area (kg $y^{-1}$)***

| Food group | Number of observations | Number of high-rate consumers | Observed maximum consumption rate for the high-rate group | Observed minimum consumption rate for the high-rate group | Observed mean consumption rate for the high-rate group | Observed 97.5 percentile consumption rate | Generic mean consumption rate | Generic 97.5 percentile consumption rate |
|---|---|---|---|---|---|---|---|---|
| Fish | 70 | 17 | 29.5 | 9.9 | 18.4 | 28.9 | 15.0 | 40.0 |
| Crustaceans | 25 | 3 | 36.6 | 13.0 | 20.9 | 22.5 | 3.5 | 10.0 |
| Molluscs | 2 | 2 | 2.7 | 1.4 | 2.1 | 2.7 | 3.5 | 10.0 |
| Wildfowl | NC | NC | NC | NC | NC | NC | ND | ND |
| Marine plants/algae | NC | NC | NC | NC | NC | NC | ND | ND |

**Notes**
NC = not consumed
ND = not determined

### *Children's consumption rates*

Consumption rate data for aquatic foods were obtained for children in the 15-year-old, 10-year-old, 5-year-old and 3-month-old age groups. No children in the 15-year-old age group were noted to be consuming crustaceans. No children in the 1-year-old age group were noted to be consuming locally caught seafood. No children were identified consuming molluscs, wildfowl or marine plants/algae. The age groups and their relevant age ranges are listed in Section 3.3.

### *Fish*

Children's consumption rates of fish are presented in Table 9.

For the 15-year-old age group, the main species of fish consumed by the high-rate group were cod, bass and mackerel. A high-rate group of one individual was identified with a consumption rate of 18 kg $y^{-1}$. The observed 97.5 percentile rate based on five observations was 17 kg $y^{-1}$. This compares with the generic mean and 97.5 percentile consumption rates of 6.5 kg $y^{-1}$ and 20 kg $y^{-1}$

respectively. The percentage breakdown of fish species consumed by the high-rate group was 64% cod, 17% bass and 14% mackerel.

For the 10-year-old age group, the main species of fish consumed by the high-rate group were sea trout, cod and mackerel. A high-rate group of three individuals was identified with a maximum consumption rate of 9.0 kg $y^{-1}$ and a mean consumption rate of 7.4 kg $y^{-1}$. The observed 97.5 percentile rate based on seven observations was 8.9 kg $y^{-1}$. This compares with the generic mean and 97.5 percentile consumption rates of 6.0 kg $y^{-1}$ and 20 kg $y^{-1}$ respectively. The percentage breakdown of fish species consumed by the high-rate group was 40% sea trout, 37% cod and 11% mackerel.

For the 5-year-old age group, the main species of fish consumed by the high-rate group were cod, haddock, mackerel, monkfish, pollack and lemon sole. A high-rate group of one individual was identified with a consumption rate of 5.9 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation. No generic data are available for this age group. The percentage breakdown of fish species consumed by the high-rate group was 17% cod, 17% haddock, 17% mackerel, 17% monkfish, 17% pollack and 15% lemon sole.

The only child in the 3-month-old age group consumed 0.5 kg $y^{-1}$ of mixed fish species. The observed 97.5 percentile rate is not applicable for one observation. This compares with the generic mean and 97.5 percentile consumption rates of 3.5 kg $y^{-1}$ and 15 kg $y^{-1}$ respectively.

*Table 9. Children's consumption rates of fish in the Dounreay area (kg $y^{-1}$)*

| Observation number | Age | Bass | Cod | Haddock | Lemon sole | Mackerel | Mixed fish | Monkfish | Pollack | Sea trout | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **15-year-old age group** | | | | | | | | | | | |
| **204** | **12** | **3.1** | **11.4** | **-** | **-** | **2.5** | **-** | **-** | **-** | **0.9** | **17.9** |
| 139 | 16 | - | 2.4 | - | - | 1.1 | - | - | 1.1 | - | 4.6 |
| 140 | 14 | - | 2.4 | - | - | 1.1 | - | - | 1.1 | - | 4.6 |
| 62 | 16 | - | - | - | - | - | 3.7 | - | - | - | 3.7 |
| 110 | 12 | - | - | - | - | 1.4 | - | - | - | - | 1.4 |
| **10-year-old age group** | | | | | | | | | | | |
| **206** | **9** | **1.6** | **5.7** | **-** | **-** | **1.3** | **-** | **-** | **-** | **0.4** | **9.0** |
| **11** | **7** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **8.5** | **8.5** |
| **142** | **10** | **-** | **2.4** | **-** | **-** | **1.1** | **-** | **-** | **1.1** | **-** | **4.6** |
| 141 | 10 | - | 1.2 | - | - | 0.6 | - | - | 0.6 | - | 2.3 |
| 143 | 8 | - | 1.2 | - | - | 0.6 | - | - | 0.6 | - | 2.3 |
| 98 | 10 | - | - | - | - | 1.8 | - | - | - | - | 1.8 |
| 99 | 8 | - | - | - | - | 1.8 | - | - | - | - | 1.8 |
| **5-year-old age group** | | | | | | | | | | | |
| **254** | **3** | **-** | **1.0** | **1.0** | **0.9** | **1.0** | **-** | **1.0** | **1.0** | **-** | **5.9** |
| **3-month-old age group** | | | | | | | | | | | |
| **255** | **0.5** | **-** | **-** | **-** | **-** | **-** | **0.5** | **-** | **-** | **-** | **0.5** |

**Notes**
Emboldened observations are the high-rate consumers

***Crustaceans***

Children's consumption rates of crustaceans are presented in Table 10. No children in the 15-year-old age group were identified consuming crustaceans.

Only one individual was identified in the 10-year-old age group with a consumption rate of 2.0 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation. This compares with the generic mean and 97.5 percentile consumption rates of 2.5 kg $y^{-1}$ and 7.0 kg $y^{-1}$, respectively. The percentage breakdown of crustacean species consumed by the high-rate group was 50% brown crab and 50% lobster.

A high-rate group of two individuals was identified in the 5-year-old age group with a maximum consumption rate of 1.0 kg $y^{-1}$ and a mean consumption rate of 0.9 kg $y^{-1}$. The observed 97.5 percentile rate based on two observations was 1.0 kg $y^{-1}$. No generic data are available for this age group. The percentage breakdown of crustacean species consumed by the high-rate group was 72% lobster and 28% brown crab.

Only one individual was identified in the 3-month-old age group with a consumption rate of 0.1 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation. No crustacean generic data are available for this age group. The percentage breakdown of crustacean species consumed by the high-rate group was 100% lobster.

***Table 10. Children's consumption rates of crustaceans in the Dounreay area (kg $y^{-1}$)***

| Observation number | Age | Brown crab | Lobster | Total |
|---|---|---|---|---|
| **10-year-old age group** | | | | |
| **259** | **8** | **1.0** | **1.0** | **2.0** |
| **5-year-old age group** | | | | |
| **260** | **4** | **0.5** | **0.5** | **1.0** |
| **254** | **3** | **-** | **0.8** | **0.8** |
| **3-month-old age group** | | | | |
| **255** | **0.5** | **-** | **0.1** | **0.1** |

**Notes**
Emboldened observations are the high-rate consumers

A summary of the children's aquatic consumption rates is presented in Table 11.

*Table 11. Summary of children's consumption rates of aquatic foods in the Dounreay area (kg $y^{-1}$)*

| Food group | Number of observations | Number of high-rate consumers | Observed maximum consumption rate for the high-rate group | Observed minimum consumption rate for the high-rate group | Observed mean consumption rate for the high-rate group | Observed 97.5 percentile consumption rate | Generic mean consumption rate | Generic 97.5 percentile consumption rate |
|---|---|---|---|---|---|---|---|---|
| **15-year-old age group** | | | | | | | | |
| Fish | 5 | 1 | 17.9 | 17.9 | 17.9 | 16.6 | 6.5 | 20.0 |
| Crustaceans | NC | NC | NC | NC | NC | NC | 2.5 | 6.0 |
| Molluscs | NC | NC | NC | NC | NC | NC | 2.5 | 6.0 |
| Wildfowl | NC | NC | NC | NC | NC | NC | ND | ND |
| Marine plants/algae | NC | NC | NC | NC | NC | NC | ND | ND |
| **10-year-old age group** | | | | | | | | |
| Fish | 7 | 3 | 9.0 | 4.6 | 7.4 | 8.9 | 6.0 | 20.0 |
| Crustaceans | 1 | 1 | 2.0 | 2.0 | 2.0 | NA | 2.5 | 7.0 |
| Molluscs | NC | NC | NC | NC | NC | NC | 2.5 | 7.0 |
| Wildfowl | NC | NC | NC | NC | NC | NC | ND | ND |
| Marine plants/algae | NC | NC | NC | NC | NC | NC | ND | ND |
| **5-year-old age group** | | | | | | | | |
| Fish | 1 | 1 | 5.9 | 5.9 | 5.9 | NA | ND | ND |
| Crustaceans | 2 | 2 | 1.0 | 0.8 | 0.9 | 1.0 | ND | ND |
| Molluscs | NC | NC | NC | NC | NC | NC | ND | ND |
| Wildfowl | NC | NC | NC | NC | NC | NC | ND | ND |
| Marine plants/algae | NC | NC | NC | NC | NC | NC | ND | ND |
| **3-month-old age group** | | | | | | | | |
| Fish | 1 | 1 | 0.5 | 0.5 | 0.5 | NA | 3.5 | 15.0 |
| Crustaceans | 1 | 1 | 0.1 | 0.1 | 0.1 | NA | ND | ND |
| Molluscs | NC | NC | NC | NC | NC | NC | ND | ND |
| Wildfowl | NC | NC | NC | NC | NC | NC | ND | ND |
| Marine plants/algae | NC | NC | NC | NC | NC | NC | ND | ND |

**Notes**
ND = not determined
NC = not consumed
NA = not applicable

## 4.8 External exposure

### *Intertidal occupancy*

Intertidal occupancy rates for adults and children are presented in Table 12. Activities were identified taking place over rock and over sand and included angling, bait digging, walking, dog walking, picnicking, winkle collecting, beach ranger duties, rock pooling, playing, horse riding, water sport preparation and sunbathing.

For occupancy over rock, the maximum rate was 330 h $y^{-1}$ for one individual who was angling from rocks at Castletown and Thurso East Mains. No other individuals had occupancy rates within a factor of three of this, which gives an occupancy rate for this group of 330 h $y^{-1}$. The observed 97.5 percentile rate based on 35 observations for rock was 120 h $y^{-1}$. For occupancy over sand, the maximum rate was 910 h $y^{-1}$ and the mean rate for the high-rate group was 470 h $y^{-1}$ for 15 individuals who were dog walking, angling, bait digging and collecting winkles. The observed 97.5 percentile rate based on 192 observations for sand is 450 h $y^{-1}$.

***Table 12. Intertidal occupancy rates in the Dounreay area (h $y^{-1}$)***

| Observation number | Location | Activity | Rock | Sand |
|---|---|---|---|---|
| **193** | **Castletown and Thurso East Mains** | **Angling** | **330** | - |
| | Castletown/Dunnet Bay | Bait digging/angling | **-** | 220 |
| 201 | Thurso East Mains and Scrabster | Angling | 88 | - |
| | Castletown, Murkle Bay and Dunnet Bay | Bait digging | - | 20 |
| 150 | Castletown and Scrabster | Angling | 75 | - |
| | Dunnet Bay and Scrabster/Dunnet Bay | Angling/bait digging | - | 100 |
| 161 | Thurso East Mains and Scrabster | Angling | 60 | - |
| | Castletown | Bait digging | - | 5 |
| 164 | Scrabster | Angling | 48 | - |
| 194 | Castletown | Angling | 40 | - |
| | Castletown and Dunnet Bay/Castletown | Angling/bait digging | - | 53 |
| 171-172 | Castletown | Angling | 39 | - |
| | Dunnet Bay/Castletown | Angling/bait digging | - | 65 |
| 186 | Dunnet Bay | Angling | 30 | - |
| | Dunnet Bay/Castletown | Angling/bait digging | - | 56 |
| 187 | Dunnet Bay | Angling | 30 | - |
| | Dunnet Bay | Angling | - | 30 |
| 85-91 | Scrabster | Angling | 27 | - |
| 206 | Scrabster | Angling | 25 | - |
| 149 | Brims Ness | Playing | 24 | - |
| 81-83 | Scrabster | Angling | 21 | - |
| 146 | Brims Ness | Playing | 20 | - |
| 147-148 | Brims Ness | Playing | 18 | - |
| 188 | Castletown | Angling | 17 | - |
| | Dunnet Bay/Castletown | Angling/bait digging | - | 20 |
| 189 | Castletown | Angling | 17 | - |
| | Dunnet Bay/Castletown | Angling /bait digging | - | 18 |
| 96 | Strathy Point and Scrabster | Angling | 16 | - |
| | Dunnet Bay | Angling | - | 8 |
| 182-183 | Dunnet Bay | Rock pooling | 11 | - |

| Observation number | Location | Activity | Rock | Sand |
|---|---|---|---|---|
| | Dunnet Bay | Playing | - | 11 |
| 97-99 | Strathy Point and Scrabster | Angling | 8 | - |
| | Dunnet Bay | Angling | - | 4 |
| 318-319 | Oigin's Geo area | Walking | 5 | - |
| | Sandside | Walking | - | 3 |
| **108** | **Thurso** | **Dog walking** | - | **913** |
| **162-163** | **Thurso East Mains** | **Dog walking** | - | **639** |
| **59-60** | **Sandside Bay** | **Dog walking** | - | **456** |
| **30-31** | **Sandside Bay, Dunnet Bay, Scrabster and Thurso** | **Dog walking** | - | **447** |
| **10** | **Between Melvich and Sandside/Melvich Bay/Strathy Bay, Melvich Bay and Sandside Bay** | **Collecting winkles/ angling/dog walking** | | **437** |
| **103-105** | **Thurso** | **Dog walking** | - | **390** |
| **74-75** | **Dunnet Bay and Scrabster** | **Dog walking** | - | **365** |
| **107** | **Thurso** | **Dog walking** | - | **365** |
| **327** | **Sandside Bay** | **Dog walking** | - | **365** |
| 19-20 | Strathy Bay, Melvich Bay and Sandside Bay | Dog walking and picnicking | - | 294 |
| 167-168 | Murkle Bay | Dog walking | - | 274 |
| 106 | Sandside Bay and Thurso | Dog walking | - | 258 |
| 102 | Thurso | Dog walking | - | 234 |
| 273-275 | Sandside Bay, Dunnet Bay, Melvich Bay and Strathy Bay | Dog walking | - | 213 |
| 92 | Scrabster Bay | Dog walking | - | 193 |
| 173 | Dunnet Bay and Thurso | Dog walking | - | 185 |
| 63 | Sandside Bay/Sandside Bay and Strathy Bay | Water sports preparation/dog walking | - | 184 |
| 197 | Dunnet Bay | Dog walking | - | 182 |
| 212 | Dunnet Bay | Ranger duties | - | 182 |
| 209-211 | Dunnet Bay | Ranger duties | - | 180 |
| 298-299 | Sandside Bay, Dunnet Bay, Melvich Bay and Strathy Bay | Angling | - | 150 |
| 324 | Sandside | Dog walking | - | 130 |
| 7 | Sandside | Walking | - | 125 |
| 144 | Scrabster | Dog walking | - | 122 |
| 116-120 | Dunnet Bay | Walking and playing | - | 117 |
| 24 | Dunnet Bay, Scrabster and Thurso | Walking | - | 108 |
| 278 | Melvich Bay | Walking | - | 108 |
| 127 | Dunnet Bay | Walking | - | 104 |
| 198-200 | Dunnet Bay | Dog walking | - | 104 |
| 1-4 | Strathy Bay | Picnicking | - | 100 |
| 279-280 | Melvich Bay | Picnicking | - | 84 |
| 294-295 | Various local beaches | Dog walking | - | 78 |
| 47, 50 | Melvich Bay, Sandside Bay, Brims Ness and Crosskirk | Dog walking | - | 71 |
| 53-54 | Thurso, Sandside Bay, Dunnet Bay and Melvich Bay | Walking | - | 70 |
| 115 | Dunnet Bay | Dog walking | - | 52 |
| 301 | Sandside Bay | Walking | - | 48 |
| 287-293 | Strathy Bay and Castletown | Playing | - | 42 |
| 145 | Thurso | Dog walking | - | 41 |
| 177 | Dunnet Bay | Dog walking | - | 40 |
| 276-277 | Sandside Bay | Dog walking | - | 39 |

