Cefas

Radiological Habits Survey: Heysham, 2006

Environment Agency

FOOD STANDARDS AGENCY

HSE Health & Safety Executive

2007

Environment Report RL09/07

Radiological Habits Survey: Heysham, 2006

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2007

Peer reviewed by B.D. Smith

The work described in this report was carried out under contract to the Environment Agency, the Food Standards Agency and the Health and Safety Executive.
Cefas contracts C1659, RB103 and C1666 respectively.
EA Project PO070206680, FSA Project RP0183 and HSE Project NS/X/374

FIGURES

TABLES

ANNEXES

SUMMARY

This report presents the results of a survey conducted in 2006 into the habits and consumption patterns of people living, working and pursuing recreational activities in the vicinity of the Heysham Stage 1 and Heysham Stage 2 nuclear power stations in Lancashire. The power stations are owned and operated by British Energy Generation Ltd. and powered by Advanced Gas-Cooled Reactors. The Heysham power stations discharge gaseous radioactive wastes via stacks to the atmosphere, liquid radioactive wastes via an outfall into Morecambe Bay and they contain sources of direct radiation.

The following potential exposure pathways related to the site were investigated:

- Consumption of locally sourced terrestrial foods
- Production, use and destination of local produce
- Consumption and use of groundwater and surface water
- Occupancy within 1 km of the site perimeter fence
- Consumption of locally sourced aquatic foods
- Occupancy of intertidal areas
- Handling fishing gear and sediment
- Occupancy in or on water
- Unusual practices such as the consumption and/or use of seaweed as fertiliser/soil conditioner and off-site transfer of contamination by wildlife
- Site-specific issues as requested by the customers (sand winning at Heysham Harbour (the practice of extracting sand from an area for relocation or use elsewhere), the redevelopment of the former Middleton Towers holiday park and occupancy in the direct radiation survey area particularly at caravan sites, Heysham golf club and the Port of Heysham).

Individuals from the local population were interviewed and data collected for 1043 individuals are presented and discussed.

Data from the survey are presented in full for each individual in order to assist in conducting dose assessments for multiple pathways. Additionally, data were analysed in three ways. Firstly by selecting potential critical group habits from the upper end of the distribution of observations (the 'cut-off' method). Secondly by using the 97.5th percentile from the distribution of observations. These methods can be used to identify the highest rates appropriate to discrete habits in the aquatic and terrestrial pathways. Finally, profiles of integrated habits data were created for use in total dose assessments.

In the aquatic survey area, internal and external exposure pathways were investigated because of the potential effects from liquid discharges. Foods consumed by adults from the aquatic survey area were fish, crustaceans, molluscs, wildfowl, marine plants/algae and salt marsh grazed sheep. For these foods, the only adult mean critical group consumption rate to exceed the respective generic 97.5 percentile rate was for crustaceans. High consumption rates for adults were also noted for wildfowl. Critical group intertidal occupancy rates were recorded for commercial fishermen and shellfish collectors, anglers, commercial bait diggers, a turf cutter, a walker, a dog walker, workmen repairing sea defences and a farmer tending livestock. Critical group fishing gear and sediment handling rates were recorded for commercial fishermen and shellfish collectors and commercial bait diggers. No houseboats or likely locations for houseboats were identified. People were interviewed who undertook water based activities such as windsurfing, sailing, jet-skiing, canoeing and swimming. No one was noted to be using any seaweed from the survey area as fertiliser.

In the terrestrial survey area, internal exposure pathways were investigated because of the potential effects from gaseous discharges. Food production was identified at 10 farms (including beef cattle, dairy cattle, lamb, pigs, chicken eggs and arable), one allotment site and a few private gardens. One beekeeping family produced honey. The adult mean critical group consumption rates for foods from the terrestrial survey area exceeded the respective generic 97.5 percentile rates for domestic fruit and honey. Other local foods consumed were green vegetables, other vegetables, root vegetables, potato, milk, cattle meat, sheep meat (excluding salt marsh grazed sheep), poultry, eggs, wild/free foods, rabbits/hares and wild fungi.

No consumption of pig meat, venison or freshwater fish was noted. Borehole water was the main source of drinking water for a family and livestock at one farm in the survey area. No other incidents of people using or drinking ground or surface water were identified.

Investigations into the off-site transfer of radioactive contamination by wildlife established that although rabbits and seagulls were considered to be a pest on the Heysham site, neither were thought to be a likely route for transferring radioactivity from the site into the human food chain.

In the direct radiation survey area, external pathways were investigated because of potential effects from ionising radiation emanating directly from the site and from exposure to gases discharged to atmosphere from the site. The highest occupancy rates were for residences, but rates were also recorded for work and recreational activities.

Comparisons are made with the results from previous aquatic, terrestrial and direct radiation surveys. Suggestions are made for changes to environmental monitoring programmes on the basis of the information collected during the survey.

1 INTRODUCTION

The public may be exposed to radiation as a result of the operations of the Heysham site either from discharges of liquid or gaseous radioactive wastes into the local environment, or from radiation emanating directly from the site. This report provides information about activities carried out by members of the public under everyday circumstances, which may influence their radiation exposure. The study has been funded by the Environment Agency, the Food Standards Agency and the Health and Safety Executive in order to support their respective roles in protecting the public from the effects of radiation.

1.1 Regulatory framework

The Environment Agency regulates discharges of waste under the Radioactive Substances Act 1993 (RSA 93) (UK Parliament, 1993) as amended by: the Environment Act 1995 (EA 95) (UK Parliament, 1995a); by legislation implementing the European Union (EU) Basic Safety Standards (BSS) Directive 96/29/Euratom (CEC, 1996); and by the Energy Act 2004 (EA 04) (UK Parliament, 2004). The Directive takes into account Recommendations of the International Commission on Radiological Protection (ICRP), particularly ICRP 60 (ICRP, 1991). Authorisations under RSA 93 are issued by the Environment Agency after wide-ranging consultation, including the Food Standards Agency. As well as being a Statutory Consultee, the Food Standards Agency has responsibilities for ensuring that any radioactivity present in food does not compromise food safety and that authorised discharges of radioactivity do not result in unacceptable doses to consumers via the food chain. The Food Standards Agency also ensures that public radiation exposure via the food chain is within EU accepted limits. Consultation papers on Statutory Guidance to the Environment Agency on the regulation of radioactive waste discharges were issued by the Department of the Environment, Transport and the Regions (DETR) (now part of the Department for Environment, Food and Rural Affairs (Defra)) in 2000 (DETR, 2000a) and the Welsh Assembly in 2002 (The Welsh Assembly Government, 2002). These draft Guidance documents include, *inter alia*, affirmation that protection of the critical groups of the public is

the appropriate radiological protection methodology to use. This report provides information to support assessments of critical groups.

Installation and operation of certain prescribed activities can only take place on sites if they are licensed under the Nuclear Installations Act 1965 (as amended) (NIA 65) (UK Parliament, 1965). The Nuclear Installations Inspectorate of the Health and Safety Executive implements this legislation and is also responsible for regulating, under the Ionising Radiations Regulations (IRR 99) (UK Parliament, 1999), the restriction of exposure of the public to direct radiation from operations occurring on these sites.

1.2 Radiological protection framework

UK policy on the control of radiation exposure has long been based on the Recommendations of ICRP, which embody the principles of justification of practices, optimisation of protection and dose limitation. Radiological protection of the public is based on the concept of a critical group of individuals. This group is defined as those people who, because of where they live and their habits, receive the highest radiation dose due to the operations of a site. It follows that, if the dose to this group is acceptable when compared to relevant dose limits and constraints, other members of the public will receive lower doses, and overall protection is provided for.

Dose standards for the public are embodied in national policy (UK Parliament, 1995b), in guidance from the International Atomic Energy Agency (IAEA), in the Basic Safety Standards for Radiation Protection (IAEA, 1996) and in European Community legislation in the EU BSS Directive 96/29/Euratom. The public dose standards were incorporated into UK law in IRR 99. In order to implement the Directive in England and Wales, the Environment Agency was issued with a direction by the DETR in 2000 (DETR, 2000b). This includes the requirements that the Environment Agency ensure, wherever applicable,

- all public radiation exposures from radioactive waste disposal are kept As Low As Reasonably Achievable (ALARA)

- the sum of such exposures does not exceed the dose limit of 1 mSv a year

The Environment Agency shall have regard for maximum doses to individuals for use at the planning stage:

- 0.3 mSv a year from any source
- 0.5 mSv a year from the discharges from any single site

The Environment Agency is also required to ensure that the dose estimates made are as realistic as possible for the population as a whole and for reference groups of the population. It is required to take all necessary steps to identify the reference groups of the population taking into account the effective pathways of transmission of radioactive substances. Guidance on the principles underlying prospective radiological assessment (i.e. assessments of potential future doses) has been provided by a group of UK Government Bodies (EA, SEPA, DoENI, NRPB and FSA, 2002). The National Dose Assessment Working Group (NDAWG) has also published principles underlying retrospective radiological assessment (i.e. assessment of doses already received from past discharges) (Allot, 2005) and possible methods of carrying out retrospective assessments of doses to the public using information provided by combined habits surveys (Camplin *et al.,* 2005). NDAWG agreed that the optimal method for performing retrospective dose assessments would be to use habits profiles (profiling method). This approach has now been applied around nuclear sites in the UK in recent RIFE publications – as combined habits surveys are completed.

This report provides information that allows the habits of members of the public to be quantified so that the most exposed groups can be identified and doses to the groups can be assessed in a realistic way.

2 THE SURVEY

2.1 Site activity

The Heysham nuclear power station site is situated to the south-west of Heysham village in Lancashire on the west coast of England, approximately 4 km south of Morecambe and 8 km west of Lancaster (see Figure 1). There are two nuclear power stations next to each other at Heysham; Stage 1 and Stage 2. For the purposes of this survey they are considered as a single site. Both power stations are owned and operated by British Energy Generation Ltd. and generate electricity from twin Advanced Gas-Cooled Reactors. Both stations are still producing electricity. Heysham Stage 1 is expected to operate until 2014 and Heysham Stage 2 is expected to operate until 2023 (www.british-energy.com). The Heysham site produces liquid and gaseous discharges and contains sources of direct radiation. Whilst the survey fieldwork was being carried out, the Heysham Stage 2 reactors were both operating at nominal full power, as was one of the Heysham Stage 1 reactors. The other Heysham Stage 1 reactor was offline for the duration of the survey fieldwork because of an outage.

Under NIA 65, the holder of the site licences for the Heysham power stations, which allow the installation and operation of certain activities, is British Energy Generation Ltd. British Energy Generation Ltd. is also responsible for the day-to-day running of the stations. Under RSA 93, it is authorised to discharge gaseous radioactive wastes via stacks to the atmosphere and liquid radioactive wastes via an outfall into Morecambe Bay. Details of the amounts of radioactive waste discharged in 2005 have been published (EA, EHS, FSA and SEPA, 2006).

2.2 Survey objectives

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook the survey in 2006 on behalf of the Environment Agency, the Food Standards Agency, and the Health and Safety Executive. The aim of the survey was to obtain integrated habits data related to public radiation exposure from the Heysham site via aquatic, terrestrial and direct radiation

pathways in order to permit realistic assessments of critical group doses. Fieldwork was undertaken in order to obtain site specific habits survey data. These data were used to establish exposure pathways for the local population and the characteristics of those most exposed. General habits survey information, such as the number and types of farms or number of angling clubs in the area was also obtained.

Investigations were carried out to ascertain the extent of the following:

- Consumption of food from the terrestrial survey area
- The production, use and destination of local produce
- Consumption and use of groundwater and surface water in the terrestrial survey area
- Occupancy within 1 km of the site perimeter fence
- Consumption of food from the aquatic survey area
- Activities and occupancy rates over intertidal substrates
- Handling rates of fishing gear and sediment
- Activities and occupancy rates in and on water
- Any unusual practices such as the use of seaweed as a fertiliser or livestock feed and the transfer of contamination off-site by wildlife

In addition to the usual investigations, extra time was spent looking into the following activities as the result of site-specific requests from the Environment Agency, the Food Standards Agency and the Health and Safety Executive:

- Sand winning at Heysham Harbour (sand winning is the practice of extracting sand from an area for relocation or use elsewhere)
- The redevelopment of the Middleton Sands holiday park
- Occupancy in the direct radiation survey area at caravan sites, Heysham golf club and the Port of Heysham

The last combined habits survey, which looked at aquatic and terrestrial pathways and briefly considered direct radiation, was conducted by Cefas in the Heysham area in 2001 (McTaggart *et al* 2002). Data from the aquatic survey are used for dose assessments for the

Heysham area (e.g. EA, EHS, FSA and SEPA, 2006). The last full direct radiation habits survey at Heysham was undertaken by Cefas in 1995 (unpublished data).

2.3 Survey areas

Three survey areas were defined to encompass the dominant activities expected for aquatic, terrestrial and direct radiation pathways.

The aquatic survey area, shown in Figure 1, included the coastline and intertidal areas from Fleetwood to South East Point on Walney Island, and the waters of Morecambe Bay offshore as far as an imaginary line between these two points. This survey was not intended to be a full investigation of the Lune and Wyre rivers and estuaries although some information on wildfowling, salt marsh grazing and commercial fishing activities was collected. The same area was used in the 2001 survey and was based on hydrographic survey information. The area is relevant to the effects of liquid discharges from the site.

The terrestrial survey area, shown in Figure 2, was defined as the circle to a radius of 5 km from the Heysham site centre (NGR SD 401 596) to encompass the main areas of potential deposition from gaseous discharges. No watercourses or bodies of freshwater were noted in the survey area. The same area was used in the 2001 survey.

The direct radiation survey area is also shown in Figure 2. The Heysham site comprises two licensed sites containing Heysham Stage 1 and Heysham Stage 2. There are separate perimeter fences around the two licensed sites, though in part they are shared. The direct radiation survey area was defined as the area within 1 km of the overall external perimeter fence of the two licensed sites, which thus excluded the shared boundary. In 1995 and 2001, the area was slightly smaller being within 1 km of the site centre.

Due to the densely populated nature of the direct radiation survey area, it was not possible to interview everyone spending time in it. Therefore, effort was concentrated on the area up to

0.25 km from the perimeter fence since it receives the greatest dose of direct radiation. Correspondence between Cefas and British Energy Generation Ltd. (personal correspondence) indicated that this closer area also receives the greatest amount of wash out from the plume of gaseous discharges.

2.4 Conduct of the survey

Prior to the start of the fieldwork, discussions were held between the Cefas survey team and representatives from British Energy Generation Ltd., the Environment Agency, the Food Standards Agency and the Health and Safety Executive. These discussions provided an outline of the main aims of the survey and highlighted areas or items, which required special attention or effort by the team.

As part of the pre-survey preparation, people with a local knowledge of the survey area were contacted for information on any aspects relevant to the various exposure pathways. Organizations that were contacted included; Lancashire County Council, Lancaster City Council, Fylde Borough Council, Morecambe Tourist Information Centre, the Marine Fisheries Agency (formerly the Sea Fisheries Inspectorate), the North Western and North Wales Sea Fisheries Committee, the British Association for Shooting and Conservation including local branches, the National Federation of Sea Anglers, the State Veterinary Service, the Lancaster Beekeeping Association and the Devonshire Road Allotment Association. People from these organizations provided information on activities in the aquatic survey area, commercial and non-commercial fishing, shellfish collecting, angling clubs, allotments, beekeeping and wildfowling. Further information regarding the habits of people in the aquatic and terrestrial survey areas was obtained from Internet searches, Ordnance Survey maps and from previous habits surveys undertaken at Heysham. A proposed fieldwork programme was sent to the Environment Agency, the Food Standards Agency, and the Health and Safety Executive for comment before the fieldwork commenced.

The fieldwork component of the survey was carried out from 5th – 15th September 2006 by a survey team of four people, according to techniques described by Leonard *et al.* (1982).

At the start of the fieldwork, on 6th September a meeting was held between the survey team and representatives from British Energy Generation Ltd. This served to provide details about site operations, waste disposal and information about potential pathways and activities in the area. Details obtained are as follows:

- Site activities at the time of the survey fieldwork included; both reactors at Heysham stage 1 and one reactor at Heysham Stage 1 were operating at nominal full power, one reactor at Heysham Stage 1 reactor was offline for the duration of the survey fieldwork because of an outage.
- Heysham Stage 1 and Stage 2 have separate outfalls; there are strict times for the discharge of liquid effluent, these times are different for Stage 1 and Stage 2.
- Information about potential pathways and activities in the area included; the cockle ban, locations of guided walks on Morecambe Bay; bird watching areas; RNLI locations; no seaweed use known of in the area; walkers and dog walkers use the Heysham Nature Reserve.

The site representatives were also asked about any wildlife studies and pest control measures in and immediately around the site. Animals could be carriers for transporting radioactive materials off-site and are also potential food items for some individuals.

During the fieldwork, individuals who were identified in the pre-survey preparation as having the potential to be exposed to radioactivity from the site were contacted and interviewed. Interviews were used to establish individuals' consumption rates of locally grown terrestrial foods and locally caught seafood, their handling rates of intertidal sediments and fishing gear, their occupancy rates relevant to external exposure and occupancy rates in and on water. Any general information of possible use to the survey was also obtained. Using the information gained in the interviews, a list of occupations and activities was built up to produce a picture of potential exposure pathways. This then enabled emphasis to be placed

on those individuals who were likely to be the most exposed, including commercial fishermen, bait diggers, anglers, farmers, allotment holders and people living and/or working close to the site.

The survey did not involve the whole population in the vicinity of Heysham, but targeted subsets or groups, chosen in order to identify those individuals potentially most exposed to radiation pathways. However, it is possible that even within a subset or group there may be people not interviewed at the time of the survey. Therefore, to aid interpretation, the number of people for whom data were obtained in each group as a percentage of what is estimated to be complete coverage for that group has been calculated. The results are summarised in Table 1. The 'groups' are described and quantified, and the numbers of people for whom data were obtained are given as percentages of the totals. It should be noted that for certain groups, such as anglers, it can be virtually impossible to calculate the total number of people who undertake the activity in the survey area as many people visit from outside or only visit occasionally during the year. In other cases, it may be necessary to estimate the number of individuals from the number of clubs, for example. These cases are explained in Table 1. Overall, although the number of potential interviewees in the terrestrial survey area was estimated to be around 23000, and several thousand people would use the aquatic survey area, information was obtained for a significantly smaller number than this. The limited fieldwork time was directed at those individuals considered to be the most exposed, such as farmers, allotment tenants, commercial fishermen, anglers, bait diggers, wildfowlers, etc. In particular, it should be noted that the survey did not include site employees, or contractors that were working on site. This is because dose criteria applicable to these people whilst at work and the dose assessment methods are different to those for members of the public.

For each of the three survey areas, the survey targeted pathways primarily relevant to that survey area. Where possible, people were asked about habits relating to the other two survey areas. People in the terrestrial survey were initially questioned because it was known that they grew significant quantities of terrestrial foodstuffs. However, they were also asked about habits that might also lead to exposure to liquid discharges and direct radiation. During

interviews with representatives from clubs such as sailing clubs, it was not possible to collect data for all pathways (such as consumption of local foods) for each member. In these cases, data were limited to those relating to the primary reason for the interview (e.g. in the case of the sailing club, data were limited to occupancy rates on water for club members). In Annexes 1 and 2 such individuals only have data for the pathways of primary interest.

Thirty-six person-days were spent investigating the survey areas and interviewing individuals who were relevant to the survey. Observations for 1043 individuals were recorded. During the survey, gamma dose rate measurements were taken to aid assessment of external exposure pathways.

3 METHODS FOR DATA ANALYSIS

3.1 Data recording

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 habits survey database where each individual for whom information was obtained was given a unique identifier (the observation number) to assist in maintaining data quality.

During the interviews, people could not always provide consumption rates in kilograms per year for food or litres per year for milk. In these cases, 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. The database converted these data into consumption rates (kg/y for food and l/y for milk) using a variety of conversion factors. These factors included produce weights (Hessayon, 1990 and 1997; Good Housekeeping, 1994), edible fraction data researched by Cefas, and information supplied by the Meat and Livestock Commission. For the purpose of data analysis, foodstuffs were aggregated into food groups as identified in Table 2. Specific food types relevant to this survey are presented in the subsequent tables.

All consumption and occupancy data in the text of this report are rounded to two significant figures to reflect 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 row totals or mean rates to appear slightly erroneous ($\pm$ 0.1). Consumption rates less than 0.05 kg/y are presented to two decimal

places in order to avoid them appearing as 0.0 kg/y. External exposure data are quoted as integers.

To ensure the quality of the data collected during the survey fieldwork and presented in the report, the following procedures have been employed:

- Experienced scientific staff were used for fieldwork and data assessment. They had been trained in the techniques of interviewing and obtaining data for all pathways that were relevant to the survey being conducted. Where individuals offered information during interview that was unusual, they were questioned further in order to double-check the validity of their claims.
- Where possible, interviewees were contacted again to confirm the results of the initial interview if, when final consumption or occupancy rates were calculated, observations were found to be high in relation to our experience of other surveys. Local factors were taken into account in these cases.
- Data were manipulated in a database using a consistent set of conversion factors.
- Data were stored in a database in order to minimise transcription and other errors.
- Draft reports and data tables were formally reviewed by an experienced consultant in radiological protection.
- Final reports were only issued when the Environment Agency, the Food Standards Agency and the Health and Safety Executive were entirely satisfied with the format and content of the draft.

The habits data are structured into groups of activities with similar attributes. For example, when considering terrestrial food consumption, all types of root vegetables are grouped together in a food group called ‘root vegetables’. Similarly, for aquatic food consumption, all crustacean species are grouped as ‘crustaceans’. For external exposure over intertidal sediments, occupancy over a common substrate, (e.g. sand) is chosen. The choice of a group of activities is made when it is reasonable to assume that consistent concentrations or dose rates would apply within the group.

In addition to grouping of activities, ingestion 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. These age groups are from 0 to 1.0 y of age (called 3 month old); more than 1.0 y to 2.0 y (called 1 year old); more than 2.0 y to 7.0 y (called 5 year old); more than 7.0 y to 12.0 y (called 10 year old); more than 12.0 y to 17.0 y (called 15 year old). Individuals over 17 years old are treated as adults. These age groupings are consistent with those used in ICRP 72 (ICRP, 1996). For direct radiation pathways, the data are grouped into distance zones from the site perimeter as a coarse indication of the potential dose rate distribution due to this source of exposure. The bands used were: 0 – 0.25 km, >0.25 – 0.5 km and >0.5 – 1 km. These distance bands are also useful when assessing exposure to gaseous discharges.

3.2 Data analysis

The main output of the study is the statement of individuals' consumption, handling and occupancy rates given in Annexes 1 and 2. These can be used by those undertaking radiological assessments of the effects of the operation of the Heysham site – taking into account the concentration and/or dose rate distributions in space and time relevant to the assessment. It is only with the outcome of such an assessment that the critical group can strictly be defined as those most exposed.

Annex 3 contains qualitative and estimated data for pathways where it was not possible to obtain quantifiable data from interviews. This includes activities that were heard about during the survey i.e. activities were dormant or were taking place at a different time of year to the survey. Annex 3 has been included in this report so that the information can be used in dose assessments, thereby ensuring that all potential pathways have been covered in the assessments that would otherwise be missed. An estimated rate for two high rate cockle consumers and a potential critical group consumption rate for molluscs have been given. Although consumption rates for cockles were obtained in the 2006 survey, there was a decrease from the previous survey; this was due to the closure of cockle beds in the area.

The estimated rates could be used in dose assessments if the cockle beds reopen in future years.

In addition to providing data in the annexes, we have also analysed them to provide estimates of rates of occupancy, handling and consumption which can be regarded as typical of those most exposed prior to a formal assessment being undertaken. Three 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 rates observed within a factor of 3 of the maximum value (termed the lower threshold value). It accords with the principle expressed by ICRP (ICRP, 1984) that the critical group should be small enough to be reasonably homogeneous with respect to age, diet and those aspects of behaviour that affect the doses received. In this report, the term critical group rate is used to represent the data derived by the 'cut-off' method for ease of presentation. A separate critical group rate was calculated for each food group, intertidal substrate and handling pathway identified in the survey. In certain cases, using the 'cut-off' method could result in only one person being 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 others were to be included, the second highest rate was divided by three to give a new cut-off value and all observations above this were included in the critical group. When the second highest rate has been used, this is explained in the table notes.

Secondly, the 97.5 percentile rate was calculated for each group using the Excel mathematical function for calculating percentiles. This method 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.

Thirdly, data has been profiled using the ‘cut-off’ approach. This gives a complete view of the habits of the individual that might lead to exposure to all the discharges and radiation from the site. The profiled data has been used to assess total dose integrated across all pathways of exposure.

For ingestion pathways, critical group rates for children have been calculated from the survey data. However, because few child consumers were identified, the rates should be viewed with caution. For assessment purposes, an alternative approach may be taken which involves scaling the critical group rates for adults by ratios. These ratios are given in Annex 4 and have been calculated using generic 97.5 percentile consumption rates.

Selection of 97.5 percentile and critical group rates for occupancy is not made for the direct radiation pathway. Such an analysis is of limited value without a detailed knowledge of the spatial extent of dose rates due to direct radiation.

4 AQUATIC RADIATION PATHWAYS

4.1 Aquatic survey area

The aquatic survey area, shown in Figure 1, included the coastline and intertidal areas from Fleetwood to South East Point on Walney Island. The survey area also included the waters of Morecambe Bay offshore as far as an imaginary line between these two points. This survey was not intended to be a full investigation of the Lune and Wyre rivers and estuaries.

Overview of survey area

The survey area includes approximately 60 km of coastline around Morecambe Bay. Morecambe Bay is a vast intertidal area where several kilometres of mud and sand interspersed with cockle and mussel beds are exposed at low tide. Most of the shoreline is made up of sandy beaches, sandy mud flats or salt marsh. The main types of commercial fishing activity in the bay are drift, haaf and lave netting for salmon (*Salmo salar*), tractor fishing or trawling for brown shrimps (*Crangon crangon*), cockling and musseling. In addition, lots of smaller scale commercial fishing activities take place around the bay including fyke netting, elver fishing, long lining, rod and line fishing and set netting.

Many activities were common to the whole survey area. Large tidal excursions at beaches allowed good access to the public for activities such as angling, walking and dog walking. Bait digging was carried out at several beaches on the mud and sand areas lower down the foreshore and wildfowling was carried out on almost every stretch of salt marsh. No houseboats or likely locations for houseboats were identified.

