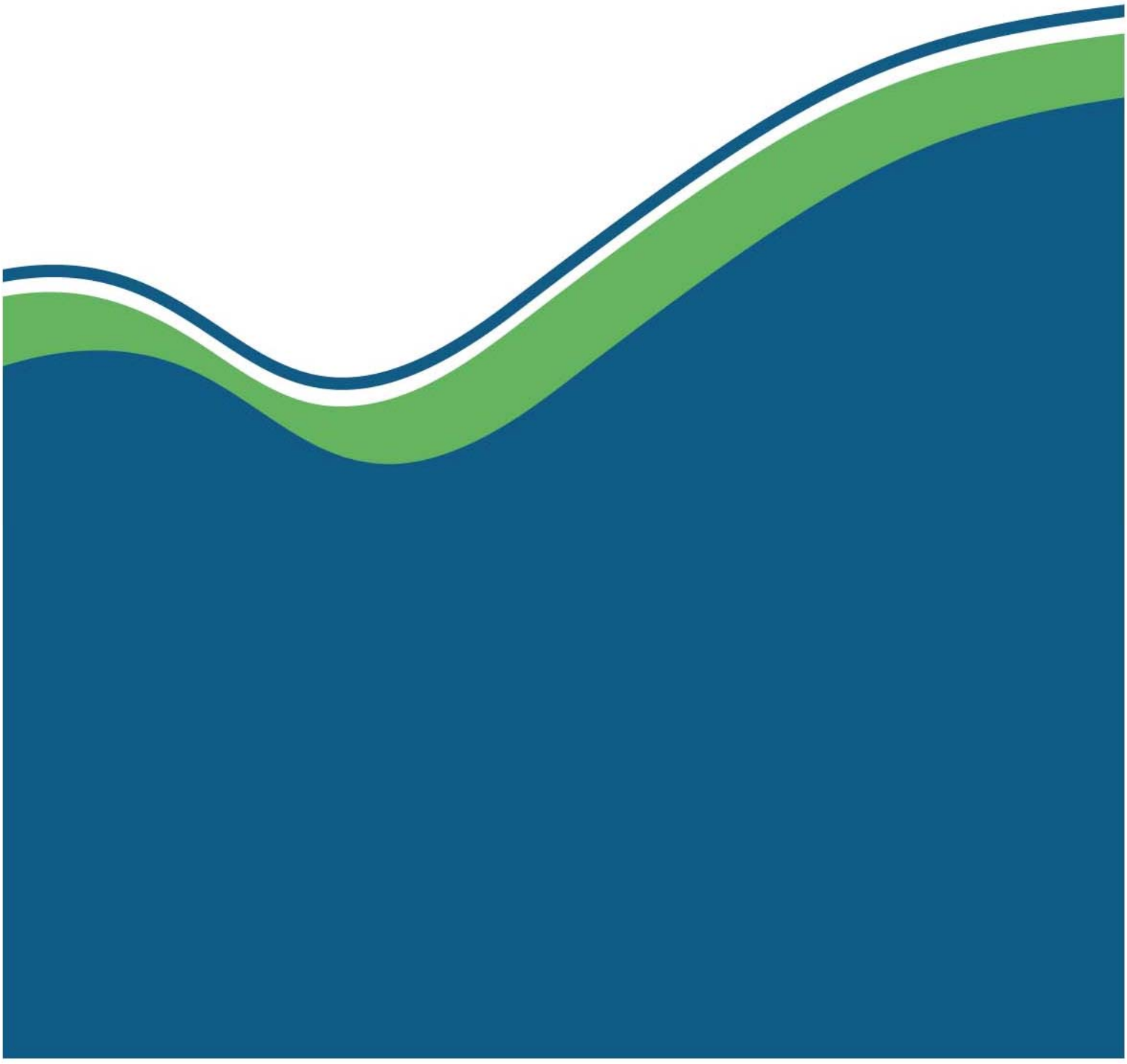
Radiological Habits Survey: Hunterston, 2007



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Radiological Habits Survey: Hunterston, 2007

FINAL REPORT

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SUMMARY

This report presents the results of a survey conducted in 2007 to determine the habits and consumption patterns of people living, working and undertaking recreational activities in the vicinity of the Hunterston nuclear site. There are two separate nuclear power stations at Hunterston, the 'A' station and the 'B' station, and tor the purpose of this survey they were considered together as one site. The site is authorised to discharge gaseous radioactive wastes via stacks to the atmosphere and liquid radioactive wastes via an outfall to the Firth of Clyde. The site also contains sources of direct radiation.

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 eastern side of the Firth of Clyde, including Fairlie Roads and the coastline between Saltcoats and Wemyss Bay. The coastline of Great Cumbrae Island was also included.
- The terrestrial survey area; extending 5 km from the Hunterston site centre (National Grid Reference NS 183 514).
- The direct radiation survey area; extending 1 km from the Hunterston site centre.

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 site centre.

Interviews were conducted with members of the public and the data collected for 277 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 critical group and 97.5 percentiles. The rates so identified can be used in dose assessments.

Aquatic survey area

The main commercial fishing methods identified in the survey area were trawling for *Nephrops* and creeling for *Nephrops,* lobsters, squat lobsters and crabs. It was reported that some commercial diving for razor shells also took place. The commercial collection of winkles was noted at various locations throughout the survey area, particularly at Saltcoats, Hunterston Sands and Seamill. There was a Pacific oyster farm located near Fairlie.

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

- 47 kg y^{-1} for fish (comprising mackerel, haddock, pollack, saithe, cod, whiting and other species, caught by anglers and by trawlers)

- 18 kg y^{-1} for crustaceans (comprising squat lobster, *Nephrops* and lobster, caught by commercial fishermen using creels and trawls)
- 21 kg y^{-1} for molluscs (comprising king scallops, mussels, razor shells, winkles and Manila clams, collected by divers and by non-commercial shellfish collectors, and Pacific oysters from a commercial oyster farm)

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

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

- For fish, 66% mackerel, 8.4% whiting, 6% haddock, 3.5% cod, 3.3% pollack, 2.9% saithe, 1.5% conger eel and 8.4% mixed fish species
- For crustaceans, 51% squat lobster, 40% *Nephrops* and 9% lobster
- For molluscs, 74.5% king scallops, 11.3% Pacific oysters, 6.4% razor shells, 4.3% mussels, 3.2% winkles and 0.3% manila clams

No consumption of seaweed by humans or livestock was identified. In the past, farmers had been identified using seaweed as a fertiliser, particularly for growing potatoes, but it was reported that this practice had ceased several years ago.

Intertidal activities identified for adults or children included angling, bait digging, mollusc collection, dog walking, walking, playing, metal detecting, oyster farming and working on the shore.

The critical group mean occupancy rates for intertidal substrates were:

- 56 h y^{-1} over mud (for two oyster farmers near Fairlie)
- 93 h y^{-1} over mud and sand (for one person metal detecting at Fairlie Sands and two people bait digging at Fairlie Sands, Ardrossan north beach and Hunterston Sands)
- 300 h y^{-1} over mud and stones (for one person bait digging at Saltcoats Harbour)
- 270 h y^{-1} over rock (for five people who were angling at various locations, at Portencross and at Saltcoats, and/or winkle collecting at Saltcoats, Hunterston Sands, Seamill and Ardrossan)
- 440 h y^{-1} over sand (for five people all dog walking at Ardrossan)
- 300 h y^{-1} over sand and stones (for one person collecting winkles at Saltcoats and for one person dog walking at Seamill beach)

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 nets. Bait diggers and shellfish collectors were identified handling sediment. The critical group mean handling rates were:

- 1200 h y^{-1} for handling fishing gear (for six commercial creel fishermen)
- 440 h y^{-1} for handling sediment (for two winkle collectors at Saltcoats, Seamill and Hunterston Sands, and a bait digger at Saltcoats Harbour)

Activities taking place in the survey area in the water around Hunterston included sub-aqua diving, swimming, kayaking and windsurfing. Activities on the water in the survey area were commercial fishing, sailing and travelling to and from diving locations. The maximum occupancy rate in water was 650 h y^{-1} for six people who were kayaking to the east of Great Cumbrae Island. The maximum occupancy rate on water was 1600 h y^{-1} for two commercial fishermen who were trawling around the Cumbraes and for two commercial fishermen who were creeling along the Fairlie Roads.

The terrestrial survey area

Farmers in the area produced beef, lamb and milk. Arable crops were also grown for animal feed. Three beekeepers were identified who kept hives within the survey area. Residents grew fruit and vegetables on a small scale and several households kept chickens. Small quantities of wild foods and game including mushrooms, blackberries, raspberries, elderberries, rabbit, hare, pheasant, and grouse were consumed. Brown trout and rainbow trout from a stocked trout lake were consumed.

In the terrestrial area, the consumption of foods from 15 food groups was identified. The critical group mean consumption rates for these food groups were:

- 16 kg y^{-1} for green vegetables
- 23 kg y^{-1} for other vegetables
- 75 kg y^{-1} for root vegetables
- 68 kg y^{-1} for potatoes
- 41 kg y^{-1} for domestic fruit
- 310 l y^{-1} for milk
- 58 kg y^{-1} for cattle meat
- 8.5 kg y^{-1} for sheep meat
- 51 kg y^{-1} for poultry
- 19 kg y^{-1} for eggs
- 4.5 kg y^{-1} for wild/free foods
- 12.4 kg y^{-1} for rabbits/hares
- 10.8 kg y^{-1} for honey
- 0.6 kg y^{-1} for wild fungi
- 24 kg y^{-1} for freshwater fish

No consumption of pig meat, venison or cereals from the survey area was identified.

The direct radiation survey area

The direct radiation survey area was sparsely populated and occupancy rates were obtained for 18 individuals. The only commercial activity noted to occur was farming.

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

- 8400 h y^{-1} for the total occupancy rate (for a resident)
- 7200 h y^{-1} for the indoor occupancy rate (for the same resident with the highest total occupancy rate)
- 3400 h y^{-1} for the outdoor occupancy rate (for two residents with identical occupancy rates who also worked in the area)

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 Hunterston site centre.

Comparisons with the previous survey

The results of the 2007 Hunterston habits survey were compared with the results of last habits survey undertaken at Hunterston in 2001. In the aquatic survey area, the adult critical group mean consumption rates had increased for fish and molluscs and had decreased for crustaceans in 2007 when compared to the 2001 results. The critical group mean occupancy rate over rock was similar in 2001 and 2007, and there was a significant increase in the critical group mean occupancy rate over sand and over sand and stones in 2007 compared with 2001. In 2007, the critical group mean handling rate for fishing gear increased and for sediment decreased, compared with 2001. In the terrestrial survey area, the critical group mean consumption rates increased in 2007 for the following food groups: root vegetables, cattle meat, poultry, wild/free foods, rabbits/hares and freshwater fish. There were decreases in the critical group mean consumption rates in the following food groups: green vegetables, other vegetables, potato, domestic fruit, milk, sheep meat, eggs, honey, wild fungi and venison (nil in 2007). Neither survey identified any consumption of pig meat or cereals. In the direct radiation survey area, the highest total occupancy rate, the highest indoor occupancy rate and the highest outdoor occupancy rate all decreased in 2007 when compared with 2001.

Suggestions for changes to the monitoring programmes

Based on the findings of this habits survey, it is considered that SEPA's current monitoring programmes provide adequate coverage for both the aquatic and terrestrial environment and no changes to these programmes are required.

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 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 critical group concept

Radiological protection of the public is based on the concept of a critical group. The critical group is defined as the people who, because of where they live and their habits, receive the highest radiation dose from the site and its discharges. It is the assessed radiation dose to the critical group that is compared to relevant limits and constraints. If the dose to the critical group is acceptable, it follows that the lower doses received by other members of the public will be below any limits and constraints, and overall protection of the public from the effects of the radioactivity is provided. This survey provides information to assist SEPA in determining critical groups around the Hunterston site.

1.3 Dose limits and constraints

Assessed radiation doses to critical groups are compared to nationally and internationally recommended dose limits, recommendations 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 the latter, 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 International Commission on Radiological Protection (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 and 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 the effects of liquid discharges, atmospheric discharges and direct radiation from the routine activities undertaken at the Hunterston 'A' and 'B' nuclear power stations. For the purpose of this survey the 'A' and the 'B' power stations were considered together as one site. The habits data are used in combination with monitoring data to determine the critical group(s) and identify critical exposure pathways to the local population. The previous full habits survey of the Hunterston area was carried out by Cefas in 2001 (Sherlock, Tipple and McTaggart, 2002). The information and data from the 2001 survey are currently being used for dose assessments around Hunterston.