| Observation number | Location | Activity | Rock | Sand |
|---|---|---|---|---|
| 28-29 | Scrabster, Dunnet Bay and Melvich Bay | Walking | - | 37 |
| 131 | Dunnet Bay | Angling | - | 28 |
| 213-234 | Scrabster | Water sports preparation | - | 26 |
| 296-297 | Various local beaches | Dog walking | - | 26 |
| 178-180 | Dunnet Bay | Playing | - | 24 |
| 43 | Melvich Bay | Playing | - | 21 |
| 32-33 | Scrabster, Dunnet Bay, Strathy Bay and Sandside Bay | Walking | - | 20 |
| 284-285 | Melvich Bay and Strathy Bay | Playing | - | 20 |
| 21-23 | Scrabster, Thurso and Castletown | Walking | - | 19 |
| 44 | Melvich Bay | Playing | - | 18 |
| 174-175 | Dunnet Bay and Thurso | Horse riding | - | 18 |
| 176 | Dunnet Bay and Thurso | Walking | - | 18 |
| 100-101 | Dunnet Bay | Dog walking | - | 18 |
| 133-137 | Dunnet Bay | Playing | - | 18 |
| 34-35 | Scrabster, Dunnet Bay, Strathy Bay and Sandside Bay | Walking | - | 17 |
| 132 | Dunnet Bay | Dog walking | - | 15 |
| 121-122 | Dunnet Bay | Walking | - | 12 |
| 40-41 | Sandside Bay | Dog walking | - | 12 |
| 123-126 | Dunnet Bay | Walking | - | 12 |
| 128-130 | Dunnet Bay | Dog walking | - | 12 |
| 181 | Castletown | Walking | - | 12 |
| 184-185 | Dunnet Bay | Playing | - | 11 |
| 55-56 | Melvich Bay | Dog walking | - | 10 |
| 165-166 | Murkle Bay | Angling | - | 10 |
| 281-282 | Melvich Bay and Dunnet Bay | Walking | - | 10 |
| 337-338 | Sandside Bay | Sunbathing | - | 9 |
| 93-95 | Scrabster | Dog walking | - | 5 |
| 15-17 | Sandside Bay, Melvich Bay, Dunnet Bay and Strathy Bay | Dog walking | - | 5 |
| 18 | Sandside Bay, Melvich Bay, Dunnet Bay and Strathy Bay | Dog walking | - | 4 |
| 57-58 | Dunnet Bay | Walking | - | 4 |
| 76 | Sandside Bay | Dog walking | - | 4 |
| 69-70 | Sandside Bay | Picnicking | - | 3 |
| 25-27 | Scrabster | Walking | - | 2 |
| 326 | Sandside Bay | Walking | - | 2 |
| 334-335 | Sandside Bay | Beach occupancy | - | 2 |
| 71-73 | Sandside Bay | Picnicking | - | 2 |
| 195-196 | Dunnet Bay | Walking | - | 2 |
| 336 | Sandside Bay | Beach occupancy | - | 2 |

**Notes**

Emboldened observations are the high-rate members

The forward slash (/), denotes the locations and associated activities.

***Gamma dose rate measurements***

Gamma dose rate measurements were taken over intertidal substrates to supplement those of SEPA's scheduled monitoring programme. These measurements are presented in Table 13 and ranged from 0.053 µGy $h^{-1}$ to 0.101 µGy $h^{-1}$ over sand and from 0.121 µGy $h^{-1}$ to 0.144 µGy $h^{-1}$ over stones. A single measurement taken over sand and stones was 0.070 µGy $h^{-1}$.

***Table 13. Gamma dose rate measurements over intertidal substrates in the Dounreay area (µGy $h^{-1}$)***

| Location | NGR | Substrate | Gamma dose rate at 1 metre[a] |
|---|---|---|---|
| Armadale beach | NC 794 645 | Sand | 0.063 |
| Strathy beach | NC 838 659 | Sand | 0.061 |
| Melvich beach | NC 888 649 | Sand | 0.075 |
| Sandside beach | NC 962 654 | Sand | 0.078 |
| Oigin's Geo | NC 995 683 | Stones | 0.144 |
| Forss Water | NC 889 648 | Sand | 0.079 |
| Crosskirk | ND 029 700 | Stones | 0.121 |
| Brims Ness | ND 043 712 | Sand | 0.101 |
| Scrabster beach | ND 100 699 | Sand | 0.069 |
| Thurso beach | ND 118 687 | Sand | 0.071 |
| Thurso East Mains | ND 123 688 | Sand and stones | 0.070 |
| Murkle Bay | ND 168 693 | Sand | 0.057 |
| Castletown | ND 199 684 | Sand | 0.061 |
| Dunnet beach (south) | ND 203 683 | Sand | 0.053 |
| Dunnet beach (north) | ND 218 705 | Sand | 0.058 |

**Notes**
[a] These measurements have not been adjusted for natural background dose rates.

***Handling fishing gear and sediment***

Handling fishing gear that has become entrained with fine sediment particles, or handling sediment while undertaking activities such as bait digging or mollusc collecting, can potentially give rise to skin exposure from beta radiation. This would be of particular importance if a fuel fragment particle were handled. Monitoring is undertaken on beaches in the vicinity of the Dounreay site in order to detect and remove these fragments. Doses to the skin need consideration, as there is a separate dose limit for skin for members of the public. There is also a contribution to effective dose due to skin exposure (ICRP, 1991). The handling of angling equipment was not considered to be a significant pathway. Therefore, as in previous surveys, data for this pathway were not collected. Table 14 presents the handling rates of fishing gear and sediment recorded during the survey.

The maximum handling rate for fishing gear was 2000 h $y^{-1}$ for two commercial creel fishermen. These fishermen undertook, on average, 200 sea trips per year for 10 hours per trip. They were

handling creels for 7 hours per sea trip, plus 70 days mending creels at 8 hours per day. The mean handling rate for the high-rate group for fishing gear was 1700 h $y^{-1}$, which included eight other commercial creel fishermen. The observed 97.5 percentile rate based on 17 observations for handing fishing gear was 2000 h $y^{-1}$. The maximum sediment handling rate was 55 h $y^{-1}$ for a bait digger. The mean handling rate for the high-rate group for sediment was 30 h $y^{-1}$, which also included five other bait diggers. The observed 97.5 percentile rate based on 11 observations for sediment was 48 h $y^{-1}$.

***Table 14. Handling rates of fishing gear and sediment in the Dounreay area (h $y^{-1}$)***

| Observation number | Location | Activity | Fishing gear | Sediment |
|---|---|---|---|---|
| **247** | **Offshore, from Melvich to Brims Ness** | **Handling creels** | **1960** | - |
| **249** | **Offshore, from Melvich to Brims Ness** | **Handling creels** | **1960** | - |
| **252** | **Offshore, from Melvich to Holborn Head** | **Handling creels** | **1800** | - |
| **250** | **Offshore, within 20 km of Scrabster** | **Handling creels** | **1740** | - |
| **251** | **Offshore, within 20 km of Scrabster** | **Handling creels** | **1740** | - |
| **256** | **Offshore, within 20 km of Scrabster** | **Handling creels** | **1660** | - |
| **257** | **Dunnet Bay area** | **Handling creels** | **1614** | - |
| **78** | **Offshore, from Strathy to Sandside** | **Handling creels** | **1560** | - |
| **328** | **Offshore, from Strathy to Sandside** | **Handling creels** | **1560** | - |
| **267** | **Offshore, within 4 km of Scrabster** | **Handling creels** | **1066** | - |
| 261 | Offshore, around Holborn Head | Handling creels | 307 | - |
| 269 | Dunnet Bay | Handling bag-nets | 217 | - |
| 270 | Dunnet Bay | Handling bag-nets | 217 | - |
| 207 | Offshore, within 4 km of Scrabster | Creel handling | 66 | - |
| 354 | Port a' Chinn | Handling bag-nets | 40 | - |
| 355 | Port a' Chinn | Handling bag-nets | 40 | - |
| 59 | Sandside Bay | Handling creels | 33 | - |
| **193** | **Castletown** | **Bait digging** | - | **55** |
| **171** | **Castletown** | **Bait digging** | - | **26** |
| **172** | **Castletown** | **Bait digging** | - | **26** |
| **186** | **Castletown** | **Bait digging** | - | **26** |
| **150** | **Dunnet Bay** | **Bait digging** | - | **25** |
| **201** | **Castletown, Murkle Bay and Dunnet Bay** | **Bait digging** | - | **20** |
| 10 | Melvich Bay | Collecting winkles | - | 18 |
| 194 | Castletown | Bait digging | - | 13 |
| 161 | Castletown | Bait digging | - | 5 |
| 188 | Castletown | Bait digging | - | 3 |
| 189 | Castletown | Bait digging | - | 2 |

**Notes**
Emboldened observations are the high-rate members
Fishermen usually wore gloves when fishing with nets or pots, although there were occasions when they took their gloves off. They did not wear gloves when mending creels or nets.

***Water based activities***

Activities taking place in or on the water can potentially lead to ingestion of water and/or inhalation of spray. These pathways are generally considered to be minor in comparison with other exposure pathways such as the ingestion of foods produced in the vicinity of a nuclear site. However, relevant data have been collected for consideration in dose assessments. Mean occupancy rates and

97.5 percentile rates have not been calculated. Activities where there is a high potential of the individual's face submersing under the water have been classified as activities 'in water' since they are likely to lead to ingestion of water. All other activities have been classified as activities 'on water'. Occupancy rates for activities taking place 'in water' and 'on water' in the survey area for adults and children are presented in Table 15.

Activities taking place in the water around Dounreay were swimming, surfing, snorkelling, scuba diving, kayaking and lying in tidal pools. Twenty-eight observations were recorded for adults and children. The highest occupancy rate was 610 h $y^{-1}$ for an adult who was surfing and snorkelling.

Activities taking place on the water in the survey area were commercial fishing, boating, sailing, angling and paddling. Eighty-nine observations were recorded for adults and children. The highest occupancy rate was 2000 h $y^{-1}$ for three commercial creel fishermen.

***Table 15. Occupancy rates in and on water in the Dounreay area (h $y^{-1}$)***

| Observation Number | Location | Activity | In water | On water |
|---|---|---|---|---|
| 108 | Thurso and Sandside Bay | Surfing and snorkelling | 609 | - |
| 339-351 | Portskerra, Dunnet Bay, Scrabster and Strathy Bay | Scuba diving and kayaking | 169 | - |
| 165 | Thurso East Mains and Sandside Bay | Surfing | 64 | - |
| 8 | Sandside Bay | Surfing | 10 | - |
| 9 | Sandside Bay | Surfing | 10 | - |
| 19 | Melvich Bay and Strathy Bay | Swimming | 6 | - |
| 147-148 | Brims Ness | Swimming | 6 | - |
| 303 | Crosskirk Bay | Swimming | 5 | - |
| 146 | Brims Ness | Swimming | 4 | - |
| 43-44 | Melvich Bay | Swimming | 3 | - |
| 337-338 | Sandside Bay | Swimming and lying in tidal pools | 3 | - |
| 63 | Sandside Bay | Surfing/angling | 2 | 4 |
| 325 | Sandside Bay | Surfing | 2 | - |
| 247,249 | Offshore, from Melvich Bay to Brims Ness | Creeling | - | 2000 |
| 252 | Offshore, from Melvich Bay to Holborn Head | Creeling | - | 2000 |
| 250-251 | Offshore, within 20 km of Scrabster | Creeling | - | 1710 |
| 256 | Offshore, within 20 km of Scrabster | Creeling | - | 1575 |
| 78, 328 | Offshore. from Strathy to Sandside | Creeling | - | 1560 |
| 257 | Dunnet Bay | Creeling | - | 1170 |
| 267 | Offshore, within 4 km of Scrabster | Creeling | - | 715 |
| 235-236 | Offshore, from Melvich to Dunnet Head | Angling boat skipper | - | 360 |
| 161 | Offshore, from Melvich to Dunnet Head | Angling | - | 312 |
| 109-110 | Dunnet Bay area | Angling | - | 270 |
| 261 | Offshore, around Dunnet Head | Creeling | - | 261 |
| 59 | Sandside Bay | Angling and creeling | - | 231 |
| 354-355 | Port a' Chinn | Servicing bag-nets | - | 217 |
| 207 | Offshore, within 4 km of Scrabster | Angling and creeling | - | 193 |
| 237-246 | Offshore, from Melvich to Dunnet Head | Angling | - | 180 |

| Observation Number | Location | Activity | In water | On water |
|---|---|---|---|---|
| 213-234 | Thurso Bay | Sailing | - | 156 |
| 151-155 | Offshore, within 20 km of Scrabster | Angling | - | 137 |
| 269-270 | Dunnet Bay | Servicing bag-nets | - | 130 |
| 201 | Thurso Bay | Angling | - | 75 |
| 188 | Offshore, from Melvich to Dunnet Head | Angling | - | 60 |
| 113 | Dunnet Bay | Angling | - | 42 |
| 138-140 | Dunnet Bay | Angling | - | 32 |
| 150 | Thurso Bay | Angling | - | 24 |
| 287-293 | Castletown and Strathy Bay | Paddling | - | 14 |
| 20 | Melvich Bay and Strathy Bay | Paddling | - | 6 |
| 284-285 | Melvich Bay and Strathy Bay | Boating | - | 5 |
| 29 | Scrabster, Dunnet Bay and Melvich Bay | Paddling | - | 4 |
| 169 | Thurso Bay | Angling | - | 4 |
| 133-137 | Dunnet Bay | Paddling | - | 4 |
| 34-35 | Dunnet Bay | Paddling | - | 3 |
| 23 | Scrabster | Paddling | - | 2 |
| 18 | Sandside Bay | Paddling | - | 1 |
| 336 | Sandside Bay | Boating and paddling | - | 1 |

# 5 TERRESTRIAL RADIATION PATHWAYS

## 5.1 Terrestrial survey area and local produce

The terrestrial survey area covered all land within 5 km of the Dounreay site centre, as shown in Figure 2. Interviews were conducted at 19 farms in the area; 15 of which produced beef and lamb, two produced beef, and two produced lamb. No dairy farms were identified in the survey area. Crops including hay, silage, barley, oats, wheat, potatoes, swedes and turnips, were grown by farmers for livestock winter feed and a small amount of potatoes were grown for human consumption at one farm. Since the 2003 Dounreay habits survey, the livestock market at Thurso had closed and the nearest livestock market to the survey area was at Wick. Lamb and beef cattle were sold to private buyers and through markets at Wick, Dumfries and Galloway, Aberdeenshire and Perth. Produce was sold directly to the public from two farms; one of which sold lamb and the other sold potatoes.

Two farmers and their families were consuming lamb produced on their own farms. No beef consumption was identified. Several farmers reported that they had ceased consuming lamb and beef since the last habits survey due to increased abattoir costs. Many farming families grew vegetables such as potatoes, swedes, turnips, cabbages and carrots, for their own consumption. Fruit and vegetables were mostly grown in small amounts at a few private households and one household was self sufficient in fruit and vegetables. Five households were identified that kept chickens for eggs for their own consumption. One of these households gave chicken eggs to family and friends. Chickens were not consumed. One household kept goats and consumed the goats' milk and goats' cheese.

Four beekeepers were identified who had hives within the survey area. A total of 14 hives were identified and they were located at Reay, Black Hills, Achvarasdal and near Sandside. The average production of honey per hive was approximately 17 kg $y^{-1}$. Excess honey was sold locally or given to family and friends.