Fleetwood to Glasson Dock

Fleetwood lies on the western side of the mouth of the Wyre Estuary. It was once an important sea fishing town but the fleet has declined over the years as fish stocks have

diminished. In Fleetwood, activities associated with commercial fishing take place at Wyre Fish Dock. The dock had a small fish market and approximately 20 processing units occupied by fish merchants. The dock had berths for commercial vessels that sold most of their catch to the fish merchants on site. However, fish from Fleetwood boats only accounted for a small percentage of the fish processed at the dock. Most of the fish processed here was bought in from fishermen based at other ports, who were operating outside the survey area and therefore not relevant to this survey. During the survey there were only about six Fleetwood based boats fishing in Morecambe Bay; most were small stern trawlers whose main catch was flatfish, such as plaice (*Pleuronectus platessa*), flounder (*Platichthys flesus*), Dover sole (*Solea solea*) and thornback ray (*Raja clavata*), or bass (*Dicentrarchus labrax*). One commercial fisherman targeted bass using a rod and line from a boat and also had a small amount of pots for crab (*Cancer pagurus*) and lobster (*Hommarus gammarus*).

Adjoining Wyre Fish Dock was Fleetwood Harbour Village Marina – a large marina with 300 berths that was home to Fleetwood Harbour Yacht club. Sailing boats and jet-skiers who had launched from Fleetwood were seen in Morecambe Bay during the survey. The sandy parts of the beaches at Fleetwood were used by the public for angling and dog walking. Further down the beach, eight commercial bait diggers dug for black lugworm on the mud and sand areas. Seven of them worked together for one company, which sold the bait nationally. The other person sold his bait to an angling shop in the survey area.

On the eastern bank of the Wyre Estuary was the village of Knott End. There was a slipway used by members of Knott End Slipway Boat Angling Club as well as others to launch boats. Shore anglers fished directly from the slipway and adjoining sea wall and also from sandy and muddy areas to either side of the slipway at low tide. One hobby fisherman set long lines on the beach at Knott End to catch fish for his own consumption. There was a coastguard's station based at Knott End manned by 13 people. The coastguard's stations around Morecambe Bay (Knott End, Arnside and Walney Island) are unique in that they are equipped to carry out rescues at sea as well as on land.

Between Knott End and Cockerham there were two tide washed salt marshes (Pilling and Cockerham). Both salt marshes were owned by farmers who grazed sheep on them. No wildfowling took place on Pilling Marsh but the shooting rights for Cockerham Marsh were let to Morecambe Bay Wildfowlers Association. The farmer who owned Cockerham Marsh picked samphire (*Salicornia europaea*) to sell commercially.

Offshore from Cockerham Marsh there was a vast sandy area called Cockerham Sands. This was used by holiday makers from a caravan site at Bank Houses and regularly by local water sports enthusiasts. Windsurfers interviewed at Bank Houses reported that when weather conditions were right, up to 20 people could be seen windsurfing at Cockerham Sands at any one time.

To the north of Cockerham Sands was Glasson Marsh. Part of this was owned by a farmer who used it for grazing sheep and cattle. No wildfowling took place there but samphire was collected and sold at a nearby retail outlet. The other part was owned by a different person who let the shooting rights to a private syndicate of three individuals. The owner collected samphire from his part of the salt marsh but did not sell it commercially.

Glasson Dock to Heysham power station

Two commercial fishing boats were kept at Glasson Dock, a small port on the southern bank of the Lune Estuary. One boat was rigged for shrimp trawling and the other for drift netting, shrimp trawling and seine netting. Interviews were not held with either of the owners because they were not fishing at the time of the survey. Glasson Sailing Club was based at the dock. The club had approximately 150 members plus their families, and a core of 50 keen sailors. Approximately 70 boats were kept on land in the club's compound and approximately 20 boats were kept on moorings in the estuary. A marina at Glasson was not considered relevant to the aquatic survey as it contained freshwater which was unaffected by liquid discharges.

The River Lune and Lune Estuary were used by 20 salmon netters, most of whom used haaf nets, and a few used drift or seine nets. Numbers of salmon caught in the 2006 season were very low due to a scarcity of fish. River Lune salt marshes on the south and north banks of the estuary included Stodday Marsh, Aldcliffe Marsh, Oxcliffe Pool, Peggymarsh Pool, Heaton Marsh, Colloway Marsh and Lades Marsh. Most were used by farmers for grazing livestock and by Morecambe Bay Wildfowlers Association for wildfowling. One wildfowler went punting in the Lune Estuary. Punting is a rare type of wildfowling carried out by lying in a boat, which is similar in shape to a canoe, and shooting the wildfowl overhead. The River Lune is intertidal upstream as far as the middle of Lancaster.

Bazil Point and Sunderland Point are located near the mouth of the River Lune on its northern bank. One hobby fisherman set fyke nets for eels on mud and sand at Bazil Point and one person went dog walking on salt marsh there. To the north-west of Sunderland Point was another stretch of salt marsh, again used by a farmer for grazing livestock.

There used to be a large holiday camp on the coast near Middleton but at the time of the survey this was being redeveloped into accommodation for elderly residents (see Section 5.1).

Immediately to the south of the Heysham power stations was another large caravan site. Residents from the site and other members of the public used Red Nab, the adjoining beach area in front of the site, especially for angling. Red Nab was a small beach with patches of sand, mud and rock. The muddy patches, and other muddy areas all around Heysham were used by one small-scale commercial fisherman for set netting.

Heysham power station to Arnside

The Heysham power stations were bordered by a sea wall to the south and the Port of Heysham to the north. The sea wall to the south of the power station and the sea wall to the north, which encompassed the Port of Heysham, were very popular sites for sea anglers, bird

watchers and walkers. Heysham Harbour and the Port of Heysham was a large, busy area with ferry terminals for freight and passenger ferries as well as several other businesses, including an aggregate extraction company and a support base for the off-shore gas industry. North of Heysham Harbour was Half Moon Bay, a sheltered, sandy beach, popular with locals for walking, jogging, playing and dog walking.

One of the customers' site-specific requests was to investigate sand winning at Heysham Harbour. Sand winning is the practice of extracting sand from an area for relocation or use elsewhere. Preliminary desk-based investigations into this activity took place prior to going on the fieldwork but no information as to who undertook or licensed the sand winning could be obtained. During the fieldwork no signs of sand winning taking place were noted at Heysham Harbour.

During the survey, work was taking place to create and repair sea defences by building up piles of boulders on 2.5 km of beaches between Half Moon Bay and Hest Bank. The work involved approximately 30 men and was an 18 month long contract, scheduled to end in July 2007.

There was a promenade from Half Moon Bay, past Sandylands and into Morecambe, which was well used by walkers, cyclists and anglers, but it was not tide-washed. Anglers also fished from sandy beaches below the promenade at low tide. Two individuals set long lines from the beach at Sandylands for their own fish consumption.

About 0.5 - 1 km offshore from the promenade were two stony mussel beds worked by commercial seed mussel and mussel collectors. Collectors operated from The Battery Slipway, Sandylands, where wholesalers also came to load the bagged-up mussels (*Mytilis edulis*) into lorries. Seed mussels were exported to Germany for re-laying.

Morecambe was a popular seaside tourist town. To the north of The Battery Slipway was Morecambe Beach, comprising a series of small bays situated between manmade structures

such as piers, slipways and rocky outcrops built for sea defence purposes. The slipways are identified on Figure 1. The substrate on these bays was generally sandy near the upper foreshore, with mud and sand on the lower foreshore, but one stretch where anglers were observed had a substrate of sand and stones. Morecambe Beach was popular with walkers, dog walkers and anglers but bait digging was not permitted between The Battery Slipway and Town Hall Slipway. One commercial fisherman set fyke nets for European eels (*Anguilla anguilla*) over mud and sand on Morecambe Beach.

The Stone Jetty was the centre of the Morecambe tourist area. This was commonly used by shore anglers but was also the base for five commercial netters who moored their boats just off shore. Seven rowing boats, some used for gaining access to the fishing boats, were observed on dry land in a compound there and they launched from the slipway on the northern side of the jetty. North of Stone Jetty was Green Street Slipway, a busy place where lots of non-commercial vessels launched for boat angling, jet-skiing and motor boating. Morecambe's only two remaining shrimp boats were anchored in the water near the slipway and fished in Morecambe Bay trawling for brown shrimps. An RNLI unit with a crew of 20 people was based just north of Green Street Slipway. The next slipway to the north was called Town Hall Slipway. This was used by Morecambe and Heysham Yacht Club and by owners of other non-powered vessels. North of Town Hall Slipway was Calton Terrace Slipway, which was used by boat anglers, some who moored boats in the water and some who launched from the slipway.

The next village to the north was Hest Bank. The majority of the beach between Morecambe and Hest Bank was completely closed during the survey due to the sea defence work that was taking place. From Hest Bank, past Bolton-le-Sands and Carnforth, up until a few kilometres north of Silverdale, the coastline was characterised by large areas of salt marsh used for grazing livestock, although these have reduced in size in recent years due to coastal erosion. At low tide, large expanses of mud and sand were exposed and people were observed walking, dog walking and bird watching. The salt marsh at Silverdale was also popular with walkers, and dog walkers and RSPB's Leighton Moss reserve attracted bird

watchers to the area. Nine RSPB wardens carried out bird monitoring work on salt marsh near Silverdale and at Warton Sands within the RSPB reserve.

Arnside to Greenodd

Arnside was a popular tourist village located on the southern bank of the Kent Estuary. Most visitors spent time on the promenade and slipway rather than the muddy beach. However, some members of Arnside Sailing Club who have boats moored on the beach and shore anglers, did spend time on intertidal areas. There was a coastguard's station at Arnside manned by a crew of 12 people. One turf cutter was identified who worked on Hazelslack Marsh just north of Arnside.

Seven salmon lave netting licences were issued for the Kent. Commercial elver fishing was also noted to take place on the upper Kent estuary.

There was very limited access to the sandy foreshore on the upper reaches of the Kent Estuary but further around the coast was the town of Grange-over-Sands. Although the beach at Grange-over-Sands previously had a sandy substrate, this has recently been replaced by a significant area of salt marsh. Few activities were therefore noted to be taking place on the foreshore at Grange-over-Sands. A wildfowling club based in the town had the shooting rights over salt marshes between Flookburgh and Haverthwaite on the Leven Estuary. This included Out Marsh, Low Marsh and Sand Gate Marsh and again, salt marshes backing the shoreline were used for grazing livestock during the summer months.

Seven commercial fishermen and two shrimp processing plants were based at Flookburgh. The majority of fishing here was done by fishermen using tractors to tow nets over the vast areas of mud and sand at low water to catch shrimps. Some set netting for fish species and hand raking for mussels and cockles (*Cerastoderma edule*) was also carried out by the shrimp fishermen during periods of less productive shrimp fishing. As well as selling peeled

shrimps to a local wholesaler, most fisherman in the village sold shrimps, which their families had prepared and potted in jars with butter, from their houses.

Greenodd to Foulney Island

Near the top of the Leven Estuary was the village of Greenodd where a large car park near the riverbank provided good access to the water's edge for local and visiting anglers. Angling matches would frequently be held here because the anglers could usually rely upon good catches of flounder.

Canal Foot was a small hamlet on the western bank of the Leven Estuary to the south of Greenodd. Three commercial lave netters with salmon licenses for the River Leven fished at Canal Foot in the summer season. One of the three also went tractor fishing for shrimps and occasionally acted as a guide for parties of people wishing to walk safely to Chapel Island over the large expanses of sand at low water. Another of the three also worked stake nets for flounders and the other had set nets but the fish caught were for their own consumption rather than sold commercially.

Just south of Canal Foot was a small village called Bardsea where a large cockle and mussel wholesaler was based. Between Bardsea and Rampside the coastal substrate was mostly sand with large areas of beach flats exposed at low tide. At locations where the main road ran close to the shore, tourists parked their vehicles and used the beaches for recreational activities such as angling, picnicking and walking. On the previous survey some non-commercial cockle collection took place on this stretch of coastline but this was not the case during the 2006 survey because cockle beds were closed.

One person based at Newbiggin was reported to collect mussels on a commercial basis and sell them to a company in north-east England to be used for bait. However, this individual was not available for interview during the survey. Two oyster farms were based along this stretch of coastline – a small one at Newbiggin where it was not possible to conduct an

interview and a larger one at Roosebeck. The oyster farm at Roosebeck reared Pacific oysters (*Crassostrea gigas*) for sale to other oyster farms in Ireland and Scotland for growing on.

Between Rampside and Roa Island causeway there was a small area of salt marsh.

Foulney Island to Walney Island

Foulney Island was a small island at the end of a shingle bank leading offshore from Roa Island, accessible at low tide and used by a couple of anglers interviewed during the survey. Piel Island was another small island off the coast of Roa Island and was accessible by boat. Some members of Glasson Sailing Club with cruise boats sailed from Glasson, on the Lune Estuary across to Piel Island and back.

Several privately owned yachts and boats were moored on both sides of the causeway leading to Roa Island. Although none were observed, it was reported that some visiting anglers launched their boats from the slipway on Roa Island. Other activities taking place at Roa Island were metal detecting and non-commercial bait digging.

To the north-west of Roa Island was the town of Barrow-in-Furness. Of interest to the survey was Barrow Harbour where approximately five commercial fishermen were based. All five had boats that fished outside the waters of Morecambe Bay. A few boat anglers fished from Barrow-in-Furness and some commercial mussel collectors worked on mussel beds near Barrow-in-Furness at low tide.

Walney Island is separated from the mainland by Walney Channel but the A590 road bridge provided vehicular access. Ferry Slipway located just next to the road bridge was frequently used by boat anglers and water sport enthusiasts launching their boats. Walney Island had a thriving boat angling club with in excess of 200 members, many of whom regularly fished in the survey area. One individual was observed collecting lobsters by hooking them up from

the shallow waters near the slipway with a stick and he also collected whelks (*Buccinum undatum*) from the mud and sand parts of Walney Channel on exceptionally low tides. Other individuals interviewed collected peeler crabs for bait from around the slipway. Other activities undertaken at Walney Island were non-commercial bait digging, metal detecting, beach combing, walking, dog walking and shore angling.

Livestock were grazed on Walney Island marshes - Tummer Hill Marsh and Wylock Marsh along the south-eastern shore of the island. A wildfowling club had the shooting rights on the foreshore all around the island, although they restricted their activities to these two salt marshes. South Walney Nature Reserve at the bottom of Walney Island had one warden who spent some time on Wylock Marsh.

4.2 Commercial fisheries

Morecambe Bay was home to many different methods of commercial fishing and shellfish collection, and most fishermen worked more than one type of gear over the course of the year.

The main hubs of commercial fishing activity were Wyre Fish Dock in Fleetwood, Stone Jetty and Green Street Slipway in Morecambe and the beach at Flookburgh. Wyre Fish Dock was home to about 12 commercial fishing boats, half of which fished within Morecambe Bay. Most of the boats fishing in Morecambe Bay used trawl gear and targeted bass or flatfish. For six months of the year one commercial fisherman used a rod and line to catch bass and pots to catch crab and lobster. Stone Jetty was where five drift netting boats anchored. These boats targeted salmon and bass but also caught by-catches of grey mullet (*Chelon labrosus*) and other fish. Morecambe's only two remaining shrimp trawl boats were based at Green Street Slipway. They were able to fish for shrimps all year. Flookburgh beach was where seven fishermen went tractor fishing for shrimps at low tide through shallow water. They tended to do this type of fishing between May and November although some of them also had salmon

licenses so they changed from shrimp fishing to salmon fishing in the Kent Estuary for a couple of months in the summer.

In addition to these three main hubs of activity, some types of commercial fishing took place all over the survey area. The Rivers Lune, Kent and Leven were used by a total of 30 fishermen who had licenses to catch salmon and sea trout (*Salmo trutta*). In the Lune Estuary, the main type of net used was a haaf net, whereas in the Kent and Leven Estuaries it was a lave net. Both of these methods involved the fishermen standing in the river facing the direction of the incoming or outgoing tide and holding a pole with a net attached to it. Haaf netting is done in deeper water than lave netting. Drift nets and seine nets (known locally as draw nets) operated from small boats were alternative methods used for catching salmon. The season for salmon fishing was from June to August.

Elver fishing in the Rivers Kent, Gilpin, Wyre, Cocker and Keer was carried out by five fishermen with licenses from the Environment Agency. Elver fishing involved standing on a steep sided, muddy riverbank with a net on a long pole in the water. It was done during the hours of darkness and the season was between January and April. Reports of a couple of unlicensed elver fishermen were heard during the survey.

One commercial fisherman set fyke nets to catch eels on one of the beaches at Morecambe.

Three commercial fisherman, one part-time and two full-time, put out set nets to catch fish including bass. One worked on several beaches around Heysham, one worked at Bazil Point and one worked on Warton Sands.

The main species of shellfish collected in Morecambe Bay were cockles and mussels, which grew on specific beds around the bay. Both species were harvested by a few local fishermen and several gangs of workers from elsewhere which travelled around the country, working whichever beds were open at the time. Both cockles and mussels were raked off the intertidal substrate and into net bags before being transported back to shore and loaded into

lorries for export. Seed mussels were exported to Germany for re-laying and cockles were exported to France and Spain.

Cockles grew on sandy beds in areas such as Fleetwood, Knott End, Pilling Sands, Middleton Sands, Heysham, Morecambe, Flookburgh, Bardsea and Aldingham. All cockle beds in Morecambe Bay were closed at the time of the survey, and with the exception of Middleton Sands, Pilling Sands and Knott End, which were open for the first four months of 2006, they had been closed since April 2005. When cockle beds are closed, they are closed to commercial and non-commercial collectors alike. However, the survey team heard reports that a few individuals continued collecting small amounts of cockles for their own consumption, despite the ban.

Mussels grew on stony outcrops known locally as skears, exposed at low tide. Mussel beds in the survey area could be found at Fleetwood, Knott End, Heysham, Sandylands, Morecambe, the Lune Estuary and Barrow-in-Furness. However, during the survey, no beds suitable for the collection of fully grown mussels were open. Seed mussel could also be collected on some beds for export and further growth elsewhere. At the time of the survey, only one bed was open for seed mussel collection. This was off the coast of Sandylands. The bed was open from Mondays to Fridays and about 75 people were seen working the beds at any time. It was possible for each person to collect up to ¾ tonne seed mussel every day.

Pacific oysters were farmed by two companies in the survey area – one large company at Roosebeck and one smaller one at Newbiggin. The larger business took spat from a farm on Walney Island and grew them on in oyster beds at Roosebeck, from where they were exported to Scotland and Ireland. No further information was obtained from the company at Newbiggin, as it was not possible to conduct an interview at this location.

4.3 Angling and hobby fishing

Shore angling was popular at many locations in the survey area. The main locations where anglers fished over intertidal substrates such as rocks or beaches were Knott End, Red Nab, Half Moon Bay, Sandylands/Morecambe, Arnside, Flookburgh and Canal Foot. Busy non-tide-washed angling spots included Knott End Slipway, the southern and northern sea walls at Heysham Harbour, the promenade between Heysham and Morecambe, Stone Jetty and Green Street Slipway in Morecambe, the sea wall at Storth and the dismantled railway line at Greenodd.

Boat angling was very common throughout the survey area. Boat angling clubs were based at Knott End, Morecambe and Walney Island where there were slipways for both club members and other individuals to launch their boats.

Two angling charter boats run by the same person were based in the survey area at Fleetwood, but nearly all angling parties were taken outside Morecambe Bay to fish in deeper water.

The most common species of fish caught in the survey area by shore and boat anglers were plaice, bass, flounder and cod (*Gadus morhua)*. Several boat anglers were also catching mackerel (*Scomber scombrus*).

Hobby fishermen were identified and interviewed during the survey. Fishing methods used by them included netting from a boat off the coast of Morecambe for shrimps, long lining on beaches at Knott End for plaice and sole in the summer and at Sandylands for cod in the winter, set netting at Canal Foot for flounder and grey mullet, and fyke netting at Bazil Point for eels. The catches were either eaten by the hobby fishermen and their families or given away to friends and neighbours.

Small amounts of other shellfish were being collected non-commercially from around the bay. One person collected cockles from Cockerham Sands. One person collected mussels from around the outfall pipe at Heysham. One person hooked lobsters and collected whelks, both from Walney Channel.

Two individuals collected peeler crab for bait from Heysham and the eastern side of Walney Island, and two people collected winkles (*Littorina littorea*) from Heysham on behalf of Cefas for environmental monitoring purposes but they did not consume any themselves.

4.4 Wildfowling

Four wildfowling clubs were identified that were shooting in the survey area, and contact was made with people from three of them. One club had the shooting rights for almost all of the salt marshes between Cockerham Marsh and Warton Marsh including the River Lune salt marshes, as well as the sands of Morecambe Bay exposed at low tide. Another shot on the salt marshes between Grange-over-Sands and Haverthwaite and the other shot on Tummer Hill Marsh and Wylock Marsh on Walney Island. The wildfowling season opened on 1st September and closed on 20th February.

The three clubs "where interviews were held" had 294 members between them – 220 at one club, 40 at another and 34 at another. Of the 294 wildfowlers, according to the club representatives interviewed, very few in fact went shooting on a regular basis, for example only four from the club with 34 members. Many individuals were only club members for the social activities and events. On part of Glasson Marsh where the shooting rights were not let to a wildfowling club, the owner of the salt marsh let the shooting rights to a private syndicate of three men.

One individual went wildfowling in a punt on the Lune Estuary in addition to his time wildfowling on the salt marsh areas.

The main species being consumed by wildfowlers and their families were goose, mallard (*Anas platyrhynchus*), wigeon (*Anas penelope*), teal (*Anas crecca*), pintail duck (*Anas acuta*) and shoveler (*Anas clypeata*).

4.5 Other Pathways

The consumption of samphire from salt marshes was identified (see Section 4.7 for details).

No one was identified using any marine plants or algae from the survey area as fertiliser on their vegetable gardens. However, one person with a market garden had used seaweed on his vegetable garden each year until 2005.

Most salt marshes in the aquatic survey area were used by farmers for grazing livestock, which was predominantly sheep, but also smaller amounts of beef cattle. Interviews were held at nine farms with intertidal grazing, three of which were in the 5 km terrestrial survey area. Livestock were on the salt marsh up to 12 months of the year but only during suitable tidal conditions. The consumption of salt marsh grazed livestock is discussed further in Section 4.7 and external exposure on salt marsh from tending the livestock is discussed further in Section 4.8.

4.6 Wholesalers and retailers

Most of the salmon and sea trout caught by the haaf netters, lave netters and drift netters was either sold privately by the fishermen to local customers or sold to a smokehouse at Glasson Dock. The smokehouse sold some produce directly from the retail outlet there and the rest was sold elsewhere around Britain. The rest of the salmon and sea trout caught by the salmon netters, along with all the other species of fish caught in the survey area was sold to two local fishmongers in Morecambe or to two of the wholesalers at Wyre Fish Dock. There were approximately 20 wholesalers at Wyre Fish Dock in Fleetwood but only a couple bought

any fish from the survey area. As the amount of fish caught in the survey area was so small, it accounted for only a tiny percentage of the fish that was bought and sold at Fleetwood.

Eels from the survey area were all sold to one company who exported them to Holland and elvers were all sold to a single buyer in Gloucester for export abroad.

Shrimps caught in the survey area were sold to two fishmongers in Morecambe, one shrimp potting/processing company in Morecambe and two shrimp potting/processing companies near Flookburgh. Most shrimpers also sold a certain amount of shrimps from their homes to local customers. The small amounts of crab and lobster caught in the survey area were sold to one of the wholesalers in Fleetwood or to one of the fishmongers in Morecambe.

There were several cockle buyers operating in the survey area. Most Morecambe Bay cockles were exported to France. At the time of the survey, seed mussel was bought by two agents for export to Germany where it was re-laid. Pacific oysters were exported to Scotland and Ireland when fully grown.

During the survey no evidence was found of wildfowl from the survey area being sold to game dealers.

Samphire was sold by two people – one who collected it from Cockerham Marsh and sold it at farmers' markets around Lancashire and another who collected it from Glasson Marsh and sold it at the smokehouse in Glasson Dock. None of the farmers' markets in Lancashire where the samphire was sold were inside the survey area – the closest one where it was sold was Lancaster farmers' market.

Cattle and sheep, which grazed on salt marsh grass, which like wildfowl are therefore considered in the aquatic survey, were sold to private customers, and via farmers markets in Lancashire and a livestock auction in Lancaster, both outside the survey area.

4.7 Food consumption data

Consumption data for local aquatic foodstuffs and salt marsh grazed sheep are presented in Tables 3 to 8 for adults and in Tables 9 to 14 for children. The tables include the mean consumption rates of the critical groups together with the observed 97.5 percentile rates calculated as described in Section 3.2. For purposes of comparison, the data are summarised in Table 15 for adults and Tables 16 to 19 for children (15 year olds, 10 year olds, 5 year olds and 1 year olds respectively). The summary tables also include mean rates and 97.5 percentile rates based on national data (referred to as 'generic' data in this report). No generic data are available for the 5 year old and 1 year old age groups.

Adult consumption rates

Adults were found consuming foods from the following six food groups; fish, crustaceans, molluscs, wildfowl, marine plants/algae and salt marsh grazed sheep. The people consuming the greatest quantities of food from the aquatic survey area were commercial fishermen, commercial and non-commercial cockle and mussel collectors, boat anglers, wildfowlers, farmers with tide washed grazing land and the families of these people.

The predominant species of fish consumed by adults were flounder, plaice, cod, bass and salmon along with much smaller quantities of whiting (*Merlangius merlangus*), mackerel, sea trout, dab (*Limanda limanda*), rays, grey mullet, pollack (*Pollachius pollachius*), lemon sole (*Microstomas kitt*), eel, Dover sole and bream (*Abramis brama*). A critical group of 22 individuals was identified with a maximum consumption rate of 47 kg/y and a mean of 25 kg/y. The observed 97.5 percentile rate based on 177 observations was 30 kg/y. This compares with the adult generic mean and 97.5 percentile consumption rates for fish of 15 kg/y and 40 kg/y respectively. The percentage breakdown of species eaten by the critical group was 20% flounder, 20% plaice, 20% cod, 15% salmon, 10% bass and 15% other species as named in Table 3. These percentages, rounded to the nearest 5%, are based on the total amount of fish consumed by this critical group and exclude observations for 'mixed fish'.

The predominant species of crustaceans consumed by adults was brown shrimps along with much smaller quantities of crab and lobster. A critical group of five individuals was identified with a maximum consumption rate of 24 kg/y and a mean of 16 kg/y. The observed 97.5 percentile rate based on 49 observations was 21 kg/y. This compares with the adult generic mean and 97.5 percentile consumption rates for crustaceans of 3.5 kg/y and 10 kg/y respectively. The only species eaten by members of the critical group was brown shrimp.