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 site centre
- Any new or unusual exposure pathways

2.2 Site activity

Hunterston 'A' is operated by Magnox Electric Ltd. on behalf of the Nuclear Decommissioning Authority (NDA). The station was powered by twin Magnox reactors and ceased electricity production in March 1990. It is currently being decommissioned. Hunterston 'B' is owned and operated by British Energy. The station is powered by a pair of Advanced Gas-cooled Reactors (AGRs). It is estimated that Hunterston 'B' will cease electricity production in 2016. Gaseous radioactive wastes are released via separate stacks to the environment from Hunterston 'A' and Hunterston 'B'. Liquid radioactive wastes from both power stations are released into the Firth of Clyde via one outfall. Discharges are made under authorisation from SEPA.

2.3 Survey areas

Following discussions with SEPA, three survey areas were defined to cover the aquatic, terrestrial and direct radiation pathways.

The aquatic survey area, shown in Figure 1, covered the eastern side of the Firth of Clyde, including Fairlie Roads and the coastline between Saltcoats and Wemyss Bay. The coastline of Great Cumbrae Island was also included but the coastline of Little Cumbrae Island was excluded as the island was uninhabited and access was difficult.

The terrestrial survey area, shown in Figure 2, covered all land within 5 km of the Hunterston site centre (National Grid Reference NS 183 514).

The direct radiation survey, also shown in Figure 2, was defined as all land and sea within 1 km of the Hunterston site centre.

2.4 Conduct of the survey

The fieldwork component of the survey was carried out during the period 27th June to 11th July 2007 by three members of staff from the Cefas Laboratory at Lowestoft, according to techniques as described by Leonard *et al* (1982).

People with a local knowledge of the survey areas were contacted for information on any aspects relevant to the exposure pathways. Interviews were used to establish individuals' consumption, occupancy and handling rates relevant to all pathways and to obtain any general information of possible use to the survey. Using this information, a list of activities was built up to produce a representation of potential exposure pathways. Emphasis was placed on those individuals who were likely to be in the most exposed groups. These included commercial fishermen, anglers, bait diggers, farmers, and individuals living and/or working within the direct radiation survey area.

Gamma dose rate measurements were taken over intertidal substrates and were also taken indoors and outdoors at most of the properties in the direct radiation survey area. For comparison, background readings were taken at distances further than 5 km from the Hunterston site centre.

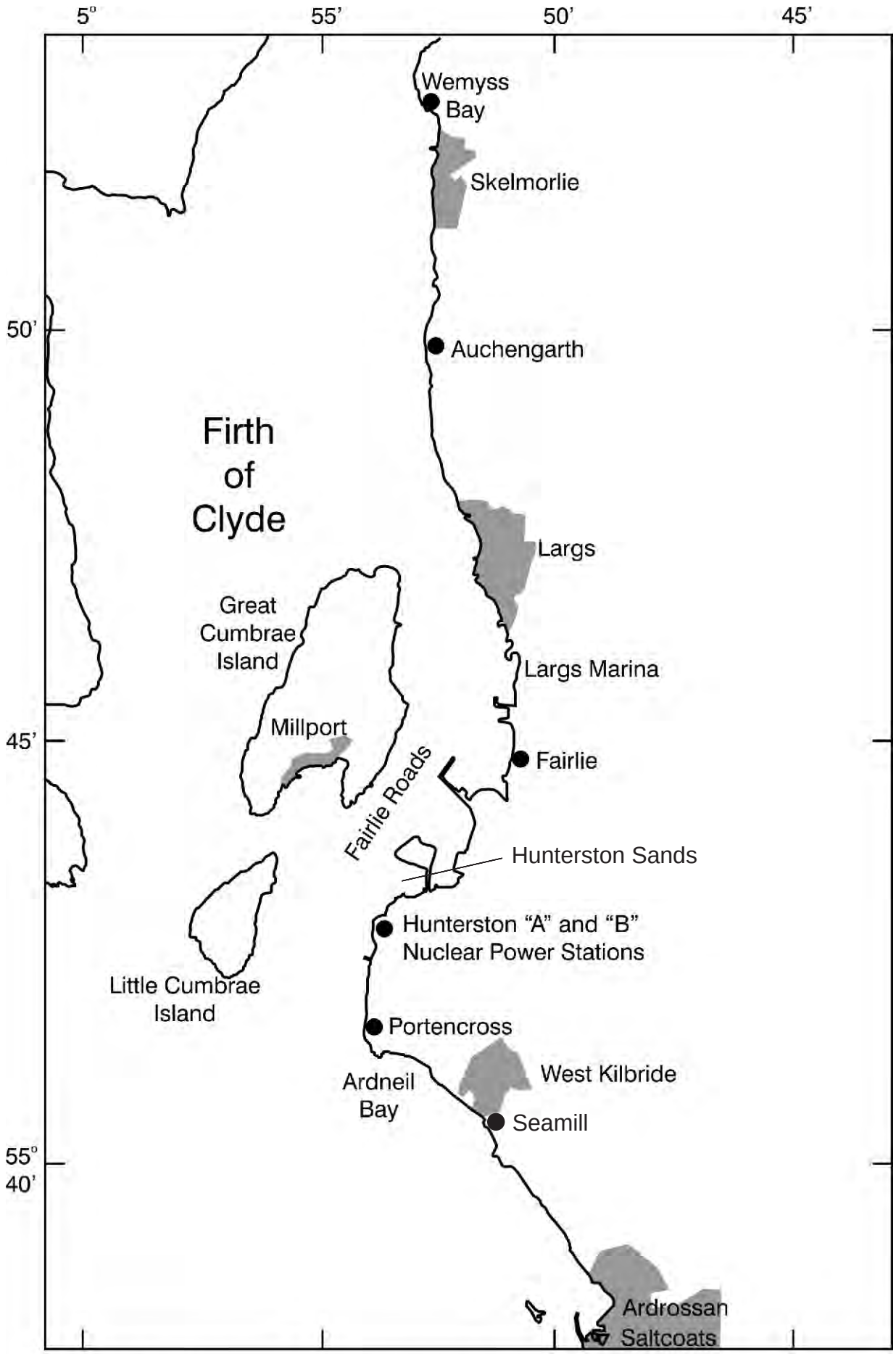

Figure 1. The Hunterston aquatic survey area.

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

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 critical 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 critical 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. This data was 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'. The typical food groups used in habits surveys are shown in Table 1. For external exposure over intertidal sediments, occupancies over the same substrate, such as sand, are grouped together.

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, grape, greengage, huckleberry, loganberry, melon, nectarine, peach, pear, plum, pumpkin, raspberry, redcurrant, rhubarb, rowan berry, strawberry, tayberry, whitecurrant
Milk	Cows' milk, goats' milk, cream, yoghurt
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, rowan berry, 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

[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 Data analysis

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 'critical group' is used to represent the individuals derived by the cut-off method. The critical group mean 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 single person in the critical group. In these cases, expert judgement was used to decide whether the critical 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 and all observations above this were included in the critical 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, critical group mean rates 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 critical 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

The aquatic survey area, shown in Figure 1, covered the eastern side of the Firth of Clyde, including Fairlie Roads and the coastline between Saltcoats and Wemyss Bay. The coastline of Great Cumbrae Island was also included. The shore mainly consisted of sandy beaches interspersed with areas of rock. There was easy access to the shore along almost the whole stretch of the aquatic survey area, including on Great Cumbrae, with many lay-bys and car parks. As a result, the shore was very popular with walkers, anglers and visitors to the area.

Saltcoats to Seamill

Saltcoats and the adjoining town of Ardrossan were located at the southernmost part of the survey area. Both towns had small harbours, which were popular locations for anglers who were also bait digging at low water, and sandy beaches, which were regularly used by walkers, dog walkers, winkle collectors and sunbathers. Hovercraft rides were available to members of the public from Ardrossan beach. The shore between Ardrossan and Seamill was rocky and no activities were observed. There was a mixture of sandy beaches and rocky prominences in the Seamill area. The beach at Seamill was popular with walkers and it was reported that this location was popular for commercial winkle collection.

Seamill to Fairlie

Adjacent to Seamill was West Kilbride beach, and further north was Ardneil Bay. The beaches at these locations were sandy. West Kilbride was used regularly by dog walkers and Ardneil Bay was used by families playing on the beach, dog walkers and anglers. Just north of Ardneil Bay was Portencross, a small hamlet, where a concrete pier was a popular fishing location for anglers. Adults and children were observed walking and playing on the beach and over the rocks near Portencross Castle. Portencross Harbour was a natural, rocky harbour where four boats were moored. North of Portencross was Hunterston Sands, which was located in front of the Hunterston site. The beach was a mixture of sand and mud interspersed with large rocks and boulders. This location was frequently visited by bait diggers and commercial winkle collectors. Other activities observed at this location were walking and horse riding. North of Hunterston Sands, access to the shore was restricted around an industrialised area, where a disused construction yard and a coal unloading terminal were located. North of the industrial area was Fairlie Sands which was also a mud and sand shore. Activities identified in this area included metal detecting and bait digging. A Pacific oyster (*Crassostrea gigas*) farm was located in the Fairlie area.

Fairlie to Auchengarth

North of Fairlie was the popular seaside resort of Largs. Largs had a large marina with approximately 700 members, a sailing school and a scuba diving school. The marina was also a popular starting point for divers heading off to dive around the Cumbrae islands. The sandy beaches at Largs were popular in the summer months and were used by the large numbers of tourists that visited each year. Between Largs and Auchengarth the coastline was predominantly large rocks with small areas of sand and stones. Angling was popular from some of the rocks that were near to the parking areas off the A78(T) road, which follows this length of coastline as far as Wemyss Bay.

Auchengarth to Wemyss Bay

The shoreline between Auchengarth and Wemyss Bay was a mixture of large rocks and areas of sand and stones. Not many intertidal activities were noted except for occasional walkers and dog walkers. At Wemyss Bay the rocky sandstone shoreline was another popular angling location because of the easy access and parking. Wemyss Bay was also a popular area for scuba divers as there was a wreck just offshore and there was easy access to the water.

Great Cumbrae Island

The coastline around Great Cumbrae Island had an approximate circumference of 16 km. Scotland's National Water Sports Centre was located on the north-east coast of the island and the University Marine Biological Station (UMBS) was located near Millport. Staff from both establishments spent time on the shore, both instructing students and maintaining equipment. There was also a coastguard station at Millport. The sandy beaches at Millport were popular with locals and tourists. Great Cumbrae Island was a popular location for visiting parties of sport divers because whichever direction the wind was blowing, sheltered water was always available on one side of the island. Anglers fished at Millport Harbour and several rocky areas around the coastline.

4.2 Commercial fisheries

Although the Clyde was a busy fishing area, most of the commercial fishing took place further down the Firth, outside the survey area, and relatively little fishing took place within the confined waters of the survey area.

The main commercial fishing methods identified in the survey area were trawling and creeling. The trawlers were targeting *Nephrops* and had a by-catch of fin fish. The creel fishermen caught *Nephrops,* lobsters, squat lobsters (Galatheidae) and crabs. The boats that were fishing in the survey area operated from Millport (on Great Cumbrae Island), Rothesay (on the Island of Bute), Ardrossan and Largs. It was reported that some commercial diving for razor shells also took place.

The commercial collection of winkles (*Littorina littorea*) was noted at various locations throughout the survey area, particularly at Saltcoats, Hunterston Sands and Seamill. There was a Pacific oyster farm located near Fairlie.

4.3 Seafood wholesalers and retailers

Approximately 90% of the crustaceans caught commercially in the survey area were sold through Troon market and were exported to Spain, Italy and France. Winkles were also exported to Spain and France. Pacific oysters were sold locally, throughout the UK and to the Far East. A popular local seafood restaurant sold *Nephrops,* lobsters and squat lobsters caught by commercial fishermen from within the survey area. No fishmongers in Largs or Millport sold seafood from the survey area.

4.4 Angling and non-commercial shellfish collecting

Angling was popular along most of foreshore of the survey area. The coastal stretches from Wemyss Bay to Largs and from Portencross to Ardrossan were the favoured areas. It was reported that angling also occurred on Great Cumbrae Island, on the foreshore adjacent to the UMBS, at Millport and at Farland Point.

Divers were collecting a variety of shellfish including scallops, lobsters and crabs for their own consumption. A small amount of mussels were collected from Ardrossan north beach and a small amount of winkles were collected from Ardrossan north beach and Saltcoats Harbour for consumption.

4.5 Wildfowling

There were no wildfowling areas in the survey area.

4.6 The use of seaweed

No consumption of seaweed by humans or livestock was identified. In the past, farmers had been identified using seaweed as a fertiliser, particularly for growing potatoes, but it was reported that this practice had ceased several years ago.

4.7 Internal exposure

Adults' consumption rates

The main consumers of seafood from the Hunterston area were commercial fishermen, anglers, sub-aqua divers and their families. No consumption of wildfowl or marine plants/algae was identified during the survey.