A large part of the survey area near the coast was particularly weather beaten and barren, and therefore, very little wild food was available. Two individuals collected rosehips for making jelly, which were collected from farmland. Two other people collected rowanberries, hazel nuts and elderberries from land near Isauld. Wild fungi was collected from farm fields and consumed.

Eight households were consuming poultry and game, which included pheasants, grouse, pigeons, ducks, geese, rabbits and venison. Pheasants were reared on an estate for private game shoots on the estate's land where both pheasant and grouse were shot. Red deer, roe deer and grouse were also shot on the estate and were sold to a game wholesaler. The estate covered a large area of land to the south-west of the Dounreay site and only part of the estate's land was in the survey area. On one farm in the area, small numbers of rabbits were trapped and were sold to a butcher in Thurso.

The human consumption of groundwater was not identified. All livestock were supplied with mains water for drinking but at several farms livestock also had access to spring, stream or ditch water.

The transfer of contamination off-site by wildlife was investigated as radionuclides could enter the food chain or contaminate the environment through this pathway. A representative from the Dounreay site reported that wildlife such as pigeons, seagulls and rabbits were observed on the site but they considered the numbers to be low. The site's wildlife management policy included keeping rabbits out of the site by means of a fence around the site perimeter and occasionally culling rabbits found on site. No monitoring of wildlife found on site was undertaken.

### 5.2 Land cover

Figure 4 shows the land cover in the survey area. The figure is reproduced from a land cover map produced by Macaulay Land Use Research Institute, with their consent.

A large proportion of the area was improved grassland, containing areas of smooth grassland, to support sheep and cattle for meat production. Near the coast, to the east and to the west of the site, there were strips of undifferentiated coarse grassland. There were also pockets of heather moor, peatland vegetation, coniferous and deciduous woodland and a small patch of wetland contained within the improved grassland.

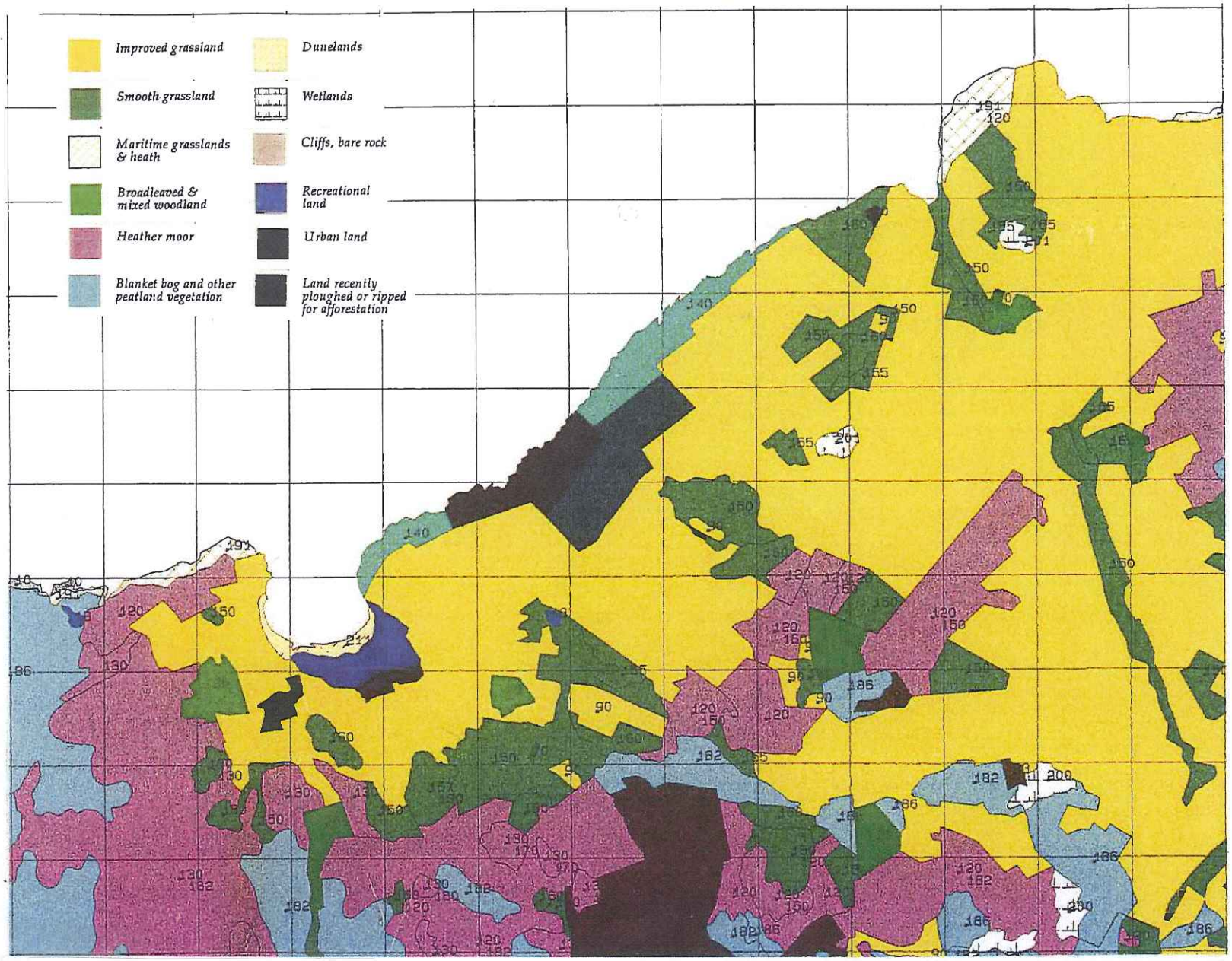


Figure 4. Land cover of survey area

Reproduced with the permission of The Macaulay Institute for Soil Research, Aberdeen.

Base scale is 1:50000

## 5.3 Internal exposure

### *Adults' consumption rates*

The consumption of terrestrial foods was identified in the following 15 food groups: green vegetables, other vegetables, root vegetables, potatoes, domestic fruit, milk (goats'), cheese (goats'), sheep meat, poultry, eggs, wild/free foods, rabbits/hares, honey, wild fungi and venison. No consumption was identified for cattle meat, pig meat, freshwater fish or cereal crops.

Adults' consumption rates of green vegetables are presented in Table 16. The mean consumption rate for the high-rate group based on the two highest adult consumers was 62 kg $y^{-1}$ and the observed 97.5 percentile rate based on 28 observations was 62 kg $y^{-1}$.

***Table 16. Adults' consumption rates of green vegetables in the Dounreay area (kg $y^{-1}$)***

| Observation number | Artichoke | Asparagus | Broccoli | Brussels sprout | Cabbage | Calabrese | Cauliflower | Courgette | Cucumber | Herbs | Kale | Lettuce | Marrow | Rocket | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **357-358** | **8.1** | **3.1** | **5.5** | **8.2** | **9.0** | **5.5** | **6.1** | **1.7** | **-** | **2.3** | **4.7** | **5.3** | **1.6** | **0.9** | **62.0** |
| 59-61 | - | 3.1 | 1.6 | 2.2 | 2.2 | - | - | - | - | - | - | - | - | - | 9.2 |
| 313-314 | - | - | - | - | - | - | 8.8 | - | - | - | - | - | - | - | 8.8 |
| 47-50 | - | - | 3.4 | - | - | - | 2.6 | 2.8 | - | - | - | - | - | - | 8.7 |
| 315-317 | - | - | - | - | 5.7 | - | 1.1 | - | - | - | - | - | - | - | 6.8 |
| 36-37 | - | - | - | - | 5.0 | - | - | - | - | - | - | - | - | - | 5.0 |
| 55-56 | - | - | - | - | 5.0 | - | - | - | - | - | - | - | - | - | 5.0 |
| 43-44 | - | - | - | - | - | - | - | - | - | - | - | 2.6 | - | - | 2.6 |
| 311-312 | - | - | - | - | - | - | - | - | 1.7 | - | - | - | - | - | 1.7 |
| 57-58 | - | - | - | 1.4 | - | - | - | - | - | - | - | - | - | - | 1.4 |
| 276 | - | - | - | - | - | - | - | 0.6 | - | - | - | - | - | - | 0.6 |
| 277 | - | - | - | - | - | - | - | 0.4 | - | - | - | - | - | - | 0.4 |
| 76-77 | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | - | 0.2 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of other vegetables are presented in Table 17. The mean consumption rate for the high-rate group based on the two highest adult consumers was 74 kg $y^{-1}$ and the observed 97.5 percentile rate based on 20 observations was 74 kg $y^{-1}$.

***Table 17. Adults' consumption rates of other vegetables in the Dounreay area (kg $y^{-1}$)***

| Observation Number | Broad bean | Chilli pepper | French bean | Mangetout | Pea | Sweet pepper | Runner bean | Sweetcorn | Tomato | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **357-358** | **6.7** | **0.8** | **1.6** | **6.7** | **-** | **1.8** | **20.1** | **3.1** | **32.8** | **73.6** |
| 311-312 | - | - | - | - | - | - | - | - | 14.4 | 14.4 |
| 51-52 | - | - | - | - | - | - | - | - | 6.3 | 6.3 |
| 47-50 | - | - | - | - | 6.0 | - | - | - | - | 6.0 |
| 306-308 | - | - | - | - | - | - | - | - | 6.0 | 6.0 |
| 276 | - | - | - | - | - | - | - | - | 3.0 | 3.0 |
| 277 | - | - | - | - | - | - | - | - | 2.0 | 2.0 |
| 59-61 | - | - | - | - | 0.6 | - | 0.6 | - | - | 1.1 |
| 57-58 | - | - | - | - | 0.05 | - | - | - | - | 0.05 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of root vegetables are presented in Table 18. The mean consumption rate for the high-rate group based on the two highest adult consumers was 78 kg $y^{-1}$ and the observed 97.5 percentile rate based on 34 observations was 78 kg $y^{-1}$.

***Table 18. Adults' consumption rates of root vegetables in the Dounreay area (kg $y^{-1}$)***

| Observation number | Jerusalem artichoke | Beetroot | Carrot | Celeriac | Celery | Chicory | Garlic | Horseradish | Leek | Onion | Parsnip | Shallot | Spring onion | Swede | Turnip | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **357-358** | **18.1** | **3.3** | **10.0** | **4.3** | **11.3** | **4.0** | **4.9** | **3.4** | **6.6** | **8.0** | **2.7** | **-** | **1.5** | **-** | **-** | **78.1** |
| 313-314 | - | - | 8.0 | - | - | - | - | - | - | - | - | - | - | - | 8.0 | 16.0 |
| 310 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 11.8 | 11.8 |
| 306-308 | - | - | 4.5 | - | - | - | - | - | - | 3.6 | - | 3.2 | - | - | - | 11.3 |
| 36-37 | - | - | - | - | - | - | - | - | 5.0 | - | - | - | - | 5.0 | - | 10.0 |
| 352-353 | - | - | 2.3 | - | - | - | - | - | - | - | - | - | - | - | 7.5 | 9.7 |
| 315-317 | - | - | 4.5 | - | - | - | - | - | - | - | - | - | - | 4.5 | - | 9.1 |
| 59-61 | - | - | 2.2 | - | - | - | - | - | - | - | 2.2 | - | - | 3.3 | - | 7.7 |
| 47-50 | - | - | 4.5 | - | - | - | - | - | - | - | 2.3 | - | - | - | - | 6.7 |
| 57-58 | - | - | 0.9 | - | - | - | 0.2 | - | - | 2.3 | - | 1.1 | - | 1.1 | - | 5.7 |
| 1-2, 40-41 | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.0 | - | 5 |
| 55-56 | - | - | 5.0 | - | - | - | - | - | - | - | - | - | - | - | - | 5.0 |
| 43-44 | - | - | - | - | - | - | - | - | - | - | - | 1.6 | - | - | - | 1.6 |
| 76-77 | - | 0.8 | - | - | - | - | - | - | - | 0.1 | - | - | - | - | - | 0.9 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of potato are presented in Table 19. The mean consumption rate for the high-rate group based on the 16 highest adult consumers was 71 kg $y^{-1}$ and the observed 97.5 percentile rate based on 34 observations was 120 kg $y^{-1}$.

***Table 19. Adults' consumption rates of potato in the Dounreay area (kg $y^{-1}$)***

| Observation number | Potato |
|---|---|
| **36, 40** | **124.2** |
| **55** | **124.0** |
| **357-358** | **87.3** |
| **59** | **84.0** |
| **37, 41, 56** | **62.0** |
| **313-314** | **47.2** |
| **352-353** | **45.5** |
| **310** | **45.4** |
| **60-61** | **42.0** |
| 50 | 39.8 |
| 43 | 31.0 |
| 47-49 | 26.5 |
| 315-317 | 23.6 |
| 57-58 | 18.1 |
| 45-46 | 17.0 |
| 44 | 15.5 |
| 306-308 | 9.1 |
| 51-52 | 1.4 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of domestic fruit are presented in Table 20. The mean consumption rate for the high-rate group based on the four highest adult consumers was 41 kg $y^{-1}$ and the observed 97.5 percentile rate based on 29 observations was 58 kg $y^{-1}$.

***Table 20. Adults' consumption rates of domestic fruit in the Dounreay area (kg $y^{-1}$)***

| Observation number | Apple | Blackberry | Blackcurrant | Blueberry | Cherry | Fig | Gooseberry | Grape | Orange | Pear | Plum | Raspberry | Redcurrant | Rhubarb | Strawberry | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **357-358** | **11.8** | **16.3** | **8.2** | **-** | **0.7** | **2.0** | **6.1** | **-** | **-** | **3.4** | **-** | **2.0** | **0.4** | **0.2** | **7.0** | **58.2** |
| **52** | **9.1** | **-** | **1.4** | **2.7** | **-** | **-** | **4.1** | **4.5** | **1.4** | **-** | **-** | **1.4** | **-** | **-** | **-** | **24.5** |
| **51** | **9.1** | **-** | **1.4** | **-** | **-** | **-** | **4.1** | **4.5** | **1.4** | **-** | **-** | **1.4** | **-** | **-** | **-** | **21.8** |
| 47-50 | - | - | 8.5 | - | - | - | - | - | - | - | - | 2.6 | - | - | 6.8 | 17.9 |
| 306-307 | - | - | 1.9 | - | - | - | - | - | - | - | 11.4 | - | - | - | - | 13.3 |
| 276 | - | - | 1.2 | - | 4.2 | - | 2.4 | - | - | - | - | 2.4 | 1.2 | 1.2 | - | 12.6 |
| 63-68 | - | - | 9.5 | - | - | - | 0.7 | - | - | - | - | 1.1 | - | - | - | 11.3 |
| 277 | - | - | 0.8 | - | 2.8 | - | 1.6 | - | - | - | - | 1.6 | 0.8 | 0.8 | - | 8.4 |
| 315 | - | - | 5.7 | - | - | - | - | - | - | - | - | - | - | - | - | 5.7 |
| 57-58 | - | - | - | - | - | - | - | - | - | - | - | 0.5 | - | 2.3 | - | 2.7 |
| 43 | - | - | 1.1 | - | - | - | - | - | - | - | - | - | - | - | - | 1.1 |
| 36-37 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.7 | - | 0.7 |
| 59-61 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.7 | 0.7 |
| 44 | - | - | 0.2 | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of milk are presented in Table 21. The mean consumption rate for the high-rate group based on the three highest adult consumers was 170 l $y^{-1}$ and the observed 97.5 percentile rate based on three observations was 170 l $y^{-1}$. The consumption of cows' milk was not identified in the area since there were no dairy farms.

***Table 21. Adults' consumption rates of milk in the Dounreay area (l $y^{-1}$)***

| Observation number | Goats' milk |
|---|---|
| **47** | **172.9** |
| **48** | **172.9** |
| **50** | **172.9** |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of cheese are presented in Table 22. The mean consumption rate for the high-rate group based on the three highest adult consumers was 7.9 kg $y^{-1}$ and the observed 97.5 percentile rate based on three observations was 7.9 kg $y^{-1}$.