The predominant species of molluscs consumed by adults were cockles, mussels and whelks along with much smaller quantities of winkles and oysters. A critical group of 10 individuals was identified with a maximum consumption rate of 7.3 kg/y and a mean of 4.5 kg/y. The observed 97.5 percentile rate based on 29 observations was 7.3 kg/y. This compares with the adult generic mean and 97.5 percentile consumption rates for molluscs of 3.5 kg/y and 10 kg/y respectively. The percentage breakdown of species eaten by the critical group, rounded to the nearest 5%, was 40% cockle, 35% mussel, 20% whelk and 5% winkles.

The predominant types of wildfowl consumed by adults were goose, mallard, wigeon, teal, pintail duck and shoveler with smaller quantities of snipe (*Gallinago gallinago*) and gadwall (*Anas strepera*). A critical group of 24 individuals was identified with a maximum consumption rate of 19 kg/y and a mean of 11 kg/y. The observed 97.5 percentile rate based on 33 observations was 17 kg/y. No generic data are available for wildfowl. The percentage breakdown of species eaten by the critical group, rounded to the nearest 5%, was 30% mallard, 25 % goose, 20% wigeon, 10% teal, 10% pintail duck and 5% shoveler.

The only species of marine plants/algae consumed by adults was samphire. A critical group of seven individuals was identified with a maximum consumption rate of 3.3 kg/y and a mean of 2.4 kg/y. The observed 97.5 percentile rate based on 16 observations was 3.3 kg/y. No generic data are available for this food group.

For salt marsh grazed sheep a critical group of 11 individuals was identified with a maximum consumption rate of 8.5 kg/y and a mean of 5.4 kg/y. The observed 97.5 percentile rate

based on 11 observations was 8.5 kg/y. No generic data are available specifically for salt marsh grazed sheep although the adult generic mean and 97.5 percentile consumption rates for sheep meat in general are 8.0 kg/y and 25 kg/y respectively.

Children's consumption rates

15 year old age group

Children in the 15 year old age group were found consuming foods from the following six food groups; fish, crustaceans, molluscs, wildfowl, marine plants/algae and salt marsh grazed sheep.

For fish, a critical group of six individuals was identified with a maximum consumption rate of 18 kg/y and a mean of 10 kg/y. The observed 97.5 percentile rate based on 14 observations was 16 kg/y. This compares with the generic mean and 97.5 percentile consumption rates for fish of 6.5 kg/y and 20 kg/y respectively.

For crustaceans, a critical group of three individuals was identified with a maximum consumption rate of 5.9 kg/y and a mean of 5.0 kg/y. The observed 97.5 percentile rate based on six observations was 5.9 kg/y. This compares with the generic mean and 97.5 percentile consumption rates for crustaceans of 2.5 kg/y and 6.0 kg/y respectively.

For molluscs, a critical group of one individual was identified with a consumption rate of 2.6 kg/y. The observed 97.5 percentile rate based on four observations was 2.5 kg/y. This compares with the generic mean and 97.5 percentile consumption rates for molluscs of 2.5 kg/y and 6.0 kg/y respectively.

For wildfowl, a critical group of two individuals was identified with a maximum consumption rate of 11 kg/y and a mean of 8.6 kg/y. The observed 97.5 percentile rate based on three observations was 11 kg/y. No generic data are available for wildfowl.

For marine plants/algae, a critical group of two individuals was identified with a maximum consumption rate of 3.3 kg/y and a mean of 2.8 kg/y. The observed 97.5 percentile rate based on five observations was 3.2 kg/y. No generic data are available for marine plants/algae.

For salt marsh grazed sheep, a critical group of three individuals was identified with a maximum and mean consumption rate of 6.6 kg/y. The observed 97.5 percentile rate based on three observations was also 6.6 kg/y. No generic data are available for salt marsh grazed livestock although the generic mean and 97.5 percentile consumption rates for 15 year olds for sheep meat in general are 5.5 kg/y and 15 kg/y respectively.

10 year old age group

Children in the 10 year old age group were found consuming foods from the following five food groups; fish, crustaceans, molluscs, wildfowl, marine plants/algae. No consumption of salt marsh grazed sheep was identified.

For fish, a critical group of five individuals was identified with a maximum consumption rate of 12 kg/y and a mean of 6.6 kg/y. The observed 97.5 percentile rate based on seven observations was 11 kg/y. This compares with the generic mean and 97.5 percentile consumption rates for fish of 6.0 kg/y and 20 kg/y respectively.

For crustaceans, a critical group of one individual was identified with a consumption rate of 5.9 kg/y. The observed 97.5 percentile rate based on three observations was 5.6 kg/y. This compares with the generic mean and 97.5 percentile consumption rates for crustaceans of 2.5 kg/y and 7.0 kg/y respectively.

For molluscs, only one individual was identified with a consumption rate of 0.45 kg/y. The 97.5 percentile rate is not applicable for one observation. This compares with the generic

mean and 97.5 percentile consumption rates for molluscs of 2.5 kg/y and 6.0 kg/y respectively.

For wildfowl, only one individual was identified with a consumption rate of 1.8 kg/y. The 97.5 percentile rate is not applicable for one observation. No generic data are available for wildfowl.

For marine plants/algae, only one individual was identified with a consumption rate of 2.3 kg/y. The 97.5 percentile rate is not applicable for one observation. No generic data are available for marine plants/algae.

5 year old age group

Children in the 5 year old age group were found consuming fish. No consumption was identified for the following five food groups: crustaceans molluscs, wildfowl, marine plants/algae and salt marsh grazed sheep.

For fish, a critical group of three individuals was identified with a maximum consumption rate of 6.4 kg/y and a mean of 4.1 kg/y. The observed 97.5 percentile rate based on three observations was 6.2 kg/y. No generic consumption rates have been derived for this age group.

1 year old age group

Children in the 1 year old age group were found consuming fish. No consumption was identified for the following five food groups: crustaceans molluscs, wildfowl, marine plants/algae and salt marsh grazed sheep.

For fish, only one individual was identified with a consumption rate of 6.4 kg/y. The observed 97.5 percentile is not applicable for one observation. No generic consumption rates have been derived for this age group.

3 month old age group

No children in the 3 month old age group were noted to be consuming any local aquatic foodstuffs or salt marsh grazed sheep.

4.8 Intertidal occupancy

Intertidal occupancy rates for adults and children are presented in Table 20. The table includes data on occupancy over six different types of substrate: mud; mud and sand; rock; salt marsh; sand; and sand and stones. Potential critical occupancies are shown in bold.

The maximum occupancy rate recorded over mud was 1300 h/y for a commercial fisherman operating set nets on the shore all around Heysham. No other individuals had occupancy rates within a factor of three of this, so this was taken as the critical group occupancy rate.

The maximum occupancy rate recorded over mud and sand was 960 h/y for two commercial oyster farmers. Eleven other people (three anglers, seven commercial bait diggers and one person who did both angling and non-commercial bait digging) had occupancy rates within a factor of three of this, giving a mean occupancy rate for this group of 700 h/y.

The maximum occupancy rate recorded over rock was 310 h/y for an angler. Four other anglers and one person angling and collecting peeler crabs for bait had occupancy rates within a factor of three of this, giving a mean occupancy rate for this group of 170 h/y.

The maximum occupancy rate recorded over salt marsh was 840 h/y for a turf cutter. Three other individuals (one walker, one dog walker and one farmer tending livestock) had

occupancy rates within a factor of three of this, giving a mean occupancy rate for this group of 490 h/y.

The maximum occupancy rate recorded over sand was 2400 h/y for 30 people repairing and constructing sea defences between Half Moon Bay and Hest Bank. Two commercial cockle and mussel collectors and an angler had occupancy rates within a factor of three of this, giving a mean occupancy rate for this group of 2300 h/y.

The contract for the sea defence work was 18 months long and work was scheduled to end in mid 2007 so it was not a permanent intertidal activity in Morecambe Bay. With this in mind, figures for a second critical group excluding people working on the sea defences are given here for consideration. In this case, the maximum occupancy rate recorded over sand was 1600 h/y for a commercial cockle and mussel collector. Seven other people (three commercial cockle and mussel collectors, one of whom also gave guided walks over Morecambe Bay, one angler and three people who went dog walking and angling, one of whom also did some of non-commercial bait digging) have occupancy rates within a factor of three of this giving a mean occupancy rate for this group of 880 h/y.

The maximum occupancy rate recorded over sand and stones was 1000 h/y for an angler. No other people had occupancy rates within a factor of three of this, so this was taken as the critical group occupancy rate.

Gamma dose rate measurements

Representative gamma dose rate measurements at 1 m above the substrate were taken over salt marsh, mud, mud and sand, and sand. These measurements (shown in Table 21) ranged from 0.076 to 0.119 μGy/h over salt marsh, 0.070 to 0.093 μGy/h over mud, 0.058 to 0.069 μGy/h over mud and sand and 0.060 to 0.066 μGy/h over sand. Natural levels of around 0.05 μGy/h over sand and around 0.07 μGy/h over mud and salt marsh are expected. A value of 0.06 μGy/h is expected for all other substrate types.

4.9 Handling of sediment, fishing gear and nets

Handling sediment, while bait digging or mollusc collecting, or handling commercial fishing gear (nets, ropes and pots), which has become entrained with fine sediment particles, can give rise to skin exposure from beta radiation. Doses to the skin need consideration as there is a separate dose limit for skin for members of the public. There is also a contribution to effective dose due to skin exposure (ICRP, 1991).

Handling of angling equipment (rods and reels) was not considered to be a significant pathway. Therefore, as in previous surveys, data for this pathway were not collected.

Fishing gear can also be a source of whole body gamma exposure due to occupancy in the vicinity of the gear. However, this pathway is minor compared with the same exposure received during occupancy over intertidal areas and it has therefore been omitted from the report.

Table 22 shows the times spent handling fishing gear and intertidal sediment recorded during the survey for adults and children. The observations for handling fishing gear do not include any children but the observations for handling intertidal sediment include two children.

The maximum fishing gear handling rate recorded was 1300 h/y for a commercial fisherman. Nine other people involved in commercial fishing had gear handling rates that came within a factor of three of this, giving a mean handling rate for this group of 800 h/y.

The maximum sediment handling rate recorded was 1600 h/y for a commercial cockle and mussel collector. Twelve other individuals (three other commercial cockle and mussel collectors, two commercial oyster farmers and seven commercial bait diggers) had occupancy rates within a factor of three of this, giving a mean handling rate for this group of 810 h/y.

4.10 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 enable dose assessment, relevant data have been collected. No manipulation of the data (for example, calculating critical group rates) has been carried out.

Occupancy rates for activities taking place in or on water potentially affected by liquid discharges from Heysham are shown in Table 23 for adults and children. For the purposes of this report, activities where there is a high likelihood of the individual's face going under water have been classified as activities in water since they are more likely to lead to ingestion of water. All other activities have been classified as activities on water. The observations for occupancy in water include one child and the observations for occupancy on water include two children. It should be noted that a lot of the data was gained through interviews with representatives from sailing clubs, the RNLI and HM Coastguards, who provided generic figures for their members.

Activities in the water

Activities taking place in the water around Heysham included windsurfing, swimming, water-skiing and jet-skiing. Seven observations were recorded and the highest occupancy rate was 160 h/y for two windsurfers.

Activities on the water

Activities taking place on the water around Heysham included commercial fishing (drift netting, elver fishing, trawling, lave netting, haaf netting, tractor fishing for shrimps, rod and line fishing from a boat and seine netting), hobby fishing (drift netting and trawling), sailing, angling, boat maintenance, RNLI and HM Coastguards duties, canoeing, punting and hooking

for lobster. One hundred and seventy-one observations were recorded. The highest occupancy rate on water was 1500 h/y for a commercial fisherman doing drift netting, elver fishing and trawling as well as some non-commercial punting.

5 TERRESTRIAL RADIATION PATHWAYS

5.1 Terrestrial survey area

The terrestrial survey area covered all land and watercourses within 5 km of the Heysham site centre (NGR SD 401 596) as shown in Figure 2.

Land in the terrestrial survey area was bordered to the west by Morecambe Bay and to the east and south-east by the River Lune. The land formed a peninsula, on which the villages of Lower and Higher Heysham, Middleton and Overton were located. The southern extent of Morecambe was located in the northern part of the survey area. The rest of the terrestrial survey area was predominantly agricultural.

Ten working farms were identified in the area and interviews were held at nine of them. Of these nine farms:

- One farm had dairy cattle, beef cattle, sheep and chickens for egg production
- Two farms had dairy cattle, beef cattle and sheep
- One farm had dairy cattle and beef cattle
- One farm had dairy cattle and sheep
- Two farms had dairy cattle only
- One farm had beef cattle and sheep
- One farm had beef cattle only

The farm where it was not possible to conduct an interview was a small-scale pig farm. No smallholdings were identified.

The only arable crops produced in the survey area were grass and silage, which were used for winter feed for the livestock at the farms where they were produced.

Most of the beef cattle and lamb from the survey area were sold through a livestock market in Lancaster. One farmer also sold some beef cattle privately to a farmer outside the survey area and another sold small amounts of beef and lamb directly to local customers. Most milk was sold to national chains outside the survey area, Arla Foods and Dairy Farmers of Britain. One farmer also sold milk via his milk round in the survey area. Chicken eggs were sold from the farm where they were produced to local customers.

Farmers and their families were noted to be consuming beef, lamb, milk and chicken eggs from their own farms.

One allotment site was located in the survey area. It was a well-maintained site with approximately 60 large plots. Many varieties of fruit and vegetables were grown on the allotments. In addition, chickens and ducks were kept for egg production on about five plots. A few private gardens and farms with a range of fruit and vegetables were noted. One of these was a market garden, where fruit and vegetables were sold to local customers. In previous years, this person had used seaweed as a fertiliser for his vegetables, but he did not plan to do so in 2006. Chickens for egg production were kept at two private residences where interviews were conducted.

One household was identified where bees were kept for honey production. The owners had six hives in their garden; four for themselves and a further two, which they looked after but which were used for beginners' beekeeping lessons. The average production of honey per hive was 27 kg/y. The beekeepers consumed some of the honey and the rest was sold to local customers or at local shows and fêtes.

The consumption of wild foods included blackberries, damsons, greengages and mushrooms. These were collected from farmland in the survey area as well as from Ocean Edge Leisure Park, Money Close Lane in Heysham and Sunderland Point. Rough shooting for rabbits was carried out by two people at locations in and around Overton and the shooters were

consuming the rabbits they shot. Another individual shot pigeon at Sunderland Point for his own consumption.

Evidence of the consumption of groundwater was found. One farming household and the livestock at that farm drank borehole water. No incidence of people using or drinking spring or well water were identified. No bodies of freshwater were noted in the terrestrial survey area so no consumption of freshwater fish or activities in/on freshwater were recorded.

5.2 Unusual pathways

The transfer of contamination from Heysham by wildlife was investigated. Representatives from British Energy Generation Ltd. were asked about wildlife that could act as carriers for the transfer of radioactivity off site. The site considered rabbits and seagulls to be pests on site. Seagulls may land anywhere on site but the only rabbits on site were found on the grassy areas away from the controlled areas. Rabbits from the survey area were consumed by two individuals but not from the immediate vicinity of the site. No consumption of seagull flesh or eggs was noted during the survey. The site does not analyse samples of rabbit or seagull flesh for radioactivity.

One of the site specific requests for the Heysham survey was to find out about the new retirement village being developed on the former Middleton Towers holiday park site to the west of Middleton. Building work on the first 35 houses was underway and the first residents were scheduled to move in during May 2007. Some of the houses will have gardens so the possibility of residents growing fruit and vegetables there cannot be ruled out. The long-term plan for the retirement village is to include 590 residences – some with and some without gardens. A small allotment site within the retirement village is planned for residents with no gardens. Although this will be relevant to future habits surveys, it will be approximately 2013 before this facility is in use. The retirement village is located slightly outside the direct radiation survey area and so is more relevant to the terrestrial part of the survey. This is not

to discount the fact that residents could spend time in the direct radiation and aquatic survey areas because they will live very close to both.

5.3 Wholesalers and retailers

No evidence was found of foods produced in the terrestrial survey area being sold to wholesalers, shops or cafes inside or outside the survey area. Interviews were held at one butchers, two grocers and one cafe in the survey area in order to find out whether they were selling produce from within the survey area, but none were.

5.4 Food consumption data

Consumption data for locally produced foodstuffs potentially affected by gaseous discharges are presented in Tables 24 to 37 for adults and Tables 38 and 39 for children. These tables include the mean consumption rates of the critical groups together with the observed 97.5 percentile rates calculated as described in Section 3.2. For purposes of comparison, the data are summarised in Table 15 for adults and in Tables 16 and 17 for children (15 year olds and 10 year olds, respectively). No children in the 5 year old, 1 year old and 3 month old age groups were noted to be consuming foods produced in the terrestrial survey area.

In order to provide information relevant to surveillance and assessment studies, the consumption rate data collected during the survey were analysed to indicate which food types most commonly contributed to each food group. The data are summarised in Table 40. Those food types shown in bold and labelled with an asterisk were sampled as part of the 2005 Food Standards Agency monitoring programme (EA, EHS, FSA and SEPA, 2006).

Adult consumption rates

Consumption of locally produced foods was identified in the following 14 food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, milk, cattle meat, sheep

meat, poultry, eggs, wild/free foods, rabbits/hares, honey and wild fungi. No consumption of pig meat, venison, freshwater fish or local cereals was identified. It should be noted that despite several attempts, it was not possible to interview anybody at the only pig farm in the survey area so it is possible that consumption of pig meat took place there.

Critical group mean consumption rates were found to be greater than the generic 97.5 percentile consumption rates in the domestic fruit and honey food groups. A further eight critical group mean consumption rates exceeded the generic mean consumption rates. These were for green vegetables, other vegetables, root vegetables, potato, milk, sheep meat, eggs and wild fungi. Four observed 97.5 percentile consumption rates exceeded the generic 97.5 percentile consumption rates. These were for root vegetables, domestic fruit, milk and honey.

Children's consumption rates

15 year old age group

The only food consumed by children in the 15 year old age group was milk and this was consumed by three children. No consumption was identified in the following 17 food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, cattle meat, pig meat, sheep meat, poultry, eggs, wild/free foods, rabbits/hares, honey, wild fungi, venison, freshwater fish and local cereals. For milk, the observed critical group mean consumption rate and 97.5 percentile consumption rate both exceeded the generic mean consumption rate but not the generic 97.5 percentile consumption rate.

10 year old age group

The only food consumed by children in the 10 year old age group was eggs and these were consumed by four children. No consumption was identified in the following 17 food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, milk, cattle meat,

pig meat, sheep meat, poultry, wild/free foods, rabbits/hares, honey, wild fungi, venison, freshwater fish and local cereals. For eggs, the observed critical group mean consumption rate and 97.5 percentile consumption rate both exceeded the generic mean consumption rate but not the generic 97.5 percentile consumption rate.

6 DIRECT RADIATION PATHWAYS

6.1 Direct radiation survey area

The direct radiation survey area is shown in Figure 2. It covered all land within 1 km of the Heysham site perimeter fence, which delineates the external boundary of Heysham 1 and Heysham 2 licensed sites. The direct radiation survey also overlaps with direct exposure to gaseous releases from the site. Information on habits from the direct radiation survey also applies to gaseous releases from the site.

At the request of HSE, occupancy rates at caravan sites, Heysham Golf Club and the Port of Heysham were investigated. All locations were visited and a representative number of observations and gamma dose rate measurements were recorded.

The Heysham site was bordered to the south-west and west by Morecambe Bay. The concrete sea wall which ran along the south-western side of the Heysham site was popular with anglers and bird watchers. The liquid discharge channels, both approximately 450 – 500 metres in length, into Morecambe Bay were exposed at low tide. One fishermen (Observation 151) set fishing nets on the beach beside these structures to catch fish that were attracted by the warm water. He spent time on the beach here every day at low water removing any fish and debris caught in them. At low tide the rest of the survey area to the south-west and west of the site was taken up with the intertidal area of Middleton Sands, and at high tide with the waters of Morecambe Bay.

Immediately to the north of the site was the Port of Heysham, incorporating Heysham Harbour. As well as freight and passenger ferries, there were other industries based at the Port of Heysham such as an aggregate extraction company and a support base for the off-shore gas industry. The sea wall, which formed the northern side of the Port of Heysham, was easily accessible by foot and vehicle and was extremely popular with angers, and to a

lesser extent, bird watchers. To the north-west and north of the sea wall, the rest of the survey area was taken up with the intertidal area of Morecambe Bay and Half Moon Bay.

The village of Higher Heysham was located to the north east of the power station site. On the outskirts of the village and to the east of the Port of Heysham was the separate Port of Heysham Industrial Park where several companies were based in 10 buildings.

The closest permanent residences to the site were located on the outskirts of Higher Heysham. As well as domestic houses, facilities within the survey area included a public house and a nursery school.

Heysham Nature Reserve was located along the eastern edge of the site. The land was owned by British Energy but managed by The Wildlife Trust. Nature wardens and volunteers spent time at the reserve undertaking conservation work, bird and insect surveys or working indoors in the field centre. Access to the nature reserve was facilitated by a car park and the site was popular with dog walkers and bird watchers. Further away from the power stations to the east was Heysham Golf Club, which also had a clubhouse and pro shop. Near to the eastern edge of the survey area was Middleton Road, where a couple of houses, a caravan site and a public house were located. No interviews were conducted at these premises because efforts were focussed on the many activities nearer to the site.

Next to the south east corner of the Heysham site was Ocean Edge Leisure Park – a large caravan site with over 800 static caravans as well as space for touring caravans. This was where the closest residences to the site were located. Seven hundred and eighty of the static caravans were owner occupied and residents were allowed to stay at the park for a maximum of 46 weeks per year. The site was completely closed for six weeks each year. Some residents only stayed at the site a few weeks of the year for their holidays, but many retired people lived there as their main place of residence. There was public access through the park to Red Nab – a stony beach and rocky promontory where several people went angling.

6.2 Residential activities

Residences in the direct radiation survey area were grouped together in two main places. The first was the Ocean Edge Leisure Park with approximately half of the 800 caravans in the park in the 0 – 0.25 km zone and the other half in the >0.25 – 0.5 km zone. The other group of residences were permanent houses on the outskirts of the village of Higher Heysham. The closest of these were just inside the >0.25 – 0.5 km zone (approximately 5 houses) but most fell in the >0.5 – 1.0 km zone (approximately 150 houses).

Interviews were conducted at 14 residences – six caravans on Ocean Edge Leisure Park and eight houses. Two caravans were in the 0 – 0.25 km zone and 4 caravans were in the >0.25 – 0.5 km zone, people were selected that were closest to the site, who had the highest occupancy rates and were available for interview at the time of the survey. The houses were in the >0.5 – 1.0 km zone, and were initially selected because they were closest to the site and were available for interview at the time of the survey. No children lived at any of the caravans where interviews took place. Five of the eight houses where interviews took place were occupied by families with children.

6.3 Leisure activities

Opportunities for leisure activities around the Heysham site were numerous. The main locations where people were observed undertaking leisure activities were the intertidal areas to the north, west and south of the site, the sea wall also to the south and that encompassing the Port of Heysham, Heysham Nature Reserve and Heysham Golf Club.

Angling, collecting peeler crabs and digging worms for bait, dog walking, walking, jogging and playing all took place on the beach at Half Moon Bay. Bait digging and angling took place at Red Nab to the south of the site. Angling and bird watching took place on and around the sea wall to the south of the site and the harbour wall to the north of the site.

Heysham Nature Reserve received approximately 8000 visitors per year, the majority of whom were dog walkers. During the Foot and Mouth outbreak in 2001 when dog walkers had to stop using farmland, the Heysham nature reserve became increasingly popular. Many of the people who started walking their dogs at the reserve at that time continued to do so. The reserve was also used regularly by bird watchers and nature enthusiasts. There were a couple of unpaid volunteers who regularly carried out bird and nature surveys at the reserve. Occupancy at Heysham golf club was a site-specific request from the customers. The club had approximately 750 regular club members as well as visitors, and they estimated that about 700 rounds of golf were played there weekly. The clubhouse and pro shop increased the amount of time that golfers spent within the direct radiation area.

As well as being a place for permanent residents, The Ocean Edge Leisure Park was also very frequently used by holidaymakers – some in static caravans and some in touring vans.

The public houses in Heysham and on Middleton Road were other locations for people to spend their leisure time within the direct radiation survey area.

6.4 Commercial activities

Occupancy rates for people working in the direct radiation survey area at the Port of Heysham was a site-specific request from the customers. Data for approximately 500 people working at the Port of Heysham and the neighbouring industrial estate and harbour were collected. Businesses included a window manufacturer, an engineering firm, a support base for the off-shore gas industry, ferry companies and a truck repair garage.

Heysham golf club was staffed by 20 people, five of whom were green keepers and so worked predominantly outdoors.

Ocean Edge Leisure Park employed 28 staff. The staff likely to receive the highest direct radiation doses were six grounds men because they worked outdoors and in areas of the park

that were closer to the power station. The rest of the staff, for example bar staff and management, worked indoors in buildings further away from the power station.

Heysham Nature Reserve was staffed by three wardens. None of the three worked full-time at the reserve but while they were there they spent up to half of their time outdoors.

One part-time commercial fisherman regularly carried out small-scale netting for flatfish on the intertidal areas all around the station.

Other places where people worked in the direct radiation survey area included the public house in Heysham, a children's nursery school in Heysham, the public house on Middleton Road and the caravan site on Middleton Road. No interviews were carried out at the public houses, the caravan site or the nursery.

The commercial activities of the employees and contractors of the Heysham power station site while at work were not included in the direct radiation survey.

6.5 Educational activities

No schools or colleges were located in the direct radiation survey area but there was one children's nursery in Heysham. As no interview could be held at the nursery, no data for the children or staff are available.

Heysham Nature Reserve staff were hoping to improve the facilities for school children in 2007 in order to encourage visiting groups to come for field trips.

6.6 Occupancy rates

Table 41 presents indoor, outdoor and total occupancy data for adults and children and includes the distance from the site perimeter fence where these occupancies took place. An analysis of the data by distance zones and occupancy rates is shown in Table 42.

0 - 0.25 km from the site perimeter fence

Occupancy data were collected for 22 individuals in the 0.0 to 0.25 km zone. Of these, four individuals were residents in the Ocean Edge Leisure Park (caravan site); on the occasions during the survey that the survey team visited within this zone, there were very few people observed in their caravans. The further 18 observations were for six staff at the Ocean Edge Leisure Park, six staff and volunteers at Heysham Nature Reserve, four anglers and two non-commercial bait diggers. A resident at Ocean Edge Leisure Park had the highest total occupancy rate of 5700 h/y. This is lower than would be expected for a permanent resident because the park was closed for six weeks per year. This resident had the highest indoor occupancy rate at 4800 h/y. The highest outdoor occupancy rate was 2000 h/y for six grounds men at the park.