Adults' consumption rates of fish are presented in Table 3. The main species of fish consumed by adults were mackerel (*Scomber scombus*), haddock (*Melanogrammus aeglefinus*), pollack (*Pollachius pollachius*), saithe (*Pollachius virens*), cod (*Gadus morhua*) and whiting (*Merlangius merlangus*). A critical group of 10 individuals was identified with a maximum consumption rate of 67 kg y^{-1} and a mean of 47 kg y^{-1}. The observed 97.5 percentile rate based on 56 observations was 64 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 critical group consisted of 66% mackerel, 8.4% whiting, 6% haddock, 3.5% cod, 3.3% pollack, 2.9% saithe, 1.5% conger eel and 8.4% mixed fish species.

Adults' consumption rates of crustaceans are presented in Table 4. The main species of crustaceans consumed by adults were squat lobster, *Nephrops* and lobster. A critical group of four individuals was identified with a maximum consumption rate of 28 kg y^{-1} and a mean of 18 kg y^{-1}. The observed 97.5 percentile rate based on 30 observations was 20 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 critical group consisted of 51% squat lobster, 40% *Nephrops* and 9% lobster.

Adults' consumption rates of molluscs are presented in Table 5. The main species of molluscs consumed by adults were king scallop (*Pecten maximus*), mussel (*Mytilus edulis*), Pacific oysters, razor shells (*Ensis siliqua*), and winkles. A critical group of six individuals was identified with a maximum consumption rate of 24 kg y^{-1} and a mean of 21 kg y^{-1}. The observed 97.5 percentile rate based on 37 observations was 24 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 critical group consisted of 74.5% king scallop, 11.3% Pacific oyster, 6.4% razor shell 4.3% mussel 3.2% winkle and 0.3% Manila clam (*Tapes philippinarum*).

Table 3 Adults' consumption rates of fish from the Hunterston area (kg y^{-1})

Observation number	Cod	Dab	Conger eel	Haddock	Mackerel	Plaice	Pollack	Saithe	Mixed fish	Whiting	Total
197					**34.6**		**11.2**	**10.3**		**10.3**	**66.5**
253					**47.6**				**16.3**		**63.9**
254					**47.6**				**16.3**		**63.9**
173	**11.8**				**35.4**						**47.2**
107-108				**22.1**						**22.1**	**44.2**
256	**1.8**		**6.0**		**28.4**		**1.7**	**1.0**			**38.9**
266-267					**34.6**						**34.6**
36					**28.8**						**28.8**
47-48	5.9			11.8							17.7
198-199					11.1		1.4			1.3	13.8
148-149					13.6						13.6
46	7.8			4.7							12.5
193					10.4						10.4
77							10.3				10.3
123-126					8.6						8.6
109-113					6.9						6.9
248-250	0.7		1.2		4.2						6.1
257-260					5.2		0.6				5.8
262-263					4.6						4.6
111					3.5						3.5
114					3.5						3.5
202-203					3.5						3.5
102-103					3.1						3.1
212					3.0						3.0
54-55					1.4		1.4				2.8
56-57					2.8						2.8
264-265		0.2			2.1	0.3					2.5
204-205					0.8						0.8
41-42				0.7							0.7
182					0.5						0.5
246									0.5		0.5
184		0.2									0.2

Notes

Emboldened observations are the critical group consumers

Table 4 Adults' consumption rates of crustaceans from the Hunterston area (kg y^{-1})

Observation number	Crab	Lobster	*Nephrops*	Squat lobster	Total
145			**7.9**	**19.8**	**27.7**
200		**5.2**	**11.8**		**17.0**
146-147			**3.5**	**9.9**	**13.3**
76-77				8.8	8.8
117-120	4.1	3.2			7.3
107-108		0.5	6.3		6.9
148-149			2.6	2.6	5.2
212			5.0		5.0
253-254	1.0	2.2	1.6		4.8
248-250	0.6	0.2	3.9		4.7
142-144	0.8	1.3			2.1
47-48			0.7	0.7	1.4
104		0.6	0.4		1.0
129-130		0.6			0.6
14-15				0.3	0.3

Notes
Emboldened observations are the critical group consumers

Table 5 Adults' consumption rates of molluscs from the Hunterston area (kg y^{-1})

Observation number	Manila clam	King scallop	Mussel	Pacific oyster	Queen scallop	Razor shell	Winkle	Total
117-120		**18.0**		**3.6**		**2.0**		**23.6**
200	**0.4**	**22.5**						**22.9**
256			**5.4**				**4.1**	**9.5**
73-75		5.4						5.4
104				2.4				2.4
142-144		1.7						1.7
248, 250		0.6	0.2	0.5		0.2		1.4
244			0.7				0.7	1.4
129-130						1.3		1.3
249		0.6	0.2			0.2		1.0
6-11					0.7			0.7
14-15			0.6					0.6
268-277							0.3	0.3

Notes
Emboldened observations are the critical group consumers

A summary of adults' consumption rates of aquatic foods in the Hunterston area is presented in Table 6.

Table 6 Summary of adults' consumption rates of aquatic foods (kg y^{-1})

Food group	Number of observations	Number of observations in the critical group	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed critical group mean consumption rate	Observed 97.5 percentile consumption rate	Generic mean consumption rate	Generic 97.5 percentile consumption rate
Fish	56	10	66.5	28.8	46.7	63.9	15.0	40.0
Crustaceans	30	4	27.7	13.3	17.8	19.9	3.5	10.0
Molluscs	37	6	23.6	9.5	21.1	23.6	3.5	10.0

Children's consumption rates

Children in the 15-year-old and 10-year-old age groups were identified consuming aquatic foods. No children in the 5-year-old, 1-year-old and 3-month-old age groups were noted to be consuming fish, crustaceans or molluscs from the survey area. No children in the 10-year-old age group were consuming molluscs and no children in any age group were consuming 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 7.

The main species of fish consumed by the 15-year-old age group were haddock, cod and mackerel. A critical group of five individuals was identified with a maximum consumption rate of 18 kg y^{-1} and a mean of 10 kg y^{-1}. The observed 97.5 percentile rate based on 15 observations was 15 kg y^{-1}. This compares with the generic mean and 97.5 percentile consumption rates for fish of 6.5 kg y^{-1} and 20 kg y^{-1} respectively. The percentage breakdown of fish species consumed by the critical group consisted of 50% haddock, 28% cod, 17% mackerel and 5% conger eel.

The only species of fish consumed by the 10-year-old age group was haddock. One individual was identified with a consumption rate of 0.7 kg y^{-1}. This compares with the generic mean and 97.5 percentile consumption rates for fish of 6.0 kg y^{-1} and 20 kg y^{-1} respectively. The observed 97.5 percentile rate is not applicable for 1 observation.

Table 7 Children's consumption rates of fish from the Hunterston area (kg y^{-1})

Observation number	Age	Cod	Conger eel	Haddock	Mackerel	Total
15-year-old age group						
49	**15**	**5.9**		**11.8**		**17.7**
50	**15**	**2.9**		**5.9**		**8.8**
51	**12**	**2.9**		**5.9**		**8.8**
251	**16**	**0.7**	**1.2**		**4.2**	**6.1**
252	**12**	**0.7**	**1.2**		**4.2**	**6.1**
261	15				4.6	4.6
115	16				3.5	3.5
116	14				3.5	3.5
195	15				1.0	1.0
194	14				1.0	1.0
196	14				1.0	1.0
206	12				0.8	0.8
43	14			0.7		0.7
44	12			0.7		0.7
183	12				0.2	0.2
10-year-old age group						
45	**9**			**0.7**		**0.7**

Notes
Emboldened observations are the critical group consumers

Crustaceans

Children's consumption rates of crustaceans are presented in Table 8.

The main species of crustaceans consumed by the 15-year-old age group were *Nephrops* and squat lobster. A critical group of three individuals with identical consumption rates was identified with a maximum consumption rate of 1.4 kg y^{-1} and a mean of 1.4 kg y^{-1}. The observed 97.5 percentile rate based on five observations was 1.4 kg y^{-1}. This compares with the generic mean and 97.5 percentile consumption rates for crustaceans of 2.5 kg y^{-1} and 6.0 kg y^{-1} respectively. The percentage breakdown of crustacean species consumed by the critical group consisted of 50% *Nephrops* and 50% squat lobster.

The only species of crustacean consumed by the 10-year-old age group was *Nephrops.* One individual was identified with a consumption rate of 12 kg y^{-1}. This compares with the generic mean and 97.5 percentile consumption rates for crustaceans of 2.5 kg y^{-1} and 7.0 kg y^{-1}, respectively. The observed 97.5 percentile rate is not applicable for 1 observation.

Table 8 Children's consumption rates of crustaceans from the Hunterston area (kg y^{-1})

Observation number	Age	Lobster	*Nephrops*	Squat lobster	Total
15-year-old age group					
49	**15**		**0.7**	**0.7**	**1.4**
50	**15**		**0.7**	**0.7**	**1.4**
51	**12**		**0.7**	**0.7**	**1.4**
251	16	0.2			0.2
252	12	0.2			0.2
10-year-old age group					
201	**7**		**11.8**		**11.8**

Notes
Emboldened observations are the critical group consumers

Molluscs

Children's consumption rates of molluscs are presented in Table 9. The only species of mollusc consumed by the 15-year-old age group was mussels. One individual was identified with a consumption rate of 0.2 kg y^{-1}. The generic mean and 97.5 percentile consumption rates for molluscs for this age group are 2.5 kg y^{-1} and 6.0 kg y^{-1} respectively. The observed 97.5 percentile rate is not applicable for 1 observation.

Table 9 Children's consumption rates of molluscs from the Hunterston area (kg y^{-1})

Observation number	Age	Mussel
15-year-old age group		
251	**16**	**0.2**

Notes
Emboldened observation is the critical group consumer

A summary of the children's aquatic consumption rates is presented in Table 10.

Table 10 Summary of children's consumption rates of aquatic foods (kg y^{-1})

Food group	Number of observations	Number of observations in the critical group	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed critical group mean consumption rate	Observed 97.5 percentile consumption rate	Generic mean consumption rate	Generic 97.5 percentile consumption rate
15-year-old age group								
Fish	15	5	17.7	6.1	9.5	14.6	6.5	20.0
Crustaceans	5	3	1.4	1.4	1.4	1.4	2.5	6.0
Molluscs	1	1	0.2	0.2	0.2	NA	2.5	6.0
10-year-old age group								
Fish	1	1	0.7	0.7	0.7	NA	6.0	20.0
Crustaceans	1	1	11.8	11.8	11.8	NA	2.5	7.0
Molluscs	NC	NC	NC	NC	NC	NC	2.5	7.0

Notes
NC = not consumed
NA = not applicable

4.8 External exposure

Intertidal occupancy

External exposure from artificial radiation to members of the public who frequent intertidal areas depends on the occupancy time and dose rate after subtraction of an appropriate value for natural background radiation. Dose rates over mud and salt marsh can be higher than those over coarser substrates due to fine grain size and consequent ability to adsorb more radioactivity. Consequently, occupancy times over these substrates are considered to be radiologically more important than similar times over other substrates. Estimates of natural backgrounds used by Cefas for assessing doses to individuals (EA, EHS, FSA and SEPA, 2007) are 0.05 µGy h^{-1} for sandy substrates, 0.07 µGy h^{-1} for mud and salt marsh and 0.06 µGy h^{-1} for all other substrates.

Occupancy rates were recorded over the following six substrates: mud; mud and sand; mud and stones; rock; sand; and sand and stones. Intertidal activities observed during the survey included angling, bait digging, oyster farming, collecting winkles and mussels, playing, walking, dog walking, working on the shore and metal detecting. The intertidal occupancy rates, grouped by the substrates, are presented in Table 11.

For mud, the maximum rate was 56 h y^{-1} and the critical group mean rate was 56 h y^{-1} for two individuals, both oyster farmers. The observed 97.5 percentile rate based on 2 observations for mud was 56 h y^{-1}. For mud and sand, the maximum rate was 150 h y^{-1} and the critical group mean rate was 93 h y^{-1} for two bait diggers and an individual who was metal detecting. The observed 97.5 percentile rate based on 3 observations for mud and sand was 150 h y^{-1}. For mud and stones, the only observation was 300 h y^{-1} for an individual who was bait digging. The observed 97.5 percentile rate is not applicable for 1 observation. For rock, the maximum rate was 350 h y^{-1} and the critical group mean rate was 270 h y^{-1} for five individuals, who were either collecting winkles or shore angling, or undertaking both activities. The observed 97.5 percentile rate based on 15 observations for rock was 350 h y^{-1}. For sand, the maximum rate was 730 h y^{-1} and the critical group mean rate was 440 h y^{-1} for five individuals, all dog walkers. The observed 97.5 percentile rate based on 18 observations for sand was 570 h y^{-1}. For sand and stones, the maximum rate was 350 h y^{-1} and the mean rate was 300 h y^{-1} for a winkle collector and a dog walker. The observed 97.5 percentile rate based on 5 observations for sand and stones was 340 h y^{-1}.