***Table 22. Adults' consumption rates of cheese in the Dounreay area (kg $y^{-1}$)***

| Observation number | Goats' cheese |
|---|---|
| **47** | **7.9** |
| **48** | **7.9** |
| **50** | **7.9** |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of sheep meat are presented in Table 23. The mean consumption rate for the high-rate group based on the four highest adult consumers was 18 kg $y^{-1}$ and the observed 97.5 percentile rate based on four observations was 24 kg $y^{-1}$.

***Table 23. Adults' consumption rates of sheep meat in the Dounreay area (kg $y^{-1}$)***

| Observation number | Lamb |
|---|---|
| **311** | **23.6** |
| **312** | **23.6** |
| **36** | **11.8** |
| **37** | **11.8** |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of poultry are presented in Table 24. The mean consumption rate for the high-rate group based on the eight highest adult consumers was 6.1 kg $y^{-1}$ and the observed 97.5 percentile rate based on 12 observations was 8.8 kg $y^{-1}$.

***Table 24. Adults' consumption rates of poultry in the Dounreay area (kg $y^{-1}$)***

| Observation number | Mixed duck species | Mixed goose species | Greylag goose | Grouse | Mallard | Pheasant | Pigeon | Total |
|---|---|---|---|---|---|---|---|---|
| **36** | **2.9** | **2.9** | **-** | **-** | **-** | **2.9** | **-** | **8.8** |
| **37** | **2.9** | **2.9** | **-** | **-** | **-** | **2.9** | **-** | **8.8** |
| **55** | **-** | **-** | **1.1** | **2.1** | **0.6** | **2.7** | **-** | **6.5** |
| **56** | **-** | **-** | **1.1** | **2.1** | **0.6** | **2.7** | **-** | **6.5** |
| **40** | **3.0** | **-** | **-** | **-** | **-** | **3.0** | **-** | **6.0** |
| **41** | **3.0** | **-** | **-** | **-** | **-** | **3.0** | **-** | **6.0** |
| **318** | **-** | **2.2** | **-** | **-** | **-** | **0.9** | **-** | **3.1** |
| **319** | **-** | **2.2** | **-** | **-** | **-** | **0.9** | **-** | **3.1** |
| 45 | 0.9 | - | - | - | - | 1.8 | - | 2.7 |
| 303 | - | - | - | - | - | 1.1 | 0.6 | 1.7 |
| 43 | - | - | - | - | - | 0.9 | - | 0.9 |
| 310 | - | - | - | - | - | 0.9 | - | 0.9 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of eggs are presented in Table 25. The mean consumption rate for the high-rate group based on the 12 highest adult consumers was 14 kg $y^{-1}$ and the observed 97.5 percentile rate based on 14 observations was 18 kg $y^{-1}$.

***Table 25. Adults' consumption rates of eggs in the Dounreay area (kg $y^{-1}$)***

| Observation number | Chicken egg |
|---|---|
| **55-56, 315-317** | **17.8** |
| **352-353** | **14.8** |
| **59-61** | **11.9** |
| **311-312** | **8.9** |
| 313-314 | 4.4 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of wild/free foods are presented in Table 26. The mean consumption rate for the high-rate group based on the two highest adult consumers was 3.7 kg $y^{-1}$ and the observed 97.5 percentile rate based on four observations was 3.7 kg $y^{-1}$.

***Table 26. Adults' consumption rates of wild/free foods in the Dounreay area (kg $y^{-1}$)***

| Observation number | Elderberry | Hazel nut | Rosehip | Rowanberry | Total |
|---|---|---|---|---|---|
| **357-358** | **0.5** | **0.9** | - | **2.3** | **3.7** |
| 311-312 | - | - | 0.9 | - | 0.9 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of rabbits/hares are presented in Table 27. The mean consumption rate for the high-rate group based on the three highest adult consumers was 4.2 kg $y^{-1}$ and the observed 97.5 percentile rate based on five observations was 5.3 kg $y^{-1}$.

***Table 27. Adults' consumption rates of rabbits/hares in the Dounreay area (kg $y^{-1}$)***

| Observation number | Rabbit |
|---|---|
| **40-41** | **5.3** |
| **303** | **2.0** |
| 357-358 | 0.2 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of honey are presented in Table 28. The mean consumption rate for the high-rate group based on the 12 highest adult consumers was 4.2 kg $y^{-1}$ and the observed 97.5 percentile rate based on 30 observations was 6.8 kg $y^{-1}$.

***Table 28. Adults' consumption rates of honey in the Dounreay area (kg $y^{-1}$)***

| Observation number | Honey |
|---|---|
| **51-52** | **6.8** |
| **357-358** | **6.0** |
| **43** | **3.6** |
| **42, 45, 46** | **3.4** |
| **19, 20, 31, 36** | **2.7** |
| 44 | 1.8 |
| 48, 50, 10, 12 | 1.1 |
| 58 | 0.9 |
| 60, 61, 63 | 0.5 |
| 38, 39, 57, 74, 75, 329-333 | 0.2 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of wild fungi are presented in Table 29. The mean consumption rate for the high-rate group based on the two highest adult consumers was 3.0 kg $y^{-1}$ and the observed 97.5 percentile rate based on seven observations was 3.0 kg $y^{-1}$.

***Table 29. Adults' consumption rates of wild fungi in the Dounreay area (kg $y^{-1}$)***

| Observation number | Mushrooms |
|---|---|
| **357-358** | **3.0** |
| 303 | 0.9 |
| 311-312 | 0.7 |
| 36-37 | 0.5 |

**Notes**
Emboldened observations are the high-rate consumers

Adults' consumption rates of venison are presented in Table 30. The mean consumption rate for the high-rate group based on the two highest adult consumers was 56 kg $y^{-1}$ and the observed 97.5 percentile rate based on 10 observations was 56 kg $y^{-1}$.

***Table 30. Adults' consumption rates of venison in the Dounreay area (kg $y^{-1}$)***

| Observation number | Venison |
|---|---|
| **40-41** | **55.8** |
| 55-56 | 10.9 |
| 36-37 | 2.9 |
| 357-358 | 2.8 |
| 74-75 | 0.9 |

**Notes**
Emboldened observations are the high-rate consumers

A summary of adults' terrestrial consumption rates is presented in Table 31. Of the 15 food groups where consumption was identified, three mean consumption rates for the high-rate groups exceeded the generic 97.5 percentile rates. These were for green vegetables, other vegetables and root vegetables. Seven further mean consumption rates for the high-rate groups were equal to or exceeded their generic means. These were for potato, domestic fruit, milk (goats'), sheep meat, eggs, honey and wild fungi. The observed 97.5 percentile consumption rates for green vegetables, other vegetables, root vegetables and potato exceeded the generic 97.5 percentile consumption rates. There are currently no generic consumption data available for venison so no comparison with the observed rate can be made.

***Table 31. Summary of adults' consumption rates of terrestrial foods in the Dounreay area (kg $y^{-1}$ or l $y^{-1}$)***

| Food group | Number of observations | Number of high-rate consumers | Observed maximum consumption rate for the high-rate group | Observed minimum consumption rate for the high-rate group | Observed mean consumption rate for the high-rate group | Observed 97.5 percentile consumption rate | Generic mean consumption rate | Generic 97.5 percentile consumption rate |
|---|---|---|---|---|---|---|---|---|
| Green vegetables | 28 | 2 | 62.0 | 62.0 | 62.0 | 62.0 | 15.0 | 45.0 |
| Other vegetables | 20 | 2 | 73.6 | 73.6 | 73.6 | 73.6 | 20.0 | 50.0 |
| Root vegetables | 34 | 2 | 78.1 | 78.1 | 78.1 | 78.1 | 10.0 | 40.0 |
| Potato | 34 | 16 | 124.2 | 42.0 | 70.7 | 124.2 | 50.0 | 120.0 |
| Domestic fruit | 29 | 4 | 58.2 | 21.8 | 40.7 | 58.2 | 20.0 | 75.0 |
| Milk (goats') | 3 | 3 | 172.9 | 172.9 | 172.9 | 172.9 | 95.0 | 240.0 |
| Cheese (goats') | 3 | 3 | 7.9 | 7.9 | 7.9 | 7.9 | 8.0 | 25.0 |
| Cattle meat | NC | NC | NC | NC | NC | NC | 15.0 | 45.0 |
| Pig meat | NC | NC | NC | NC | NC | NC | 15.0 | 40.0 |
| Sheep meat | 4 | 4 | 23.6 | 11.8 | 17.7 | 23.6 | 8.0 | 25.0 |
| Poultry | 12 | 8 | 8.8 | 3.1 | 6.1 | 8.8 | 10.0 | 30.0 |
| Eggs | 14 | 12 | 17.8 | 8.9 | 14.3 | 17.8 | 8.5 | 25.0 |
| Wild/free foods | 4 | 2 | 3.7 | 3.7 | 3.7 | 3.7 | 7.0 | 25.0 |
| Rabbits/hares | 5 | 3 | 5.3 | 2.0 | 4.2 | 5.3 | 6.0 | 15.0 |
| Honey | 30 | 12 | 6.8 | 2.7 | 4.2 | 6.8 | 2.5 | 9.5 |
| Wild fungi | 7 | 2 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 10.0 |
| Venison | 10 | 2 | 55.8 | 55.8 | 55.8 | 55.8 | ND | ND |
| Cereals | NC | NC | NC | NC | NC | NC | 50 | 100 |
| Freshwater fish | NC | NC | NC | NC | NC | NC | 15.0 | 40.0 |

**Notes**

ND = not determined
NC = not consumed

The percentage contribution each food type makes to its terrestrial food group for adults is presented in Table 32.

***Table 32. Percentage contribution each food type makes to its terrestrial food group for adults***

| | | | | | |
|---|---|---|---|---|---|
| **Green vegetables** | | **Root vegetables** | | **Milk** | |
| **Cabbage** | 23.9 % | Carrot | 26.2 % | ***Goat*** | 100.0 % |
| Cauliflower | 16.9 % | Swede | 14.1 % | **Cheese** | |
| Broccoli | 11.5 % | ***Turnip*** | 10.8 % | Goat | 100.0 % |
| Brussels sprout | 10.0 % | Artichoke | 9.1 % | **Sheep meat** | |
| Artichoke | 6.3 % | Onion | 7.9 % | ***Lamb*** | 100.0 % |
| Lettuce | 6.3 % | Leek | 5.9 % | **Poultry** | |
| Asparagus | 6.1 % | Celery | 5.7 % | Pheasant | 43.3 % |
| Courgettes | 6.0 % | Parsnip | 5.3 % | Duck | 23.3 % |
| Calabrese | 4.3 % | Shallot | 3.8 % | Goose | 18.7 % |
| Kale | 3.7 % | Garlic | 2.6 % | Grouse | 7.6 % |
| Herbs | 1.8 % | Celeriac | 2.2 % | Greylag goose | 4.0 % |
| Cucumber | 1.3 % | Beetroot | 2.1 % | Mallard | 2.0 % |
| Marrow | 1.3 % | Chicory root | 2.0 % | Pigeon | 1.0 % |
| Rocket | 0.7 % | Horseradish | 1.7 % | **Eggs** | |
| **Other vegetables** | | Spring onion | 0.7 % | Chicken egg | 100.0 % |
| Tomato | 54.4 % | **Potato** | | **Wild/free foods** | |
| Runner bean | 17.5 % | ***Potato*** | 100.0 % | Rowanberry | 49.5 % |
| Pea | 10.8 % | **Domestic fruit** | | Hazel nuts | 19.8 % |
| Broad bean | 5.6 % | Blackcurrant | 32.9 % | ***Rosehip*** | 19.8 % |
| Mangetout | 5.6 % | Strawberry | 11.4 % | Elderberry | 10.9 % |
| Sweetcorn | 2.6 % | Apple | 11.0 % | **Rabbits/hares** | |
| Pepper | 1.5 % | Plum | 9.0 % | Rabbit | 100.0 % |
| French bean | 1.4 % | ***Blackberry*** | 8.6 % | **Honey** | |
| Chilli pepper | 0.7 % | Raspberry | 7.6 % | Honey | 100.0 % |
| | | Gooseberry | 7.5 % | **Wild fungi** | |
| | | Grape | 2.4 % | ***Mushrooms*** | 100.0 % |
| | | Cherry | 2.2 % | **Venison** | |
| | | Rhubarb | 2.2 % | ***Venison*** | 100.0 % |
| | | Pear | 1.8 % | | |
| | | Fig | 1.1 % | | |
| | | Redcurrant | 0.7 % | | |
| | | Blueberry | 0.7 % | | |
| | | Orange | 0.7 % | | |

**Notes**

Food types in emboldened italics were monitored by SEPA in 2007 (EA, EHS, FSA and SEPA, 2008). Other foods monitored were beef muscle, beef offal, oats and red berries.

Percentages are based on the consumption of all adults in the survey consuming that particular food group.

***Children's consumption rates***

Consumption rate data were obtained for children in the 15-year-old, 10-year-old and 5-year old age groups. No children in the 1-year and 3-month old age groups were identified consuming foods from the terrestrial survey area.

For the 15-year-old age group, consumption of terrestrial foods was identified in the following seven food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, eggs and honey. No consumption was identified for the following food groups: milk, cattle meat, pig meat, sheep meat, poultry, wild/free foods, rabbits/hares, wild fungi, venison, freshwater fish or cereals.

For the 10-year-old age group, consumption of terrestrial foods was identified in the following two food groups: root vegetables and honey. No consumption was identified for the following food groups: green vegetables, other vegetables, potato, domestic fruit, milk, cattle meat, pig meat, sheep meat, poultry, eggs, wild/free foods, rabbits/hares, wild fungi, venison, freshwater fish or cereals.

For the 5-year-old age group, consumption of terrestrial foods was identified only for honey. No consumption was identified for the following food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, milk, cattle meat, pig meat, sheep meat, poultry, eggs, wild/free foods, rabbits/hares, wild fungi, venison, freshwater fish or cereals.

The consumption rates of green vegetables for the 15-year-old age group are presented in Table 33. The consumption rate for the high-rate group based on the only 15-year-old age group consumer was 9.2 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation.

***Table 33. Children's consumption rates of green vegetables in the Dounreay area (kg $y^{-1}$)***

| Observation number | Age | Asparagus | Broccoli | Brussels sprout | Cabbage | Total |
|---|---|---|---|---|---|---|
| **15-year-old age group** | | | | | | |
| **62** | **16** | **3.1** | **1.6** | **2.2** | **2.2** | **9.2** |

**Notes**
Emboldened observation is the high-rate consumer

The consumption rates of other vegetables for the 15-year-old age group are presented in Table 34. The consumption rate for the high-rate group based on the only 15-year-old age group consumer was 1.1 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation.

***Table 34. Children's consumption rates of other vegetables in the Dounreay area (kg $y^{-1}$)***

| Observation number | Age | Pea | Runner bean | Total |
|---|---|---|---|---|
| **15-year-old age group** | | | | |
| **62** | **16** | **0.6** | **0.6** | **1.1** |

**Notes**
Emboldened observation is the high-rate consumer

The consumption rates of root vegetables for the 15-year-old and 10-year-old age groups are presented in Table 35. The mean consumption rate for the high-rate group based on two 15-year-old age group consumers was 6.4 kg $y^{-1}$. The observed 97.5 percentile rate based on two observations was 7.6 kg $y^{-1}$. The consumption rate for the high-rate group based on the only 10-year-old age group consumer was 5.0 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation.

***Table 35. Children's consumption rates of root vegetables in the Dounreay area (kg $y^{-1}$)***

| Observation number | Age | Carrot | Parsnip | Swede | Total |
|---|---|---|---|---|---|
| **15-year-old age group** | | | | | |
| **62** | **16** | **2.2** | **2.2** | **3.3** | **7.7** |
| **4** | **12** | **-** | **-** | **5.0** | **5.0** |
| **10-year-old age group** | | | | | |
| **3** | **10** | **-** | **-** | **5.0** | **5.0** |

**Notes**
Emboldened observations are the high-rate consumers

The consumption rates of potato for the 15-year-old age group are presented in Table 36. The consumption rate for the high-rate group based on the only 15-year-old age group consumer was 42 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation.