>0.25 – 0.5 km from the site perimeter fence

Occupancy data were collected for 445 people in the >0.25 to 0.5 km zone. The observations were for seven residents at Ocean Edge Leisure Park (caravan site), seven residents in houses to the north-east of the site, 22 staff at the Ocean Edge Leisure Park and 409 staff at businesses including the Port of Heysham and the Port of Heysham Industrial Estate. A resident had the highest total occupancy rate of 8000 h/y. The highest indoor occupancy rate was 7500 h/y for a young child resident in the survey area and the highest outdoor occupancy rate was 2500 h/y for an employee at the sand extraction company at the Port of Heysham.

>0.5 – 1.0 km from the site perimeter fence

Occupancy data were collected for 99 people in the >0.5 to 1.0 km zone. The observations were for 16 residents in houses to the north-east of the site, 82 staff at businesses in the Port of Heysham Industrial Estate and a dog walker. A resident had the highest total occupancy rate of 8200 h/y and the highest indoor occupancy rate of 7900 h/y. The highest outdoor occupancy rate was 1600 h/y for two residents.

6.7 Gamma dose rate measurements

Table 43 presents gamma dose rate measurements for the Heysham direct radiation survey. Representative gamma dose rate measurements were taken at a height of 1 metre both inside and outside a selection of residences and at outdoor background locations outside the direct radiation survey area. Outdoor measurements inside the survey area were taken approximately 5 to 10 metres from the nearest buildings and outdoor background readings were taken, where possible, in open grassy fields. It should be noted that the measurements have not been adjusted for natural background dose rates.

In the survey area, outdoor measurements ranged from 0.066 to 0.082 µGy/h over grass and 0.051 to 0.092 µGy/h over concrete. Indoor measurements ranged from 0.056 to 0.12 µGy/h. Indoor measurements in semi-permanent structures such as caravans were lower than the corresponding outdoor measurements but, with one exception, indoor measurements in permanent structures such as houses were higher than their corresponding outdoor measurements. This is likely to be because there is more natural radioactivity in building materials like brick, stone and concrete than there is in materials used to make caravans. It should be noted that due to one of the four reactors at Heysham being off-line for the duration of the survey, the gamma dose rates measured may be lower than usual.

Outside the direct radiation survey area, background readings were both 0.071 μGy/h. At the time of the survey, four outdoor measurements from within the direct radiation survey area were lower than the background measurement and ten were higher.

Comprehensive studies of background radiation have been carried out on a national scale by the National Radiological Protection Board (since 1st April 2005 the Radiation Protection Division of the Health Protection Agency), the most recent of these being a review conducted during 2005 (Watson *et al*, 2005). The results from this review could be used for comparison.

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 Annexes 1 and 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 assessment are shown in Table 44. Each of the 25 combinations shown in Table 44 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 44 do not correlate directly with observation numbers in Annex 1. Other individuals from Annex 1 have combinations that are not listed in Table 44 because they have fewer pathways and a dose assessment for them would be adequately covered by one of the 25 listed combinations.

Qualitative and estimated data shown in Annex 3 have not been included in Table 44. This is because data in Annex 3 are estimated rates for pathways that were heard about during the survey, but not quantified by interviewees.

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

7.1 Use of the data for assessing total dose

The Environment Agencies and the Food Standards Agency have considered ways of using habits data to calculate total dose retrospectively. The adopted approach is to use the adult consumption and occupancy data collected in each habits survey to create a matrix with a series of habits profiles for each site. The relevant matrix for the Heysham adults' profiled habits data is shown in Annex 5. The National Dose Assessment Working Group (NDAWG) has considered this approach to assessing retrospective total doses (Camplin *et al*, 2005) and has agreed that using habits profiles is an appropriate approach. Retrospective total doses around Heysham will in future be made using these profiles and reported in the Radioactivity in Food and the Environment Reports (See Appendix 7 in EA, EHS, FSA and SEPA, 2006). Data from Annex 3 are not included in Annex 5.

8 CONCLUSIONS AND SUGGESTIONS

8.1 Survey findings

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

- Discharges of liquid radioactive waste into Morecambe Bay
- Discharges of gaseous radioactive waste to the atmosphere
- Emissions of direct radiation

Data were collected for 1043 individuals including commercial and hobby fishermen, shore and boat anglers, commercial and non-commercial bait diggers, people pursuing water sports, wildfowlers, farmers, allotment holders, beekeepers and people spending time within 1 km of the site. These people were targeted because their habits and where they live may cause them to be exposed to radioactivity from the site. However, it should be noted that the most exposed people can only be defined with the outcome of a dose assessment.

All consumption rates recorded in this report are only for locally produced or caught foods.

The adult mean critical group rates (as defined in Section 3.2) for the separate local aquatic consumption pathways were:

- 25 kg/y for fish
- 16 kg/y for crustaceans
- 4.5 kg/y for molluscs
- 11 kg/y for wildfowl
- 2.4 kg/y for marine plants/algae
- 5.4 kg/y for salt marsh grazed sheep

The predominant aquatic species consumed by the respective critical groups were flounder, plaice, cod, salmon and bass; brown shrimp; cockle, mussel and whelk; mallard, goose and wigeon; samphire; and salt marsh grazed sheep.

The use of seaweed as a fertiliser or cattle feed was not identified in the survey area.

The mean critical group occupancy rates over the separate intertidal substrates were:

- 1300 h/y for mud
- 700 h/y for mud and sand
- 170 h/y for rock
- 490 h/y for salt marsh
- 2300 h/y for sand (or 880 h/y excluding the temporary activity of working on the sea defences)
- 1000 h/y for sand and stone

The mean critical group rate for handling fishing gear was 800 h/y and for handling sediment was 810 h/y.

The maximum occupancy rate in water was 160 h/y and the maximum occupancy rate for time spent on water was 1500 h/y. No houseboats or likely locations for houseboats were identified.

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

- 32 kg/y for green vegetables
- 25 kg/y for other vegetables
- 33 kg/y for root vegetables
- 63 kg/y for potato
- 85 kg/y for domestic fruit
- 200 l/y for milk

- 10 kg/y for cattle meat
- 13 kg/y for sheep meat
- 2.8 kg/y for poultry
- 13 kg/y for eggs
- 3.8 kg/y for wild/free foods
- 5.6 kg/y for rabbits/hares
- 11 kg/y for honey
- 4.5 kg/y for wild fungi

No consumption of pig meat, venison, freshwater fish or local cereals was identified, although it should be noted that no interview was conducted at the only pig farm in the survey area so it is possible that consumption of pig meat took place there. Consumption of foodstuffs by children was also recorded. Combinations of food groups (both aquatic and terrestrial) consumed at critical group rates, together with external exposures pathway, may be derived from the data for individuals in Annexes 1 and 2. Rates for individuals making up the critical groups are presented in bold type.

Evidence of the consumption of groundwater was found. One farming household and the livestock at that farm drank borehole water. No incidents of people using or drinking spring or well water were identified. No bodies of freshwater were noted in the terrestrial survey area so no consumption of freshwater fish or activities in/on freshwater were recorded.

Transfer of radioactive contamination from the site into the surrounding area by wildlife was investigated. The site considered rabbits and seagulls to be pests on site. Seagulls may land anywhere on site but the only rabbits on site were found on the grassy areas away from the controlled areas. Rabbits from the survey area were consumed by two individuals but not from the immediate vicinity of the site. No consumption of seagull was noted during the survey.

For occupancy by members of the public within 1 km of the Heysham site perimeter fence, the highest rates (indoors plus outdoors) were:

- 5700 h/y for the 0 to 0.25 km zone
- 8000 h/y for the >0.25 to 0.5 km zone
- 8200 h/y for the >0.5 to 1.0 km zone

In the 0 to 0.25 km zone the highest occupancy rates were for residents at the Ocean Edge Leisure Site. In the >0.25 to 0.5 km zone and the >0.5 to 1.0 km zone, the highest occupancy rates were for permanent residents.

The highest indoor occupancy rates were:

- 4800 h/y for the 0 to 0.25 km zone
- 7500 h/y for the >0.25 to 0.5 km zone
- 7900 h/y for the >0.5 to 1.0 km zone

The highest outdoor occupancy rates were:

- 2000 h/y for the 0 to 0.25 km zone
- 2500 h/y for the >0.25 to 0.5 km zone
- 1600 h/y for the >0.5 to 1.0 km zone

The site-specific requests from the customers were addressed as follows:

- Sand winning at Heysham Harbour – desk-based and fieldwork enquiries were made but no information was obtained. No one interviewed during the survey knew anything about the practice.
- Redevelopment of the Middleton Towers holiday park – a retirement village with 590 residences is planned for the site. Some will have gardens and a small allotment site is planned for the residents with no gardens. Building work is underway on 35 houses and residents should start moving in during 2007, but it is not thought that the allotment facility will be in use until around 2013.

- Occupancy in the direct radiation survey area particularly at caravan sites, Heysham golf club and the Port of Heysham – occupancy rates for staff and some of the more permanent residents at the Ocean Edge Leisure Park were obtained. The site was open for 46 weeks of the year and the residents living there are the power stations closest neighbours. One other caravan site was located on the outskirts of the survey area but no interviews were held there due to the distance from the site compared to the Ocean Edge Leisure Park. Occupancy rates for approximately 500 employees at the Port of Heysham and neighbouring harbour and industrial estate were obtained. Although no detailed occupancy rate data was obtained from Heysham golf club, information about the number of staff and club members was collected.

8.2 Comparisons with previous surveys

The aquatic and terrestrial results from this 2006 survey can be compared with the data from the last combined habits survey undertaken by Cefas at Heysham in 2001 (McTaggart *et al* 2002). The same aquatic and terrestrial survey areas were used in both surveys. The combined habits survey in 2001 only made a limited investigation of occupancy rates in the direct radiation survey area, so the direct radiation results from the 2006 survey are compared instead with the data obtained in the 1995 direct radiation survey (unpublished data). In 1995, the survey area was defined as the area within 1 km of the Heysham site centre, not within 1 km of the licensed site perimeter as in 2006. The area used in 1995 was smaller, and so care is needed when comparing data. During the 2006 and 1995 surveys, three of the four reactors at Heysham were running at nominal full power and one was off-line.

All comparisons for consumption pathways include data for adults only. All comparisons for occupancy and handling pathways include data for both adults and children.

Aquatic survey

In 2001, the critical group mean consumption rate for fish was 36 kg/y for a group of 21 people, and the maximum consumption rate was 62 kg/y. In 2006, the critical group consumption rate had decreased to 25 kg/y and the maximum consumption rate decreased to 47 kg/y. The number of people in the critical group was very similar at 22. In 2001, the main species of fish consumed by the critical group were plaice, cod, Dover sole, flounder and salmon. The main species consumed by the 2006 critical group were flounder, plaice, cod, salmon and bass.

In 2001, the critical group mean consumption rate for crustaceans was 18 kg/y, the maximum consumption rate was 31 kg/y and the number of people in the critical group was three. In 2006, the critical group consumption rate was similar at 16 kg/y, the maximum consumption rate had decreased to 24 kg/y and the number in the critical group had increased slightly to five. In both the 2001 and 2006 surveys, the only species of crustacean eaten by members of the critical group was brown shrimps.

In 2001, the critical group mean consumption rate for molluscs was 19 kg/y, the maximum consumption rate was 30 kg/y and the number of people in the critical group was 10. In 2006, the critical group consumption rate had decreased significantly to 4.5 kg/y, the maximum consumption rate decreased significantly to 7.3 kg/y but the number of people in the critical group stayed the same at 10. The largest decreases in consumption rates were seen for cockles and whelks. The decrease in consumption of cockles was probably caused by several of the cockle beds in the survey area being closed for the past 18 months. The main species consumed in 2006 were the same as in 2001; cockles, mussels and whelks.

In 2001, consumption rates for wildfowl were included with poultry. However, the 2001 data have been re-assessed to enable a comparison with consumption rates for wildfowl in 2006. In 2001, the critical group mean consumption rate, recalculated to include only duck and geese (identified as wildfowl in 2001) was 11 kg/y, the maximum consumption rate was 23

kg/y and the number of people in the critical group was 16. In 2006, the critical group consumption rate was the same at 11 kg/y, the maximum consumption rate had decreased to 19 kg/y and the number of people in the critical group had increased to 24. It should be noted that in 2001, all duck species were just recorded as duck or geese, whereas species such as snipe were also consumed in 2006.

In 2001, the critical group mean and maximum consumption rates for marine plants/algae were 3.0 kg/y and there were two people in the critical group. In 2006, the critical group consumption rate was similar at 2.4 kg/y, the maximum consumption rate was 3.3 kg/y and the number of people in the critical group had increased to seven. In both surveys, the only species consumed was samphire.

Consumption of salt marsh grazed sheep was not investigated in 2001 so no comparison with 2006 data can be made.

For occupancy of intertidal substrates recorded in 2001 and 2006, the substrates that can be compared are mud, mud and sand (previously called sand and mud), rock, salt marsh and sand. No occupancy over sand and stones was noted in 2001 so no comparison is possible for this substrate.

For external pathways, it should be noted that the methodology for determining the critical group has changed since the 2001 survey (see Section 3.2) so care is needed when comparing results. In the following paragraphs, the critical group rates from the 2001 survey have been recalculated using the current method and the rates in brackets were calculated using the original method.

The 2001 critical group mean intertidal occupancy rate over mud using the 2006 methodology was 340 h/y for three commercial shellfish collectors (mean of 410 h/y for two commercial shellfish collectors). The maximum rate was 440 h/y. The 2006 critical group mean and maximum intertidal occupancy rates over mud were 1300 h/y for one commercial fisherman

using set nets. Although there were other observations for people spending time over mud, they were all significantly lower so this was taken to be the critical group rate.

The 2001 critical group mean intertidal occupancy rate over mud and sand using the 2006 methodology was 960 h/y for 13 people, of which nine were commercial cockle collectors and/or set netters, two were commercial bait diggers, one did set netting and guided walks across Morecambe Bay and one person's activity was unspecified (mean of 1200 h/y for seven people – six commercial cockle collectors and/or set netters and one person who did set netting and gave guided walks across Morecambe Bay). The maximum rate was 1400 h/y. The 2006 critical group mean intertidal occupancy rate over mud and sand was lower at 700 h/y for 13 people (two commercial oyster farmers, three anglers, seven commercial bait diggers and one person who did both angling and non-commercial bait digging). The maximum rate was also lower at 960 h/y.

The 2001 critical group mean intertidal occupancy rate over rock using the 2006 methodology was 400 h/y for two anglers (also a mean of 400 h/y for two anglers). The maximum rate was 410 h/y. The 2006 critical group mean intertidal occupancy rate over rock was lower at 170 h/y for six anglers, one of whom also collected peeler crabs for bait. The maximum rate for intertidal occupancy over rock was also lower at 310 h/y.

The 2001 critical group mean intertidal occupancy rate over salt marsh using the 2006 methodology was 580 h/y for three turf cutters (1000 h/y for one turf cutter). The maximum rate was 1000 h/y. The 2006 critical group mean intertidal occupancy rate over salt marsh was similar at 490 h/y. This was for one turf cutter, one walker, one dog walker and one farmer tending his livestock. The maximum rate for intertidal occupancy over salt marsh was lower at 840 h/y.

The 2001 critical group mean intertidal occupancy rate over sand using the 2006 methodology was 520 h/y for four people – three commercial shellfish collectors and an angler (910 h/y for one commercial shellfish collector). The maximum rate was 910 h/y. The

2006 critical group mean intertidal occupancy rate over sand was 2300 h/y for 33 people. Of these, 30 people were constructing and repairing sea defences, two were commercial cockle and mussel collectors and one was an angler. The maximum rate for intertidal occupancy over sand was 2400 h/y. Excluding the temporary activity of working on the sea defences, the critical group mean intertidal occupancy rate over sand would be 880 h/y for eight people – four commercial cockle and mussel collectors, one of whom also gave guided walks over Morecambe Bay, one angler and three people who went dog walking and angling, one of whom also did some of non-commercial bait digging. The maximum rate would be 1600 h/y.

In 2001, the critical group mean handling rate for commercial fishing gear using the 2006 methodology was 610 h/y for 12 commercial fishermen (mean of 890 h/y for four commercial fishermen). The maximum gear handling rate was 1000 h/y. The 2006 critical group mean handling rate for fishing gear had increased to 800 h/y for 10 commercial fishermen. The maximum rate had also increased to 1300 h/y.

In 2001, the critical group mean handling rate for sediment using the 2006 methodology was 740 h/y for 10 people - seven commercial shellfish collectors, one turf cutter and two commercial bait diggers (mean of 1200 h/y for one commercial shellfish collector and one turf cutter). The maximum sediment handling rate was 1300 h/y. The 2006 critical group mean handling rate for sediment was similar at 810 h/y for 13 people (four commercial cockle and mussel collectors, two oyster farmers and seven commercial bait diggers). The maximum rate was higher at 1600 h/y.

A comparison of occupancy rates in and on water cannot be made because these pathways were not investigated in the 2001 survey.

Terrestrial survey

For terrestrial food groups, the critical group mean consumption rates (kg/y and l/y) in the 2006 survey are tabulated below, together with those of the 2001 survey for ease of comparison:

	2001	2006
• Green vegetables	34	32
• Other vegetables	29	25
• Root vegetables	36	33
• Potato	65	63
• Domestic fruit	66	85
• Milk	240	200
• Cattle meat	Nil	10
• Sheep meat	5.7	13
• Poultry	3.0*	2.8
• Eggs	12	13
• Wild/free foods	9.1	3.8
• Rabbits/hares	1.7	5.6
• Honey	11	11
• Wild fungi	1.3	4.5

* The critical group rate given in 2001 for poultry was 12 kg/y but this included wild duck and geese, which are now included in the wildfowl food group. The critical group rate for poultry excluding wildfowl was 3.0 kg/y.

Neither the 2001 or 2006 survey identified any consumption of pig meat, venison or local cereals.

Consumption rates had increased in 2006 in the following food groups: domestic fruit, cattle meat, sheep meat, eggs, rabbits/hares and wild fungi. Consumption rates had decreased in

2006 in the following food groups: green vegetables, other vegetables, root vegetables, potato, milk, poultry and wild/free foods. Rates for honey remained the same.

Direct radiation survey

Some comparison between the 1995 and 2006 direct radiation survey data can be made. A detailed comparison of the results is not possible because the survey areas used were not exactly the same. In 2006 the direct radiation survey area covered all land within 1 km of the site perimeter fence, whereas in 1995 it was defined as covering all land within 1 km of the site.

The highest occupancy rate recorded in the 1995 survey was 8700 h/y and in 2006 it was 8200 h/y. In 1995 the highest occupancy rate was for residents at the Ocean Edge Leisure Park and in 2006 the highest rate was for a resident living in a house to the north-east of the site. As the highest rate in 1995 was for caravan occupancy, no attempt to differentiate between indoor and outdoor occupancy was made.

The commercial and leisure activities noted in 1995 and 2006 were very similar. The Port of Heysham with its freight ferries was operational during both surveys, as was a support base for the off-shore gas industry. The names of the companies operating these businesses have, however, changed over the years. Other activities noted during both the 1995 and 2006 surveys include work (including voluntary work) at the Heysham Nature Reserve, angling, bird watching, dog walking, golf and netting on the foreshore.

Two outdoor gamma dose rate measurements from 2006 can be compared with gamma dose rate measurements taken at similar locations in 1995. In 1995, gamma measurements were presented as μGy/h above the background rate, which was measured as being 0.078 μGy/h. The 2006 results are shown here in the same way but the background reading used for 2006 was 0.071 μGy/h. IB stands for Indistinguishable from Background and means that the detected result was the same as or lower than the relevant background rate.

The comparable locations are:

- Heysham Nature reserve IB in 1995 0.006 μGy/h in 2006.
- Heysham Harbour – north wall IB in 1995 IB in 2006.

It should be noted that at the time of both the 1995 and the 2006 surveys, three of the four reactors at Heysham were operating at nominal full power and the other one was off-line.

8.3 Suggestions for environmental monitoring

The 2005 monitoring programmes operated by the Environment Agency and the Food Standards Agency included the following samples and measurements (EA, EHS, FSA and SEPA, 2006):

Aquatic surveillance

- Flounder from Flookburgh
- Plaice from Flookburgh and Morecambe
- Bass from Morecambe
- Whitebait from Sunderland Point
- Shrimps from Flookburgh
- Cockles from Middleton Sands and Flookburgh
- Winkles from Red Nab Point
- Mussels from Morecambe
- *Fucus vesiculosus* and seaweed from Half Moon Bay
- Samphire from Cockerham Marsh
- Sediment from Flookburgh, Half Moon Bay, Pott's Corner, Heysham pipelines, Morecambe central pier, Sunderland Point, Condor Green and Sand Gate Marsh
- Mud and sand from Half Moon Bay
- Turf from Condor Green and Sand Gate Marsh
- Seawater from the pipeline, the inlet, Half Moon Bay and Heysham Harbour

Gamma dose rate measurements were taken over the following substrates:

- Mud at Sunderland, Sunderland Point and Condor Green
- Mud and sand at Arnside, Heysham pipelines and Sunderland Point
- Mud and pebbles at Morecambe central pier
- Salt marsh at Sand Gate Marsh, Flookburgh, High Foulshaw, Arnside, Colloway Marsh, Aldcliffe Marsh and Condor Green
- Salt marsh and mud at Flookburgh, High Foulshaw and Colloway Marsh
- Sand at Arnside, Heysham pipelines and Middleton Sands
- Rock and sand at Half Moon Bay
- Pebbles and sand at Morecambe central pier and Half Moon Bay
- Grass at Lancaster
- Grass and mud at Greenodd Salt Marsh, Sand Gate Marsh, High Foulshaw, Sunderland, Lancaster, Aldcliffe Marsh and Condor Green

Terrestrial surveillance

- Apples
- Blackberries
- Brussel sprouts
- Cabbage
- Honey
- Milk
- Onions
- Potatoes
- Freshwater

The following lists are suggestions for changes to the current environmental monitoring programmes. It should be noted that the suggestions are based on the findings of this survey. They are not the outcome of any form of assessment. It is suggested that samples currently monitored, which are not listed below, remain unchanged in the monitoring programme.

Environment Agency monitoring

- The turf samples at Condor Green and Sand Gate Marsh could be replaced by one from Hazelslack Marsh because that is where the turf cutter worked.
- Gamma dose rate measurements over mud at Sunderland and Sunderland Point could be replaced by ones at Heysham since this is where the greatest occupancy over mud was found.
- Gamma dose rate measurements over mud and sand at Sunderland Point could be replaced by ones at Roosebeck and Fleetwood since this is where the greatest occupancies over mud and sand were found.
- The gamma dose rate measurement over rock and sand at Half Moon Bay could be replaced by one over sand because this is the substrate where higher occupancies were observed.

Food Standards Agency monitoring

- Whitebait, which was not consumed by anyone on the survey, could be replaced with cod because cod was eaten at fairly high rates.
- A sample of salmon from the River Lune, Kent or Leven could be introduced since salmon was one of the main species consumed by members of the critical group for fish.
- A sample of whelks could be introduced since they were one of the species eaten by members of the critical group.
- A one-off sample of wildfowl could be introduced.
- A sample of salt marsh grazed sheep meat could be introduced since it was eaten by a reasonable number of people, including children.
- The sample of brussel sprouts could be dropped since cabbage is most commonly eaten in the green vegetable food group and it is already monitored.
- A sample of tomato could be introduced because this is the most commonly eaten other vegetable and no sample for this food group is currently taken.
- A sample of sheep meat from the terrestrial survey area could be introduced since it was eaten at rates above the generic mean rate.

- Samples of rabbit and wild fungi could be introduced since consumption rates have increased for these food types.

9 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 Environment Agency, the Food Standards Agency and the Health and Safety Executive. The project officers for these organisations gave considerable help during the planning of the survey and the drafting of the report.

10 REFERENCES

Byrom, J., Robinson, C., Simmonds, J.R., Walters, B., and Taylor, R.R., 1995. Food consumption rates for use in generalised radiological dose assessments. J. Radiol. Prot. 1995 Vol. 15 No 4 335-341.

Camplin, W.C., Grzechnik, M.P. and Smedley, C.A., 2005. Methods for assessment of total dose in the Radioactivity in Food and the Environment report. Presented to the *National Dose Assessments Working Group (NDAWG)*. Paper NDAWG/3/2005, 27th April 2005.

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

DETR, 2000a. Statutory Guidance on the Regulation of Radioactive Discharges into the Environment from Nuclear Licensed Sites. A consultation paper. DETR, London.

DETR, 2000b. Radioactive Substances (Basic Safety Standards) (England and Wales) Direction 2000. DETR, London.

EA, EHS, FSA and SEPA, 2006. Radioactivity in Food and the Environment, 2005. EA, EHS, FSA and SEPA, Warrington, Belfast, London and Stirling. RIFE(11).

EA, SEPA, DoENI, NRPB and FSA, 2002. Authorisation of discharges of radioactive waste to the environment. Principles for the assessment of prospective public doses. Interim Guidance. EA, SEPA, DoENI, NRPB and FSA, Lancaster.

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

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

Hessayon, D. G., 1990. The Fruit Expert, pbi Publications, Waltham Cross.

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

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

IAEA, 1996. International basic safety standards for protection against ionizing radiation and for the safety of radiation sources. Saf. Ser. No. 115. IAEA, Vienna.

ICRP, 1984. A Compilation of the Major Concepts and Quantities in use by ICRP. Pergamon Press, Oxford, (ICRP Publ. 42.).

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

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

Leonard, D.R.P., Hunt, G.J. and Jones, P.G.W., 1982. Investigation of individual radiation exposures from disposals to the aquatic environment: techniques used in habits surveys. pp. 512-517. In "Proc. 3rd Int. Symp. Soc. Radiol. Prot., Inverness, 2" Society of Radiological Protection.

McTaggart, K.A., Sherlock, M., Tipple, J.R. and Joyce, A.E., 2002. Radiological Habits Survey : Heysham, 2001. FSA, London.

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

The Welsh Assembly Government, 2002. Statutory Guidance on the Regulation of Radioactive Discharges into the Environment from Nuclear Licensed Sites in Wales. A consultation paper. The Welsh Assembly Government, Cardiff.

UK Parliament, 1965. Nuclear Installations Act, 1965 (as amended). HMSO, London.

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

UK Parliament, 1995a. Environment Act, 1995. HMSO, London.