Table 11 Intertidal occupancy rates in the Hunterston area (h y^{-1})

Observation number	Location	Activity	Mud	Mud and sand	Mud and stones	Rock	Sand	Sand and stones
105-106	**Fairlie**	**Oyster farming**	**56**					
264	**Ardrossan north beach and Hunterston Sands**	**Bait digging**		**150**				
	Various locations	**Angling**				**150**	150	
121	**Fairlie Sands**	**Bait digging**		**78**				
122	**Fairlie Sands**	**Metal detecting**		**52**				
266	**Saltcoats Harbour**	**Bait digging**			**300**			
255	**Saltcoats**	**Collecting winkles**				**350**		**350**
244	**Portencross and Saltcoats**	**Angling**				**351**		
	Saltcoats and Hunterston Sands	**Collecting winkles**						
	Saltcoats and Hunterston Sands	Collecting winkles					39	
20	**Seamill, Hunterston Sands and Ardrossan**	**Collecting winkles**				**312**		
253	**Various locations**	**Angling**				**200**		
109-111	Wemyss Bay	Angling				90		
56	Wemyss Bay	Angling				80		
229-230	Southern end of Great Cumbrae Island	Working on the shore				50		50
252	Portencross and Ardneil Bay	Playing, angling				40	100	
251	Portencross and Ardneil Bay	Playing				40	40	
54	Wemyss Bay	Angling				30		
268	Saltcoats Harbour	Collecting winkles				10		
177	**Ardrossan south beach**	**Dog walking**					**730**	
129	**Ardrossan**	**Dog walking**					**365**	
187	**Ardrossan south beach**	**Dog walking**					**365**	
191-192	**Ardrossan south beach**	**Dog walking**					**365**	
188-190	Ardrossan south beach	Dog walking					183	
186	Ardrossan south beach	Dog walking					78	
178	West Kilbride beach	Dog walking					50	
179-181	West Kilbride beach	Dog walking					24	
36	Saltcoats	Bait digging					8	
1	**Seamill beach**	**Dog walking**						**242**
256	Ardrossan north beach	Walking and collecting mussels and winkles						88

Notes
Emboldened observations are the critical group members

Gamma dose rate measurements were taken at selected locations, shown in Table 12, to supplement those of SEPA's scheduled monitoring programme. These data (where comparison can be made) are consistent to those reported by SEPA (EA, EHS, FSA and SEPA, 2007).

Table 12 Gamma dose rate measurements over intertidal substrates in the Hunterston area (µGy h^{-1})

Location	National Grid Reference	Substrate	Gamma dose rate at 1 metre[a]
Saltcoats Harbour	NS 246 410	Mud and stones	0.066
Saltcoats Harbour	NS 244 410	Stones	0.075
Ardrossan beach	NS 238 418	Sand	0.053
Adrossan beach	NS 225 429	Sand	0.058
South of Seamill	NS 209 455	Rock	0.057
Seamill beach	NS 198 472	Sand	0.054
Seamill beach	NS 194 476	Rock	0.062
Ardneil Bay	NS 185 485	Sand	0.044
Portencross	NS 175 491	Rock	0.073
Hunterston Sands	NS 185 525	Sand	0.053
Fairlie oyster beds	NS 198 541	Mud and sand	0.065
Fairlie Sands	NS 205 543	Mud and sand	0.062
Millport Bay	NS 165 548	Sand	0.054

Notes

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

Handling

Handling sediment while bait digging or mollusc collecting can potentially give rise to skin exposure from beta radiation. This needs consideration even though the annual dose limit for skin is a factor of 50 times higher than that for effective dose. There is also a contribution to effective dose due to skin exposure (ICRP, 1991). Table 13 presents the handling rates of fishing gear and sediment.

For handling fishing gear, the maximum rate was 1600 h y^{-1} and the critical group mean rate was 1200 h y^{-1} for six commercial creel fishermen. The observed 97.5 percentile rate based on 17 observations for fishing gear was 1600 h y^{-1}. For handling sediment, the maximum rate was 700 h y^{-1}.and the critical group mean rate was 440 h y^{-1} for a bait digger and two winkle collectors. The observed 97.5 percentile rate based on 10 observations for sediment was 613 h y^{-1}.

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 13 Handling rates of fishing gear and sediment in the Hunterston area (h y^{-1})

Observation number	Location	Activity	Fishing gear	Sediment
107-108	**Fairlie Roads**	**Creeling**	**1600**	
145-146	**Fairlie Roads**	**Creeling**	**1400**	
76-77	**Fairlie Roads**	**Creeling**	**726**	
148	Fairlie Roads	Creeling	468	
47	Fairlie Roads	Trawling	396	
41	Fairlie Roads	Trawling	360	
18-19	Off the Cumbraes	Trawling	266	
231-235	Hunterston area	Trawling	250	
16	Off the Cumbraes	Creeling	80	
255	**Saltcoats**	**Collecting winkles**		**700**
20	**Seamill, Saltcoats and Hunterston Sands**	**Collecting winkles**		**312**
266	**Saltcoats Harbour**	**Bait digging**		**300**
264	Ardrossan north beach and Hunterston sands	Bait digging		150
121	Fairlie Sands	Bait digging		78
244	Saltcoats and Hunterston Sands	Collecting winkles		78
105	Fairlie	Oyster farming		56
106	Fairlie	Oyster farming		56
268	Saltcoats Harbour	Collecting winkles		10
36	Saltcoats	Bait digging		8

Notes
Emboldened observations are the critical group members

4.9 Water based activities

Activities taking place in or on the water can 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, in order to allow for their assessment, relevant data have been collected. 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 or on seawater in the survey area are shown in Table 14. No further manipulation of the data (for example, calculating critical group mean rates) has been carried out.

Activities in and on the water

Activities in the water in the survey area included sub-aqua diving, swimming, kayaking and windsurfing. Activities on the water in the survey area included commercial fishing, sailing and travelling to and from diving locations.

Table 14 Occupancy rates in and on water in the Hunterston area (h y^{-1})

Observation number	Location	Activity	In water	On water
78 -83	East of Great Cumbrae Island	Kayaking/sailing	650	650
84-101	East of Great Cumbrae Island	Kayaking/sailing	460	460
160-169	Fairlie Roads	Kayaking	182	
142	Fairlie Roads	Diving/sailing	150	516
200	Fairlie Roads	Diving/on dive boat	150	28
102	East of Great Cumbrae Island	Windsurfing	150	
52-53	Fairlie Roads	Diving/on dive boat	100	144
127-128	Fairlie Roads	Diving/on dive boat	96	480
229-230	Off south Great Cumbrae Island and off east Little Cumbrae Island	Diving/on dive boat	88	100
33	Fairlie Roads	Kayaking	72	
68-73	Fairlie Roads	Diving/on dive boat	38	300
6-11	Off Great Cumbrae Island/Fairlie Roads	Diving/on dive boat	20	192
213-214	Fairlie Roads	Swimming, windsurfing/sailing	20	20
129-130	Fairlie Roads	Diving/on dive boat	18	72
251-252	Ardneil Bay/Fairlie Roads	Swimming/sailing	10	600
5	Fairlie Sands	Swimming	10	
58-63	Fairlie Roads	Diving/on dive boat	6	40
132-141	Fairlie Roads	Diving/on dive boat	3	16
64-67	Fairlie Roads	Diving/on dive boat	3	15
18-19	Around the Cumbraes	Trawling		1600
107-108	Fairlie Roads	Potting		1600
145-146	Fairlie Roads	Potting		1400
231-235	Fairlie Roads	Trawling		1063
76-77	Fairlie Roads	Potting		726
248-249	Fairlie Roads	Sailing		700
16	Around the Cumbraes	Potting		640
250	Fairlie Roads	Sailing		600
148	Fairlie Roads	Potting		468
131	Ardrossan beach	On dive boat		437
47	Fairlie Roads	Trawling		396
41	Fairlie Roads	Trawling		360
150-159	Fairlie Roads	Sailing		270
185	Saltcoats	Push netting		1

5 TERRESTRIAL RADIATION PATHWAYS

5.1 Terrestrial survey area and local produce

The terrestrial survey area, shown in Figure 2, covered the area up to 5 km from the centre of the Hunterston site (National Grid Reference NS 183 514). Interviews were conducted at 13 working farms in the survey area, one of which was located on Great Cumbrae Island. No food production was identified on Little Cumbrae Island. Three of the 13 farms were dairy, one of which also produced beef and sheep. Six farms produced beef and lamb, one produced beef, lamb and potatoes, one produced beef, and two produced sheep. Most of the farmers grew winter feed (including grass, turnips, barley, wheat and oats) for their livestock. The dairy farmers sold milk produced on their farms to First Milk. Most of the beef cattle and lambs were sold at Ayr and Stirling markets. Most of the potatoes were sold to a large supermarket chain. Three farms supplied beef and lamb to a local butcher and one farm supplied potatoes to two local shops. Most of the farmers kept small amounts of their produce for their household's consumption. At several farms, livestock were supplied with spring water and had access to streams.

There was one new allotment site in the survey area but this was its first year and the allotment holders had not yet consumed any fruit or vegetables from the site. However, several residents were interviewed that grew a variety of fruit and vegetables in their gardens. Several households kept chickens, and large quantities of chicken and chicken eggs were consumed. Three beekeepers were interviewed that had hives in the area. The honey production from these hives was 180 kg y^{-1} from a total of 19 hives, 45 kg y^{-1} from a total of five hives, and 15 kg y^{-1} from a total of four hives. The honey was sold locally or consumed by the beekeepers and their family and friends. It was reported that there were another three beekeepers with hives in the area but the survey team were unable to contact them.

The collection of wild foods from within the survey area by individuals was limited but the consumption of small amounts of mushrooms, blackberries, raspberries and elderberries was identified. The consumption of garden snails, noted in the previous survey, was not identified on this survey. Small amounts of locally caught rabbit, hare, pheasant, pigeon and grouse were consumed. Freshwater fish (brown trout and rainbow trout) from a stocked trout lake were consumed; no freshwater molluscs or crustaceans were consumed. No households were noted to use spring, well or stream water for human consumption.

5.2 Unusual pathways

Unusual pathways such as peat cutting and the consumption of unusual foods were investigated during the survey but none were found.

5.3 Land cover

Figure 3 shows the land cover in the terrestrial survey area. The figure is reproduced from a land cover map published by Macaulay Land Use Research Institute (Macaulay Institute, 1988), with their consent. On the mainland, a large proportion of the survey area was arable land and there were areas of heather moor to the east and smooth grassland to the north. The main urban area was West Kilbride which was located to the south of the survey area. The southern part of Great Cumbrae Island was within the survey area and the land was arable and heather moor. The town of Millport was located in this area. Little Cumbrae Island was predominantly smooth grassland.

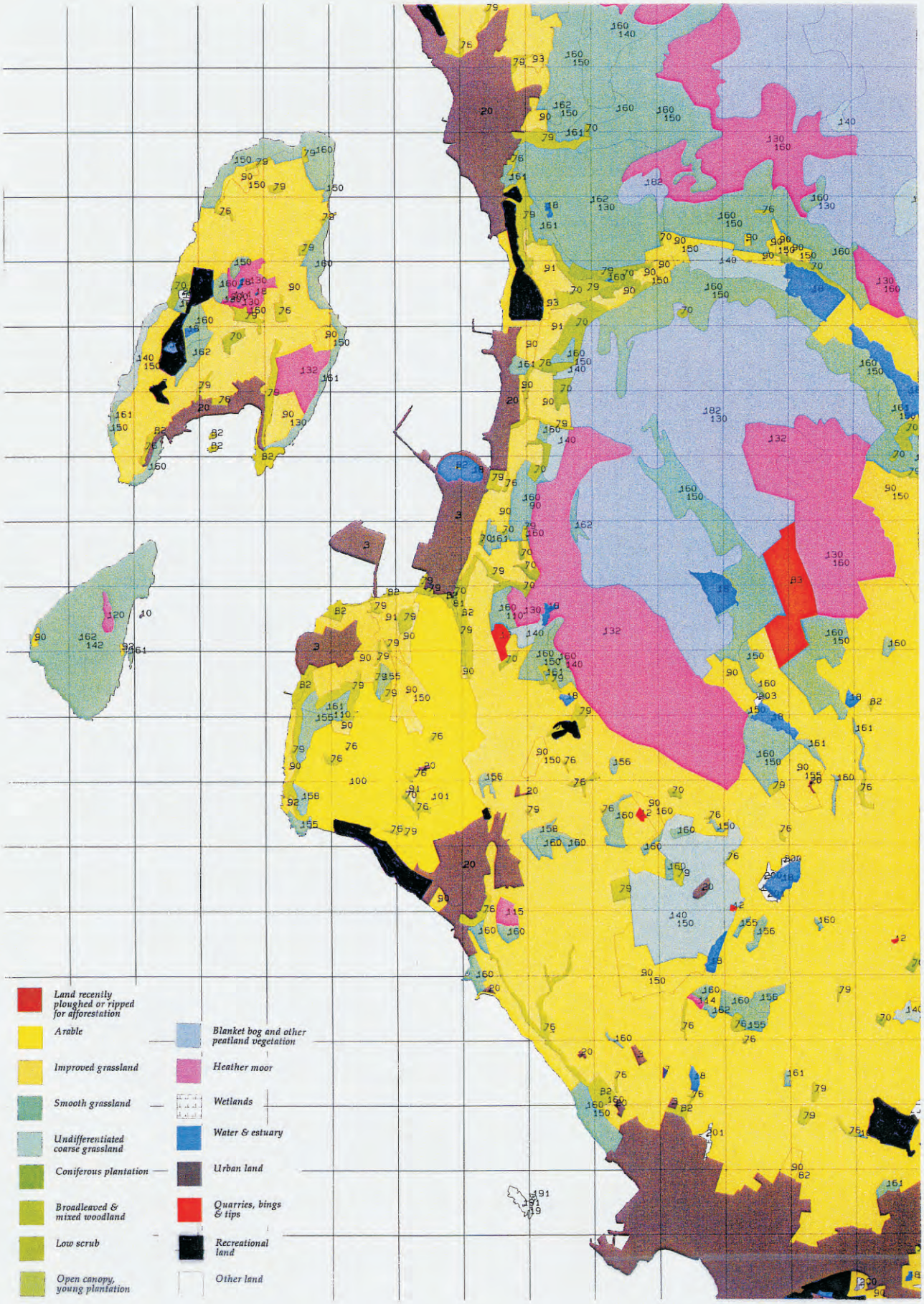

Figure 3. Land cover around Hunterston .