***Table 36. Children's consumption rates of potato in the Dounreay area (kg $y^{-1}$)***

| Observation number | Age | Potato |
|---|---|---|
| **15-year-old age group** | | |
| **62** | **16** | **42.0** |

**Notes**
Emboldened observation is the high-rate consumer

The consumption rates of domestic fruit for the 15-year-old age group are presented in Table 37. The mean consumption rate for the high-rate group based on the only 15-year-old age group consumer was 0.7 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation.

***Table 37. Children's consumption rates of domestic fruit in the Dounreay area (kg $y^{-1}$)***

| Observation Number | Age | Strawberry |
|---|---|---|
| **15-year-old age group** | | |
| **62** | **16** | **0.7** |

**Notes**
Emboldened observation is the high-rate consumer

The consumption rates of eggs for the 15-year-old age group are presented in Table 38. The consumption rate for the high-rate group based on the only 15-year-old age group consumer was 12 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation.

***Table 38. Children's consumption rates of eggs in the Dounreay area (kg $y^{-1}$)***

| Observation number | Age | Chicken egg |
|---|---|---|
| **15-year-old age group** | | |
| **62** | **16** | **11.9** |

**Notes**
Emboldened observation is the high-rate consumer

The consumption rates of honey for the 15-year-old, 10-year-old and 5-year-old age groups are presented in Table 39. The mean consumption rate for the high-rate group based on the two highest 15-year-old age group consumers was 0.8 kg $y^{-1}$. The observed 97.5 percentile rate based on three observations was 1.1 kg $y^{-1}$. The consumption rate for the high-rate group based on the only 10-year-old age group consumer was 1.1 kg $y^{-1}$. The consumption rate for the high-rate group based on the only 5-year-old age group consumer was 1.1 kg $y^{-1}$. The observed 97.5 percentile rate is not applicable for one observation.

***Table 39. Children's consumption rates of honey in the Dounreay area (kg $y^{-1}$)***

| Observation Number | Age | Honey |
|---|---|---|
| **15-year-old age group** | | |
| **13** | **12** | **1.1** |
| **62** | **16** | **0.5** |
| 332 | 15 | 0.2 |
| **10-year-old age group** | | |
| **11** | **7** | **1.1** |
| **5-year-old age group** | | |
| **14** | **2** | **1.1** |

**Notes**
Emboldened observations are the high-rate consumers

A summary of the 15-year-old, 10-year-old and 5-year-old terrestrial consumption rates is presented in Tables 40, 41 and 42 respectively.

For the 15-year-old age group, no mean consumption rates for the high-rate groups exceeded the generic 97.5 percentile rates. Two mean consumption rates for the high-rate groups exceeded the generic mean consumption rates; these were for green vegetables and eggs. No observed 97.5 percentile rates were greater than the generic 97.5 percentile rates. For the 10-year-old age group, no mean consumption rates for the high-rate groups exceeded the generic 97.5 percentile or mean rates. No observed 97.5 percentile rates were greater than the generic 97.5 percentile rates. For the 5-year-old age group, comparisons cannot be made since no generic rates have been determined for this age group.

***Table 40. Summary of consumption rates of terrestrial foods for children in the 15-year-old age group in the Dounreay area (kg $y^{-1}$ or l $y^{-1}$)***

| Food group | Number of observations | Number of high-rate consumers | Observed maximum consumption rate for the high-rate group | Observed minimum consumption rate for the high-rate group | Observed mean consumption rate for the high-rate group | Observed 97.5 percentile consumption rate | Generic mean consumption rate | Generic 97.5 percentile consumption rate |
|---|---|---|---|---|---|---|---|---|
| **Green vegetables** | 1 | 1 | 9.2 | 9.2 | 9.2 | NA | 9.0 | 25.0 |
| **Other vegetables** | 1 | 1 | 1.1 | 1.1 | 1.1 | NA | 10.0 | 30.0 |
| **Root vegetables** | 2 | 2 | 7.7 | 5.0 | 6.4 | 7.6 | 7.5 | 20.0 |
| **Potato** | 1 | 1 | 42.0 | 42.0 | 42.0 | NA | 60.0 | 130.0 |
| **Domestic fruit** | 1 | 1 | 0.7 | 0.7 | 0.7 | NA | 15.0 | 50.0 |
| **Milk (goats')** | NC | NC | NC | NC | NC | NC | 110.0 | 260.0 |
| **Cattle meat** | NC | NC | NC | NC | NC | NC | 15.0 | 35.0 |
| **Pig meat** | NC | NC | NC | NC | NC | NC | 10.0 | 30.0 |
| **Sheep meat** | NC | NC | NC | NC | NC | NC | 5.5 | 15.0 |
| **Poultry** | NC | NC | NC | NC | NC | NC | 6.5 | 20.0 |
| **Eggs** | 1 | 1 | 11.9 | 11.9 | 11.9 | NA | 7.0 | 25.0 |
| **Wild/free foods** | NC | NC | NC | NC | NC | NC | 3.0 | 13.0 |
| **Rabbits/hares** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Honey** | 3 | 2 | 1.1 | 0.5 | 0.8 | 1.1 | 2.0 | 5.0 |
| **Wild fungi** | NC | NC | NC | NC | NC | NC | 2.0 | 5.5 |
| **Venison** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Cereals** | NC | NC | NC | NC | NC | NC | 50 | 95 |
| **Freshwater fish** | NC | NC | NC | NC | NC | NC | 6.5 | 20.0 |

**Notes**
ND = not determined
NC = not consumed
NA = not applicable

***Table 41. Summary of consumption rates of terrestrial foods for children in the 10-year-old age group in the Dounreay area (kg $y^{-1}$ or l $y^{-1}$)***

| Food group | Number of observations | Number of high-rate consumers | Observed maximum consumption rate for the high-rate group | Observed minimum consumption rate for the high-rate group | Observed mean consumption rate for the high-rate group | Observed 97.5 percentile consumption rate | Generic mean consumption rate | Generic 97.5 percentile consumption rate |
|---|---|---|---|---|---|---|---|---|
| **Green vegetables** | NC | NC | NC | NC | NC | NC | 6.0 | 20.0 |
| **Other vegetables** | NC | NC | NC | NC | NC | NC | 8.0 | 25.0 |
| **Root vegetables** | 1 | 1 | 5.0 | 5.0 | 5.0 | NA | 6.0 | 20.0 |
| **Potato** | NC | NC | NC | NC | NC | NC | 45.0 | 85.0 |
| **Domestic fruit** | NC | NC | NC | NC | NC | NC | 15.0 | 50.0 |
| **Milk (goats')** | NC | NC | NC | NC | NC | NC | 110.0 | 240.0 |
| **Cattle meat** | NC | NC | NC | NC | NC | NC | 15.0 | 30.0 |
| **Pig meat** | NC | NC | NC | NC | NC | NC | 8.5 | 25.0 |
| **Sheep meat** | NC | NC | NC | NC | NC | NC | 4.0 | 10.0 |
| **Poultry** | NC | NC | NC | NC | NC | NC | 5.5 | 15.0 |
| **Eggs** | NC | NC | NC | NC | NC | NC | 6.5 | 20.0 |
| **Wild/free foods** | NC | NC | NC | NC | NC | NC | 3.0 | 11.0 |
| **Rabbits/hares** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Honey** | 1 | 1 | 1.1 | 1.1 | 1.1 | NA | 2.0 | 7.5 |
| **Wild fungi** | NC | NC | NC | NC | NC | NC | 1.5 | 4.5 |
| **Venison** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Cereals** | NC | NC | NC | NC | NC | NC | 45 | 75 |
| **Freshwater fish** | NC | NC | NC | NC | NC | NC | 6.0 | 20.0 |

**Notes**

ND = not determined
NC = not consumed
NA = not applicable

***Table 42. Summary of consumption rates of terrestrial foods for children in the 5-year-old age group in the Dounreay area (kg $y^{-1}$ or l $y^{-1}$)***

| Food group | Number of observations | Number of high-rate consumers | Observed maximum consumption rate for the high-rate group | Observed minimum consumption rate for the high-rate group | Observed mean consumption rate for the high-rate group | Observed 97.5 percentile consumption rate | Generic mean consumption rate | Generic 97.5 percentile consumption rate |
|---|---|---|---|---|---|---|---|---|
| **Green vegetables** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Other vegetables** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Root vegetables** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Potato** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Domestic fruit** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Milk (goats')** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Cattle meat** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Pig meat** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Sheep meat** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Poultry** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Eggs** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Wild/free foods** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Rabbits/hares** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Honey** | 1 | 1 | 1.1 | 1.1 | 1.1 | NA | ND | ND |
| **Wild fungi** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Venison** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Cereals** | NC | NC | NC | NC | NC | NC | ND | ND |
| **Freshwater fish** | NC | NC | NC | NC | NC | NC | ND | ND |

**Notes**

ND = not determined

NC = not consumed

NA = not applicable

# 6 DIRECT RADIATION

## 6.1 Direct radiation survey area

The direct radiation survey area, shown in Figure 2, covered all land within 1 km of the Dounreay licensed site boundary. The direct radiation survey area was bisected from the north-east to the south-west by the rocky coastline. The shore comprised shelving rocks and deep clefts and could only be accessed by crossing farm fields. The Dounreay site extended for approximately 2 km along the shoreline and this part of the shore was relatively inaccessible. Commercial fishing, both at sea and from the shore, was prohibited in the survey area due to a 2 km fishing exclusion zone around the site. The land within the direct radiation survey area was agricultural, with the exception of a disused airfield to the east of the site. The survey area was sparsely populated. There were nine residences, four of which were farms and one was unoccupied. The main concentration of houses was to the east of the site at Buldoo.

## 6.2 Occupancy rates and gamma dose rate measurements

Interviews were conducted with seven of the households, three of which were families with children. Indoor, outdoor and total occupancy rates for adults and children are presented in Table 43. All of the occupancy rates obtained were for residents, some of whom also worked in the area. The highest total occupancy rate was 8500 h $y^{-1}$ and the highest outdoor occupancy rate was 2600 h $y^{-1}$, for the same person who lived and worked in the area. The two identical highest indoor occupancy rates were 7100 h $y^{-1}$ for two residents.

It should be noted that the activities of the Dounreay site employees and contractors while at work were not considered in the direct radiation survey. This is because dose criteria applicable to these people whilst at work and the dose assessment methods are different from those for members of the public.

Gamma dose rate measurements taken at residences in the direct radiation survey area are also presented in Table 43. Gamma dose rate measurements were taken both indoors and outdoors at all residences where interviews were conducted. Outdoor measurements were taken approximately 5 to 10 metres from the nearest building. Background gamma dose rate measurements taken at distances further than 5 km from the site centre for comparison are presented in Table 44. All measurements were taken at a height of 1 metre above the substrate. It should be noted that these measurements have not been adjusted for natural background dose rates.

The gamma dose rate measurements taken inside properties ranged from 0.098 µGy $h^{-1}$ to 0.127 µGy $h^{-1}$ and the gamma dose rates measured outside properties over grass ranged from 0.096 µGy $h^{-1}$ to 0.110 µGy $h^{-1}$. The background measurements taken over grass ranged from

0.048 µGy $h^{-1}$ to 0.109 µGy $h^{-1}$. It should be noted that the underlying geology may cause variations in the gamma dose measurement readings. The geology of the areas where measurements were taken during this survey was not investigated. The gamma dose rate measurements were taken at varying times of the day.

***Table 43. Occupancy rates and gamma dose rate measurements in the Dounreay direct radiation survey area***

| Observation number | Sex | Age (years) | Indoor occupancy (h $y^{-1}$) | Outdoor occupancy (h $y^{-1}$) | Total occupancy (h $y^{-1}$) | Gamma dose rate inside the property (µGy $h^{-1}$) | Gamma dose rate outside the property (µGy $h^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Adult observations** | | | | | | | |
| 1 | F | 48 | 5869 | 2639 | 8508 | 0.108 | 0.098 |
| 2 | M | 53 | 5869 | 2379 | 8248 | 0.108 | 0.098 |
| 318 | M | 56 | 6534 | 1330 | 7864 | 0.125 | 0.110 |
| 329 | F | 70 | 6676 | 1008 | 7684 | 0.127 | 0.096 |
| 5 | M | 72 | 7083 | 572 | 7655 | 0.111 | 0.101 |
| 6 | F | 70 | 7083 | 572 | 7655 | 0.111 | 0.101 |
| 319 | F | 53 | 5554 | 1330 | 6884 | 0.125 | 0.110 |
| 300 | M | 79 | 6290 | 398 | 6688 | 0.113 | 0.103 |
| 301 | F | 61 | 6290 | 398 | 6688 | 0.113 | 0.103 |
| 310 | M | 65 | 5274 | 1250 | 6524 | 0.103 | 0.096 |
| 330 | F | 19 | 5784 | 620 | 6404 | 0.127 | 0.096 |
| 331 | M | 18 | 5598 | 620 | 6218 | 0.127 | 0.096 |
| 79 | F | 39 | 5393 | 754 | 6147 | 0.098 | 0.103 |
| 78 | M | 44 | 4776 | 936 | 5712 | 0.098 | 0.103 |
| 333 | F | 34 | 2316 | 156 | 2472 | 0.127 | 0.096 |
| 302 | M | 27 | 480 | 1440 | 1920 | 0.113 | 0.103 |
| **Child observations** | | | | | | | |
| 4 | F | 12 | 5287 | 1820 | 7107 | 0.108 | 0.098 |
| 3 | M | 10 | 5209 | 1820 | 7029 | 0.108 | 0.098 |
| 332 | M | 15 | 5598 | 620 | 6218 | 0.127 | 0.096 |
| 80 | F | 13 | 4516 | 1274 | 5790 | 0.098 | 0.103 |
| 320 | F | 5 | 1024 | 282 | 1306 | 0.125 | 0.110 |
| 321 | M | 4 | 1024 | 282 | 1306 | 0.125 | 0.110 |
| 322 | M | 3 | 1024 | 282 | 1306 | 0.125 | 0.110 |
| 323 | F | 2 | 1024 | 282 | 1306 | 0.125 | 0.110 |

***Table 44. Background gamma dose rates***

| | Location | National Grid Reference | Substrate | Gamma dose rate at 1 metre (µGy $h^{-1}$) |
|---|---|---|---|---|
| Background 1 | Near Broubster | ND 020 627 | Grass | 0.109 |
| Background 2 | Crosskirk | ND 030 699 | Grass | 0.103 |
| Background 3 | Near Strathy | NC 815 649 | Rough grass | 0.052 |
| Background 4 | Near Reay | NC 919 644 | Rough grass | 0.048 |
| | | | Mean background | 0.078 |

## 7 COMBINED PATHWAYS

In determining habits data for the purposes of assessing radiological doses to the public, it may be necessary to consider a combination of pathways. Data are provided in Annex 1 and Annex 2 so that the full effect of combining pathways can be assessed for individual observations, given the concentrations and dose rates for a particular assessment. In some circumstances, it will be possible to make simplifying assumptions and define the consumption and external exposure rates appropriate to a series of potential high-rate groups. Such assumptions will depend on the assessment in question but some initial observations are provided here as a starting point for those undertaking assessments. The most extensive combinations of pathways for adult dose assessment are shown in Table 45. Each of the 19 combinations shown in this table represents an actual individual (or individuals) from Annex 1 who has positive data (irrespective of the magnitude), for each pathway marked with an asterisk. It should be noted that combination numbers in Table 45 do not correlate directly with observation numbers in Annex 1. Other individuals from Annex 1 have combinations that are not listed in Table 45 because they have fewer pathways and a dose assessment for them would be adequately covered by one of the 19 listed combinations. Combinations of pathways using mean rates for the high-rate groups may be achieved by considering the data in Annex 1 and Annex 2.