UK Parliament, 1995b. Review of Radioactive Waste Management Policy. HMSO, London, 55pp. (Cm 2919).

UK Parliament, 1999. The Ionising Radiation Regulations 1999. Stat. Inst. 1999/3232. HMSO, London, 67pp.

UK Parliament, 2004. Energy Act, 2004. HMSO, London.

Watson, S.J., Jones, A.L., Oatway, W.B. and Hughes, J.S., 2005. Ionising Radiation Exposure of the UK Population: 2005 review. HPA-RPD-001, Chilton.

www.british-energy.com

www.statistics.gov.uk

Figure 1. The Heysham aquatic survey area

1 - Colloway Marsh
2 - Heaton Marsh
3 - Peggymarsh Pool
4 - Oxcliffe Pool
5 - Aldcliffe Marsh
6 - Stodday Marsh
7 - The Battery Slipway
8 - Stone Jetty
9 - Green Street Slipway
10 - Town Hall Slipway
11 - Calton Terrace Slipway

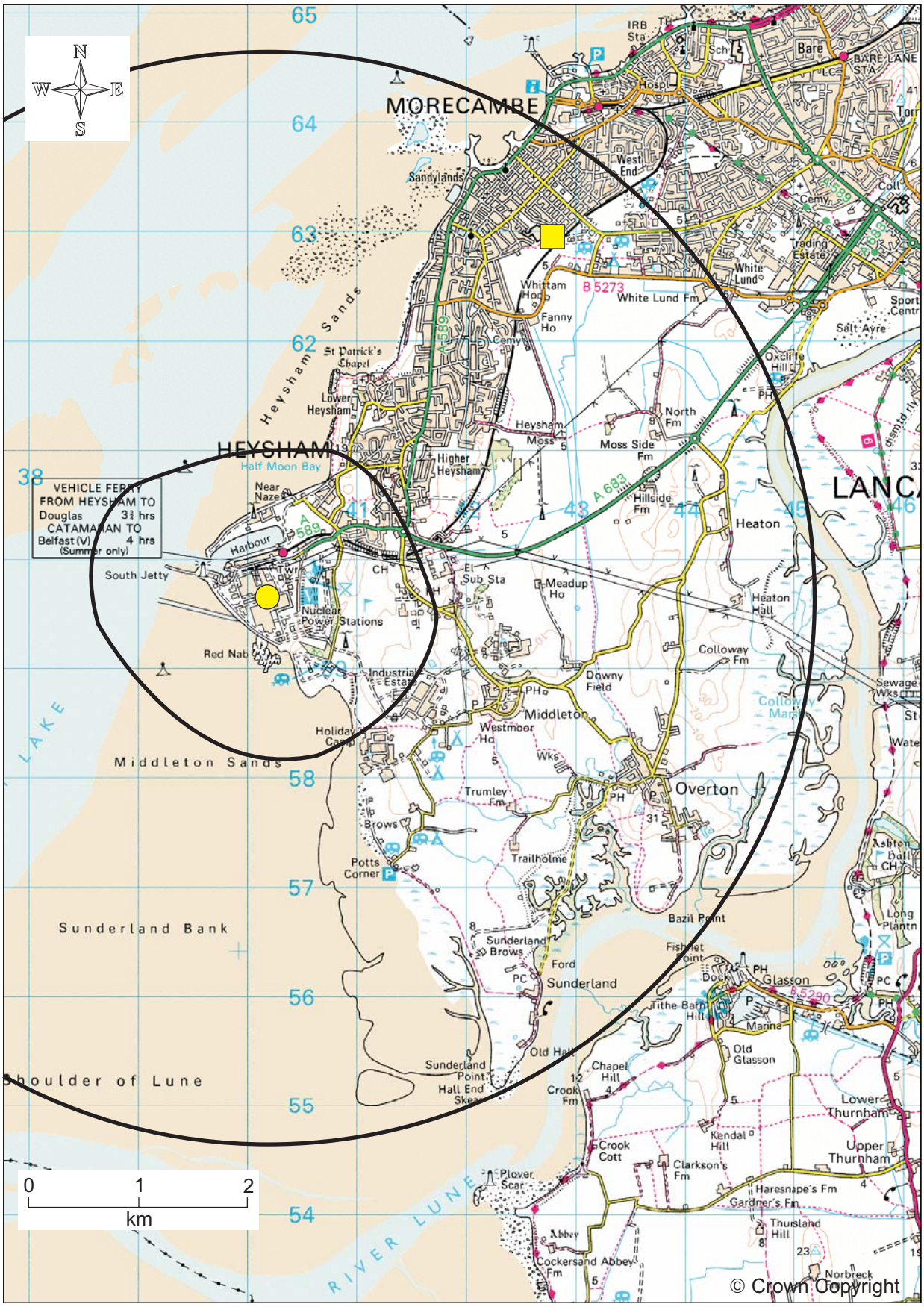

Figure 2. The Heysham terrestrial (outer ring) and direct radiation (inner ring) survey areas

Heysham site centre

Devonshire Road allotments

Table 1. Survey coverage

Group	Criteria	Estimate of complete coverage	Number for whom positive data were obtained	Coverage for positive observations	Notes
SUMMARY OF ALL PATHWAYS					
All potential people in Heysham aquatic, terrestrial and direct radiation survey areas	Number of people resident in terrestrial survey area (excluding those resident in the direct radiation survey area) (See (B) terrestrial pathways)	23500[a]	81[b]	<1%	The survey targeted individuals who were potentially the most exposed (see Section 2.4), mostly producers of local food (farmers and allotment holders). The number for whom positive data were obtained includes 9 people who lived outside 5 km, but mainly consumed terrestrial foods and 7 people who lived in the terrestrial survey area but are only affected by liquid discharges.
	Number of people resident in the direct radiation survey area (See C, direct radiation pathways)	430	37	9%	Number for whom positive data was obtained includes 14 people who live at Ocean Edge Leisure Park.
	Number of people working in or visiting, but not resident in the direct radiation survey area (See C, direct radiation pathways)	U	522	U	Excluding employees and contractors of British Energy Generation Ltd., and people who live in the direct radiation survey area.
	Number of people affected by liquid discharges (excluding people resident in the terrestrial survey area) (See (A) aquatic pathways)	U	403[b]	U	
	Approximate total for aquatic, terrestrial and direct radiation survey areas	U	1043[b]	U	In the Summary of All Pathways section each interviewee for whom positive data was obtained has only been counted once. This is in the section where their predominant activities took place.
(A) AQUATIC PATHWAYS					
Commercial fishermen	Number of commercial fishermen actively fishing in survey area	44	32	73%	Includes 3 crew members. Excludes 4 licensed fishermen with who were not fishing at the time of the survey
Commercial shell fish collectors/farmers	Number of commercial shell fish collectors/farmers actively working in survey area	U	14	U	An estimate of complete coverage for this group is virtually impossible to calculate because of the numbers of transient shellfish collectors working in the area.
Commercial baitdiggers	Number of commercial baitdiggers spoken to or heard of during the survey	8	8	100%	Excludes people who go baitdigging for their own angling purposes.
Hobby fishermen	Number spoken to or heard of during the survey	6	6	100%	Includes people using fishing gear such as long lines, set nets, stake nets and fyke nets to catch fish non-commercially. Excludes non-commercial shellfish collectors.
HM Coastguards and RNLI	Number of crew based at stations around Morecambe Bay	95	45	47%	There were 3 RNLI stations and 3 HM Coastguards stations in the survey area. Interviews with people from 1 RNLI station and 2 coastguard stations provided data for 44 members.
Boat anglers, shore anglers and other beach users	Number spoken to, seen, or heard of during the survey	U	101	U	
Wildfowlers	Number of regular shooters spoken to or heard of during the survey	60	16	27%	There were 4 wildfowling clubs in the survey area and interviews were held at 3 of them. In addition, there was one private syndicate of 3 people who were not interviwed.
Water and beach sports participants	Members of clubs in survey area and people seen in action or spoken to during survey period	U	71	U	Interview at 1 sailing club provided generic data for 56 of the keenest members.

Table 1. Survey coverage

Group	Criteria	Estimate of complete coverage	Number for whom positive data were obtained	Coverage for positive observations	Notes
(B) TERRESTRIAL PATHWAYS[c]					
Farms	Number of farmers and their family members consuming farm produce from the survey area	35	34	97%	Estimate of 10 farms in the survey area, 9 of which were interviewed.
Allotment holders	Number of people consuming allotment produce from the survey area	U	24	U	One allotment site with 60 plots was located in the survey area and interviews were held with 9 allotment plot owners.
Bee keepers	Number of people consuming honey from the survey area	U	2	U	There was only one family of beekeepers keeping bees in the survey area and we interviewed them.
(C)DIRECT RADIATION PATHWAYS					
Occupancy of area	Number with occupancies > 100 hours (excluding site employees)	U	561	U	Excludes 5 people (2 anglers, 2 bait diggers and 1 dog walker) who have occupancies of > 100 h/y.
Residents	Number of residents in the survey area	430	34	9%	Estimate of 200 occupied residences in the area (including permanently occupied caravans), occupants from 15 of which were interviewed.
Employees	Number of people predominantly based in survey area (>500 hours)	600	463	77%	Excludes 59 people who work < 500 hours, site employees and contractors.
BREAKDOWN OF AGE GROUPS					
Adults	Individuals over 17	U	996	U	
15 year old	More than 12.0 year old to 17.0 year old	U	23	U	
10 year old	More than 7.0 year old to 12.0 year old	U	14	U	
5 year old	More than 2.0 year old to 7.0 year old	U	6	U	
1 year old	More than 1.0 year old to 2.0 year old	U	3	U	
3 months old	From 0 to 1.0 year old	U	1	U	

Notes

[a] - Data from www.statistics.gov.uk were used to estimate this figure for people resident in the 5 km survey area

[b] - The number of people for whom positive data was obtained, for pathways (A) and (B), will not equal the relevant totals in the summary. This is because some individuals, for example someone who fishes from a boat and the shore and digs their own bait, will be counted three times within the pathway, whereas others, such as the families of fishermen, will not be counted at all.

[c] - 4 retail outlets were visited during the survey

U - Unknown

Table 2. Typical food groups used in habits surveys

Green vegetables	Globe artichoke, asparagus, broccoli, brussel sprout, cabbage, calabrese, cauliflower, chard, courgettes, cucumber, gherkin, herbs, kale, leaf beet, lettuce, marrow, spinach
Other vegetables	Aubergine, broad bean, chilli pepper, french bean, mangetout, pea, pepper, runner bean, sweetcorn, tomato
Root vegetables	Jerusalem artichoke, beetroot, carrot, celeriac, celery, chicory, fennel, garlic, kohl rabi, leek, onion, parsnip, radish, shallot, spring onion, swede, turnip
Potato	
Domestic fruit	Apple, apricot, blackberry, blackcurrant, boysenberry, cherry, damson, fig, gooseberry, grapes, greengages, huckleberry, loganberry, melon, nectarines, peach, pear, plum, pumpkin, raspberry, redcurrants, rhubarb, rowanberry, strawberry, tayberry, whitecurrant
Milk	Milk, butter, cream, cheese, yoghurt, goats milk
Cattle meat †	
Pig meat †	
Sheep meat †	
Poultry	Chicken, duck, goose, grouse, guinea fowl, partridge, pheasant, pigeon, snipe, turkey, woodcock
Eggs	Chicken egg, duck egg, goose egg
Wild/free foods	Blackberry, blackcurrant, chestnut, crab apple, damson, dandelion root, elderberry, nettle, raspberry, rowanberry, samphire, sloe, strawberry, watercress, wild apple
Honey	
Wild Fungi	Mushrooms
Rabbits/Hare	Hare, rabbit
Venison †	
Fish (sea)	Bass, brill, cod, common ling, dab, Dover sole, flounder, gurnard, haddock, hake, herring, lemon sole, mackerel, monkfish, mullet, plaice, pollack, witch saithe, salmon, sea trout, squid*, cuttlefish*, rays, turbot, whitebait, whiting
Fish (freshwater)	Brown trout, rainbow trout, perch, pike, salmon (river), eels
Crustaceans	Brown crab, spider crab, crawfish, lobster, *Nephrops*, squat lobster, prawn, shrimp
Molluscs	Cockles, limpets, mussels, oysters, queens, scallops, razor shell, whelks, winkles

Notes:
* Although squid and cuttlefish are molluscs, radiologically they are more akin to fish
† Including offal

Table 3. Adults' consumption rates of fish in the Heysham area (kg/y)

Observation number	Bass	Bream	Cod	Dab	Dover sole	Eel	Flounder	Grey mullet	Lemon sole	Mackerel	Mixed fish	Plaice	Pollack	Rays	Salmon	Sea trout	Whiting	Total
1001			**9.1**	**13.6**								**20.0**		**4.5**				**47.2**
1002	**3.6**											**36.3**		**4.5**				**44.5**
92	**4.3**	**0.3**	**29.9**									**6.0**						**40.5**
91	**4.3**	**0.3**	**29.9**									**6.0**						**40.5**
151							**31.8**											**31.8**
1000			**2.3**		**4.5**							**18.8**		**2.3**				**27.8**
13							**26.5**											**26.5**
61											**26.5**							**26.5**
62											**26.5**							**26.5**
775	**3.5**														**18.0**			**21.5**
776	**3.5**														**18.0**			**21.5**
1034	**2.7**						**2.0**	**2.6**							**11.4**	**2.5**		**21.2**
1035	**2.7**						**2.0**	**2.6**							**11.4**	**2.5**		**21.2**
1039			**5.0**			**2.0**					**7.6**	**1.2**	**2.8**					**18.6**
1040			**5.0**			**2.0**					**7.6**	**1.2**	**2.8**					**18.6**
1041			**5.0**			**2.0**					**7.6**	**1.2**	**2.8**					**18.6**
522	**7.8**														**5.8**	**4.6**		**18.2**
1028	**7.8**														**5.8**	**4.6**		**18.2**
35							**5.1**					**5.0**					**6.5**	**16.6**
36							**5.1**					**5.0**					**6.5**	**16.6**
70							**15.9**											**15.9**
71							**15.9**											**15.9**
68-69	8.8						6.6											15.5
103-104			9.0							2.8		3.0						14.7
896			12.0	1.8								0.9						14.7
689	4.3						5.0	4.7										13.9
93										13.8								13.8
41-44							4.3					4.2					5.4	13.8
681	5.6											8.0						13.6
94-95			11.2									2.0						13.2
17-18	2.0						10.7											12.7
1005	0.9											9.5		1.4				11.8
1008	0.9											9.5		1.4				11.8
4-5												11.8						11.8
1006-1007	0.9											9.5		1.4				11.8
1009	0.9											9.5		1.4				11.8

Table 3. Adults' consumption rates of fish in the Heysham area (kg/y)

Observation number	Bass	Bream	Cod	Dab	Dover sole	Eel	Flounder	Grey mullet	Lemon sole	Mackerel	Mixed fish	Plaice	Pollack	Rays	Salmon	Sea trout	Whiting	Total
67							10.6											10.6
112-114	4.3		4.0				1.5					0.7						10.5
683-686	3.3		6.9															10.2
1-2	1.4						3.7					3.7			0.8			9.7
762-763							1.3		1.8	1.8		1.2			2.0		1.6	9.7
45							5.1								4.2			9.3
1030															2.9	6.3		9.2
58							9.2											9.2
8												8.8						8.8
9							8.8											8.8
690-691	5.6						2.0					1.0						8.7
719-720	2.4		2.0	0.4			1.7										2.1	8.6
37-40							2.6					2.5					3.2	8.3
693-694												8.3						8.3
14-15							8.0											8.0
715-716												7.9						7.9
717-718							2.0			3.3		2.0						7.3
1024-1025	1.9						1.0	1.1				1.0			2.3			7.2
143			7.2															7.2
837-838	1.4		4.0									1.0						6.4
57							6.1											6.1
149-150												6.0						6.0
97-100	0.5		3.0				1.0					0.7						5.3
101-102							1.0			4.2								5.2
147	1.6		1.8				1.6											5.0
841-843											5.0							5.0
55-56			2.0	1.5								1.3						4.8
682	4.7																	4.7
1032-1033	1.9														2.7			4.6
765-767	1.0		1.3						1.3			1.0						4.6
33-34							4.6											4.6
753-754	1.1		1.5				1.0					1.0						4.6
46-50															4.2			4.2
678-679	2.4							1.8										4.1
3												4.1						4.1
746-747															4.1			4.1

Table 3. Adults' consumption rates of fish in the Heysham area (kg/y)

Observation number	Bass	Bream	Cod	Dab	Dover sole	Eel	Flounder	Grey mullet	Lemon sole	Mackerel	Mixed fish	Plaice	Pollack	Rays	Salmon	Sea trout	Whiting	Total
721	1.5		1.2				0.7					0.7						4.0
723	1.5		1.2				0.7					0.7						4.0
1021-1022															3.9			3.9
148							3.7											3.7
984										1.8		1.2						3.0
27-32							2.6											2.6
748-749							1.0			0.5		1.0						2.6
20-25							2.4											2.4
728-729	1.4											0.8						2.2
798	0.4							0.4							1.3			2.1
795	0.4							0.4							1.3			2.1
59-60							2.0											2.0
973					0.6							1.3						1.9
1019-1020															1.2	0.6		1.9
144	1.7																	1.7
891							1.7											1.7
726-727							0.8					0.8						1.7
750-752	0.8											0.8						1.5
890	0.9											0.4						1.4
796															1.3			1.3
797															1.3			1.3
105-108	1.3																	1.3
142	1.0																	1.0
832-833	0.2		0.7															0.9
1012-1014							0.9											0.9
759-761															0.9			0.9
792-793															0.9			0.9
19							0.8											0.8
110-111	0.4																	0.4
893							0.2					0.1						0.3
895							0.2					0.1						0.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of fish based on the 22 highest adult consumers is 25.2 kg/y

The observed 97.5 percentile rate based on 177 observations is 30.2 kg/y

Table 4. Adults' consumption rates of crustaceans in the Heysham area (kg/y)

Observation number	Brown shrimp	Crab	Lobster	Total
4	**23.6**			**23.6**
5	**23.6**			**23.6**
1	**11.8**			**11.8**
2	**11.8**			**11.8**
6	**8.8**			**8.8**
9	5.9			5.9
715	5.4			5.4
716	5.4			5.4
770	5.4			5.4
771	5.4			5.4
45	4.7			4.7
8	4.4			4.4
13	4.0			4.0
3	3.7			3.7
522	3.3			3.3
1028	3.3			3.3
1034	3.2			3.2
1035	3.2			3.2
1000			2.2	2.2
762	1.5			1.5
763	1.5			1.5
54			1.3	1.3
792	1.0	0.05		1.0
793	1.0	0.05		1.0
82	1.0			1.0
89	1.0			1.0
750	0.8			0.8
751	0.8			0.8
752	0.8			0.8
127	0.7			0.7
128	0.7			0.7
765	0.7			0.7
766	0.7			0.7
767	0.7			0.7
1039			0.6	0.6
1040			0.6	0.6
1041			0.6	0.6
759	0.3			0.3
760	0.3			0.3
761	0.3			0.3
827	0.3			0.3
829	0.3			0.3
984		0.3		0.3
1024	0.2			0.2
1025	0.2			0.2
795	0.1			0.1
796	0.1			0.1
797	0.1			0.1
798	0.1			0.1

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of crustaceans based on the 5 highest adult consumers is 15.9 kg/y

The observed 97.5 percentile rate based on 49 observations is 21.2 kg/y

Table 5. Adults' consumption rates of molluscs in the Heysham area (kg/y)

Observation number	Cockle	Mussel	Oyster	Whelk	Winkle	Total
4	**7.3**					**7.3**
5	**7.3**					**7.3**
763	**2.2**	**3.3**				**5.5**
1039		**1.2**		**2.9**	**0.3**	**4.5**
1040		**1.2**		**2.9**	**0.3**	**4.5**
1041		**1.2**		**2.9**	**0.3**	**4.5**
762		**3.3**				**3.3**
841	**2.0**	**1.2**				**3.2**
522		**2.6**				**2.6**
1028		**2.6**				**2.6**
151		1.0			1.0	2.0
690	1.9					1.9
1042	1.9					1.9
1043	1.9					1.9
54				1.8		1.8
795	0.6					0.6
796	0.6					0.6
797	0.6					0.6
798	0.6					0.6
1024	0.5					0.5
1025	0.5					0.5
837	0.2	0.2				0.4
839	0.2	0.2				0.4
792	0.4					0.4
775			0.2			0.2
776			0.2			0.2
765		0.01				0.01
766		0.01				0.01
767		0.01				0.01

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of molluscs based on the 10 highest adult consumers is 4.5 kg/y

The observed 97.5 percentile rate based on 29 observations is 7.3 kg/y

Table 6. Adults' consumption rates of wildfowl in the Heysham area (kg/y)

Observation number	Gadwall	Goose	Mallard	Pintail duck	Shoveler	Snipe	Teal	Wigeon	Total
795		**6.6**	**5.4**	**0.4**	**0.7**	**0.1**	**1.9**	**4.2**	**19.2**
775	**0.4**	**13.2**	**1.8**	**1.4**			**0.2**		**16.9**
776	**0.4**	**13.2**	**1.8**	**1.4**			**0.2**		**16.9**
1030		**8.8**	**2.7**				**1.0**	**2.1**	**14.6**
792		**5.9**	**4.8**					**0.4**	**11.0**
793		**5.9**	**4.8**					**0.4**	**11.0**
73				**1.8**	**1.6**		**2.0**	**5.3**	**10.6**
74				**1.8**	**1.6**		**2.0**	**5.3**	**10.6**
75				**1.8**	**1.6**		**2.0**	**5.3**	**10.6**
76				**1.8**	**1.6**		**2.0**	**5.3**	**10.6**
77				**1.8**	**1.6**		**2.0**	**5.3**	**10.6**
78				**1.8**	**1.6**		**2.0**	**5.3**	**10.6**
79				**1.8**	**1.6**		**2.0**	**5.3**	**10.6**
80				**1.8**	**1.6**		**2.0**	**5.3**	**10.6**
765		**6.6**	**1.1**	**0.9**			**0.4**	**0.5**	**9.5**
766		**6.6**	**1.1**	**0.9**			**0.4**	**0.5**	**9.5**
82			**6.4**	**0.9**			**0.9**	**0.9**	**9.1**
83			**6.4**	**0.9**			**0.9**	**0.9**	**9.1**
84			**6.4**	**0.9**			**0.9**	**0.9**	**9.1**
85			**6.4**	**0.9**			**0.9**	**0.9**	**9.1**
86			**6.4**	**0.9**			**0.9**	**0.9**	**9.1**
87			**6.4**	**0.9**			**0.9**	**0.9**	**9.1**
88			**6.4**	**0.9**			**0.9**	**0.9**	**9.1**
89			**6.4**	**0.9**			**0.9**	**0.9**	**9.1**
522		4.4	1.8						6.2
1028		4.4	1.8						6.2
796		1.1	1.1					0.9	3.1
797		1.1	1.1					0.9	3.1
841		2.2						0.4	2.6
842		2.2						0.4	2.6
843		2.2						0.4	2.6
1024		1.1	0.7						1.8
1025		1.1	0.7						1.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wildfowl based on the 24 highest adult consumers is 11.1 kg/y

The observed 97.5 percentile rate based on 33 observations is 17.4 kg/y

Table 7. Adults' consumption rates of marine plants/algae in the Heysham area (kg/y)

Observation number	Samphire
522	**3.3**
1028	**3.3**
1024	**2.3**
1025	**2.3**
775	**2.3**
776	**2.3**
841	**1.4**
765	0.7
766	0.7
767	0.7
762	0.5
763	0.5
795	0.2
1012	0.1
1013	0.1
1014	0.1

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of marine plants/algae based on the 7 highest adult consumers is 2.4 kg/y
The observed 97.5 percentile rate based on 16 observations is 3.3 kg/y

Table 8. Adults' consumption rates of salt marsh grazed sheep in the Heysham area (kg/y)

Observation number	Lamb
1032-1033	**8.5**
1012-1014	**6.6**
956-961	**3.8**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of salt marsh grazed sheep based on the 11 highest adult consumers is 5.4 kg/y
The observed 97.5 percentile rate based on 11 observations is 8.5 kg/y

Table 9. Children's consumption rates of fish in the Heysham area (kg/y)

15 year old age group

Observation number	Age	Bass	Cod	Flounder	Grey mullet	Mackerel	Plaice	Rays	Salmon	Sea trout	Whiting	Total
1029	**15**	**7.8**							**5.8**	**4.6**		**18.2**
1003	**14**	**0.9**					**9.5**	**1.4**				**11.8**
10	**13**			**8.8**								**8.8**
11	**12**			**8.8**								**8.8**
1026	**16**	**1.9**		**1.0**	**1.1**		**1.0**		**2.3**			**7.2**
688	**12**		**4.0**								**2.1**	**6.1**
724	16	1.5	1.2	0.7			0.7					4.0
722	12	1.5	1.2	0.7			0.7					4.0
986	14					1.8	1.2					3.0
892	14			1.7								1.7
1015	16			0.9								0.9
1016	14			0.9								0.9
1017	12			0.9								0.9
794	15								0.9			0.9

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of fish based on the 6 highest 15 year old age group consumers is 10.2 kg/y
The observed 97.5 percentile rate based on 14 observations is 16.1 kg/y

10 year old age group

Observation number	Age	Bass	Cod	Flounder	Grey mullet	Mackerel	Plaice	Rays	Salmon	Sea trout	Whiting	Total
1004	**10**	**0.9**					**9.5**	**1.4**				**11.8**
1027	**10**	**1.9**		**1.0**	**1.1**		**1.0**		**2.3**			**7.2**
12	**7**			**5.9**								**5.9**
51	**8**								**4.2**			**4.2**
725	**10**	**1.5**	**1.2**	**0.7**			**0.7**					**4.0**
987	9					1.8	1.2					3.0
894	7			0.2			0.1					0.3

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of fish based on the 5 highest 10 year old age group consumers is 6.6 kg/y
The observed 97.5 percentile rate based on 7 observations is 11.1 kg/y

Table 9. Children's consumption rates of fish in the Heysham area (kg/y)

5 year old age group

Observation number	Age	Bass	Cod	Flounder	Grey mullet	Mackerel	Plaice	Rays	Salmon	Sea trout	Whiting	Total
1010	**3**	**0.5**					**5.2**	**0.7**				**6.4**
52	**5**								**2.9**			**2.9**
53	**2.5**								**2.9**			**2.9**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of fish based on the 3 highest 5 year old age group consumers is 4.1 kg/y
The observed 97.5 percentile rate based on 3 observations is 6.2 kg/y