Number codes on the figure relate to point and line features not shown in the key.
Reproduced with the permission of the Macaulay Institute for Soil Research, Aberdeen.
Base Scale is 1:50000

5.4 Internal exposure

Adults' consumption rates

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

Five critical group mean consumption rates exceeded the generic 97.5 percentile rates; these were for root vegetables, milk, cattle meat, poultry and honey. A further eight critical group mean consumption rates exceeded their generic means; these were for green vegetables, other vegetables, potato, domestic fruit, sheep meat, eggs, rabbits/hares and freshwater fish. Two critical group mean consumption rates were less than the generic means; these were for wild/free foods and wild fungi. The observed 97.5 percentile consumption rates for root vegetables, milk, cattle meat, poultry, eggs and honey exceeded the generic 97.5 percentile consumption rates.

Adults' consumption rates of green vegetables are presented in Table 15. The critical group mean consumption rate based on the five highest adult consumers was 16 kg y^{-1} and the observed 97.5 percentile rate based on 16 observations was 20 kg y^{-1}.

Table 15 Adults' consumption rates of green vegetables from the Hunterston area (kg y^{-1})

Observation number	Asparagus	Broccoli	Cabbage	Cauliflower	Chard	Courgette	Cucumber	Lettuce	Total
225-226			**11.1**	**8.8**					**19.9**
242-243			**4.0**	**1.2**			**8.5**		**13.8**
247	**1.4**		**5.1**	**4.1**					**10.5**
211-212						2.0		2.4	4.4
12		1.4			1.2			1.0	3.6
240-241								3.0	3.0
13		0.7			1.2			1.0	2.9
172-173			2.3						2.3
248-250							0.7		0.7

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of other vegetables are presented in Table 16. The critical group mean consumption rate based on the five highest adult consumers was 23 kg y^{-1} and the observed 97.5 percentile rate based on 17 observations was 28 kg y^{-1}.

Table 16 Adults' consumption rates of other vegetables from the Hunterston area (kg y^{-1})

Observation number	Broad bean	Chilli pepper	French bean	Pea	Pepper	Runner bean	Sweetcorn	Tomato	Total
245-246	**6.1**			**6.1**				**16.2**	**28.4**
247	**2.7**			**3.2**				**20.4**	**26.3**
227-228	**5.9**			**5.9**				**3.6**	**15.4**
242-243				3.0	1.0			1.4	5.3
248-250		0.1			0.3			4.5	4.9
211-212	0.8			0.8				2.4	4.0
172-173							2.3		2.3
240-241			0.9			0.9			1.8
33			1.5						1.5

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of root vegetables are presented in Table 17. The critical group mean consumption rate based on the four highest adult consumers was 75 kg y^{-1} and the observed 97.5 percentile rate based on 25 observations was 94 kg y^{-1}.

Table 17 Adults' consumption rates of root vegetables from the Hunterston area (kg y^{-1})

Observation number	Beetroot	Carrot	Garlic	Leek	Onion	Parsnip	Radish	Swede	Turnip	Total
227-228	**11.8**	**35.4**		**11.8**	**11.8**				**23.6**	**94.3**
245-246		**11.8**	**1.8**	**18.2**	**14.6**			**9.2**		**55.6**
225-226		5.9						5.9	5.9	17.7
247	4.5			3.2	3.2			4.5		15.4
33		12.5					2.5			15.0
117-120		5.0		5.0	5.0					15.0
12-13	1.2	1.4			6.5		0.5		0.8	10.4
172-173	2.3								6.8	9.1
240-241	2.3	2.9		2.3						7.5
211-212	4.0									4.0
242-243		1.5			2.4					3.9
248-250						0.3				0.3

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of potato are presented in Table 18. The critical group mean consumption rate based on the 16 highest adult consumers was 68 kg y^{-1} and the observed 97.5 percentile rate based on 30 observations was 120 kg y^{-1}.

Table 18 Adults' consumption rates of potato from the Hunterston area (kg y^{-1})

Observation number	Potato
172-173	**117.9**
227-228	**82.6**
240	**70.8**
12-13	**65.5**
245-246	**61.4**
225-226	**55.6**
33	**50.0**
117-120	**50.0**
222-223	18.1
242-243	18.0
211-212	12.0
30-32	8.7
248-250	4.5
26-27	2.9

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of domestic fruit are presented in Table 19. For domestic fruit, the critical group mean consumption rate based on the five highest adult consumers was 41 kg y^{-1} and the observed 97.5 percentile rate based on 11 observations was 46 kg y^{-1}.

Table 19 Adults' consumption rates of domestic fruit from the Hunterston area (kg y^{-1})

Observation number	Apple	Blackberry	Blackcurrant	Cherry	Damson	Gooseberry	Peach	Pear	Plum	Raspberry	Redcurrant	Rhubarb	Strawberry	Tayberry	Total
242-243	**3.6**	**1.1**	**2.7**	**0.5**	**0.1**	**2.7**		**0.9**	**0.1**	**1.4**		**2.7**	**28.6**	**1.4**	**45.8**
173	**41.6**					**2.3**	**0.9**					**0.9**			**45.7**
245-246	**7.5**		**3.0**					**2.5**		**3.0**		**8.3**	**8.5**		**32.8**
172						2.3	0.9					0.9			4.1
211-212			2.4								1.6				4.0
249	0.5	0.5	0.1	0.1		2.3				0.5	0.1				3.9
248	0.5	0.5	0.1	0.1						0.5	0.1				1.6
250	0.5	0.5	0.1	0.1						0.5	0.1				1.6

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of milk are presented in Table 20. The critical group mean consumption rate based on the eight highest adult consumers was 310 l y^{-1} and the observed 97.5 percentile rate based on eight observations was 410 l y^{-1}.

Table 20 Adults' consumption rates of milk from the Hunterston area (l y^{-1})

Observation number	Milk
17	**414.9**
215-218	**365.0**
208-210	**207.4**

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of cattle meat are presented in Table 21. The critical group mean consumption rate based on the four highest adult consumers was 58 kg y^{-1} and the observed 97.5 percentile rate based on four observations was 58 kg y^{-1}.

Table 21 Adults' consumption rates of cattle meat from the Hunterston area (kg y^{-1})

Observation number	Beef
236-239	**58.3**

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of sheep meat are presented in Table 22. The critical group mean consumption rate based on the four highest adult consumers was 8.5 kg y^{-1} and the observed 97.5 percentile rate based on four observations was 11 kg y^{-1}.

Table 22 Adults' consumption rates of sheep meat from the Hunterston area (kg y^{-1})

Observation number	Lamb/mutton
28-29	**11.3**
220-221	**5.7**

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of poultry are presented in Table 23. The critical group mean consumption rate based on the two highest adult consumers was 51 kg y^{-1} and the observed 97.5 percentile rate based on six observations was 51 kg y^{-1}.

Table 23 Adults' consumption rates of poultry from the Hunterston area (kg y^{-1})

Observation number	Chicken	Grouse	Pheasant	Pigeon	Total
172-173	**39.0**	**2.1**	**6.8**	**3.5**	**51.3**
14-15			0.9		0.9
211-212			0.3		0.3

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of eggs are presented in Table 24. The critical group mean consumption rate of eggs based on the six highest adult consumers was 19 kg y^{-1} and the observed 97.5 percentile rate based on 15 observations was 27 kg y^{-1}.

Table 24 Adults' consumption rates of eggs from the Hunterston area (kg y^{-1})

Observation number	Eggs
24	**32.6**
25	**17.8**
172-173	**17.8**
227-228	**14.8**
245-246	8.9
21-22	2.0
248-250	0.6
242-243	0.3

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of wild/free foods are presented in Table 25. The critical group mean consumption rate based on the two highest adult consumers was 4.5 kg y^{-1} and the observed 97.5 percentile rate based on eight observations was 4.5 kg y^{-1}.

Table 25 Adults' consumption rates of wild/free foods from the Hunterston area (kg y^{-1})

Observation number	Blackberry	Elderberry	Raspberry	Total
172-173	**2.3**	**2.3**		**4.5**
24-25	1.4			1.4
211-212	0.4		0.8	1.2
14-15	0.5			0.5

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of rabbits/hares are presented in Table 26. The critical group mean consumption rate based on the two highest adult consumers was 12 kg y^{-1} and the observed 97.5 percentile rate based on four observations was 12 kg y^{-1}.

Table 26 Adults' consumption rates of rabbits/hares from the Hunterston area (kg y^{-1})

Observation number	Hare	Rabbit	Total
172-173	**5.6**	**6.8**	**12.4**
14-15		0.9	0.9

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of honey are presented in Table 27. The critical group mean consumption rate based on the five highest adult consumers was 11 kg y^{-1} and the observed 97.5 percentile rate based on 11 observations was 14 kg y^{-1}.

Table 27 Adults' consumption rates of honey from the Hunterston area (kg y^{-1})

Observation number	Honey
245-246	**13.6**
37	**10.9**
26	**9.1**
38	**6.8**
248-250	1.1
30-32	0.9

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of wild fungi are presented in Table 28. The critical group mean consumption rate based on the 3 highest adult consumers was 0.6 kg y^{-1} and the observed 97.5 percentile rate based on 6 observations was 0.9 kg y^{-1}.

Table 28 Adults' consumption rates of wild fungi from the Hunterston area (kg y^{-1})

Observation number	Mushrooms
33	**1.0**
211-212	**0.4**
248-250	0.1

Notes
Emboldened observations are the critical group consumers

Adults' consumption rates of freshwater fish are presented in Table 29. The critical group mean consumption rate based on the six highest adult consumers was 24 kg y^{-1} and the observed 97.5 percentile rate based on 11 observations was 31 kg y^{-1}.

Table 29 Adults' consumption rates of freshwater fish from the Hunterston area (kg y^{-1})

Observation number	Brown trout	Rainbow trout	Total
2-4		**30.7**	**30.7**
176	**22.3**		**22.3**
170-171		**15.3**	**15.3**
39-40		6.1	6.1
21		3.8	3.8
174	3.2		3.2
175	2.1		2.1

Notes
Emboldened observations are the critical group consumers

A summary of adults' consumption rates of foods from the terrestrial survey area is presented in Table 30.

Table 30 Summary of adults' consumption rates of foods from the terrestrial survey area (kg y^{-1} or l y^{-1})

Food group	Number of observations	Number of observations in the critical group	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed critical group mean consumption rate	Observed 97.5 percentile consumption rate	Generic mean consumption rate	Generic 97.5 percentile consumption rate
Green vegetables	16	5	19.9	10.5	15.6	19.9	15.0	45.0
Other vegetables	17	5	28.4	15.4	22.8	28.4	20.0	50.0
Root vegetables	25	4	94.3	55.6	75.0	94.3	10.0	40.0
Potato	30	16	117.9	50.0	67.9	117.9	50.0	120.0
Domestic fruit	11	5	45.8	32.8	40.6	45.8	20.0	75.0
Milk	8	8	414.9	207.4	312.1	406.1	95.0	240.0
Cattle meat	4	4	58.3	58.3	58.3	58.3	15.0	45.0
Pig meat	NC	NC	NC	NC	NC	NC	15.0	40.0
Sheep meat	4	4	11.3	5.7	8.5	11.3	8.0	25.0
Poultry	6	2	51.3	51.3	51.3	51.3	10.0	30.0
Eggs	15	6	32.6	14.8	19.3	27.4	8.5	25.0
Wild/free foods	8	2	4.5	4.5	4.5	4.5	7.0	25.0
Rabbits/hares	4	2	12.4	12.4	12.4	12.4	6.0	15.0
Honey	11	5	13.6	6.8	10.8	13.6	2.5	9.5
Wild fungi	6	3	1.0	0.4	0.6	0.9	3.0	10.0
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Cereals	NC	NC	NC	NC	NC	NC	50	100
Freshwater fish	11	6	30.7	15.3	24.2	30.7	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 shown in Table 31.