***Table 45. Combinations of adult pathways for consideration in dose assessments***

| Combination number | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | * | | | | | | | | | | | | | * | | | | | * | * |
| 2 | * | | * | | | | | | | | | | | | * | | | | * | | * | | | | |
| 3 | | * | | * | | * | * | * | | | * | | | | * | | | | * | | | * | | | |
| 4 | * | | | | | | | * | | | | | | | * | | | | * | | | * | * | | |
| 5 | * | | | * | | * | * | * | | * | * | | | | * | * | * | | | | | | | | |
| 6 | | | | | | * | * | | | | * | | | * | | | * | | * | | | | | | |
| 7 | | | | * | * | * | * | * | * | | | | | | * | | | | * | | | | | | |
| 8 | | | | * | | * | * | | | | * | * | | | | | * | | * | | | | | | |
| 9 | * | * | | * | * | * | * | * | | | | * | | | | | | | * | * | | | * | | |
| 10 | * | * | | * | * | * | * | * | | | | * | | | * | | | | * | | | | | | |
| 11 | | | | | | | | | | | | | | | * | | * | | * | | | | | | |
| 12 | | * | | | | | | | | | | | | | | | | | | * | | | * | * | * |
| 13 | * | | | | | | | | | | | | | | | | | * | * | | * | | * | | |
| 14 | | | | | | | | | | | | | | | | | | * | | | | * | | | |
| 15 | * | | | | | | | | | | * | | | * | | * | | | | | | * | | | |
| 16 | | | | | | * | * | | | | * | | | | | | | | | | | | | * | * |
| 17 | | | | * | * | | | | | * | | * | * | | | * | | | | | | | | | |
| 18 | | | | | | | | | | | * | | | | | | | * | * | | | | | * | * |
| 19 | * | * | | | | | | | | | | | | | * | | | | | | | | | * | * |

## 8 COMPARISON WITH THE PREVIOUS SURVEY

The results from this 2008 survey can be compared with results from the last habits survey, undertaken in the Dounreay area in 2003.

***Aquatic survey***

A comparison between the 2003 and 2008 adults' consumption rates of aquatic foods is presented in Table 46. The mean consumption rate for the adult high-rate group decreased for fish and increased significantly for crustaceans and molluscs in 2008 when compared with 2003. The main species of fish consumed by the adult high-rate group in 2003 were cod, haddock, and salmon, and in 2008 were cod, bass, sea trout and mackerel. The main crustacean species consumed by the adult high-rate group in 2003 and 2008 were lobsters and brown crabs. The consumption of velvet swimming crabs was identified in 2008 but not in 2003. The large increase in crustacean consumption was due to one individual, who was newly identified in 2008 and was consuming high rates of crab, lobster and velvet swimming crabs. In 2003, the main species of molluscs consumed by the adult high-rate group were mussels and winkles, and in 2008 the predominant species were winkles and quahog clams. No consumption of wildfowl or marine plants/algae was identified in the 2003 or 2008 surveys,

***Table 46. Comparison between 2003 and 2008 consumption rates of aquatic foods for adults (kg $y^{-1}$)***

| | 2003 | | | 2008 | | |
|---|---|---|---|---|---|---|
| **Food group** | **Number in the high-rate group** | **Maximum consumption rate** | **Mean consumption rate for the high-rate group** | **Number in the high-rate group** | **Maximum consumption rate** | **Mean consumption rate for the high-rate group** |
| **Fish** | 14 | 51.5 | 29.5 | 17 | 29.5 | 18.4 |
| **Crustaceans** | 12 | 14.0 | 8.9 | 3 | 36.6 | 20.9 |
| **Molluscs** | 2 | 0.7 | 0.5 | 2 | 2.7 | 2.1 |

A comparison between the 2003 and 2008 aquatic external exposure pathways for adults and children is presented in Table 47. In 2003, intertidal occupancy was identified over rock, over sand and over sand and stones. In 2008, intertidal occupancy was identified over rock and over sand. Therefore, occupancy over rock and over sand can be compared for the two years. The mean occupancy rate for the high-rate group over rock decreased in 2008. This is because there were two commercial winkle collectors and two salmon net-and-coble fishermen in the high-rate group in 2003 that were not identified in 2008. In 2008, salmon net-and-coble fishing was no longer carried out in the survey area. The mean occupancy rate for the high-rate group over sand increased in 2008 owing to higher times for dog walkers. In 2008, the mean handling rates for the high-rate group for fishing gear increased slightly and for handing sediment decreased significantly compared with 2003. This significant decrease in the mean handling rate for sediment is because two commercial winkle collectors, who were in the high-rate group in 2003, were not identified in 2008.

***Table 47. Comparison between 2003 and 2008 aquatic external exposure pathways (h $y^{-1}$)***

| | 2003 | | | 2008 | | |
|---|---|---|---|---|---|---|
| **Intertidal substrate or handling pathway** | **Number in high-rate group** | **Maximum occupancy or handling rate** | **Mean occupancy or handling rate for the high-rate group** | **Number in high-rate group** | **Maximum occupancy or handling rate** | **Mean occupancy or handling rate for the high-rate group** |
| **Rock** | 4 | 780 | 528 | 1 | 330 | 330 |
| **Sand** | 17 | 468 | 303 | 15 | 913 | 471 |
| **Fishing gear** | 9 | 2040 | 1515 | 10 | 1960 | 1666 |
| **Sediment** | 2 | 780 | 755 | 6 | 55 | 30 |

**Notes**
Fishermen usually wear gloves when fishing with nets or pots, although there are occasions when they take their gloves off. They do not wear gloves when mending creels or nets.

Water based activities were not investigated in 2003, so comparisons cannot be made with the 2008 survey.

***Terrestrial survey***

A comparison between the 2003 and 2008 mean consumption rates for the adult high-rate groups for terrestrial foods in the Dounreay area is presented in Table 48. In 2008, consumption rates had increased in the following food groups; green vegetables, other vegetables, root vegetables, cheese (goats') (not identified in 2003), wild/free foods, wild fungi and venison. Consumption rates had decreased in the following food groups: potato, domestic fruit, milk (goats'), cattle meat (not identified in 2008), sheep meat, poultry, eggs, rabbits/hares, honey and freshwater fish (not identified in 2008). Neither survey identified any consumption of pig meat or cereals.

The food groups showing significant increases in consumption rates in 2008 were cheese (goats'), wild/free foods and wild fungi. The most significant decreases in consumption rates were for domestic fruit, cattle meat, poultry and freshwater fish.

There was a decline in the number of people consuming lamb in 2008 and this was due to an increase in costs associated with sending meat back from the abattoir to the producer. Cattle meat was no longer consumed in 2008 for the same reason. No specific reasons were identified for the other changes in consumption rates.

***Table 48. Comparison between 2003 and 2008 mean consumption rates for the adult high-rate group for terrestrial food groups (kg $y^{-1}$ or l $y^{-1}$)***

| Food group | 2003 | 2008 |
|---|---|---|
| **Green vegetables** | 53.3 | 62.0 |
| **Other vegetables** | 72.8 | 73.6 |
| **Root vegetables** | 68.7 | 78.1 |
| **Potato** | 119.7 | 70.7 |
| **Domestic fruit** | 123.1 | 40.7 |
| **Milk (goats')** | 216.5 | 172.9 |
| **Cheese (goats')** | Not identified | 7.9 |
| **Cattle meat** | 35.4 | Not identified |
| **Sheep meat** | 33.9 | 17.7 |
| **Poultry** | 18.9 | 6.1 |
| **Eggs** | 25.8 | 14.3 |
| **Wild/free foods** | 1.6 | 3.7 |
| **Rabbits/hares** | 4.5 | 4.2 |
| **Honey** | 7.2 | 4.2 |
| **Wild fungi** | 0.8 | 3.0 |
| **Venison** | 42.6 | 55.8 |
| **Freshwater fish** | 0.4 | Not identified |

***Direct radiation survey***

Within the direct radiation survey area, the residences were the same in 2003 and 2008. There were some changes to commercial and leisure activities. In 2008, the Dounreay site visitor centre had closed and the café next to the visitor centre had also closed. In 2003, members of a local club were identified that spent time on the disused runway adjacent to the site, but in 2008 it was reported that the runway was rarely used.

A comparison between the 2003 and 2008 direct radiation occupancy rates is presented in Table 49. The highest total occupancy rate in 2008 was the same in 2003, whereas the highest indoor occupancy rate and the highest outdoor occupancy rate had declined slightly in 2008 compared with 2003. The highest total occupancy rates in 2003 were for two individuals who were living and working in the area. In 2008, the highest total occupancy rate and highest outdoor occupancy rate was for one of these individuals. The highest indoor occupancy rates in 2003 and 2008 were for residents. The highest outdoor occupancy rate in 2003 was for one individual who also worked in the area.

***Table 49. Comparison between 2003 and 2008 direct radiation occupancy rates (h $y^{-1}$)***

| | *2003* | *2008* |
|---|---|---|
| **Highest total** | 8508 | 8508 |
| **Highest indoor** | 8114 | 7083 |
| **Highest outdoor** | 3833 | 2639 |

# 9 MAIN FINDINGS

## 9.1 Survey findings

The survey investigated three potential sources of public radiation exposure from the Dounreay site, which were:

- Discharges of liquid radioactive waste to the Pentland Firth
- Discharges of gaseous radioactive waste to the atmosphere
- Emissions of direct radiation

Data were collected for 358 individuals including commercial fishermen, anglers, people spending time on intertidal substrates, farmers, smallholders, gardeners, beekeepers and people spending time within 1 km of the Dounreay licensed site boundary.

***The aquatic survey area***

The mean consumption rate for the adult high-rate group for the separate aquatic consumption pathways for foods potentially affected by liquid discharges were:

- 18 kg $y^{-1}$ fish
- 21 kg $y^{-1}$ crustaceans
- 2.1 kg $y^{-1}$ molluscs

The predominant foods consumed by the respective adult high-rate groups for these food groups were: cod (*Gadus morhua*), bass (*Dicentrarchus labrax*), sea trout (*Salmo trutta*), mackerel (*Scomber scombrus*); lobsters (*Homarus gammarus*), brown crabs (*Cancer pagurus*); winkles (*Littorina littorea*) and quahog clams (*Arctica islandica*). No consumption of wildfowl or marine plants/algae was identified during the survey.

Two individuals were identified who used seaweed as a fertiliser on land used for growing fruit and vegetables. One individual used *Fucus vesiculosus* collected from Crosskirk Bay and another individual used a single unidentified species collected from Dunnet Bay. Consumption rates of vegetables and fruit grown in soil where seaweed collected from Crosskirk Bay was used as a fertiliser were obtained. No human or livestock consumption of seaweed was identified.

The mean occupancy rates for the high-rate groups over the separate intertidal substrates were:

- 330 h $y^{-1}$ over rock
- 470 h $y^{-1}$ over sand

The mean handling rates for the high-rate groups were:

- 1700 h $y^{-1}$ for handling fishing gear
- 30 h $y^{-1}$ for handling sediment

It should be noted that fishermen usually wear gloves when fishing with nets or pots, although there are occasions when they take their gloves off. They do not wear gloves when mending creels or nets. Bait diggers generally did not wear gloves.

For water-based activities, the maximum occupancy rate in water was 610 h $y^{-1}$ and the maximum occupancy rate on water was 2000 h $y^{-1}$.

The results of the investigations requested by SEPA into specific activities in the aquatic survey area were:

- The main activity occurring at Sandside Bay was dog walking. Other activities included walking, picnicking, sunbathing, angling, surfing, swimming, paddling and snorkelling. The western section of the beach was most frequently used as the main access points to the beach were in this area. The way people were dressed varied with the weather and the activity that they were undertaking.
- No evidence was found of long-lining from the shore at Sandside Bay.
- For commercial fishing catches, it was estimated that 50% of the crustaceans were caught from within a zone extending from 2-10 km from the pipeline outfall and 50% were from a zone extending from 10-20 km zone from the outfall pipe.; 33% of the salmon were caught from the 2-10 km zone and 67% from the 10-20 km zone; 20% of the demersal fish were caught from the 2-10 km zone and 80% from the 10-20 km zone; and 100% of the scallops and winkles were caught from the 10-20 km zone.

***The terrestrial survey area***

The mean consumption rates for the adult high-rate groups for the separate consumption pathways for foods potentially affected by gaseous discharges were:

- 62 kg $y^{-1}$ green vegetables
- 74 kg $y^{-1}$ other vegetables
- 78 kg $y^{-1}$ root vegetables
- 71 kg $y^{-1}$ potato
- 41 kg $y^{-1}$ domestic fruit
- 170 l $y^{-1}$ milk (goats')
- 7.9 kg $y^{-1}$ cheese (goats')
- 18 kg $y^{-1}$ sheep meat
- 6.1 kg $y^{-1}$ poultry
- 14 kg $y^{-1}$ eggs
- 3.7 kg $y^{-1}$ wild/free foods
- 4.2 kg $y^{-1}$ rabbits/hares
- 4.2 kg $y^{-1}$ honey
- 3.0 kg $y^{-1}$ wild fungi
- 56 kg $y^{-1}$ venison

No individuals were identified consuming cattle meat, pig meat, freshwater fish or cereals from the terrestrial survey area.

***The direct radiation survey area***

The highest total and outdoor occupancy rates in the direct radiation survey area were 8500 h $y^{-1}$ and 2600 h $y^{-1}$ respectively, for a resident who worked in the area. The highest identical indoor occupancy rates were 7100 h $y^{-1}$ for two other residents.

## 10 RECOMMENDATIONS

Information collected during the 2008 Dounreay habits survey can be used to make recommendations for changes to the current monitoring programmes.

### 10.1 Current environmental monitoring programmes

The 2007 SEPA aquatic monitoring programme was composed of the following samples and measurements (EA, EHS, FSA and SEPA, 2008).

- Crustaceans: crabs from pipeline inner zone, pipeline, Strathy, Kinlochbervie and Melvich Bay.
- Molluscs: winkles from Brims Ness and Sandside Bay; mussels from Echnaloch Bay and Thurso East Mains.
- Seaweed: *Fucus vesiculosus* from Kinlochbervie, Brims Ness, Sandside Bay and Burwick Pier.
- Sediment from Oigin's Geo, Brims Ness, Sandside Bay and Rennibister.
- Seawater from Brims Ness and Sandside Bay.
- Spume from Oigin's Geo.
- Gamma dose rate measurements: Sandside Bay (sand and winkle bed), Oigin's Geo (spume/sludge), Brims Ness (shingle and stones), Melvich (salt marsh and sand), Strathy (sand), Thurso (riverbank), Achreregan Hill (soil), Thurso Park (soil), Borrowston Mains (soil), east of Dounreay (soil), Castletown Harbour (sand) and Dunnet (sand).
- Beta dose rate measurements: Sandside Bay (sediment), Oigin's Geo (surface sediment), Thurso (riverbank) and Castletown Harbour (surface sediment).

The 2007 SEPA terrestrial monitoring programme was composed of the following samples and measurements (EA, EHS, FSA and SEPA, 2008).

- Beef (muscle and offal), blackberries, cabbage, goats' milk, lamb (muscle), mushrooms, oats, potatoes, red berries, rose hips, turnips, venison.
- Grass and soil.
- Air sampling at Shebster, Reay and Balmore.

### 10.2 Suggestions for changes to the current monitoring programmes

It is considered that SEPA's current monitoring programmes provide adequate coverage. However, based on the findings of this habits survey, the following suggestions are presented for consideration:

- A sample of cod could be added to the aquatic monitoring programme as cod was consumed in large quantities by adults in the high-rate group for fish. No seawater fish species are currently monitored. A quarterly sample of cod is suggested and this could be reduced to a biannual sample if concentrations of radionuclides were found to be low.
- An annual sample of honey could be added to the terrestrial monitoring programme.

- Red berries are currently sampled but no one was identified consuming red berries in the 2008 Dounreay habits survey. Rowanberries are in the same food group and were being collected from an area near Isauld and consumed. Therefore it is recommended that an annual sample of rowanberries should replace the sample of red berries.

It is recommended that all other samples currently monitored remain unchanged.

## 11 ACKNOWLEDGEMENTS

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## 12 REFERENCES


Byrom, J., Robinson, C., Simmonds, J. R., Walters, B., and Taylor, R.R., 1995. Food consumption rates for use in generalised radiological dose assessments. J. Radiol. Prot. Vol. 15 (4) 335-341.