1 year old age group

Observation number	Age	Bass	Cod	Flounder	Grey mullet	Mackerel	Plaice	Rays	Salmon	Sea trout	Whiting	Total
1011	**1**	**0.5**					**5.2**	**0.7**				**6.4**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of fish based on the only 1 year old age group consumer is 6.4 kg/y
The observed 97.5 percentile rate is not applicable for 1 observation

Table 10. Children's consumption rates of crustaceans in the Heysham area (kg/y)

15 year old age group

Observation number	Age	Brown shrimp	Crab	Total
10	**13**	**5.9**		**5.9**
11	**12**	**5.9**		**5.9**
1029	**15**	**3.3**		**3.3**
794	15	1.0	0.0	1.0
986	14		0.3	0.3
1026	16	0.2		0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of crustaceans based on the 3 highest 15 year old age group consumers is 5.0 kg/y

The observed 97.5 percentile rate based on 6 observations is 5.9 kg/y

10 year old age group

Observation number	Age	Brown shrimp	Crab	Total
12	**7**	**5.9**		**5.9**
987	9		0.3	0.3
1027	10	0.2		0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of crustaceans based on the highest 10 year old age group consumer is 5.9 kg/y

The observed 97.5 percentile rate based on 3 observations is 5.6 kg/y

Table 11. Children's consumption rates of molluscs in the Heysham area (kg/y)

15 year old age group

Observation number	Age	Cockle	Mussel	Total
1029	**15**		**2.6**	**2.6**
1026	16	0.5		0.5
840	14	0.2	0.2	0.4
794	15	0.4		0.4

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of molluscs based on the highest 15 year old age group consumer is 2.6 kg/y
The observed 97.5 percentile rate based on 4 observations is 2.5 kg/y

10 year old age group

Observation number	Age	Cockle	Mussel	Total
1027	**10**	**0.5**		**0.5**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of molluscs based on the only 10 year old age group consumer is 0.5 kg/y
The observed 97.5 percentile rate is not applicable for 1 observation

Table 12. Children's consumption rates of wildfowl in the Heysham area (kg/y)

15 year old age group

Observation number	Age	Goose	Mallard	Wigeon	Total
794	**15**	**5.9**	**4.8**	**0.4**	**11.0**
1029	**15**	**4.4**	**1.8**		**6.2**
1026	16	1.1	0.7		1.8

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of wildfowl based on the 2 highest 15 year old age group consumers is 8.6 kg/y
The observed 97.5 percentile rate based on 3 observations is 10.8 kg/y

10 year old age group

Observation number	Age	Goose	Mallard	Wigeon	Total
1027	**10**	**1.1**	**0.7**		**1.8**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of wildfowl based on the only 10 year old age group consumer is 1.8 kg/y
The observed 97.5 percentile rate is not applicable for 1 observation

Table 13. Children's consumption rates of marine plants/algae in the Heysham area (kg/y)

15 year old age group

Observation number	Age	Samphire
1029	**15**	**3.3**
1026	**16**	**2.3**
1015	16	0.1
1016	14	0.1
1017	12	0.1

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of marine plants/algae based on the 2 highest 15 year old age group consumers is 2.8 kg/y
The observed 97.5 percentile rate based on 5 observations is 3.2 kg/y

10 year old age group

Observation number	Age	Samphire
1027	**10**	**2.3**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of marine plants/algae based on the only 10 year old age group consumer is 2.3 kg/y
The observed 97.5 percentile rate is not applicable for 1 observation

Table 14. Children's consumption rates of salt marsh grazed sheep in the Heysham area (kg/y)

15 year old age group

Observation number	Age	Lamb
1015	**16**	**6.6**
1016	**14**	**6.6**
1017	**12**	**6.6**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of salt marsh grazed sheep based on the 3 highest 15 year old age group consumers is 6.6 kg/y
The observed 97.5 percentile rate based on 3 observations is 6.6 kg/y

Table 15. Summary of adults' consumption rates in the Heysham area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	177	22	47.2	15.9	25.2	30.2	15.0	40.0
Crustaceans	49	5	23.6	8.8	15.9	21.2	3.5	10.0
Molluscs	29	10	7.3	2.6	4.5	7.3	3.5	10.0
Wildfowl	33	24	19.2	9.1	11.1	17.4	ND	ND
Marine plants/algae	16	7	3.3	1.4	2.4	3.3	ND	ND
Salt marsh grazed sheep	11	11	8.5	3.8	5.4	8.5	8.0[a]	25.0[a]
Green vegetables	21	10	40.4	21.4	32.4	40.4	15.0	45.0
Other vegetables	28	11	34.8	11.7	24.5	34.8	20.0	50.0
Root vegetables	27	11	44.7	18.6	32.9	44.7	10.0	40.0
Potato	28	11	102.4	34.7	62.6	102.4	50.0	120.0
Domestic fruit	26	2	85.5	85.5	85.5	85.5	20.0	75.0
Milk	31	21	311.1	148.2	195.2	311.1	95.0	240.0
Cattle meat	5	5	10.4	10.4	10.4	10.4	15.0	45.0
Pig meat	NC	NC	NC	NC	NC	NC	15.0	40.0
Sheep meat	9	9	15.2	11.3	13.5	15.2	8.0	25.0
Poultry	1	1	2.8	2.8	2.8	NA	10.0	30.0
Eggs	17	17	17.8	7.1	12.5	17.8	8.5	25.0
Wild/free foods	21	7	6.4	2.3	3.8	6.4	7.0	25.0
Rabbits/hares	2	2	9.0	2.3	5.6	8.8	6.0	15.0
Honey	2	2	11.3	11.3	11.3	11.3	2.5	9.5
Wild fungi	11	6	4.5	4.5	4.5	4.5	3.0	10.0
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Fish (freshwater)	NC	NC	NC	NC	NC	NC	15.0	40.0

Notes

ND = not determined

NC = not consumed

NA = not applicable

[a] = the generic rates shown are applicable to sheep meat, not specifically salt marsh grazed sheep

For 1 observation, the terms maximum, minimum and mean are not strictly valid

Table 16. Summary of 15 year old children's consumption rates in the Heysham area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	14	6	18.2	6.1	10.2	16.1	6.5	20.0
Crustaceans	6	3	5.9	3.3	5.0	5.9	2.5	6.0
Molluscs	4	1	2.6	2.6	2.6	2.5	2.5	6.0
Wildfowl	3	2	11.0	6.2	8.6	10.8	ND	ND
Marine plants/algae	5	2	3.3	2.3	2.8	3.2	ND	ND
Salt marsh grazed sheep	3	3	6.6	6.6	6.6	6.6	5.5[a]	15[a]
Green vegetables	NC	NC	NC	NC	NC	NC	9.0	25.0
Other vegetables	NC	NC	NC	NC	NC	NC	10.0	30.0
Root vegetables	NC	NC	NC	NC	NC	NC	7.5	20.0
Potato	NC	NC	NC	NC	NC	NC	60.0	130.0
Domestic fruit	NC	NC	NC	NC	NC	NC	15.0	50.0
Milk	3	3	165.9	69.1	127.7	165.0	110.0	260.0
Cattle meat	NC	NC	NC	NC	NC	NC	15.0	35.0
Pig meat	NC	NC	NC	NC	NC	NC	10.0	30.0
Sheep meat	NC	NC	NC	NC	NC	NC	5.5	15.0
Poultry	NC	NC	NC	NC	NC	NC	6.5	20.0
Eggs	NC	NC	NC	NC	NC	NC	7.0	25.0
Wild/free foods	NC	NC	NC	NC	NC	NC	3.0	13.0
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	2.0	5.0
Wild fungi	NC	NC	NC	NC	NC	NC	2.0	5.5
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Fish (freshwater)	NC	NC	NC	NC	NC	NC	6.5	20.0

Notes

ND = not determined

NC = not consumed

[a] = the generic rates shown are applicable to sheep meat, not specifically salt marsh grazed sheep

Table 17. Summary of 10 year old children's consumption rates in the Heysham area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	7	5	11.8	4.0	6.6	11.1	6.0	20.0
Crustaceans	3	1	5.9	5.9	5.9	5.6	2.5	7.0
Molluscs	1	1	0.5	0.5	0.5	NA	2.5	7.0
Wildfowl	1	1	1.8	1.8	1.8	NA	ND	ND
Marine plants/algae	1	1	2.3	2.3	2.3	NA	ND	ND
Salt marsh grazed sheep	NC	NC	NC	NC	NC	NC	4.0[a]	10.0[a]
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	NC	NC	NC	NC	NC	NC	45.0	85.0
Domestic fruit	NC	NC	NC	NC	NC	NC	15.0	50.0
Milk	NC	NC	NC	NC	NC	NC	110.0	240.0
Cattle meat	NC	NC	NC	NC	NC	NC	15.0	30.0
Pig meat	NC	NC	NC	NC	NC	NC	8.5	25.0
Sheep meat	NC	NC	NC	NC	NC	NC	4.0	10.0
Poultry	NC	NC	NC	NC	NC	NC	5.5	15.0
Eggs	4	4	10.5	10.5	10.5	10.5	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
Fish (freshwater)	NC	NC	NC	NC	NC	NC	6.0	20.0

Notes

ND = not determined

NC = not consumed

NA = not applicable

[a] = the generic rates shown are applicable to sheep meat, not specifically salt marsh grazed sheep

For 1 observation, the terms maximum, minimum and mean are not strictly valid

Table 18. Summary of 5 year old children's consumption rates in the Heysham area (kg/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	3	3	6.4	2.9	4.1	6.2	ND	ND
Crustaceans	NC	NC	NC	NC	NC	NC	ND	ND
Molluscs	NC	NC	NC	NC	NC	NC	ND	ND
Wildfowl	NC	NC	NC	NC	NC	NC	ND	ND
Marine plants/algae	NC	NC	NC	NC	NC	NC	ND	ND
Salt marsh grazed sheep	NC	NC	NC	NC	NC	NC	ND	ND
Green vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Other vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Root vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Potato	NC	NC	NC	NC	NC	NC	ND	ND
Domestic fruit	NC	NC	NC	NC	NC	NC	ND	ND
Milk	NC	NC	NC	NC	NC	NC	ND	ND
Cattle meat	NC	NC	NC	NC	NC	NC	ND	ND
Pig meat	NC	NC	NC	NC	NC	NC	ND	ND
Sheep meat	NC	NC	NC	NC	NC	NC	ND	ND
Poultry	NC	NC	NC	NC	NC	NC	ND	ND
Eggs	NC	NC	NC	NC	NC	NC	ND	ND
Wild/free foods	NC	NC	NC	NC	NC	NC	ND	ND
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	ND	ND
Wild fungi	NC	NC	NC	NC	NC	NC	ND	ND
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Fish (freshwater)	NC	NC	NC	NC	NC	NC	ND	ND

Notes
ND = not determined
NC = not consumed

Table 19. Summary of 1 year old children's consumption rates in the Heysham area (kg/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	1	1	6.4	6.4	6.4	NA	ND	ND
Crustaceans	NC	NC	NC	NC	NC	NC	ND	ND
Molluscs	NC	NC	NC	NC	NC	NC	ND	ND
Wildfowl	NC	NC	NC	NC	NC	NC	ND	ND
Marine plants/algae	NC	NC	NC	NC	NC	NC	ND	ND
Salt marsh grazed sheep	NC	NC	NC	NC	NC	NC	ND	ND
Green vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Other vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Root vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Potato	NC	NC	NC	NC	NC	NC	ND	ND
Domestic fruit	NC	NC	NC	NC	NC	NC	ND	ND
Milk	NC	NC	NC	NC	NC	NC	ND	ND
Cattle meat	NC	NC	NC	NC	NC	NC	ND	ND
Pig meat	NC	NC	NC	NC	NC	NC	ND	ND
Sheep meat	NC	NC	NC	NC	NC	NC	ND	ND
Poultry	NC	NC	NC	NC	NC	NC	ND	ND
Eggs	NC	NC	NC	NC	NC	NC	ND	ND
Wild/free foods	NC	NC	NC	NC	NC	NC	ND	ND
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	ND	ND
Wild fungi	NC	NC	NC	NC	NC	NC	ND	ND
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Fish (freshwater)	NC	NC	NC	NC	NC	NC	ND	ND

Notes

ND = not determined

NC = not consumed

NA = not applicable

For 1 observation, the terms maximum, minimum and mean are not strictly valid

Table 20. Intertidal occupancy rates in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	Mud	Mud and sand	Rock	Salt marsh	Sand	Sand and stones
151	**Heysham**	**Set netting[b]**	**1288**					
775	Cockerham Marsh/Rivers Wyre, Cocker & Keer	Wildfowling/Elver fishing[b]	260					
	Morecambe Bay/Warton Sands	Collecting cockles[b]/Set netting[b]		48				
765	Cockerham Marsh and R. Lune marshes/Rivers Wyre, Cocker & Keer	Wildfowling/Elver fishing[b]	201					
	Heysham, Fleetwood, The Lune & Barrow-in-Furness /Pilling Sands, Middleton Sands and Fleetwood	Collecting mussels[b]/Collecting cockles[b]		185				
841	Rivers Kent and Gilpin	Elver fishing[b]	160					
	Morecambe Beach	Fyke netting[b]		180				
94	Morecambe Bay	Bait digging	90					
792	Cockerham Marsh and R. Lune marshes	Wildfowling	50					
794[c]	Cockerham Marsh and R. Lune marshes	Wildfowling	50					
145-146	Red Nab	Bait digging	48					
	Sandylands	Long lining					16	
973	Knott End	Fixing moorings and coastguard duties	38					
	Knott End	Long lining		10				
	Knott End	Coastguard duties				9		
	Knott End	Coastguard duties					9	
96	Arnside	Angling	32					
	Bardsea	Angling		120				
	Arnside	Bait digging, angling and dog walking					660	
971-972	Knott End	Coastguard duties	14					
	Knott End	Coastguard duties				9		
	Knott End	Coastguard duties					9	
974-983	Knott End	Coastguard duties	12					
64	**Roosebeck**	**Oyster farming[b]**		**960**				
65	**Roosebeck**	**Oyster farming[b]**		**960**				
66	**Baycliff and Arnside**	**Angling**		**780**				
984	**Fleetwood**	**Bait digging[b]**		**672**				
	Fleetwood	Dog walking					365	
988-993	**Fleetwood**	**Bait digging[b]**		**672**				
683	**Half Moon Bay/Morecambe Beach**	**Bait digging/Angling**		**650**				
68	**Various**	**Angling**		**624**				

Table 20. Intertidal occupancy rates in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	Mud	Mud and sand	Rock	Salt marsh	Sand	Sand and stones
70	**Various**	**Angling**		**416**				
748	Heysham and Morecambe	Bait digging		288				
681	Morecambe Beach/South of The Battery Slipway	Angling/Bait digging		275				
682	Morecambe Beach	Angling		250				
719	Morecambe Bay	Bait digging		240				
	Morecambe Bay	Angling					420	
762	Morecambe, Knott End and Barrow-in-Furness/Pilling Sands, Middleton Sands and Fleetwood/Heysham	Collecting mussels[b]/Collecting cockles[b]/Collecting winkles		221				
763	Morecambe, Knott End and Barrow-in-Furness/Pilling Sands, Middleton Sands and Fleetwood/Heysham	Collecting mussels[b]/Collecting cockles[b]/Collecting winkles		221				
81	Walney Channel	Angling and collecting crabs		136				
678	South of The Battery Slipway	Bait digging		100				
721	Arnside	Angling		88				
722[c]	Arnside	Angling		88				
728	Arnside	Angling		72				
97	Walney Island	Dog walking		50				
1038	Morecambe Bay	Collecting cockles[b]		40				
	Heysham	Collecting mussels[b]					425	
726	Arnside	Angling		18				
955	Glasson Dock	Water sports preparation		18				
1034	Bazil Point	Fyke netting		15				
	Bazil Point	**Dog walking**				**365**		
893-894[c]	Knott End	Bait digging		12				
	Fleetwood and Knott End	Angling					44	
	Foulney Island	Angling						6
54	Walney Channel	Collecting whelks		12				
93	Morecambe Bay	Bait digging		10				
	Walney Island	Beach combing						90
522	Heysham outfall	Collecting mussels		10				
890	Knott End	Angling		4				
142	**Morecambe Bay**	**Angling**			**312**			
147	**Morecambe Bay/Half Moon Bay**	**Angling/Collecting crabs**			**218**			
16	**Red Nab**	**Angling**			**150**			

Table 20. Intertidal occupancy rates in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	Mud	Mud and sand	Rock	Salt marsh	Sand	Sand and stones
141	**Stone Jetty, Morecambe**	**Angling**			**144**			
143	**Stone Jetty, Morecambe**	**Angling**			**104**			
144	**Morecambe Bay**	**Angling**			**104**			
791	**Hazelslack Marsh**	**Turf cutting**				**840**		
72	**Tummer Hill Marsh and Wylock Marsh**	**Walking**				**390**		
1012	**Cockerham Marsh**	**Tending livestock**				**365**		
73-76	Tummer Hill Marsh and Wylock Marsh	Wildfowling				150		
956	Pilling Marsh	Tending livestock				150		
958	Pilling Marsh	Tending livestock				150		
1018	Glasson Marsh	Tending livestock				120		
782-785	Silverdale	Bird watching				110		
795	Warton Marsh and Cockerham Marsh	Wildfowling				65		
786-790	Silverdale	Bird watching				60		
119	Peggymarsh Pool	Tending livestock				52		
82-88	Out Marsh, Low Marsh and Sand Gate Marsh	Wildfowling				50		
777	Sunderland Point	Tending livestock				50		
994	Heaton Marsh	Tending livestock				46		
995	Heaton Marsh	Tending livestock				46		
997	Heaton Marsh	Tending livestock				46		
998	Heaton Marsh	Tending livestock				46		
773	Hest Bank	Bird watching				44		
774	Hest Bank	Bird watching				44		
63	South Walney Nature Reserve	Marsh warden				6		
860-889	**Morecambe and Sandylands**	**Sea defence work**					**2400**	
3	**Morecambe Bay**	**Collecting cockles[b] and mussels[b]**					**1560**	
677	**Half Moon Bay**	**Angling**					**1130**	
1	**Morecambe Bay**	**Collecting cockles[b] and mussels[b]**					**970**	
856	Half Moon Bay	Dog walking and angling					754	
6	Morecambe Bay	Collecting cockles[b] and mussels[b] and leading guided walks					714	
7	Morecambe Bay	Collecting cockles[b] and mussels[b]					684	
851	Half Moon Bay/Arnside	Dog walking/Angling					587	
858	Morecambe and Sandylands	Dog walking					260	
4	Morecambe Bay	Collecting cockles[b] and mussels[b]					218	

Table 20. Intertidal occupancy rates in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	Mud	Mud and sand	Rock	Salt marsh	Sand	Sand and stones
5	Morecambe Bay	Collecting cockles[b] and mussels[b]					218	
8	Morecambe Bay	Collecting mussels[b]					215	
673	Half Moon Bay	Walking					160	
674	Half Moon Bay	Walking					160	
772	Morecambe Beach	Dog walking					150	
717	Storth	Angling					144	
852[c]	Half Moon Bay	Dog walking					144	
853[c]	Half Moon Bay	Dog walking					144	
854[c]	Half Moon Bay	Dog walking					144	
855	Half Moon Bay	Dog walking					144	
13	Canal Foot	Stake netting					137	
19	Flookburgh, Bardsea and The Battery Slipway	Angling					130	
680	Half Moon Bay	Angling					125	
690	Green Street Slipway, Morecambe	Angling					120	
968	Cockerham Sands	Beach occupancy					104	
969[c]	Cockerham Sands	Beach occupancy					104	
667	Half Moon Bay	Jogging					100	
668	Half Moon Bay	Jogging					100	
675	Half Moon Bay	Dog walking					100	
755	Morecambe Beach	Walking					84	
756	Morecambe Beach	Walking					84	
757[c]	Morecambe Beach	Walking					84	
758[c]	Morecambe Beach	Walking					84	
847[c]	Half Moon Bay	Playing					70	
848	Half Moon Bay	Playing					70	
26	Flookburgh, Bardsea and The Battery Slipway	Angling					60	
33	Flookburgh, Bardsea and The Battery Slipway	Angling					60	
1023	Wyre Light	Bait digging[b]					52	
103	Walney Island	Bait digging					50	
91	Roa Island Beach	Bait digging					45	
112	South Walney Nature Reserve/Walney Island	Angling/Bait digging					32	
859	The Battery Slipway	Dog walking					26	
9	Morecambe Bay	Leading guided walks					24	
139	The Battery Slipway	Bait digging					23	

Table 20. Intertidal occupancy rates in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	Mud	Mud and sand	Rock	Salt marsh	Sand	Sand and stones
140	The Battery Slipway	Bait digging					23	
896	Knott End	Angling					20	
101	Barrow-in-Furness/Walney Island	Angling/Bait digging					18	
827	Half Moon Bay	Dog walking					12	
836	Half Moon Bay	Playing					12	
850	Half Moon Bay	Walking					6	
45	Canal Foot	Set netting					4	
1024	Cockerham Sands	Collecting cockles					4	
753	**Morecambe Beach**	**Angling**						**1000**
90	Roa Island and Walney Island	Metal detecting						100
962	Heysham to Hest Bank	Bird watching						23

Notes

Emboldened observations are the critical group members
The critical group intertidal occupancy rate over mud based on 1 observation is 1288 h/y
The observed 97.5 percentile rate based on 23 observations for mud is 723 h/y
The critical group intertidal occupancy rate over mud and sand based on 13 observations is 700 h/y
The observed 97.5 percentile rate based on 40 observations for mud and sand is 960 h/y
The critical group intertidal occupancy rate over rock based on 6 observations is 172 h/y
The observed 97.5 percentile rate based on 6 observations for rock is 300 h/y
The critical group intertidal occupancy rate over salt marsh based on 4 observations is 490 h/y
The observed 97.5 percentile rate based on 40 observations for salt marsh is 401 h/y
The critical group intertidal occupancy rate over sand based on 33 observations is 2293 h/y
The observed 97.5 percentile rate based on 92 observations for sand is 2400 h/y
The critical group intertidal occupancy rate over sand and stones based on 1 observation is 1000 h/y
The observed 97.5 percentile rate based on 6 observations for sand and stones is 888 h/y

[a] Where an individual has occupancy over more than one substrate, information relating to each substrate is on a separate line. Where an individual has two or more activities at separate locations but over the same substrate, the locations and respective activities are sepatated by a / symbol. Where there are two or more activities over the same substrate, activities are ordered from highest to lowest occupancy rates.

[b] Denotes that this activity was undertaken commercially.

[c] Denotes child observations.

Table 21. Gamma dose rate measurements over intertidal substrates in the Heysham area (µGy/h)

Location	NGR	Substrate	Gamma dose rate at 1 metre
Walney Marsh	SD 209 640	Salt marsh	0.119
Baycliff	SD 293 724	Salt marsh	0.097
Walney Slipway	SD 187 688	Mud	0.093
Hest Bank	SD 467 668	Salt marsh	0.093
Flookburgh	SD 352 755	Salt marsh	0.085
Cockerham Marsh	SD 441 527	Salt marsh	0.083
Heysham Harbour (north wall)	SD 405 606	Mud	0.079
Canal Foot	SD 314 775	Salt marsh	0.077
Silverdale	SD 456 749	Salt marsh	0.076
Battery Bay	SD 421 636	Mud	0.072
Arnside	SD 454 787	Mud	0.072
Knott End	SD 346 487	Mud	0.070
Newbiggin Scar	SD 272 692	Mud and sand	0.069
Half Moon Bay	SD 407 608	Sand	0.066
Canal Foot	SD 314 775	Mud and sand	0.065
Morecambe	SD 425 641	Sand	0.061
Battery Bay	SD 421 636	Sand	0.060
Mussel bed near Sandylands	SD 411 631	Mud and sand	0.058

Table 22. Handling rates of fishing gear and sediment in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	Fishing gear	Sediment
151	**Morecambe Bay**	**Gear handling[b]**	**1288**	
792	**Heysham and River Lune**	**Gear handling[b]**	**1100**	
	Cockerham Marsh and R. Lune marshes	Wildfowling		50
765	**Morecambe Bay**	**Gear handling[b]**	**837**	
	Cockerham Marsh and R. Lune marshes	Wildfowling		330
	Heysham, Fleetwood, The Lune & Barrow-in-Furness	Collecting mussels[b]		
	Pilling Sands, Middleton Sands and Fleetwood	Collecting cockles[b]		
762	**Morecambe Bay, near Sunderland Point**	**Gear handling[b]**	**832**	
	Morecambe, Knott End and Barrow-in-Furness	Collecting mussels[b]		221
	Pilling Sands, Middleton Sands and Fleetwood	Collecting cockles[b]		
	Heysham	Collecting winkles		
770	**Morecambe Bay**	**Gear handling[b]**	**750**	
775	**Morecambe Bay and Lune Estuary**	**Gear handling[b]**	**743**	
	Cockerham Marsh	Wildfowling		225
	Morecambe Bay	Collecting cockles[b]		
763	**Morecambe Bay, near Sunderland Point**	**Gear handling[b]**	**712**	
	Morecambe, Knott End and Barrow-in-Furness	Collecting mussels[b]		221
	Pilling Sands, Middleton Sands and Fleetwood	Collecting cockles[b]		
	Heysham	Collecting winkles		
841	**Morecambe Bay**	**Gear handling[b]**	**695**	
8	**Morecambe Bay**	**Gear handling[b]**	**536**	
	Morecambe Bay	Collecting mussels[b]		215
1	**Morecambe Bay**	**Gear handling[b]**	**535**	
	Morecambe Bay	**Collecting cockles[b] and mussels[b]**		**970**
6	**Morecambe Bay**	Gear handling[b]	410	
	Morecambe Bay	**Collecting cockles[b] and mussels[b]**		**684**
7	**Morecambe Bay**	Gear handling[b]	410	
	Morecambe Bay	**Collecting cockles[b] and mussels[b]**		**684**
4	Morecambe Bay	Gear handling[b]	294	
	Morecambe Bay	Collecting cockles[b] and mussels[b]		218
5	Morecambe Bay	Gear handling[b]	294	
	Morecambe Bay	Collecting cockles[b] and mussels[b]		218
1034	Morecambe Bay	Gear handling[b]	272	

Table 22. Handling rates of fishing gear and sediment in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	Fishing gear	Sediment
1021	R. Lune and Lune Estuary	Gear handling[b]	270	
3	Morecambe Bay	Gear handling[b]	263	
	Morecambe Bay	**Collecting cockles[b] and mussels[b]**		**1560**
522	R. Lune - Oxcliffe	Gear handling[b]	260	
	Heysham outfall	Collecting mussels		10
1030	Bazil Point	Gear handling[b]	234	
159	Morecambe Bay	Gear handling[b]	200	
160	Morecambe Bay	Gear handling[b]	200	
13	Canal Foot	Gear handling[b]	189	
9	Morecambe Bay	Gear handling[b]	184	
759	Lune Estuary	Gear handling[b]	180	
1019	R. Lune - Ashton	Gear handling[b]	130	
1038	R. Lune - Oxcliffe	Gear handling[b]	120	
	Morecambe Bay	Collecting cockles[b]		465
	Heysham	Collecting mussels[b]		
45	Canal Foot	Gear handling	88	
715	Morecambe Bay	Gear handling	48	
1024	Cockerham Sands	Gear handling	33	
	Cockerham Sands	Collecting cockles		4
1000	Fleetwood	Gear handling	27	
1001	Fleetwood	Gear handling	27	
764	Morecambe Bay	Gear handling	20	
145	Sandylands	Gear handling	16	
	Red Nab	Bait digging		48
146	Sandylands	Gear handling	16	
	Red Nab	Bait digging		48
973	Knott End	Gear handling	10	
	Knott End	Fixing moorings		24
64	**Roosebeck**	**Oyster farming[b]**		**960**
65	**Roosebeck**	**Oyster farming[b]**		**960**
984	**Fleetwood**	**Bait digging[b]**		**672**
988-993	**Fleetwood**	**Bait digging[b]**		**672**
96	Arnside	Bait digging		400
683	Half Moon Bay	Bait digging		400

Table 22. Handling rates of fishing gear and sediment in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	Fishing gear	Sediment
748	Heysham and Morecambe	Bait digging		288
719	Morecambe Bay	Bait digging		240
73-76	Tummer Hill Marsh and Wylock Marsh	Wildfowling		150
678	South of The Battery Slipway	Bait digging		100
94	Morecambe Bay	Bait digging		90
795	Warton Marsh and Cockerham Marsh	Wildfowling		65
1023	Wyre Light	Bait digging[b]		52
82-88	Out Marsh, Low Marsh and Sand Gate Marsh	Wildfowling		50
103	Walney Island	Bait digging		50
794[c]	Cockerham Marsh and R. Lune marshes	Wildfowling		50
91	Roa Island Beach	Bait digging		45
681	South of The Battery Slipway	Bait digging		25
139	The Battery Slipway	Bait digging		23
140	The Battery Slipway	Bait digging		23
81	Walney Channel	Collecting crabs		16
54	Walney Channel	Collecting whelks		12
893	Knott End	Bait digging		12
894[c]	Knott End	Bait digging		12
93	Morecambe Bay	Bait digging		10
147	Half Moon Bay	Collecting crabs		10
101	Walney Island	Bait digging		8
112	Walney Island	Bait digging		8

Notes

Emboldened observations are the critical group members

The critical group fishing gear handling rate based on 10 observations is 803 h/y

The observed 97.5 percentile rate based on 35 observations for fishing gear is 1128 h/y

The critical group sediment handling rate based on 13 observations is 809 h/y

The observed 97.5 percentile rate based on 60 observations for sediment is 965 h/y

[a] Where an individual has information for gear handling and sediment, they are displayed in separate lines.
Where an individual has two or more activities at different locations for handling sediment, they are displayed in separate lines.
Where there are two or more activities for handling sediment, activities are ordered from highest to lowest rates.