Table 31 Percentage contribution each food type makes to its terrestrial food group for adults

Domestic fruit		**Other vegetables**	
Strawberry	33.4 %	Tomato	51.8 %
Apple	29.4 %	Pea	22.1 %
Rhubarb	10.7 %	Broad bean	18.1 %
Blackcurrant	7.4 %	Sweetcorn	2.9 %
Gooseberry	5.5 %	French bean	2.1 %
Raspberry	4.5 %	Pepper	1.8 %
Pear	3.1 %	Runner bean	1.2 %
Blackberry	1.6 %	Chilli pepper	0.1 %
Redcurrant	1.6 %	**Root vegetables**	
Tayberry	1.2 %	***Carrot***	30.3 %
Peach	0.8 %	***Onion***	18.9 %
Cherry	0.5 %	Leek	17.7 %
Damson	0.1 %	***Turnip***	15.0 %
Plum	0.1 %	Beetroot	9.6 %
Green vegetables		Swede	7.0 %
Cabbage	37.7 %	Radish	0.7 %
Cauliflower	22.9 %	Garlic	0.7 %
Cucumber	18.0 %	Parsnip	0.2 %
Lettuce	12.1 %	**Wild/free foods**	
Courgettes	3.8 %	***Blackberry***	59.4 %
Chard	2.3 %	Elderberry	30.0 %
Broccoli	1.9 %	Raspberry	10.6 %
Asparagus	1.3 %	**Eggs**	
Poultry		***Chicken egg***	100.0 %
Chicken	74.3 %	**Freshwater fish**	
Pheasant	15.1 %	Rainbow trout	83.4 %
Pigeon	6.6 %	Brown trout	16.6 %
Grouse	4.0 %	**Rabbits/hares**	
		Rabbit	57.7 %
		Hare	42.3 %

Notes

Food types in emboldened italics were monitored by SEPA in 2005 (EA, EHS, FSA and SEPA, 2006). Other foods monitored were milk, honey, potato, rosehips, nettles and rowan 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 was obtained for the 15-year-old and 10-year-old age groups. No children in the 5-year-old, 1-year-old or 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 10 food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, poultry, eggs, wild/free foods, honey and wild fungi. For these food groups, no critical group mean consumption rates exceeded the generic 97.5 percentile or mean rates. No consumption of foods from the following food groups was identified: milk, cattle meat, pig meat, sheep meat, rabbits/hares, venison, freshwater fish and cereals.

For the 10-year-old age group, consumption of terrestrial foods was identified in the following four food groups: potato, milk, poultry and eggs. The critical group mean for milk consumption exceeded the generic 97.5 percentile rate; this was for a single observation. The other three critical group mean consumption rates were less than their respective generic mean rates. No consumption of foods from the following food groups was identified: green vegetables, other vegetables, root vegetables, domestic fruit, cattle meat, pig meat, sheep meat, wild/free foods, rabbits/hares, honey, wild fungi, venison, freshwater fish and cereals.

Children's consumption rates of green vegetables are presented in Table 32. For the 15-year-old age group, the critical group mean consumption rate based on the three highest consumers was 1.2 kg y^{-1} and the observed 97.5 percentile rate based on three observations was 2.1 kg y^{-1}.

Table 32 Children's consumption rates of green vegetables from the Hunterston area (kg y^{-1})

Observation number	Age	Courgettes	Cucumber	Lettuce	Total
15-year-old age group					
213	**13**	**1.0**		**1.2**	**2.2**
251	**16**		**0.7**		**0.7**
252	**12**		**0.7**		**0.7**

Notes
Emboldened observations are the critical group consumers

Children's consumption rates of other vegetables are presented in Table 33. For the 15-year-old age group, the critical group mean consumption rate based on the two highest consumers was 3.4 kg y^{-1} and the observed 97.5 percentile rate based on three observations was 4.7 kg y^{-1}.

Table 33 Children's consumption rates of other vegetables from the Hunterston area (kg y^{-1})

Observation number	Age	Broad bean	Chilli pepper	Pea	Pepper	Tomato	Total
15-year-old age group							
252	**12**				**0.3**	**4.5**	**4.8**
213	**13**	**0.4**		**0.4**		**1.2**	**2.0**
251	16		0.1		0.3		0.3

Notes
Emboldened observations are the critical group consumers

Children's consumption rates of root vegetables are presented in Table 34. For the 15-year-old age group, the critical group mean consumption rate based on the three highest consumers was 0.8 kg y^{-1} and the observed 97.5 percentile rate based on three observations was 1.9 kg y^{-1}.

Table 34 Children's consumption rates of root vegetables from the Hunterston area (kg y^{-1})

Observation number	Age	Beetroot	Parsnip	Total
15-year-old age group				
213	**13**	**2.0**		**2.0**
251	**16**		**0.3**	**0.3**
252	**12**		**0.3**	**0.3**

Notes
Emboldened observations are the critical group consumers

Children's consumption rates of potato are presented in Table 35. For the 15-year-old age group, the critical group mean consumption rate based on the three highest consumers was 5.0 kg y^{-1} and the observed 97.5 percentile rate based on three observations was 5.9 kg y^{-1}. For the 10-year-old age group, the critical group consumption rate of potato, based on the only consumer, was 18 kg y^{-1}. The observed 97.5 percentile rate is not applicable for one observation.

Table 35 Children's consumption rates of potato from the Hunterston area (kg y^{-1})

Observation number	Age	Potato
15-year-old age group		
213	**13**	**6.0**
251	**16**	**4.5**
252	**12**	**4.5**
10-year-old age group		
224	**9**	**18.1**

Notes
Emboldened observations are the critical group consumers

Children's consumption rates of domestic fruit are presented in Table 36. For the 15-year-old age group, the critical group mean consumption rate based on the three highest consumers was 2.5 kg y^{-1} and the observed 97.5 percentile rate based on three observations was 3.8 kg y^{-1}.

Table 36 Children's consumption rates of domestic fruit from the Hunterston area (kg y^{-1})

Observation number	Age	Apple	Blackberry	Blackcurrant	Cherry	Gooseberry	Raspberry	Redcurrant	Total
15-year-old age group									
251	**16**	**0.5**	**0.5**	**0.1**	**0.1**	**2.3**	**0.5**	**0.1**	**3.9**
213	**13**			**1.2**				**0.8**	**2.0**
252	**12**	**0.5**	**0.5**	**0.1**	**0.1**		**0.5**	**0.1**	**1.6**

Notes
Emboldened observations are the critical group consumers

Children's consumption rates of milk are presented in Table 37. For the 10-year-old age group, the critical group consumption rate, based on the only consumer, was 370 l y^{-1}. The observed 97.5 percentile rate is not applicable for one observation.

Table 37 Children's consumption rates of milk from the Hunterston area (l y^{-1})

Observation number	Age	Milk
10-year-old age group		
219	**11**	**365.0**

Notes
Emboldened observation is the critical group consumer

Children's consumption rates of poultry are presented in Table 38. For the 15-year-old age group, the critical group consumption rate, based on the only consumer, was 0.2 kg y^{-1}. For the 10-year-old age group, the critical group consumption rate of poultry, based on the only consumer, was 0.2 kg y^{-1}. The observed 97.5 percentile rate is not applicable for one observation.

Table 38 Children's consumption rates of poultry from the Hunterston area (kg y^{-1})

Observation number	Age	Pheasant
15-year-old age group		
213	**13**	**0.2**
10-year-old age group		
214	**10**	**0.2**

Notes
Emboldened observations are the critical group consumers

Children's consumption rates of eggs are presented in Table 39. For the 15-year-old age group, the critical group mean consumption rate based on the two highest consumers was 0.6 kg y^{-1} and the observed 97.5 percentile rate based on two observations was 0.6 kg y^{-1}. For the 10-year-old age group, the critical group consumption rate of eggs, based on the only consumer, was 2.0 kg y^{-1}. The observed 97.5 percentile rate is not applicable for one observation.

Table 39 Children's consumption rates of eggs from the Hunterston area (kg y^{-1})

Observation number	Age	Eggs
15-year-old age group		
251	**16**	**0.6**
252	**12**	**0.6**
10-year-old age group		
23	**11**	**2.0**

Notes
Emboldened observations are the critical group consumers

Children's consumption rates of wild/free foods are presented in Table 40. For the 15-year-old age group, the critical group consumption rate based on the only consumer was 0.6 kg y^{-1}. The observed 97.5 percentile rate is not applicable for one observation.

Table 40 Children's consumption rates of wild/free foods from the Hunterston area (kg y^{-1})

Observation number	Age	Blackberry	Raspberry	Total
15-year-old age group				
213	**13**	**0.2**	**0.4**	**0.6**

Notes
Emboldened observation is the critical group consumer

Children's consumption rates of honey are presented in Table 41. For the 15-year-old age group, the critical group mean consumption rate based on the two highest consumers was 1.1 kg y^{-1} and the observed 97.5 percentile rate based on two observations was 1.1 kg y^{-1}.

Table 41 Children's consumption rates of honey from the Hunterston area (kg y^{-1})

Observation number	Age	Honey
15-year-old age group		
251	**16**	**1.1**
252	**12**	**1.1**

Notes
Emboldened observations are the critical group consumers

Children's consumption rates of wild fungi are presented in Table 42. For the 15-year-old age group, the critical group mean consumption rate of wild fungi based on the three highest consumers was 0.1 kg y^{-1} and the observed 97.5 percentile rate based on three observations was 0.2 kg y^{-1}.

Table 42 Children's consumption rates of wild fungi from the Hunterston area (kg y^{-1})

Observation number	Age	Mushrooms
15-year-old age group		
213	**13**	**0.2**
251	**16**	**0.1**
252	**12**	**0.1**

Notes
Emboldened observations are the critical group consumers

A summary of the consumption rates of foods from the terrestrial survey area for the 15-year-old and 10-year-old age groups is presented in Table 43.

Table 43 Summary of consumption rates of terrestrial foods for children in the Hunterston area (kg y^{-1} or l y^{-1})

Food group	Number of observations	Number of observations in the critical group	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed critical group mean consumption rate	Observed 97.5 percentile consumption rate	Generic mean consumption rate	Generic 97.5 percentile consumption rate
15-year-old age group								
Green vegetables	3	3	2.2	0.7	1.2	2.1	9.0	25.0
Other vegetables	3	2	4.8	2.0	3.4	4.7	10.0	30.0
Root vegetables	3	3	2.0	0.3	0.8	1.9	7.5	20.0
Potato	3	3	6.0	4.5	5.0	5.9	60.0	130.0
Domestic fruit	3	3	3.9	1.6	2.5	3.8	15.0	50.0
Milk	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	1	1	0.2	0.2	0.2	NA	6.5	20.0
Eggs	2	2	0.6	0.6	0.6	0.6	7.0	25.0
Wild/free foods	1	1	0.6	0.6	0.6	NA	3.0	13.0
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	2	2	1.1	1.1	1.1	1.1	2.0	5.0
Wild fungi	3	3	0.2	0.1	0.1	0.2	2.0	5.5
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Freshwater fish	NC	NC	NC	NC	NC	NC	6.5	20.0
10-year-old age group								
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	NC	NC	NC	NC	NC	NC	6.0	20.0
Potato	1	1	18.1	18.1	18.1	NA	45.0	85.0
Domestic fruit	NC	NC	NC	NC	NC	NC	15.0	50.0
Milk	1	1	365.0	365.0	365.0	NA	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	1	1	0.2	0.2	0.2	NA	5.5	15.0
Eggs	1	1	2.0	2.0	2.0	NA	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	NC	NC	NC	NC	NC	NC	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
Freshwater fish	NC	NC	NC	NC	NC	NC	6.5	20.0

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

6 DIRECT RADIATION

The direct radiation survey area, shown in Figure 2 extended up to 1 km from the centre of the Hunterston site (National Grid Reference NS 183 514). The activities of the Hunterston 'A' and Hunterston 'B' employees and contractors while at work were not considered in the direct radiation survey.

6.1 Direct radiation survey area

The Hunterston nuclear site is positioned on the coast, approximately 4 km north of West Kilbride and 4 km south of Fairlie. The 'A' station is on the south side of the site and the 'B' station is on the north-east side of the site. The direct radiation survey area comprises rough grazing to the north and east, a tree covered hill (immediately behind the 'A' station) to the south, and tidal sands to the west and north. A public footpath ran beside the Hunterston site access road and south along the coast to Portencross. A small number of dwellings were located within the direct radiation survey area. The only commercial activity noted to occur was farming.