CEC, 1996. Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. Off. J. Eur. Commun., 39 (L159): 1-114.

EA, EHS, FSA and SEPA, 2008. Radioactivity in Food and the Environment, 2007. EA, EHS, FSA and SEPA, Warrington, Belfast, London and Stirling. (12), 242 pp.

FSA, 2002. Assessment Methodology for the Potential Impact on Food of Radioactive Discharges to the Environment. FSA, London.

Good Housekeeping, 1994. Good Housekeeping Cook Book. Ebury Press, London.

Hessayon, D. G., 1997. The New Vegetable & Herb Expert. Expert Books, London.

Hunt, G. J., Hewett, C. J. and Shepherd, J.G., 1982. The identification of critical groups and its application to fish and shellfish consumers in the coastal area of the north-east Irish Sea. Health Physics, Vol. 43, No 6, pp. 875-889.

ICRP, 1991. 1990 Recommendations of the International Commission on Radiological Protection. Annal. ICRP 21 (1-3). Pergamon Press, Oxford, 201 pp. (ICRP Publ. 60.).

ICRP, 1996. Age-dependant doses to members of the public from intake of radionuclides. Annal. ICRP 26 (1). Elsevier Science, Oxford, (ICRP Publ. (72)).

ICRP, 2007. Assessing the dose of the representative person for the purpose of radiological protection of the public and the optimisation of radiological protection. Annal. ICRP 36 (3). Elsevier Science, Oxford, (ICRP Publ. 101.).

Leonard, D. R. P., Hunt, G. J. AND Jones, P. G. W., 1982. Investigations of individual radiation exposures from discharges to the aquatic environment: the technique of habit surveys. pp. 512-517 *In:* 'Proceedings of the Third International Symposium on Radiological Protection - Advances in Theory and Practice', Inverness, 6-11 June 1982, Volume 2. The Society of Radiological Protection.

Macaulay Institute For Soil Research, Land cover of Scotland 1988, (LCS88) 1:50,000 series Sheet 11, Dounreay.

Scottish Executive, 2000. Radioactive Substances (Basic Safety Standards) (Scotland) Direction 2000. Scottish Executive, Edinburgh.

Smith, K.R. and Jones, A.L., 2003. Generalised habit data for radiological assessments. NRPB-W41. NRPB, Chiltern.

Tipple, J.R., McTaggart, K.A., and Clyne, F. J., 2004. Radiological Habits Survey, Dounreay, 2003. Environment Report RL 05/04. SEPA, Stirling.

UK Parliament, 1993. Radioactive Substances Act, 1993. HMSO, London.

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F | 48 | U | - | - | - | - | - | 5.0 | - | - | - | - | - | - | - | - | - | - | - | - | 100 | - | - | - | - | 5869 | 2639 |
| 2 | M | 53 | U | - | - | - | - | - | 5.0 | - | - | - | - | - | - | - | - | - | - | - | - | 100 | - | - | - | - | 5869 | 2379 |
| 5 | M | 72 | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 7083 | 572 |
| 6 | F | 70 | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 7083 | 572 |
| 7 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 125 | - | - | - | - | - | - |
| 10 | M | 39 | U | 8.5 | - | **2.7** | - | - | - | - | - | - | - | - | - | - | - | 1.1 | - | - | - | **437** | - | 18 | - | - | - | - |
| 12 | F | 39 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.1 | - | - | - | - | - | - | - | - | - | - |
| 15 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - | - | - | - | - | - |
| 19 | F | 65 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **2.7** | - | - | - | 294 | - | - | 6 | - | - | - |
| 20 | M | 65 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **2.7** | - | - | - | 294 | - | - | - | 6 | - | - |
| 21 | F | 28 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 19 | - | - | - | - | - | - |
| 22 | M | 51 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 19 | - | - | - | - | - | - |
| 24 | F | 49 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 108 | - | - | - | - | - | - |
| 25 | M | 76 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| 26 | F | 74 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| 28 | M | 71 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 37 | - | - | - | - | - | - |
| 29 | F | 71 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 37 | - | - | - | 4 | - | - |
| 30 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **447** | - | - | - | - | - | - |
| 31 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **2.7** | - | - | - | **447** | - | - | - | - | - | - |
| 32 | F | 41 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 20 | - | - | - | - | - | - |
| 33 | M | 41 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 20 | - | - | - | - | - | - |
| 36 | M | 60 | U | 1.6 | - | - | 5.0 | - | 10.0 | **124.2** | 0.7 | - | **11.8** | **8.8** | - | - | - | **2.7** | 0.5 | 2.9 | - | - | - | - | - | - | - | - |
| 37 | F | 59 | U | 1.6 | - | - | 5.0 | - | 10.0 | **62.0** | 0.7 | - | **11.8** | **8.8** | - | - | - | - | 0.5 | 2.9 | - | - | - | - | - | - | - | - |
| 38 | M | 78 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | - | - | - | - | - | - | - | - | - |
| 39 | F | 72 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | - | - | - | - | - | - | - | - | - |
| 40 | M | 54 | U | - | - | - | - | - | 5.0 | **124.2** | - | - | - | **6.0** | - | - | **5.3** | - | - | **55.8** | - | 12 | - | - | - | - | - | - |
| 41 | F | 53 | U | - | - | - | - | - | 5.0 | **62.0** | - | - | - | **6.0** | - | - | **5.3** | - | - | **55.8** | - | 12 | - | - | - | - | - | - |
| 42 | F | 81 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **3.4** | - | - | - | - | - | - | - | - | - | - |
| 43 | M | U | U | - | 0.4 | - | 2.6 | - | 1.6 | 31.0 | 1.1 | - | - | 0.9 | - | - | - | **3.6** | - | - | - | 21 | - | - | 3 | - | - | - |
| 44 | F | U | U | - | - | - | 2.6 | - | 1.6 | 15.5 | 0.2 | - | - | - | - | - | - | 1.8 | - | - | - | 18 | - | - | 3 | - | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | M | 75 | U | - | - | - | - | - | - | 17.0 | - | - | - | 2.7 | - | - | - | **3.4** | - | - | - | - | - | - | - | - | - | - |
| 46 | F | 68 | U | - | - | - | - | - | - | 17.0 | - | - | - | - | - | - | - | **3.4** | - | - | - | - | - | - | - | - | - | - |
| 47 | F | 61 | U | - | - | - | 8.7 | 6.0 | 6.7 | 26.5 | 17.9 | **180.7** | - | - | - | - | - | - | - | - | - | 71 | - | - | - | - | - | - |
| 48 | F | 34 | U | - | - | - | 8.7 | 6.0 | 6.7 | 26.5 | 17.9 | **180.7** | - | - | - | - | - | 1.1 | - | - | - | - | - | - | - | - | - | - |
| 49 | F | 31 | U | - | - | - | 8.7 | 6.0 | 6.7 | 26.5 | 17.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | M | 62 | U | - | - | - | 8.7 | 6.0 | 6.7 | 39.8 | 17.9 | **180.7** | - | - | - | - | - | 1.1 | - | - | - | 71 | - | - | - | - | - | - |
| 51 | M | 65 | U | - | - | - | - | 6.3 | - | 1.4 | **21.8** | - | - | - | - | - | - | **6.8** | - | - | - | - | - | - | - | - | - | - |
| 52 | F | 65 | U | - | - | - | - | 6.3 | - | 1.4 | **24.5** | - | - | - | - | - | - | **6.8** | - | - | - | - | - | - | - | - | - | - |
| 53 | M | 60 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 70 | - | - | - | - | - | - |
| 54 | F | 58 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 70 | - | - | - | - | - | - |
| 55 | M | U | U | - | - | - | 5.0 | - | 5.0 | **124.0** | - | - | - | **6.5** | **17.8** | - | - | - | - | 10.9 | - | 10 | - | - | - | - | - | - |
| 56 | F | U | U | - | - | - | 5.0 | - | 5.0 | **62.0** | - | - | - | **6.5** | **17.8** | - | - | - | - | 10.9 | - | 10 | - | - | - | - | - | - |
| 57 | M | U | U | - | - | - | 1.4 | 0.0 | 5.7 | 18.1 | 2.7 | - | - | - | - | - | - | 0.2 | - | - | - | 4 | - | - | - | - | - | - |
| 58 | F | U | U | - | - | - | 1.4 | 0.0 | 5.7 | 18.1 | 2.7 | - | - | - | - | - | - | 0.9 | - | - | - | 4 | - | - | - | - | - | - |
| 59 | M | 47 | U | 3.7 | 10.0 | - | 9.2 | 1.1 | 7.7 | **84.0** | 0.7 | - | - | - | **11.9** | - | - | - | - | - | - | **456** | 33 | - | - | 231 | - | - |
| 60 | F | 45 | U | 3.7 | 10.0 | - | 9.2 | 1.1 | 7.7 | **42.0** | 0.7 | - | - | - | **11.9** | - | - | 0.5 | - | - | - | **456** | - | - | - | - | - | - |
| 61 | F | 18 | U | 3.7 | - | - | 9.2 | 1.1 | 7.7 | **42.0** | 0.7 | - | - | - | **11.9** | - | - | 0.5 | - | - | - | - | - | - | - | - | - | - |
| 63 | M | U | U | 0.9 | - | - | - | - | - | - | 11.3 | - | - | - | - | - | - | 0.5 | - | - | - | 184 | - | - | 2 | 4 | - | - |
| 64 | M | U | U | - | - | - | - | - | - | - | 11.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 65 | M | U | U | - | - | - | - | - | - | - | 11.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 66 | M | U | U | - | - | - | - | - | - | - | 11.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 67 | F | U | U | - | - | - | - | - | - | - | 11.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 68 | F | U | U | - | - | - | - | - | - | - | 11.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 69 | M | 23 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - |
| 70 | F | 23 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - |
| 71 | F | 42 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| 74 | M | 50 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | 0.9 | - | **365** | - | - | - | - | - | - |
| 75 | F | 49 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | 0.9 | - | **365** | - | - | - | - | - | - |
| 76 | F | 40 | U | - | - | - | 0.2 | - | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - | - | - | - | - |
| 77 | M | 40 | U | - | - | - | 0.2 | - | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 78 | M | 44 | 0.9 | - | 7.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1560** | - | - | 1560 | 4776 | 936 |
| 79 | F | 39 | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5393 | 754 |
| 81 | M | 22 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 21 | - | - | - | - | - | - | - |
| 82 | M | 22 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 21 | - | - | - | - | - | - | - |
| 83 | M | 21 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 21 | - | - | - | - | - | - | - |
| 84 | M | 52 | U | 5.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 85 | M | 41 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 27 | - | - | - | - | - | - | - |
| 86 | M | 18 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 27 | - | - | - | - | - | - | - |
| 87 | F | 39 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 27 | - | - | - | - | - | - | - |
| 91 | M | 17 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 27 | - | - | - | - | - | - | - |
| 92 | M | 34 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 193 | - | - | - | - | - | - |
| 93 | M | 60 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - | - | - | - | - | - |
| 94 | F | 59 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - | - | - | - | - | - |
| 96 | M | 31 | U | 3.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 16 | 8 | - | - | - | - | - | - |
| 97 | F | 30 | U | 3.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 8 | 4 | - | - | - | - | - | - |
| 100 | M | 54 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18 | - | - | - | - | - | - |
| 101 | F | 53 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18 | - | - | - | - | - | - |
| 102 | F | 38 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 234 | - | - | - | - | - | - |
| 104 | F | 63 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **390** | - | - | - | - | - | - |
| 105 | F | 37 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **390** | - | - | - | - | - | - |
| 106 | M | 66 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 258 | - | - | - | - | - | - |
| 107 | M | 63 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **365** | - | - | - | - | - | - |
| 108 | M | 33 | U | **17.7** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **913** | - | - | 609 | - | - | - |
| 109 | M | 22 | U | 1.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 270 | - | - |
| 111 | M | U | U | 1.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 112 | F | U | U | 1.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 113 | M | 56 | U | 9.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 42 | - | - |
| 114 | F | 55 | U | 9.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 115 | M | 33 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 52 | - | - | - | - | - | - |
| 116 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 117 | - | - | - | - | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 117 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 117 | - | - | - | - | - | - |
| 121 | M | 65 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 122 | M | 63 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 123 | M | 44 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 126 | F | 42 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 127 | F | 31 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 104 | - | - | - | - | - | - |
| 128 | M | 57 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 129 | F | 57 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 130 | F | 21 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 131 | M | 40 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 28 | - | - | - | - | - | - |
| 132 | M | 43 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 15 | - | - | - | - | - | - |
| 133 | M | 34 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18 | - | - | - | 4 | - | - |
| 134 | F | 33 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18 | - | - | - | 4 | - | - |
| 138 | M | 43 | U | 4.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 32 | - | - |
| 144 | F | 29 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 122 | - | - | - | - | - | - |
| 146 | M | 76 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 20 | - | - | - | 4 | - | - | - |
| 149 | F | 70 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 24 | - | - | - | - | - | - | - |
| 150 | M | U | U | **9.9** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 75 | 100 | - | **25** | - | 24 | - | - |
| 151 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 137 | - | - |
| 152 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 137 | - | - |
| 153 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 137 | - | - |
| 154 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 137 | - | - |
| 155 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 137 | - | - |
| 156 | U | U | U | 4.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 157 | U | U | U | 4.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 158 | U | U | U | 4.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 159 | U | U | U | 4.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 160 | U | U | U | 4.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 161 | M | U | U | 7.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 60 | 5 | - | 5 | - | 312 | - | - |
| 162 | F | 60 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **639** | - | - | - | - | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 163 | F | 66 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **639** | - | - | - | - | - | - |
| 164 | M | U | U | 1.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 48 | - | - | - | - | - | - | - |
| 165 | M | 29 | U | 1.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 10 | - | - | 64 | - | - | - |
| 166 | M | 28 | U | 1.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 10 | - | - | - | - | - | - |
| 167 | F | 57 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 274 | - | - | - | - | - | - |
| 168 | M | 70 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 274 | - | - | - | - | - | - |
| 169 | M | 54 | U | 2.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - |
| 170 | F | U | U | 2.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 171 | M | U | U | **17.5** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 39 | 65 | - | **26** | - | - | - | - |
| 172 | M | U | U | **17.5** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 39 | 65 | - | **26** | - | - | - | - |
| 173 | F | 48 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 185 | - | - | - | - | - | - |
| 174 | F | 23 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18 | - | - | - | - | - | - |
| 175 | F | 26 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18 | - | - | - | - | - | - |
| 176 | M | 39 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18 | - | - | - | - | - | - |
| 177 | M | 50 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 40 | - | - | - | - | - | - |
| 178 | F | 34 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 24 | - | - | - | - | - | - |
| 181 | F | 60 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 182 | F | 25 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 11 | 11 | - | - | - | - | - | - |
| 184 | F | 60 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 11 | - | - | - | - | - | - |
| 185 | F | 60 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 11 | - | - | - | - | - | - |
| 186 | M | U | U | 8.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 30 | 56 | - | **26** | - | - | - | - |
| 187 | F | U | U | 8.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 30 | 30 | - | - | - | - | - | - |
| 188 | M | U | U | 8.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 17 | 20 | - | 3 | - | 60 | - | - |
| 189 | M | U | U | 2.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 17 | 18 | - | 2 | - | - | - | - |
| 190 | F | U | U | 8.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 191 | F | U | U | 0.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 192 | F | U | U | 0.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 193 | M | U | U | 7.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **330** | 220 | - | **55** | - | - | - | - |
| 194 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 40 | 53 | - | 13 | - | - | - | - |
| 195 | F | 29 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 197 | F | 55 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 182 | - | - | - | - | - | - |
| 198 | M | 56 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 104 | - | - | - | - | - | - |
| 199 | F | 33 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 104 | - | - | - | - | - | - |
| 201 | M | U | U | **17.9** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 88 | 20 | - | **20** | - | 75 | - | - |
| 202 | F | U | U | **17.9** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 203 | F | 20 | U | **17.9** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 205 | M | 17 | U | **17.9** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 207 | M | U | U | 7.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 66 | - | - | 193 | - | - |
| 208 | F | U | U | 7.4 | 3.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 209 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - | - | - | - | - |
| 210 | F | 27 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - | - | - | - | - |
| 211 | F | 19 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - | - | - | - | - |
| 212 | M | 66 | U | - | - | **1.4** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 182 | - | - | - | - | - | - |
| 213 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 214 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 215 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 216 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 217 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 218 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 219 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 220 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 221 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 222 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 223 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 224 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 225 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 226 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 227 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26 | - | - | - | 156 | - | - |
| 235 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 360 | - | - |
| 236 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 360 | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 237 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 238 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 239 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 240 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 241 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 242 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 243 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 244 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 245 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 246 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 | - | - |
| 247 | M | 60 | U | 7.4 | **13.0** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1960** | - | - | 2000 | - | - |
| 248 | F | 61 | U | 7.4 | **13.0** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 249 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1960** | - | - | 2000 | - | - |
| 250 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1740** | - | - | 1710 | - | - |
| 251 | M | U | U | - | **36.6** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1740** | - | - | 1710 | - | - |
| 252 | M | U | U | **29.5** | 1.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1800** | - | - | 2000 | - | - |
| 253 | F | U | U | **29.5** | 1.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 256 | M | U | U | **28.7** | 4.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1660** | - | - | 1575 | - | - |
| 257 | M | U | U | - | 4.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1614** | - | - | 1170 | - | - |
| 258 | F | U | U | - | 4.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 261 | M | U | U | **14.7** | 3.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 307 | - | - | 261 | - | - |
| 262 | F | U | U | **14.7** | 3.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 263 | M | U | U | - | 3.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 264 | F | U | U | - | 3.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 265 | M | U | U | - | 0.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 266 | F | U | U | - | 0.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 267 | M | U | U | - | 7.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1066** | - | - | 715 | - | - |
| 268 | F | U | U | - | 7.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 269 | M | U | U | 4.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 217 | - | - | 130 | - | - |
| 270 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 217 | - | - | 130 | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 271 | F | U | U | 4.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 272 | M | U | U | 4.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 273 | F | 42 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 213 | - | - | - | - | - | - |
| 276 | F | 54 | U | - | - | - | 0.6 | 3.0 | - | - | 12.6 | - | - | - | - | - | - | - | - | - | - | 39 | - | - | - | - | - | - |
| 277 | F | 21 | U | - | - | - | 0.4 | 2.0 | - | - | 8.4 | - | - | - | - | - | - | - | - | - | - | 39 | - | - | - | - | - | - |
| 278 | F | 61 | U | 3.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 108 | - | - | - | - | - | - |
| 281 | M | 63 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 10 | - | - | - | - | - | - |
| 282 | F | 63 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 10 | - | - | - | - | - | - |
| 283 | F | 65 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 284 | M | 38 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 20 | - | - | - | 5 | - | - |
| 286 | M | 71 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 287 | M | 42 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 42 | - | - | - | 14 | - | - |
| 288 | F | 40 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 42 | - | - | - | 14 | - | - |
| 289 | F | 39 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 42 | - | - | - | 14 | - | - |
| 294 | M | 56 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 78 | - | - | - | - | - | - |
| 295 | F | 60 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 78 | - | - | - | - | - | - |
| 298 | M | 35 | U | **15.1** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 150 | - | - | - | - | - | - |
| 299 | M | 36 | U | **15.1** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 150 | - | - | - | - | - | - |
| 300 | M | 79 | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6290 | 398 |
| 301 | F | 61 | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 48 | - | - | - | - | 6290 | 398 |
| 302 | M | 27 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 480 | 1440 |
| 303 | M | U | U | 3.4 | - | - | - | - | - | - | - | - | - | 1.7 | - | - | **2.0** | - | 0.9 | - | - | - | - | - | 5 | - | - | - |
| 304 | M | U | U | 1.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 305 | F | U | U | 1.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 306 | M | 84 | U | - | - | - | - | 6.0 | 11.3 | 9.1 | 13.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 307 | F | 78 | U | - | - | - | - | 6.0 | 11.3 | 9.1 | 13.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 308 | M | 45 | U | - | - | - | - | 6.0 | 11.3 | 9.1 | 13.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 309 | F | U | U | 3.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 310 | M | 65 | 0.9 | - | - | - | - | - | 11.8 | **45.4** | - | - | - | 0.9 | - | - | - | - | - | - | - | - | - | - | - | - | 5274 | 1250 |
| 311 | M | 59 | U | - | - | - | 1.7 | 14.4 | - | - | - | - | **23.6** | - | **8.9** | 0.9 | - | - | 0.7 | - | - | - | - | - | - | - | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 312 | F | 57 | U | - | - | - | 1.7 | 14.4 | - | - | - | - | **23.6** | - | **8.9** | 0.9 | - | - | 0.7 | - | - | - | - | - | - | - | - | - |
| 313 | M | U | U | - | - | - | 8.8 | - | 16.0 | **47.2** | - | - | - | - | 4.4 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 314 | F | U | U | - | - | - | 8.8 | - | 16.0 | **47.2** | - | - | - | - | 4.4 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 315 | M | 62 | U | - | 4.1 | - | 6.8 | - | 9.1 | 23.6 | 5.7 | - | - | - | **17.8** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 316 | F | 63 | U | - | 1.4 | - | 6.8 | - | 9.1 | 23.6 | - | - | - | - | **17.8** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 317 | M | 87 | U | - | 1.4 | - | 6.8 | - | 9.1 | 23.6 | - | - | - | - | **17.8** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 318 | M | 56 | 0.6 | - | - | - | - | - | - | - | - | - | - | **3.1** | - | - | - | - | - | - | 5 | 3 | - | - | - | - | 6534 | 1330 |
| 319 | F | 53 | 0.6 | - | - | - | - | - | - | - | - | - | - | **3.1** | - | - | - | - | - | - | 5 | 3 | - | - | - | - | 5554 | 1330 |
| 324 | F | 43 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 130 | - | - | - | - | - | - |
| 325 | M | 21 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - |
| 326 | F | 47 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| 327 | F | 49 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **365** | - | - | - | - | - | - |
| 328 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **1560** | - | - | 1560 | - | - |
| 329 | F | 70 | 0.5 | 1.6 | 0.7 | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | - | - | - | - | - | - | - | 6676 | 1008 |
| 330 | F | 19 | 0.5 | 1.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | - | - | - | - | - | - | - | 5784 | 620 |
| 331 | M | 18 | 0.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | - | - | - | - | - | - | - | 5598 | 620 |
| 333 | F | 34 | 0.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.2 | - | - | - | - | - | - | - | - | 2316 | 156 |
| 334 | M | 35 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| 335 | F | 34 | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| 339 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 340 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 341 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 342 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 343 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 344 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 345 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 346 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 347 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 348 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 349 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |

**Annex 1. Adults' consumption rates (kg $y^{-1}$ or l $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site (km) | Fish | Crustaceans | Molluscs | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Milk | Sheep meat | Poultry | Eggs | Wild/free foods | Rabbits/hares | Honey | Wild fungi | Venison | Intertidal occupancy over rock | Intertidal occupancy over sand | Handling fishing gear | Handling sediment | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 350 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 351 | F | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 169 | - | - | - |
| 352 | F | 49 | U | 3.3 | - | - | - | - | 9.7 | **45.5** | - | - | - | - | **14.8** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 353 | M | 59 | U | 3.3 | - | - | - | - | 9.7 | **45.5** | - | - | - | - | **14.8** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 354 | M | U | U | 5.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 40 | - | - | 217 | - | - |
| 355 | M | U | U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 40 | - | - | 217 | - | - |
| 356 | F | U | U | 5.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 357 | M | 73 | U | **15.8** | - | - | **62.0** | **73.6** | **78.1** | **87.3** | **58.2** | - | - | - | - | **3.7** | 0.2 | **6.0** | **3.0** | 2.8 | - | - | - | - | - | - | - | - |
| 358 | F | 65 | U | **15.8** | - | - | **62.0** | **73.6** | **78.1** | **87.3** | **58.2** | - | - | - | - | **3.7** | 0.2 | **6.0** | **3.0** | 2.8 | - | - | - | - | - | - | - | - |

**Notes**

Emboldened observations are the high-rate individuals

U = Unknown

**Annex 2. Children's consumption rates (kg $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site | Fish | Crustaceans | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Eggs | Honey | Intertidal occupancy over rock | Intertidal occupancy over sand | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **15-year-old age group** | | | | | | | | | | | | | | | | | | |
| 4 | F | 12 | U | | | | | **5.0** | | | | | | 100 | | | 5287 | 1820 |
| 8 | M | 12 | U | | | | | | | | | | | | 10 | | | |
| 13 | M | 12 | U | | | | | | | | | **1.1** | | | | | | |
| 16 | F | 14 | U | | | | | | | | | | | 5 | | | | |
| 17 | M | 12 | U | | | | | | | | | | | 5 | | | | |
| 62 | F | 16 | U | 3.7 | | **9.2** | **1.1** | **7.7** | **42.0** | **0.7** | **11.9** | **0.5** | | | | | | |
| 80 | F | 13 | 0.9 | | | | | | | | | | | | | | 4516 | 1274 |
| 88 | F | 15 | U | | | | | | | | | | 27 | | | | | |
| 89 | F | 14 | U | | | | | | | | | | 27 | | | | | |
| 90 | F | 12 | U | | | | | | | | | | 27 | | | | | |
| 103 | F | 15 | U | | | | | | | | | | | **390** | | | | |
| 110 | M | 12 | U | 1.4 | | | | | | | | | | | | 270 | | |
| 118 | F | 13 | U | | | | | | | | | | | 117 | | | | |
| 124 | M | 16 | U | | | | | | | | | | | 12 | | | | |
| 125 | M | 14 | U | | | | | | | | | | | 12 | | | | |
| 139 | M | 16 | U | 4.6 | | | | | | | | | | | | 32 | | |
| 140 | M | 14 | U | 4.6 | | | | | | | | | | | | 32 | | |
| 147 | F | 15 | U | | | | | | | | | | 18 | | 6 | | | |
| 148 | F | 13 | U | | | | | | | | | | 18 | | 6 | | | |
| 204 | F | 12 | U | **17.9** | | | | | | | | | | | | | | |
| 230 | M | 12 | U | | | | | | | | | | | 26 | | 156 | | |
| 231 | M | 13 | U | | | | | | | | | | | 26 | | 156 | | |
| 232 | M | 14 | U | | | | | | | | | | | 26 | | 156 | | |
| 233 | M | 15 | U | | | | | | | | | | | 26 | | 156 | | |
| 234 | M | 16 | U | | | | | | | | | | | 26 | | 156 | | |
| 280 | F | 14 | U | | | | | | | | | | | 84 | | | | |
| 296 | F | 14 | U | | | | | | | | | | | 26 | | | | |
| 332 | M | 15 | 0.5 | | | | | | | | | 0.2 | | | | | 5598 | 620 |
| 337 | F | 13 | U | | | | | | | | | | | 9 | 3 | | | |
| 338 | F | 13 | U | | | | | | | | | | | 9 | 3 | | | |
| **10-year-old age group** | | | | | | | | | | | | | | | | | | |
| 3 | M | 10 | U | | | | | **5.0** | | | | | | 100 | | | 5209 | 1820 |
| 9 | M | 8 | U | | | | | | | | | | | | 10 | | | |
| 11 | M | 7 | U | **8.5** | | | | | | | | **1.1** | | | | | | |
| 18 | M | 7 | U | | | | | | | | | | | 4 | | 1 | | |
| 27 | F | 7 | U | | | | | | | | | | | 2 | | | | |
| 34 | M | 10 | U | | | | | | | | | | | 17 | | 3 | | |
| 72 | M | 10 | U | | | | | | | | | | | 2 | | | | |
| 98 | M | 10 | U | 1.8 | | | | | | | | | 8 | 4 | | | | |
| 99 | F | 8 | U | 1.8 | | | | | | | | | 8 | 4 | | | | |
| 119 | F | 11 | U | | | | | | | | | | | 117 | | | | |
| 135 | F | 8 | U | | | | | | | | | | | 18 | | 4 | | |

**Annex 2. Children's consumption rates (kg $y^{-1}$) and occupancy rates (h $y^{-1}$) in the Dounreay area**

| Observation number | Sex | Age (years) | Distance from site | Fish | Crustaceans | Green vegetables | Other vegetables | Root vegetables | Potato | Domestic fruit | Eggs | Honey | Intertidal occupancy over rock | Intertidal occupancy over sand | Occupancy in water | Occupancy on water | Indoor occupancy within 1 km of the licensed site boundary | Outdoor occupancy within 1 km of the licensed site boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 136 | F | 7 | U | | | | | | | | | | | 18 | | 4 | | |
| 141 | M | 10 | U | 2.3 | | | | | | | | | | | | | | |
| 142 | F | 10 | U | **4.6** | | | | | | | | | | | | | | |
| 143 | M | 8 | U | 2.3 | | | | | | | | | | | | | | |
| 145 | M | 9 | U | | | | | | | | | | | 41 | | | | |
| 179 | F | 8 | U | | | | | | | | | | | 24 | | | | |
| 200 | F | 11 | U | | | | | | | | | | | 104 | | | | |
| 206 | M | 9 | U | **9.0** | | | | | | | | | 25 | | | | | |
| 228 | F | 10 | U | | | | | | | | | | | 26 | | 156 | | |
| 229 | M | 11 | U | | | | | | | | | | | 26 | | 156 | | |
| 259 | M | 8 | U | | **2.0** | | | | | | | | | | | | | |
| 274 | M | 8 | U | | | | | | | | | | | 213 | | | | |
| 275 | M | 11 | U | | | | | | | | | | | 213 | | | | |
| 279 | F | 11 | U | | | | | | | | | | | 84 | | | | |
| 290 | M | 11 | U | | | | | | | | | | | 42 | | 14 | | |
| 336 | M | 10 | U | | | | | | | | | | | 2 | | 1 | | |
| **5-year-old age group** | | | | | | | | | | | | | | | | | | |
| 14 | M | 2.5 | U | | | | | | | | | **1.1** | | | | | | |
| 23 | M | 2 | U | | | | | | | | | | | 19 | | 2 | | |
| 35 | M | 6 | U | | | | | | | | | | | 17 | | 3 | | |
| 73 | M | 6 | U | | | | | | | | | | | 2 | | | | |
| 95 | F | 3 | U | | | | | | | | | | | 5 | | | | |
| 120 | M | 2 | U | | | | | | | | | | | 117 | | | | |
| 137 | M | 5 | U | | | | | | | | | | | 18 | | 4 | | |
| 180 | F | 4 | U | | | | | | | | | | | 24 | | | | |
| 183 | M | 3 | U | | | | | | | | | | 11 | 11 | | | | |
| 196 | F | 6 | U | | | | | | | | | | | 2 | | | | |
| 254 | F | 3 | U | **5.9** | **0.8** | | | | | | | | | | | | | |
| 260 | M | 4 | U | | **1.0** | | | | | | | | | | | | | |
| 285 | F | 3 | U | | | | | | | | | | | 20 | | 5 | | |
| 291 | M | 3 | U | | | | | | | | | | | 42 | | 14 | | |
| 292 | M | 2 | U | | | | | | | | | | | 42 | | 14 | | |
| 293 | F | 4 | U | | | | | | | | | | | 42 | | 14 | | |
| 297 | F | 6 | U | | | | | | | | | | | 26 | | | | |
| 320 | F | 5 | 0.6 | | | | | | | | | | | | | | 1024 | 282 |
| 321 | M | 4 | U | | | | | | | | | | | | | | 1024 | 282 |
| 322 | M | 3 | U | | | | | | | | | | | | | | 1024 | 282 |
| 323 | F | 2 | U | | | | | | | | | | | | | | 1024 | 282 |
| **3-month-old age group** | | | | | | | | | | | | | | | | | | |
| 255 | M | 0.5 | U | **0.5** | **0.1** | | | | | | | | | | | | | |

**Notes**

U=Unknown

Emboldened observations are the high-rate individuals

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