[b] Denotes that this activity was undertaken commercially.

[c] Denotes child observations.

Table 23. Occupancy rates in and on water in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	In water	On water
897	Cockerham Sands	Windsurfing	156	
898	Cockerham Sands	Windsurfing	156	
968	Cockerham Sands	Water-skiing, swimming and jet-skiing	78	
969	Cockerham Sands	Water-skiing, swimming and jet-skiing	78	
966	Cockerham Sands	Windsurfing	50	
	Glasson Dock	Sailing		12
955	Glasson Dock	Windsurfing	36	
	Glasson Dock to Piel Island	Sailing		250
692	Morecambe Bay and Lune Estuary	Jet-skiing	12	
765	Morecambe Bay and Lune Estuary/River Wyre, River Cocker & River Keer/Morecambe Bay/Lune Estuary	Drift netting[b]/Elver fishing[b]/Trawling[b]/Punting		1544
770	Morecambe Bay	Trawling[b]		1500
841	Morecambe Bay/River Kent	Drift netting[b] and trawling[b]/Lave netting[b]		1280
792	Heysham/Lune Estuary	Drift netting[b]/Haaf netting[b]		1230
762	Morecambe Bay, near Sunderland Point	Drift netting[b] and trawling[b]		1180
775	Morecambe Bay/Lune Estuary/Rivers Wyre, Cocker & Keer	Drift netting[b]/Haaf netting[b]/Elver fishing[b]		1050
159	Morecambe Bay	Trawling[b]		960
160	Morecambe Bay	Trawling[b]		960
763	Morecambe Bay, near Sunderland Point	Drift netting[b] and trawling[b]		880
8	Morecambe Bay	Tractor fishing for shrimps[b]		858
6	Morecambe Bay	Tractor fishing for shrimps[b]		819
7	Morecambe Bay	Tractor fishing for shrimps[b]		819
61	Morecambe Bay	Boat angling		780
1	Morecambe Bay/River Kent	Tractor fishing for shrimps[b]/Lave netting[b]		760
1000	Fleetwood	Trawling[b]		660
1001	Fleetwood	Trawling[b]		660
984	Morecambe Bay	Boat angling[b]		600
985	Morecambe Bay	Boat angling[b]		600
4	Morecambe Bay/River Kent	Tractor fishing for shrimps[b]/Lave netting[b]		528
5	Morecambe Bay/River Kent	Tractor fishing for shrimps[b]/Lave netting[b]		528
3	Morecambe Bay	Tractor fishing for shrimps[b]		526
693	Morecambe Bay	Boat angling		500

Table 23. Occupancy rates in and on water in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	In water	On water
1039	Morecambe Bay	Boat angling		392
1040	Barrow-in-Furness	Boat angling		392
1041	Barrow-in-Furness	Boat angling		392
9	Morecambe Bay/Canal Foot	Tractor fishing for shrimps[b]/Lave netting[b]		386
1034	Lune Estuary/Morecambe Bay	Haaf netting/Drift netting[b] and trawling[b]		350
522	R. Lune at Oxcliffe/Heysham outfall	Haaf netting[b]/Angling (wading in water)		290
91	Morecambe Bay	Boat angling		282
1021	R. Lune and Lune Estuary	Haaf netting[b]		270
1002	Fleetwood	Boat maintenance		260
687	Morecambe Bay	Boat angling		240
688	Morecambe Bay	Boat angling		240
759	Lune Estuary	Drift netting[b]		240
970	Glasson Dock to Piel Island	Sailing		240
1030	Bazil Point	Haaf netting[b]		234
1024	Cockerham Sands	Seine netting[b] and drift netting		201
94	Morecambe Bay	Boat angling		192
681	Morecambe Bay	Boat angling		180
109	Morecambe Bay	Boat angling		164
41	Walney Channel	Boat angling		160
42	Walney Channel	Boat angling		160
35	Walney Channel	Boat angling		150
37	Walney Channel	Boat angling		150
695-714	Morecambe Bay	RNLI		144
96	Morecambe Bay	Boat angling		138
1019	R. Lune at Ashton	Haaf netting[b]		130
734-745	Arnside	Coastguard duties		120
891	Knott End	Boat angling		120
892	Knott End	Boat angling		120
1038	R. Lune at Oxcliffe	Haaf netting[b]		120
732	Morecambe Bay	Sailing		110
733	Morecambe Bay	Sailing		110
103	Morecambe Bay	Boat angling		104
93	Morecambe Bay	Boat angling		96

Table 23. Occupancy rates in and on water in the Heysham area for adults and children (h/y)

Observation number	Location[a]	Activity[a]	In water	On water
97	Morecambe Bay	Boat angling		96
715	Morecambe Bay	Boat angling		96
45	Canal Foot	Lave netting[b]		88
730	Morecambe Bay	Sailing and canoeing		76
731	Morecambe Bay	Sailing and canoeing		76
55	Mouth of Walney Channel	Boat angling		72
973	Knott End	Coastguard duties and sailing		55
13	Canal Foot	Lave netting[b]		53
909-918	Glasson Dock	Sailing		52
690	Morecambe Bay	Boat angling		48
112	Morecambe Bay	Boat angling		41
764	Morecambe Bay	Trawling		36
971	Knott End	Coastguard duties		35
972	Knott End	Coastguard duties		35
974-983	Knott End	Coastguard duties		35
105	Morecambe Bay	Boat angling		33
919-954	Glasson Dock to Piel Island	Sailing		30
899-908	Glasson Dock	Sailing		26
54	Walney Channel	Hooking for lobster		12
101	Morecambe Bay	Boat angling		12
893	Fleetwood	Boat angling		8
110	Morecambe Bay	Boat angling		3

Notes

* Observations 688, 892 and 969 are for children aged 12, 14 and 14 respectively

[a] Where more than one activity occurs on water but at different locations, the different locations and respective activities are separated by a / symbol.
Where there are two or more activities in or on water, activities are ordered from highest to lowest occupancy rates.

[b] denotes that this activity was undertaken commercially.

Table 24. Adults' consumption rates of green vegetables in the Heysham area (kg/y)

Observation number	Artichoke	Asparagus	Broccoli	Brussel sprout	Cabbage	Cauliflower	Chard	Courgettes	Cucumber	Kale	Lettuce	Marrow	Spinach	Total
1032	**2.7**	**3.4**	**1.1**	**1.1**	**11.1**	**2.3**		**6.8**	**1.7**		**10.0**		**0.2**	**40.4**
1033	**2.7**	**3.4**	**1.1**	**1.1**	**11.1**	**2.3**		**6.8**	**1.7**		**10.0**		**0.2**	**40.4**
132				**3.6**	**24.1**			**6.1**	**2.8**					**36.6**
133				**3.6**	**24.1**			**6.1**	**2.8**					**36.6**
127				**2.0**	**9.1**	**4.2**				**9.6**	**2.3**		**7.9**	**35.2**
128				**2.0**	**9.1**	**4.2**				**9.6**	**2.3**		**7.9**	**35.2**
125			**1.0**		**10.6**	**4.7**	**1.0**	**5.5**	**2.1**	**1.4**	**1.3**		**1.0**	**28.6**
126			**1.0**		**10.6**	**4.7**	**1.0**	**5.5**	**2.1**	**1.4**	**1.3**		**1.0**	**28.6**
138				**5.5**	**11.0**	**2.2**		**1.8**				**0.9**		**21.4**
137				**5.5**	**11.0**	**2.2**		**1.8**				**0.9**		**21.4**
134					6.8			2.2			2.4			11.4
135					6.8			2.2			2.4			11.4
136					6.8			2.2			2.4			11.4
124			3.8	0.6	2.9	1.0		0.2			0.2			8.6
129				0.6	2.3	2.3			2.1					7.3
130				0.6	2.3	2.3			2.1					7.3
131				1.2	2.5	1.5		1.4						6.6
1034					4.3									4.3
1035					4.3									4.3
1036					4.3									4.3
1037					4.3									4.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of green vegetables based on the 10 highest adult consumers is 32.4 kg/y

The observed 97.5 percentile rate based on 21 observations is 40.4 kg/y

Table 25. Adults' consumption rates of other vegetables in the Heysham area (kg/y)

Observation number	Broad bean	French bean	Mangetout	Pea	Runner bean	Squash	Sweetcorn	Tomato	Total
137	**5.5**				**16.3**			**13.1**	**34.8**
138	**5.5**				**16.3**			**13.1**	**34.8**
134		**8.2**			**6.5**			**13.0**	**27.7**
135		**8.2**			**6.5**			**13.0**	**27.7**
136		**8.2**			**6.5**			**13.0**	**27.7**
1032	**4.5**	**2.3**	**1.1**		**4.5**			**11.3**	**23.8**
1033	**4.5**	**2.3**	**1.1**		**4.5**			**11.3**	**23.8**
132							**1.5**	**21.4**	**22.9**
133							**1.5**	**21.4**	**22.9**
127		**5.0**		**6.8**					**11.7**
128		**5.0**		**6.8**					**11.7**
125					5.6			5.4	11.0
126					5.6			5.4	11.0
746		1.8			6.8				8.6
747		1.8			6.8				8.6
124	0.7				0.8			5.4	6.9
129								6.5	6.5
130								6.5	6.5
1034	1.6			0.6				3.6	5.8
1035	1.6			0.6				3.6	5.8
1036	1.6			0.6				3.6	5.8
1037	1.6			0.6				3.6	5.8
759								5.3	5.3
760								5.3	5.3
761								5.3	5.3
131		1.0				0.2		1.5	2.6
675								0.7	0.7
676								0.7	0.7

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of other vegetables based on the 11 highest adult consumers is 24.5 kg/y

The observed 97.5 percentile rate based on 28 observations is 34.8 kg/y

Table 26. Adults' consumption rates of root vegetables in the Heysham area (kg/y)

Observation number	Beetroot	Carrot	Garlic	Leek	Onion	Parsnip	Radish	Shallot	Swede	Turnip	Total
132				**17.8**					**26.9**		**44.7**
133				**17.8**					**26.9**		**44.7**
1032	**4.5**		**0.2**	**5.0**	**18.8**	**3.4**	**0.2**	**6.8**	**4.1**	**0.5**	**43.6**
1033	**4.5**		**0.2**	**5.0**	**18.8**	**3.4**	**0.2**	**6.8**	**4.1**	**0.5**	**43.6**
127	**6.2**			**16.9**	**11.7**		**1.6**	**2.4**		**4.1**	**42.8**
128	**6.2**			**16.9**	**11.7**		**1.6**	**2.4**		**4.1**	**42.8**
125	**1.4**	**1.8**		**7.9**	**5.5**		**0.1**		**5.1**		**21.7**
126	**1.4**	**1.8**		**7.9**	**5.5**		**0.1**		**5.1**		**21.7**
134		**3.7**		**14.9**							**18.6**
135		**3.7**		**14.9**							**18.6**
136		**3.7**		**14.9**							**18.6**
138			0.3	10.8	3.3						14.4
137			0.3	10.8	3.3						14.4
746				4.5	9.0						13.5
747				4.5	9.0						13.5
1034	0.8	1.1			11.0						12.8
1035	0.8	1.1			11.0						12.8
1036	0.8	1.1			11.0						12.8
1037	0.8	1.1			11.0						12.8
124	1.2	0.9		2.9					3.7		8.7
131		0.6		1.8	0.5				3.7		6.6
129	0.5			2.8	2.3				0.9		6.4
130	0.5			2.8	2.3				0.9		6.4
115				2.5	2.7						5.2
116				2.5	2.7						5.2
117				2.5	2.7						5.2
118				2.5	2.7						5.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of root vegetables based on the 11 highest adult consumers is 32.9 kg/y

The observed 97.5 percentile rate based on 27 observations is 44.7 kg/y

Table 27. Adults' consumption rates of potato in the Heysham area (kg/y)

Observation number	Potato
127	**102.4**
128	**102.4**
132	**90.1**
133	**90.1**
137	**54.6**
138	**54.6**
746	**45.5**
747	**45.5**
759	**34.7**
760	**34.7**
761	**34.7**
1032	34.0
1033	34.0
134	30.0
135	30.0
136	30.0
129	15.9
130	15.9
115	14.8
116	14.8
117	14.8
118	14.8
124	13.5
131	8.6
1034	6.4
1035	6.4
1036	6.4
1037	6.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato based on the 11 highest adult consumers is 62.6 kg/y

The observed 97.5 percentile rate based on 28 observations is 102.4 kg/y

Table 28. Adults' consumption rates of domestic fruit in the Heysham area (kg/y)

Observation number	Apple	Black-berry	Black-currant	Damson	Goose-berry	Grapes	Logan-berry	Melon	Pear	Plum	Pumpkin	Raspberry	Red-currant	Rhubarb	Straw-berry	Tay-berry	Total
1033	**46.0**	**1.1**	**1.1**	**4.5**	**1.1**	**1.1**	**0.7**		**5.7**	**9.1**		**11.3**	**0.5**	**0.5**	**2.3**	**0.5**	**85.5**
1032	**46.0**	**1.1**	**1.1**	**4.5**	**1.1**	**1.1**	**0.7**		**5.7**	**9.1**		**11.3**	**0.5**	**0.5**	**2.3**	**0.5**	**85.5**
132														15.2			15.2
133														15.2			15.2
747												6.8		3.5	4.8		15.0
746												6.8		3.5	4.8		15.0
137											0.2			4.6	8.5		13.3
138											0.2			4.6	8.5		13.3
134			6.8											2.8			9.6
135			6.8											2.8			9.6
136			6.8											2.8			9.6
127												2.8			3.1		5.9
128												2.8			3.1		5.9
124			0.6		1.0			0.2				1.5		1.4	1.0		5.7
125															3.4		3.4
126															3.4		3.4
131														1.4			1.4
129															1.2		1.2
130															1.2		1.2
827			0.2									0.2	0.2				0.5
828			0.2									0.2	0.2				0.5
829			0.2									0.2	0.2				0.5
830			0.2									0.2	0.2				0.5
831			0.2									0.2	0.2				0.5
675					0.1									0.1			0.2
676					0.1									0.1			0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the 2 highest adult consumers is 85.5 kg/y

The observed 97.5 percentile rate based on 26 observations is 85.5 kg/y

Table 29. Adults' consumption rates of milk in the Heysham area (l/y)

Observation number	Milk
768	**311.1**
769	**311.1**
827	**219.0**
828	**219.0**
829	**219.0**
830	**219.0**
831	**219.0**
115	**207.4**
116	**207.4**
117	**207.4**
118	**207.4**
119	**165.9**
120	**165.9**
122	**165.9**
123	**165.9**
152	**148.2**
153	**148.2**
155	**148.2**
156	**148.2**
157	**148.2**
158	**148.2**
994	69.1
995	69.1
996	69.1
997	69.1
998	69.1
777	29.6
778	29.6
779	29.6
780	29.6
781	29.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of milk based on the 21 highest adult consumers is 195.2 l/y

The observed 97.5 percentile rate based on 31 observations is 311.1 l/y

Table 30. Adults' consumption rates of cattle meat in the Heysham area (kg/y)

Observation number	Beef
827	**10.4**
828	**10.4**
829	**10.4**
830	**10.4**
831	**10.4**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of cattle meat based on the 5 highest adult consumers is 10.4 kg/y
The observed 97.5 percentile rate based on 5 observations is 10.4 kg/y

Table 31. Adults' consumption rates of sheep meat in the Heysham area (kg/y)

Observation number	Lamb
827	**15.2**
828	**15.2**
829	**15.2**
830	**15.2**
831	**15.2**
115	**11.3**
116	**11.3**
117	**11.3**
118	**11.3**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of sheep meat based on the 9 highest adult consumers is 13.5 kg/y
The observed 97.5 percentile rate based on 9 observations is 15.2 kg/y
The observations exclude those for salt marsh grazed sheep (see Table 8)

Table 32. Adults' consumption rates of poultry in the Heysham area (kg/y)

Observation number	Pigeon
759	**2.8**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of poultry based on the only adult consumer is 2.8 kg/y
The observed 97.5 percentile rate is not applicable for 1 observation

Table 33. Adults' consumption rates of eggs in the Heysham area (kg/y)

Observation number	Chicken egg	Duck egg	Total
762	**17.8**		**17.8**
763	**17.8**		**17.8**
777	**17.8**		**17.8**
778	**17.8**		**17.8**
779	**17.8**		**17.8**
780	**17.8**		**17.8**
781	**17.8**		**17.8**
652	**7.5**	**3.0**	**10.5**
653	**7.5**	**3.0**	**10.5**
654	**7.5**	**3.0**	**10.5**
659	**7.5**	**3.0**	**10.5**
660	**7.5**	**3.0**	**10.5**
827	**7.1**		**7.1**
828	**7.1**		**7.1**
829	**7.1**		**7.1**
830	**7.1**		**7.1**
831	**7.1**		**7.1**

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of eggs based on the 17 highest adult consumers is 12.5 kg/y
The observed 97.5 percentile rate based on 17 observations is 17.8 kg/y

Table 34. Adults' consumption rates of wild/free foods in the Heysham area (kg/y)

Observation number	Blackberry	Damson	Greengage	Total
762	**5.7**		**0.7**	**6.4**
763	**5.7**		**0.7**	**6.4**
1030	**1.4**	**3.2**		**4.5**
661	**2.3**			**2.3**
662	**2.3**			**2.3**
675	**2.3**			**2.3**
676	**2.3**			**2.3**
777-781	1.0			1.0
673	0.9			0.9
836	0.9			0.9
834	0.5			0.5
835	0.5			0.5
827-831	0.2			0.2

Notes
Emboldened observations are the critical group consumers
The critical group consumption rate of wild/free foods based on the 7 highest adult consumers is 3.8 kg/y
The observed 97.5 percentile rate based on 21 observations is 6.4 kg/y

Table 35. Adults' consumption rates of rabbits/hares in the Heysham area (kg/y)

Observation number	Rabbit
1034	**9.0**
1030	**2.3**

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of rabbits/hares based on the 2 highest adult consumers is 5.6 kg/y (Taking the highest consumption rate of 9.0 kg/y and dividing by 3 would give a cut-off value for the critical group of 3.0 kg/y. However, judgement has been used and in this case the lower value of 2.3 kg/y has been included in the critical group.

The observed 97.5 percentile rate based on 2 observations is 8.8 kg/y

Table 36. Adults' consumption rates of honey in the Heysham area (kg/y)

Observation number	Honey
1032	**11.3**
1033	**11.3**

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of honey based on the 2 highest adult consumers is 11.3 kg/y

The observed 97.5 percentile rate based on 2 observations is 11.3 kg/y

Table 37. Adults' consumption rates of wild fungi in the Heysham area (kg/y)

Observation number	Mushrooms
762	**4.5**
763	**4.5**
1034	**4.5**
1035	**4.5**
1036	**4.5**
1037	**4.5**
1030	0.9
746	0.7
747	0.7
830	0.5
831	0.5

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wild fungi based on the 6 highest adult consumers is 4.5 kg/y

The observed 97.5 percentile rate based on 11 observations is 4.5 kg/y

Table 38. Children's consumption rates of milk in the Heysham area (l/y)

15 year old age group

Observation number	Age	Milk
121	**16**	**165.9**
154	**14**	**148.2**
999	**15**	**69.1**

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of milk based on the 3 highest 15 year old age group consumers is 127.7 l/y

The observed 97.5 percentile rate based on 3 observations is 165.0 l/y

Table 39. Children's consumption rates of eggs in the Heysham area (kg/y)

10 year old age group

Observation number	Age	Chicken egg	Duck egg	Total
655	**11**	**7.5**	**3.0**	**10.5**
658	**11**	**7.5**	**3.0**	**10.5**
656	**8**	**7.5**	**3.0**	**10.5**
657	**8**	**7.5**	**3.0**	**10.5**

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of eggs based on the 4 highest 10 year old age group consumers is 10.5 kg/y

The observed 97.5 percentile rate based on 4 observations is 10.5 kg/y

Table 40. Percentage contribution each food type makes to its terrestrial food group for adults

Green vegetables	
***Cabbage**	**44.1 %**
Courgettes	12.0 %
Lettuce	8.5 %
Cauliflower	8.4 %
***Brussel sprout**	**6.8 %**
Kale	5.4 %
Spinach	4.5 %
Cucumber	4.3 %
Broccoli	2.0 %
Asparagus	1.7 %
Artichoke	1.3 %
Chard	0.5 %
Marrow	0.4 %

Other vegetables	
Tomato	51.9 %
Runner bean	23.4 %
French bean	11.7 %
Broad bean	7.3 %
Pea	4.2 %
Sweetcorn	0.8 %
Mangetout	0.6 %
Squash	0.1 %

Root vegetables	
Leek	36.9 %
***Onion**	**30.2 %**
Swede	15.7 %
Beetroot	5.7 %
Carrot	4.0 %
Shallot	3.6 %
Turnip	1.7 %
Parsnip	1.3 %
Radish	0.8 %
Garlic	0.2 %

Domestic fruit	
***Apple**	**28.9 %**
Rhubarb	18.4 %
Strawberry	14.9 %
Raspberry	13.9 %
Blackcurrant	7.6 %
Plum	5.7 %
Pear	3.6 %
Damson	2.9 %
Gooseberry	1.1 %
Grapes	0.7 %
Blackberry	0.7 %
Redcurrants	0.6 %
Loganberry	0.4 %
Tayberry	0.3 %
Pumpkin	0.2 %
Melon	0.1 %

Poultry	
Pigeon	100.0 %

Eggs	
Chicken egg	93.0 %
Duck egg	7.0 %

Wild/free foods	
***Blackberry**	**87.1 %**
Damson	9.1 %
Greengage	3.9 %

Rabbits/hares	
Rabbit	100.0 %

Notes

Food types asterisked and emboldened were monitored by FSA in 2005 (EA, EHS, FSA and SEPA, 2006). Other foods monitored were milk, honey and potato

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

Table 41. Occupancy rates in the Heysham direct radiation survey area for for adults and children (h/y)

Observation Number	Age (in years) (U if unknown)	Distance from site perimeter fence (km)	Indoor occupancy	Outdoor occupancy	Total occupancy
0 to 0.25 km zone					
664	63	0.11	4847	840	5687
665	57	0.11	4792	640	5432
666	57	0.11	4792	640	5432
663	63	0.11	4662	640	5302
799	U	0.20		2016	2016
800	U	0.20		2016	2016
801	U	0.20		2016	2016
802	U	0.20		2016	2016
803	U	0.20		2016	2016
804	U	0.20		2016	2016
962	U	0.15	594	726	1320
963	31	0.15	576	576	1152
964	31	0.15	576	576	1152
1031	52	0.15	686	354	1040
965	24	0.15	720	240	960
967	U	0.15		520	520
149	45	0.04		140	140
147	50	0.25		128	128
145	45	0.18		48	48
146	60	0.18		48	48
144	72	0.25		20	20
148	70	0.25		18	18
>0.25 to 0.5 km zone					
845	23	0.50	7096	878	7974
847	1	0.50	7474	500	7974
846	6	0.50	7320	480	7800
832	70	0.30	5993	1131	7124
833	70	0.30	6155	969	7124
837	63	0.34	5869	1099	6968
838	65	0.34	6792	176	6968
836	63	0.34	5045	1806	6851
844	32	0.50	5001	1053	6054
834	72	0.27	4106	1369	5475
835	68	0.27	4106	1369	5475
669	15	0.50	4765	400	5165
667	43	0.50	4134	556	4690
668	34	0.50	4134	556	4690
161	60	0.34		2530	2530
292	37	0.50	1880	470	2350
293	37	0.50	1880	470	2350
294	46	0.50	1880	470	2350
805-814	U	0.36	2304		2304
165-284	U	0.43	2300		2300
522	54	0.40	1579	677	2256
578-651	U	0.50	1840		1840
315-324	U	0.40	1748		1748
815-826	U	0.36	1536		1536
470-520	U	0.40	1520		1520
151	50	0.40		1288	1288
325-459	U	0.40	256	960	1216
521	16	0.40	256	960	1216
162	34	0.34		360	360
163	38	0.34		360	360
164	41	0.34		360	360
460-469	U	0.40	320		320
>0.5 to 1 km zone					
676	74	0.54	7947	235	8182
673	67	0.54	7054	830	7884
674	59	0.54	7519	365	7884
675	68	0.54	7055	455	7510
671	3	0.52	6996	156	7152
670	28	0.52	6901	156	7057