6.2 Occupancy within direct radiation survey area

Local residents and individuals were interviewed and their occupancy rates within the direct radiation survey area are presented in Table 44. Eight adults and one child had occupancy rates greater than 7000 h y^{-1}. The highest total occupancy rate (indoors plus outdoors) was 8400 h y^{-1} for a resident. The highest outdoor occupancy rate was 3400 h y^{-1} for two residents with identical occupancy rates who also worked in the area. The highest indoor occupancy rate was 7100 h y^{-1} for a resident.

6.3 Gamma dose rate measurements

Gamma dose rate measurements taken at residences in the direct radiation survey area are also presented in Table 44. Gamma dose rate measurements were taken both indoors and outdoors of most residences where interviews were conducted. Outdoor measurements were taken approximately 5 to 10 metres from the nearest building. Background gamma dose rate measurements taken for comparison at distances further than 5 km from the Hunterston site centre are presented in Table 45. 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 outdoor measurements were generally low and indistinguishable from background. The maximum gamma dose rate measured inside a property was 0.118 µGy h^{-1} and the maximum gamma dose rate measured outside a property was 0.077 µGy h^{-1}. These readings were taken at different

locations. For comparison, the mean of the three background gamma dose rates also taken over grass was 0.068 µGy h^{-1}.

Table 44 Occupancy rates (h y^{-1}) and gamma dose rates (µGy h^{-1}) in the Hunterston direct radiation survey area

Observation number	Sex	Age in years	Indoor occupancy	Outdoor occupancy	Total occupancy	Gamma dose rate inside the property	Gamma dose rate outside the property over grass
24	M	65	7200	1248	8448	0.118	0.066
21	M	59	5920	2184	8104	0.104	0.065
28	M	60	4520	3360	7880	NM	0.077
29	F	56	4520	3360	7880	NM	0.077
34	F	61	6449	1274	7723	NM	0.054
25	F	64	6420	1092	7512	0.118	0.066
12	M	62	6778	546	7324	0.096	0.061
13	F	65	7142	182	7324	0.096	0.061
22	F	44	4515	2184	6699	0.104	0.065
30	F	60	6492	78	6570	0.112	0.077
31	M	56	5534	104	5638	0.112	0.077
33	M	36	4669	650	5319	0.092	0.055
32	M	28	5164	-	5164	0.112	0.077
15	M	71	5040	-	5040	0.083	NM
14	F	48	4368	364	4732	0.083	NM
35	M	66	-	1974	1974	NM	0.054
207	M	U	-	76.5	76.5	NM	NM
23	M	11	4945	2184	7129	0.104	0.065

Notes
NM = not measured
U = Unknown

Table 45 Background gamma dose rates

National Grid Reference	Location	Substrate	µGy h^{-1}
NS 216 471	South-east of West Kilbride	Grass	0.064
NS 239 515	Knockendon picnic site	Grass	0.069
NS 199 653	Between Largs and Wemyss Bay	Grass	0.071

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 critical 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 assessments are shown in Table 46. Each of the 23 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 46 do not correlate directly with observation numbers in Annex 1. Other individuals from Annex 1 have combinations that are not listed in Table 46 because they have fewer pathways and a dose assessment for them would be adequately covered by one of the 23 listed combinations.

Combinations of pathways at critical group rates may be achieved by considering the data in Annex 1 and Annex 2. Although critical group rates are not given in the tables, the rates for individuals making up the groups are shown emboldened. Possible combinations of pathways and their associated critical group rates are therefore apparent.

Table 46 Combinations of adult pathways for consideration in dose assessments in the Hunterston area

Combination number	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
1																						*		*			*	*		
2													*					*											*	*
3		*	*																				*				*	*		
4				*		*	*																						*	*
5		*	*									*		*	*														*	*
6	*	*																							*			*		
7									*																					
8			*																			*	*			*				
9													*	*															*	*
10							*									*													*	*
11											*																		*	*
12					*	*	*										*										*		*	*
13	*																			*		*	*			*				
14	*	*																				*								
15	*																										*			
16																			*							*				
17	*	*	*	*	*	*	*	*					*			*	*											*		
18	*			*	*	*	*	*				*	*	*	*															
19	*	*		*	*	*	*	*				*		*			*													
20										*																				
21																						*		*		*				
22	*		*																					*						
23	*																				*					*				

8 COMPARISONS WITH THE PREVIOUS SURVEY

The results from this 2007 survey can be compared with results from the last habits survey undertaken at Hunterston in 2001.

Aquatic survey

The comparisons for consumption rates of aquatic foods include adult data only. The adult critical group mean consumption rates for aquatic food groups in 2001 and 2007 are presented in Table 47.

Table 47 Comparison between 2001 and 2007 consumption rates of aquatic foods (kg y^{-1})

	2001			2007		
Food group	**Number in the critical group**	**Maximum rate**	**Critical group mean**	**Number in the critical group**	**Maximum rate**	**Critical group mean**
Fish	27	45.1	28.6	10	66.5	46.7
Crustaceans	8	28.3	22.1	4	27.7	17.8
Molluscs	4	2.8	2.0	6	23.6	21.1

The adult critical group mean consumption rates had increased for fish and molluscs and had decreased for crustaceans in 2007 when compared to the rates obtained from the 2001 survey. The main reason for the significant increase in mollusc consumption was that a local diver had located a bed of king scallops in the Fairlie Roads which were collected and consumed. In both the 2001 and 2007 surveys, no consumption of wildfowl or marine plants/algae was identified.

A comparison between the 2001 and 2007 aquatic external exposure pathways is presented in Table 48. For intertidal occupancy and handling rates, it should be noted that the methodology for determining critical groups has changed since the 2001 survey, so care is needed when comparing results. In previous surveys a factor of 1.5 instead of 3 was used to define the cut-off value for intertidal occupancy and handling rates. However, it is now considered appropriate that a factor of 3 is used. The factor reflects variations in the doses likely to be received due to natural variations in the interactions of radiation with tissues caused by, for example, differences in anatomy.

Table 48 Comparison between 2001 and 2007 aquatic external exposure pathways (h y^{-1})

	2001			2007		
Intertidal occupancy and handling	**Number in critical group**	**Maximum occupancy or handling rate**	**Critical group mean**	**Number in critical group**	**Maximum occupancy or handling rate**	**Critical group mean**
Rock	3 (2)	312	262 (312)	5	350	273
Sand	12 (8)	274	187 (207)	5	730	438
Sand and stones	2 (1)	156	108 (156)	2	350	296
Fishing gear	14 (3)	1615	1009 (1566)	6	1600	1242
Sediment	2 (2)	520	520 (520)	3	700	437

Figures in parenthesis were calculated using the former method of dividing by 1.5.

In 2001, occupancy over the following six substrates was identified: muddy sand; rock; sand; sand and stones; sandy mud; and stones. In 2007, occupancy over the following six substrates was identified: mud; mud and sand; mud and stones; rock; sand; and sand and stones. Therefore occupancy over rock, over sand and over sand and stones can be compared. The critical group mean occupancy rate over rock was similar in 2001 and 2007. In 2007, the critical group mean occupancy rates over sand and over sand and stones increased significantly. In 2007, the critical group mean rate for handling fishing gear increased, and the critical group mean rate for handling sediment decreased, compared to 2001.

Water based activities were not investigated in 2001, and therefore, no comparisons can be made.

Terrestrial survey

A comparison between the 2001 and 2007 adult critical group mean consumption rates for terrestrial foods in the Hunterston area is presented in Table 49.

Table 49 Comparison between 2001 and 2007 mean consumption rates for the adult critical groups for terrestrial groups (kg y^{-1})

Food group	2001	2007
Green vegetables	31.3	15.6
Other vegetables	33.0	22.8
Root vegetables	54.4	75.0
Potato	125.2	67.9
Domestic fruit	129.7	40.6
Milk	321.5	312.1
Cattle meat	52.5	58.3
Sheep meat	13.7	8.5
Poultry	13.0	51.3
Eggs	30.3	19.3
Wild/free foods	4.4	4.5
Rabbits/hares	7.0	12.4
Honey	15.2	10.8
Wild fungi	3.8	0.6
Venison	2.0	Not identified
Freshwater fish	18.5	24.2

In 2007, consumption rates had increased in the following food groups: root vegetables, cattle meat, poultry, wild/free foods, rabbits/hares and freshwater fish. Consumption rates had decreased in the following food groups: green vegetables, other vegetables, potato, domestic fruit, milk, sheep meat, eggs, honey, wild fungi and venison (nil in 2007). Neither survey identified any consumption of pig meat or cereals. The food group showing the most significant increase was poultry, from 13 kg y^{-1} in 2001 to 51 kg y^{-1} in 2007. The most significant decreases were for green vegetables, 31 kg y^{-1} in 2001 to 16 kg y^{-1} in 2007, potato, 130 kg y^{-1} in 2001 to 68 kg y^{-1} in 2007, domestic fruit, 130 kg y^{-1} in

2001 to 41 kg y^{-1} in 2007, wild fungi, 3.8 kg y^{-1} in 2001 to 0.6 kg y^{-1} in 2007 and venison, 2.0 kg y^{-1} in 2001 to nil in 2007.

In the 2001 survey, one individual was identified who consumed garden snails. This was investigated in 2007, however, the individual has since moved out of the area.

Direct radiation survey

In common with the 2001 direct radiation survey, the 2007 survey identified several individuals living in the area who spent more than 7000 h y^{-1} within 1 km of the site centre. Comparisons between the 2001 and 2007 direct radiation surveys are shown below in Table 50.

Table 50 Comparison between 2001 and 2007 direct radiation occupancy rates (h y^{-1})

	2001	***2007***
Highest total rate	8730	8448
Highest indoor rate	8548	7200
Highest outdoor rate	3819	3360

The highest total occupancy rate, the highest indoor occupancy rate and the highest outdoor occupancy rate all decreased in 2007, when compared with 2001. The most significant decrease being the indoor rate. The highest total and indoor occupancy rates in 2001 and 2007 were for residents. The highest outdoor occupancy rates in 2001 and 2007 were for individuals who lived and worked in the area.

9 MAIN FINDINGS AND RECOMMENDATIONS

9.1 Survey findings

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

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

Data were collected for 249 adults and 28 children including commercial fishermen, anglers, people spending time on intertidal substrates, farmers, gardeners, beekeepers and people living and working within the direct radiation area.

Aquatic survey area

The adult critical group mean consumption rates of aquatic foods were:

- 47 kg y^{-1} for fish
- 18 kg y^{-1} for crustaceans
- 21 kg y^{-1} for molluscs

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

The critical group mean occupancy rates over intertidal areas were:

- 56 h y^{-1} for mud
- 93 h y^{-1} for mud and sand
- 300 h y^{-1} for mud and stones
- 270 h y^{-1} for rock
- 440 h y^{-1} for sand
- 300 h y^{-1} for sand and stones

The critical group mean handling rates were:

- 1200 h y^{-1} for handling fishing gear
- 440 h y^{-1} for handling sediment

For water-based activities, the maximum occupancy rates were:

- 650 h y^{-1} for in water
- 1600 h y^{-1} for on water

Terrestrial survey area

The adult critical group mean consumption rates for the separate consumption pathways for foods potentially affected by gaseous discharges were:

- 16 kg y^{-1} for green vegetables
- 23 kg y^{-1} for other vegetables
- 75 kg y^{-1} for root vegetables
- 68 kg y^{-1} for potatoes
- 41 kg y^{-1} for domestic fruit
- 310 l y^{-1} for milk
- 58 kg y^{-1} for cattle meat
- 8.5 kg y^{-1} for sheep meat
- 51 kg y^{-1} for poultry
- 19 kg y^{-1} for eggs
- 4.5 kg y^{-1} for wild/free foods
- 12 kg y^{-1} for rabbits/hares
- 11 kg y^{-1} for honey
- 0.6 kg y^{-1} for wild fungi
- 24 kg y^{-1} for freshwater fish

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

Direct radiation survey area

The highest total occupancy rate (indoors plus outdoors) was 8400 h y^{-1} for a resident. The highest outdoor occupancy rate was 3400 h y^{-1} for two residents who also worked in the area and the highest indoor occupancy rate was 7200 h y^{-1} for the same resident with the highest total occupancy rate.

9.2 Current environmental monitoring programmes

The 2006 SEPA aquatic and terrestrial monitoring programmes around the Hunterston site comprised the following samples and measurements (EA, EHS, FSA and SEPA, 2007).

- Cod, hake, crabs, *Nephrops*, lobsters, squat lobsters, winkles, scallops, oysters, seaweed, sediment and seawater
- Milk, blackberries, cabbage, carrots, eggs, honey, nettles, onions, potatoes, rabbits, rosehips, rowan berries, turnips, grass and soil
- Gamma dose rate measurements were taken at Largs Bay, Kilchatten Bay, Millport, Gulls Walk, 0.5 km north and south of the pipeline, Ardneil Bay and Ardrossan Bay.
- Beta dose rates were taken over sand were taken at Millport and Fairlie.
- Air samples were taken at Fencebay, West Kilbride and Crosbie Mains.

9.3 Recommendations for environmental monitoring

Based on the findings of this habits survey, it is considered that SEPA's current monitoring programmes provide adequate coverage for both the aquatic and terrestrial environment and no changes to these programmes are required.

10 ACKNOWLEDGEMENTS

Gratitude is expressed to representatives of local authorities and associations and members of the public who offered helpful advice and information during the survey. This survey was undertaken on behalf of the Scottish Environment Protection Agency, who provided the funding for this study.

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

Observation number	Sex	Age in years (U if unknown)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
1	M	62																								**242**						
2	M	75																		**30.7**												
3	F	52																		**30.7**												
4	F	68																		**30.7**												
6	M	U			0.7																								20	192		
7	M	U			0.7																								20	192		
8	M	U			0.7																								20	192		
9	M	U			0.7																								20	192		
10	M	U			0.7																								20	192		
11	M	U			0.7																								20	192		
12	M	62				3.6		10.4	**65.5**																					6778	546
13	F	65				2.9		10.4	**65.5**																					7142	182
14	F	48		0.3	0.6									0.9		0.5	0.9													4368	364
15	M	71		0.3	0.6									0.9		0.5	0.9													5040	
16	M	52																									80			640		
17	M	47									**414.9**																					
18	M	47																									266			1600		
19	M	17																									266			1600		
20	M	55																						**312**				**312**				
21	M	59													2.0					3.8											5920	2184
22	F	44													2.0																4515	2184
24	M	65													**32.6**	1.4															7200	1248
25	F	64													**17.8**	1.4															6420	1092
26	M	62							2.9									**9.1**														
27	F	61							2.9																							
28	M	60											**11.3**																		4520	3360
29	F	56											**11.3**																		4520	3360
30	F	60							8.7									0.9													6492	78
31	M	56							8.7									0.9													5534	104
32	M	28							8.7									0.9													5164	
33	M	36					1.5	15.0	**50.0**										**1.0**											72		4669	650
34	F	61																													6449	1274

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

Observation number	Sex	Age in years (U if unknown)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
35	M	66																														1974
36	M	U	**28.8**																						8			8				
37	M	64																**10.9**														
38	F	61																**6.8**														
39	M	73																		6.1												
40	F	71																		6.1												
41	M	45	0.7																								360			360		
42	F	45	0.7																													
46	M	68	12.5																													
47	M	43	17.7	1.4																							396			396		
48	F	42	17.7	1.4																												
52	M	49																											100	144		
53	M	51																											100	144		
54	M	47	2.8																					30								
55	F	47	2.8																													
56	M	35	2.8																					80								
57	F	35	2.8																													
58	M	U																											6	40		
59	M	U																											6	40		
60	M	U																											6	40		
61	M	U																											6	40		
62	M	U																											6	40		
63	F	U																											6	40		
64	M	U																											3	15		
65	M	U																											3	15		
66	M	U																											3	15		
67	M	U																											3	15		
68	M	U																											38	300		
69	M	U																											38	300		
70	M	U																											38	300		
71	M	U																											38	300		
72	M	U																											38	300		

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

Observation number	Sex	Age in years (U if unknown)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
73	M	U			5.4																								38	300		
74	M	U			5.4																											
75	F	U			5.4																											
76	M	56		8.8																							**726**			726		
77	M	31	10.3	8.8																							**726**			726		
78	M	U																											650	650		
79	M	U																											650	650		
80	M	U																											650	650		
81	F	U																											650	650		
82	F	U																											650	650		
83	F	U																											650	650		
84	F	U																											460	460		
85	F	U																											460	460		
86	F	U																											460	460		
87	F	U																											460	460		
88	F	U																											460	460		
89	F	U																											460	460		
90	F	U																											460	460		
91	F	U																											460	460		
92	F	U																											460	460		
93	M	U																											460	460		
94	M	U																											460	460		
95	M	U																											460	460		
96	M	U																											460	460		
97	M	U																											460	460		
98	M	U																											460	460		
99	M	U																											460	460		
100	M	U																											460	460		
101	M	U																											460	460		
102	M	36	3.1																										150			
103	F	36	3.1																													
104	M	45		1.0	2.4																											

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

Observation number	Sex	Age in years (U if unknown)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
105	M	U																			**56**							56				
106	M	U																			**56**							56				
107	M	41	**44.2**	6.9																							**1600**			1600		
108	F	38	**44.2**	6.9																							**1600**			1600		
109	M	36	6.9																					90								
110	M	29	6.9																					90								
111	M	28	3.5																					90								
112	F	36	6.9																													
113	F	36	6.9																													
114	F	36	3.5																													
117	M	52		7.3	**23.6**			15.0	**50.0**																							
118	F	51		7.3	**23.6**			15.0	**50.0**																							
119	F	U		7.3	**23.6**			15.0	**50.0**																							
120	F	U		7.3	**23.6**			15.0	**50.0**																							
121	M	40																				**78**						78				
122	M	65																				**52**										
123	M	38	8.6																													
124	M	29	8.6																													
125	F	38	8.6																													
126	F	29	8.6																													
127	M	50																											96	480		
128	M	U																											96	480		
129	M	47		0.6	1.3																				**365**				18	72		
130	F	45		0.6	1.3																								18	72		
131	M	51																												437		
132	M	U																											3	16		
133	M	U																											3	16		
134	M	U																											3	16		
135	M	U																											3	16		
136	M	U																											3	16		
137	M	U																											3	16		
138	M	U																											3	16		

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

Observation number	Sex	Age in years (U if unknown)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
139	M	U																											3	16		
140	M	U																											3	16		
141	M	U																											3	16		
142	M	38		2.1	1.7																								150	516		
143	F	38		2.1	1.7																											
144	M	U		2.1	1.7																											
145	M	30		**27.7**																							**1400**			1400		
146	M	29		**13.3**																							**1400**			1400		
147	F	29		**13.3**																												
148	M	59	13.6	5.2																							468			468		
149	F	59	13.6	5.2																												
150	M	U																												270		
151	M	U																												270		
152	M	U																												270		
153	M	U																												270		
154	M	U																												270		
155	M	U																												270		
156	M	U																												270		
157	M	U																												270		
158	M	U																												270		
159	M	U																												270		
160	M	U																												182		
161	M	U																												182		
162	M	U																												182		
163	M	U																												182		
164	M	U																												182		
165	F	U																												182		
166	F	U																												182		
167	F	U																												182		
168	F	U																												182		
169	F	U																												182		
170	M	U																		**15.3**												

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

Observation number	Sex	Age in years (U if unknown)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
171	F	U																		**15.3**												
172	M	50				2.3	2.3	9.1	**117.9**	4.1				**51.3**	**17.8**	**4.5**	**12.4**																
173	M	92	**47.2**			2.3	2.3	9.1	**117.9**	**45.7**				**51.3**	**17.8**	**4.5**	**12.4**																
174	M	52																		3.2												
175	F	51																		2.1												
176	M	61																		**22.3**												
177	M	37																							**730**							
178	M	42																							50							
182	M	35	0.5																													
184	M	55	0.2																													
185	M	45																												1		
186	M	52																							78							
187	M	60																							**365**							
188	F	58																							183							
191	M	65																							**365**							
192	F	65																							**365**							
193	F	54	10.4																													
197	M	70	**66.5**																													
198	M	30	13.8																													
199	M	27	13.8																													
200	M	32		**17.0**	**22.9**																									150	28		
202	M	U	3.5																													
203	F	U	3.5																													
204	M	U	0.8																													
205	F	U	0.8																													
207	M	U																														77
208	M	66									**207.4**																					
209	F	58									**207.4**																					
210	M	36									**207.4**																					
211	M	48				4.4	4.0	4.0	12.0	4.0				0.3		1.2			**0.4**													
212	F	47	3.0	5.0		4.4	4.0	4.0	12.0	4.0				0.3		1.2			**0.4**													
215	M	41									**365.0**																					

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

Observation number	Sex	Age in years (U if unknown)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
216	F	44									**365.0**																					
217	M	72									**365.0**																					
218	F	70									**365.0**																					
220	M	U											**5.7**																			
221	F	U											**5.7**																			
222	M	60							18.1																							
223	F	50							18.1																							
225	M	62				**19.9**		17.7	**55.6**																							
226	F	64				**19.9**		17.7	**55.6**																							
227	M	80					**15.4**	**94.3**	**82.6**						**14.8**																	
228	F	77					**15.4**	**94.3**	**82.6**						**14.8**																	
229	M	35																						50		50			88	100		
230	M	56																						50		50			88	100		
231	M	U																									250			1063		
232	M	U																									250			1063		
233	M	U																									250			1063		
234	M	U																									250			1063		
235	M	U																									250			1063		
236	M	74										**58.3**																				
237	F	74										**58.3**																				
238	M	35										**58.3**																				
239	F	41										**58.3**																				
240	M	63				3.0	1.8	7.5	**70.8**																							
241	F	36				3.0	1.8	7.5																								
242	F	57				**13.8**	5.3	3.9	18.0	**45.8**					0.3																	
243	M	58				**13.8**	5.3	3.9	18.0	**45.8**					0.3																	
244	M	U			1.4																			**351**	39			78				
245	M	60					**28.4**	**55.6**	**61.4**	**32.8**					8.9			**13.6**														
246	F	58	0.5				**28.4**	**55.6**	**61.4**	**32.8**					8.9			**13.6**														
247	M	U				**10.5**	**26.3**	15.4																								
248	M	53	6.1	4.7	1.4	0.7	4.9	0.3	4.5	1.6					0.6			1.1	0.1											700		
249	F	50	6.1	4.7	1.0	0.7	4.9	0.3	4.5	3.9					0.6			1.1	0.1											700		

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

Observation number	Sex	Age in years (U if unknown)	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Freshwater fish	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud and stones	Intertidal occupancy over rock	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
250	F	18	6.1	4.7	1.4	0.7	4.9	0.3	4.5	1.6					0.6			1.1	0.1												600		
253	M	U	**63.9**	4.8																				**200**								
254	F	U	**63.9**	4.8																												
255	M	U																						**350**		**350**		**700**				
256	M	U	**38.9**		**9.5**																					88						
257	M	U	5.8																													
258	F	U	5.8																													
259	M	U	5.8																													
260	F	U	5.8																													
262	M	U	4.6																													
263	F	U	4.6																													
264	M	U	2.5																			**150**		**150**	150			150				
265	F	U	2.5																													
266	M	U	**34.6**																				**300**					**300**				
267	F	U	**34.6**																													
268	M	U			0.3																			10				10				
269	F	U			0.3																											
270	M	U			0.3																											
271	M	U			0.3																											
272	M	U			0.3																											
273	M	U			0.3																											
274	F	U			0.3																											
275	F	U			0.3																											
276	F	U			0.3																											
277	F	U			0.3																											

Notes

Emboldened observations are the critical group members

Annex 2. Children's consumption rates (kg y^{-1} or l y^{-1}) and occupancy rates (h y^{-1}) in the Hunterston area

Observation number	Sex	Age in years	Fish	Crustaceans	Molluscs	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Poultry	Eggs	Wild/free foods	Honey	Wild fungi	Intertidal occupancy over rock	Intertidal occupancy over sand	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site centre	Outdoor occupancy within 1 km of the site centre
15-year-old age group																						
43	M	14	0.7																			
44	F	12	0.7																			
49	M	15	**17.7**	**1.4**																		
50	F	15	**8.8**	**1.4**																		
51	M	12	**8.8**	**1.4**																		
115	M	16	3.5																			
116	F	14	3.5																			
183	M	12	0.2																			
194	M	14	1.0																			
195	M	15	1.0																			
196	M	14	1.0																			
206	M	12	0.8																			
213	F	13				**2.2**	**2.0**	**2.0**	**6.0**	**2.0**		**0.2**		**0.6**		**0.2**			20	20		
251	F	16	**6.1**	0.2	**0.2**	**0.7**	0.3	**0.3**	**4.5**	**3.9**			**0.6**		**1.1**	**0.1**	40	40	10	600		
252	M	12	**6.1**	0.2		**0.7**	**4.8**	**0.3**	**4.5**	**1.6**			**0.6**		**1.1**	**0.1**	40	100	10	600		
261	M	15	4.6																			
10-year-old age group																						
5	M	9																	10			
23	M	11											**2.0**								4945	2184
45	M	9	**0.7**																			
179	M	11																24				
180	F	9																24				
190	M	9																183				
201	M	7		**11.8**																		
214	M	10										**0.2**							20	20		
219	M	11									**365.0**											
224	M	9							**18.1**													
5-year-old age group																						
181	F	6																24				
189	M	5																183				

Notes

Emboldened observations are the critical group members

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