Table 41. Occupancy rates in the Heysham direct radiation survey area for for adults and children (h/y)

Observation Number	Age (in years) (U if unknown)	Distance from site perimeter fence (km)	Indoor occupancy	Outdoor occupancy	Total occupancy
672	0	0.52	6901	156	7057
850	62	0.54	6360	480	6840
854	2	0.61	6422	364	6786
851	31	0.61	5008	1582	6590
856	49	0.59	4916	1560	6476
852	7	0.61	5293	854	6147
853	4	0.61	5293	854	6147
855	25	0.61	4476	1582	6058
849	56	0.54	5216	600	5816
857	16	0.59	5477	156	5633
310	U	0.71	2585		2585
311	U	0.71	2585		2585
312	U	0.71	2068	517	2585
313	U	0.71	2068	517	2585
314	U	0.71	2585		2585
569	U	0.64	2350		2350
570	U	0.64	2350		2350
571	16	0.64	2350		2350
295-307	U	0.75	1955		1955
572	U	0.64	1880		1880
573	U	0.64	1880		1880
574	U	0.64	1880		1880
575	U	0.64	1880		1880
576	U	0.64	1880		1880
577	U	0.64	1880		1880
285	U	0.55	1840		1840
286	U	0.55	1840		1840
287	U	0.55	1840		1840
288	U	0.55	1840		1840
289	U	0.55	1840		1840
290	U	0.55	1840		1840
291	U	0.55	1840		1840
308	U	0.75	978		978
309	U	0.75	978		978
523-568	U	0.64	400	70	470
827	50	0.80		12	12

Table 42. Analysis of occupancy rates in the Heysham direct radiation survey area

0 to 0.25 km zone	
Number of hours per year	Number of observations
8000 to 8760	0
7000 to 8000	0
6000 to 7000	0
5000 to 6000	4
4000 to 5000	0
3000 to 4000	0
2000 to 3000	6
1000 to 2000	4
0 to 1000	8

>0.25 to 0.5 km zone	
Number of hours per year	Number of observations
8000 to 8760	0
7000 to 8000	5
6000 to 7000	4
5000 to 6000	3
4000 to 5000	2
3000 to 4000	0
2000 to 3000	135
1000 to 2000	284
0 to 1000	13

>0.5 to 1 km zone	
Number of hours per year	Number of observations
8000 to 8760	1
7000 to 8000	6
6000 to 7000	7
5000 to 6000	2
4000 to 5000	0
3000 to 4000	0
2000 to 3000	8
1000 to 2000	26
0 to 1000	49

Table 43. Gamma dose rate measurements for the Heysham direct radiation survey (µGy/h)

Location	Distance (km)	NGR	Outdoor substrate	Gamma dose rate at 1 metre	Indoor substrate	Gamma dose rate at 1 metre
Heysham Nature Reserve	0.07	SD 405 598	Grass	0.077	Unknown	0.058
Caravan 1	0.11	SD 404 591		NM	Unknown	0.071
Heysham Harbour - north wall	0.25	SD 396 601	Concrete	0.051		
Caravan 2	0.27	SD 406 590	Grass	0.077	Unknown	0.065
Caravan 3	0.30	SD 406 590	Grass	0.066	Unknown	0.056
Caravan 4	0.34	SD 406 589	Grass	0.069	Unknown	0.065
Caravan 5	0.34	SD 406 589		NM	Unknown	0.063
Business 1	0.34	SD 397 603	Concrete	0.063		NM
House 1	0.50	SD 409 602	Grass	0.080	Unknown	0.113
House 2	0.52	SD 409 602	Concrete	0.092	Unknown	0.106
House 3	0.54	SD 408 603	Grass	0.077	Unknown	0.101
House 4	0.54	SD 408 603	Grass	0.077	Unknown	0.103
House 5	0.54	SD 409 602	Grass	0.078	Unknown	0.120
House 6	0.59	SD 408 604	Grass	0.076	Unknown	0.098
House 7	0.61	SD 408 604	Grass	0.072	Unknown	0.058
Business 2	0.84	SD 414 600	Grass	0.082		

Background 1	9.5	SD 468 668	Grass	0.071
Background 2	10	SD 492 642	Grass	0.071

Notes

It should be noted that during the survey, one of the four reactors at Heysham was offline due to an outage so gamma dose rates detected at this time may be lower than usual.

NM = Not measured

Table 44. Examples of food groups eaten and external exposure combinations by adults for consideration for dose assessment purposes

Combination number	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
1	*	*	*	*	*																				*		*	*		*		
2	*																						*					*				*
3	*	*	*	*	*																	*					*	*		*	*	*
4	*	*	*	*	*																			*				*				
5	*																					*			*	*		*		*		
6	*	*	*	*	*																*	*					*	*		*		
7	*																				*	*		*	*		*	*		*		
8									*	*		*		*																		
9												*				*	*							*								
10		*					*	*	*	*	*																					
11																					*				*		*	*				*
12	*	*	*		*											*	*			*		*					*	*		*		
13								*			*						*								*						*	*
14																						*							*	*		
15	*							*	*	*	*									*												
16	*	*						*		*					*												*			*		
17		*									*	*	*	*		*	*								*							*
18											*	*	*	*		*	*			*												
19	*				*	*																		*								
20																									*						*	*
21																									*				*			
22	*	*																				*			*			*		*		
23	*			*													*	*		*							*			*		
24	*					*		*	*	*	*	*							*													
25	*	*					*	*	*	*								*		*		*		*			*			*		

Notes

The food groups and external exposure pathways marked with an asterisk are combined for the corresponding combination number.

For example, combination number 1 represents an individual (or individuals) from Annex 1 who had positive data in the following pathways; fish, crustaceans, molluscs, wildfowl, marine plants/algae, intertidal occupancy over sand, handling fishing gear, handling sediment and occupancy on water.

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
1	M	60	U	9.7	**11.8**																							**970**		**535**	**970**		760		
2	F	60	U	9.7	**11.8**																														
3	M	31	U	4.1	3.7																							**1560**		263	**1560**		526		
4	M	58	U	11.8	**23.6**	**7.3**																						218		294	218		528		
5	M	30	U	11.8	**23.6**	**7.3**																						218		294	218		528		
6	M	35	U		**8.8**																							714		410	**684**		819		
7	M	60	U																									684		410	**684**		819		
8	M	51	U	8.8	4.4																							215		**536**	215		858		
9	M	49	U	8.8	5.9																							24		184			386		
13	M	74	U	**26.5**	4.0																							137		189			53		
14	M	51	U	8.0																															
15	F	51	U	8.0																															
16	M	55	U																							**150**									
17	F	75	U	12.7																															
18	M	U	U	12.7																															
19	M	45	U	0.8																								130							
20	M	U	U	2.4																															
21	M	U	U	2.4																															
22	M	U	U	2.4																															
23	F	U	U	2.4																															
24	F	U	U	2.4																															
25	F	U	U	2.4																															
26	M	56	U																									60							
27	M	65	U	2.6																															
28	M	65	U	2.6																															
29	M	65	U	2.6																															
30	F	65	U	2.6																															
31	F	65	U	2.6																															
32	F	65	U	2.6																															
33	M	56	U	4.6																								60							
34	F	52	U	4.6																															
35	M	45	U	**16.6**																													150		
36	F	45	U	**16.6**																															
37	M	38	U	8.3																													150		
38	F	38	U	8.3																															
39	F	U	U	8.3																															
40	M	U	U	8.3																															
41	M	56	U	13.8																													160		
42	M	25	U	13.8																													160		
43	M	U	U	13.8																															
44	F	U	U	13.8																															
45	M	66	U	9.3	4.7																							4		88			88		

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
46	M	U	U	4.2																															
47	M	U	U	4.2																															
48	M	U	U	4.2																															
49	F	U	U	4.2																															
50	F	U	U	4.2																															
54	M	50	U		1.3	1.8																		12						12		12		
55	M	53	U	4.8																												72			
56	F	53	U	4.8																															
57	M	48	U	6.1																															
58	M	45	U	9.2																															
59	M	51	U	2.0																															
60	F	51	U	2.0																															
61	M	62	U	**26.5**																												780			
62	F	62	U	**26.5**																															
63	M	28	U																								6								
64	M	40	U																					**960**						**960**				
65	M	40	U																					**960**						**960**				
66	M	59	U																					**780**										
67	F	59	U	10.6																															
68	M	66	U	15.5																				**624**										
69	F	66	U	15.5																															
70	M	39	U	**15.9**																				**416**										
71	F	39	U	**15.9**																															
72	M	57	U																								**390**								
73	M	U	U				**10.6**																				150				150				
74	M	U	U				**10.6**																				150				150				
75	M	U	U				**10.6**																				150				150				
76	M	U	U				**10.6**																				150				150				
77	F	U	U				**10.6**																												
78	F	U	U				**10.6**																												
79	F	U	U				**10.6**																												
80	F	U	U				**10.6**																												
81	M	46	U																						136						16				
82	M	45	U		1.0		**9.1**																				50				50				
83	M	U	U				**9.1**																				50				50				
84	M	U	U				**9.1**																				50				50				
85	M	U	U				**9.1**																				50				50				
86	M	U	U				**9.1**																				50				50				
87	M	U	U				**9.1**																				50				50				
88	M	U	U				**9.1**																				50				50				
89	F	45	U		1.0		**9.1**																												
90	M	U	U																										100						

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
91	M	59	U	**40.5**																								45			45		282		
92	F	58	U	**40.5**																															
93	M	55	U	13.8																					10				90		10		96		
94	M	U	U	13.2																				90							90		192		
95	F	U	U	13.2																															
96	M	U	U																					32	120			660			400		138		
97	M	61	U	5.3																					50								96		
98	F	51	U	5.3																															
99	M	41	U	5.3																															
100	M	51	U	5.3																															
101	M	U	U	5.2																								18			8		12		
102	F	U	U	5.2																															
103	M	U	U	14.7																								50			50		104		
104	F	U	U	14.7																															
105	M	U	U	1.3																													33		
106	F	U	U	1.3																															
107	F	U	U	1.3																															
108	M	U	U	1.3																															
109	M	U	U																														164		
110	M	U	U	0.4																													3		
111	F	U	U	0.4																															
112	M	35	U	10.5																								32			8		41		
113	F	46	U	10.5																															
114	M	17	U	10.5																															
115	F	53	4.0									5.2	14.8		**207.4**		**11.3**																		
116	M	53	4.0									5.2	14.8		**207.4**		**11.3**																		
117	M	22	4.0									5.2	14.8		**207.4**		**11.3**																		
118	F	24	4.0									5.2	14.8		**207.4**		**11.3**																		
119	M	53	4.0												**165.9**												52								
120	F	51	4.0												**165.9**																				
122	F	24	4.0												**165.9**																				
123	M	27	4.0												**165.9**																				
124	M	69	U							8.6	6.9	8.7	13.5	5.7																					
125	M	66	U							**28.6**	11.0	**21.7**		3.4																					
126	F	64	U							**28.6**	11.0	**21.7**		3.4																					
127	M	69	U		0.7					**35.2**	**11.7**	**42.8**	**102.4**	5.9																					
128	F	65	U		0.7					**35.2**	**11.7**	**42.8**	**102.4**	5.9																					
129	M	85	U							7.3	6.5	6.4	15.9	1.2																					
130	F	82	U							7.3	6.5	6.4	15.9	1.2																					
131	M	74	U							6.6	2.6	6.6	8.6	1.4																					
132	M	73	U							**36.6**	**22.9**	**44.7**	**90.1**	15.2																					
133	F	73	U							**36.6**	**22.9**	**44.7**	**90.1**	15.2																					

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
134	M	67	U							11.4	**27.7**	**18.6**	30.0	9.6																					
135	M	65	U							11.4	**27.7**	**18.6**	30.0	9.6																					
136	F	79	U							11.4	**27.7**	**18.6**	30.0	9.6																					
137	M	65	U							**21.4**	**34.8**	14.4	**54.6**	13.3																					
138	F	54	U							**21.4**	**34.8**	14.4	**54.6**	13.3																					
139	M	63	U																									23			23				
140	M	63	U																									23			23				
141	M	35	U																							**144**									
142	M	54	U	1.0																						**312**									
143	M	25	U	7.2																						**104**									
144	M	72	U	1.7																						**104**									20
145	M	45	U																					48				16		16	48				48
146	M	60	U																					48				16		16	48				48
147	M	50	U	5.0																						**218**					10				128
148	M	70	U	3.7																															18
149	M	45	U	6.0																															140
150	F	46	U	6.0																															
151	M	50	U	**31.8**		2.0																		**1288**						**1288**					1288
152	M	45	3.6												**148.2**																				
153	F	43	3.6												**148.2**																				
155	M	17	3.6												**148.2**																				
156	M	18	3.6												**148.2**																				
157	M	75	3.6												**148.2**																				
158	F	73	3.6												**148.2**																				
159	M	37	U																											200			960		
160	M	42	U																											200			960		
161	M	60	U																																2530
162	M	34	U																																360
163	M	38	U																																360
164	M	41	U																																360
165-224	M	U	U																															2300	
225-284	F	U	U																															2300	
285	M	U	U																															1840	
286	M	U	U																															1840	
287	M	U	U																															1840	
288	M	U	U																															1840	
289	F	U	U																															1840	
290	F	U	U																															1840	
291	F	U	U																															1840	
292	M	37	U																															1880	470
293	M	37	U																															1880	470
294	M	46	U																															1880	470

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
295-305	M	U	U																															1955	
306	F	U	U																															1955	
307	F	U	U																															1955	
308	M	U	U																															978	
309	M	U	U																															978	
310	M	U	U																															2585	
311	M	U	U																															2585	
312	M	U	U																															2068	517
313	M	U	U																															2068	517
314	F	U	U																															2585	
315-324	F	U	U																															1748	
325-339	F	U	U																															256	960
340-459	M	U	U																															256	960
460-469	M	U	U																															320	
470-491	M	U	U																															1520	
492-500	F	U	U																															1520	
501-516	M	U	U																															1520	
517	F	U	U																															1520	
518	F	U	U																															1520	
519	F	U	U																															1520	
520	F	U	U																															1520	
522	M	54	U	**18.2**	3.3	**2.6**	6.2	**3.3**																	10					260	10		290	1579	677
523-568	M	U	U																															400	70
569	M	U	U																															2350	
570	M	U	U																															2350	
572	M	U	U																															1880	
573	M	U	U																															1880	
574	M	U	U																															1880	
575	M	U	U																															1880	
576	F	U	U																															1880	
577	F	U	U																															1880	
578-637	M	U	U																															1840	
638	F	U	U																															1840	
639	F	U	U																															1840	
640	F	U	U																															1840	
641	F	U	U																															1840	
642	M	U	U																															1840	
643	M	U	U																															1840	
644	M	U	U																															1840	
645	M	U	U																															1840	
646	M	U	U																															1840	
647	F	U	U																															1840	

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
648	F	U	U																**10.5**															1840	
649	F	U	U																**10.5**															1840	
650	F	U	U																**10.5**															1840	
651	F	U	U																**10.5**															1840	
652	M	39	U																**10.5**																
653	F	32	U																**10.5**																
654	F	17	U																**10.5**																
659	M	55	U																**10.5**																
660	F	52	U																**10.5**																
661	M	U	4.3																	**2.3**																
662	F	U	4.3																	**2.3**																
663	F	63	0.1																															4662	640
664	M	63	0.1																															4847	840
665	F	57	0.1																															4792	640
666	M	57	0.1																															4792	640
667	M	43	0.5																									100						4134	556
668	F	34	0.5																									100						4134	556
670	F	28	0.5																															6901	156
673	M	67	0.5																	0.9								160						7054	830
674	F	59	0.5																									160						7519	365
675	M	68	0.5								0.7			0.2						**2.3**								100						7055	455
676	F	74	0.5								0.7			0.2						**2.3**														7947	235
677	M	62	U																									**1130**							
678	M	46	U	4.1																					100						100				
679	F	U	U	4.1																															
680	M	65	U																									125							
681	M	58	U	13.6																					275						25		180		
682	M	51	U	4.7																					250										
683	M	64	U	10.2																					**650**						400				
684	U	U	U	10.2																															
685	U	U	U	10.2																															
686	U	U	U	10.2																															
687	M	U	0.2																													240			
689	F	U	0.2	13.9																															
690	M	U	U	8.7		1.9																						120				48			
691	F	U	U	8.7																															
692	M	35	U																													12			
693	M	41	U	8.3																												500			
694	F	U	U	8.3																															
695-714	M	U	U																													144			
715	M	U	U	7.9	5.4																									48			96		
716	F	U	U	7.9	5.4																														

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
717	M	U	U	7.3																								144							
718	F	U	U	7.3																															
719	M	66	U	8.6																					240				420			240				
720	F	U	U	8.6																															
721	M	U	U	4.0																					88										
723	F	U	U	4.0																															
726	M	65	U	1.7																					18										
727	F	U	U	1.7																															
728	M	25	U	2.2																					72										
729	F	U	U	2.2																															
730	M	58	U																														76		
731	M	42	U																														76		
732	M	43	U																														110		
733	F	40	U																														110		
734	F	U	U																														120		
735-745	M	U	U																														120		
746	M	82	3.8	4.1							8.6	13.5	**45.5**	15.0									0.7												
747	F	72	3.8	4.1							8.6	13.5	**45.5**	15.0									0.7												
748	M	U	U	2.6																					288							288				
749	F	U	U	2.6																															
750	M	U	U	1.5	0.8																														
751	M	U	U	1.5	0.8																														
752	M	U	U	1.5	0.8																														
753	M	U	U	4.6																									**1000**						
754	F	U	U	4.6																															
755	M	U	U																									84							
756	F	U	U																									84							
759	M	U	4.2	0.9	0.3						5.3		**34.7**					**2.8**												180			240		
760	F	U	4.2	0.9	0.3						5.3		**34.7**																						
761	M	U	4.2	0.9	0.3						5.3		**34.7**																						
762	M	U	4.3	9.7	1.5	**3.3**		0.5											**17.8**	**6.4**			**4.5**		221						**832**	221		1180		
763	F	U	4.3	9.7	1.5	**5.5**		0.5											**17.8**	**6.4**			**4.5**		221						**712**	221		880		
764	M	76	U																											20			36		
765	M	59	8.0	4.6	0.7	0.01	**9.5**	0.7																201	185						**837**	330		1544		
766	F	58	8.0	4.6	0.7	0.01	**9.5**	0.7																											
767	F	22	8.0	4.6	0.7	0.01		0.7																											
768	M	U	2.3												**311.1**																				
769	M	U	2.3												**311.1**																				
770	M	U	U		5.4																										**750**		1500		
771	F	U	U		5.4																														
772	F	66	U																									150							
773	M	U	U																								44								

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
774	F	U	U																								44								
775	M	U	8.0	**21.5**		0.2	**16.9**	**2.3**																260	48					**743**	225		1050		
776	F	U	8.0	**21.5**		0.2	**16.9**	**2.3**																											
777	M	U	3.8												29.6				**17.8**	1.0								50								
778	F	U	3.8												29.6				**17.8**	1.0															
779	M	U	3.8												29.6				**17.8**	1.0															
780	M	U	3.8												29.6				**17.8**	1.0															
781	F	U	3.8												29.6				**17.8**	1.0															
782	U	U	U																								110								
783	U	U	U																								110								
784	U	U	U																								110								
785	U	U	U																								110								
786	U	U	U																								60								
787	U	U	U																								60								
788	U	U	U																								60								
789	U	U	U																								60								
790	U	U	U																								60								
791	M	39	U																								**840**								
792	M	U	12.5	0.9	1.0	0.4	**11.0**																	50						**1100**	50		1230		
793	F	U	12.5	0.9	1.0		**11.0**																												
795	M	46	3.6	2.1	0.1	0.6	**19.2**	0.2																			65				65				
796	F	81	9.0	1.3	0.1	0.6	3.1																												
797	M	75	9.0	1.3	0.1	0.6	3.1																												
798	F	48	3.6	2.1	0.1	0.6																													
799	M	U	U																																2016
800	M	U	U																																2016
801	M	U	U																																2016
802	M	U	U																																2016
803	M	U	U																																2016
804	M	U	U																																2016
805	M	U	U																															2304	
806	M	U	U																															2304	
807	M	U	U																															2304	
808	F	U	U																															2304	
809	F	U	U																															2304	
810	F	U	U																															2304	
811	F	U	U																															2304	
812	F	U	U																															2304	
813	F	U	U																															2304	
814	F	U	U																															2304	
815	M	U	U																															1536	
816	M	U	U																															1536	

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
817	M	U	U																															1536	
818	M	U	U																															1536	
819	F	U	U																															1536	
820	F	U	U																															1536	
821	F	U	U																															1536	
822	F	U	U																															1536	
823	F	U	U																															1536	
824	F	U	U																															1536	
825	F	U	U																															1536	
826	F	U	U																															1536	
827	M	50	3.6		0.3									0.5	**219.0**	**10.4**	**15.2**		**7.1**	0.2								12							12
828	M	17	3.6											0.5	**219.0**	**10.4**	**15.2**		**7.1**	0.2															
829	F	89	3.6		0.3									0.5	**219.0**	**10.4**	**15.2**		**7.1**	0.2															
830	M	59	3.6											0.5	**219.0**	**10.4**	**15.2**		**7.1**	0.2			0.5												
831	F	59	3.6											0.5	**219.0**	**10.4**	**15.2**		**7.1**	0.2			0.5												
832	F	70	0.3	0.9																														5993	1131
833	M	70	0.3	0.9																														6155	969
834	M	72	0.3																	0.5														4106	1369
835	F	68	0.3																	0.5														4106	1369
836	F	63	0.3																	0.9								12						5045	1806
837	F	63	0.3	6.4		0.4																												5869	1099
838	M	65	0.3	6.4																														6792	176
839	F	39	U			0.4																													
841	M	62	3.1	5.0		**3.2**	2.6	**1.4**																160	180					**695**			1280		
842	F	52	3.1	5.0			2.6																												
843	M	19	3.1	5.0			2.6																												
844	M	32	0.5																															5001	1053
845	F	23	0.5																															7096	878
848	M	58	2.3																									70							
849	M	56	0.5																															5216	600
850	F	62	0.5																									6						6360	480
851	M	31	0.6																									587						5008	1582
855	F	25	0.6																									144						4476	1582
856	M	49	0.6																									754						4916	1560
858	M	40	6.0																									260							
859	F	47	6.0																									26							
860-889	M	U	U																									**2400**							
890	M	69	U	1.4																					4										
891	M	42	U	1.7																													120		
893	M	40	U	0.3																					12			44	6		12		8		
895	M	63	U	0.3																															
896	M	42	U	14.7																								20							

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
897	M	62	17.0																													156			
898	M	51	11.0																													156			
899-908	U	U	U																														26		
909-918	U	U	U																														52		
919-954	U	U	U																														30		
955	M	68	9.0																						18							36	250		
956	M	U	11.0						**3.8**																		150								
957	F	U	11.0						**3.8**																										
958	M	35	11.0						**3.8**																		150								
959	F	U	11.0						**3.8**																										
960	F	U	11.0						**3.8**																										
961	M	U	U						**3.8**																										
962	M	U	U																										23					594	726
963	M	31	U																															576	576
964	F	31	U																															576	576
965	M	24	U																															720	240
966	M	20	5.5																													50	12		
967	M	U	U																																520
968	M	41	U																									104				78			
970	M	74	U																														240		
971	M	U	U																					14			9	9					35		
972	M	U	U																					14			9	9					35		
973	M	20	U	1.9																				38	10		9	9		10	24		55		
974	M	U	U																					12									35		
975	M	U	U																					12									35		
976	M	U	U																					12									35		
977	M	U	U																					12									35		
978	M	U	U																					12									35		
979	M	U	U																					12									35		
980	M	U	U																					12									35		
981	M	U	U																					12									35		
982	M	U	U																					12									35		
983	F	U	U																					12									35		
984	M	41	U	3.0	0.3																				**672**			365					600		
985	M	54	U																														600		
988	M	U	U																						**672**						**672**				
989	M	U	U																						**672**						**672**				
990	M	U	U																						**672**						**672**				
991	M	U	U																						**672**						**672**				
992	M	U	U																						**672**						**672**				
993	M	U	U																						**672**						**672**				
994	M	72	4.0												69.1												46								

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	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 perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
995	M	43	4.0												69.1												46								
996	F	43	4.0												69.1																				
997	M	19	4.0												69.1												46								
998	M	17	4.0												69.1												46								
1000	M	43	14.0	**27.8**	2.2																									27			660		
1001	M	46	U	**47.2**																										27			660		
1002	M	59	14.0	**44.5**																													260		
1005	F	36	U	11.8																															
1006	M	28	U	11.8																															
1007	F	32	U	11.8																															
1008	M	28	U	11.8																															
1009	F	34	U	11.8																															
1012	M	48	8.0	0.9				0.1	**6.6**																		**365**								
1013	F	45	8.0	0.9				0.1	**6.6**																										
1014	M	19	8.0	0.9				0.1	**6.6**																										
1018	M	26	6.0																								120								
1019	M	78	6.5	1.9																										130			130		
1020	F	72	6.5	1.9																															
1021	M	48	9.0	3.9																										270			270		
1022	F	46	9.0	3.9																															
1023	M	U	U																									52			52				
1024	M	47	5.3	7.2	0.2	0.5	1.8	**2.3**																				4		33	4		201		
1025	F	46	5.3	7.2	0.2	0.5	1.8	**2.3**																											
1028	M	50	U	**18.2**	3.3	**2.6**	6.2	**3.3**																											
1030	M	64	3.8	9.2			**14.6**													**4.5**	**2.3**		0.9							234			234		
1031	F	52	U																															686	354
1032	M	64	4.3	4.6					**8.5**	**40.4**	**23.8**	**43.6**	34.0	**85.5**								**11.3**														
1033	F	56	4.3	4.6					**8.5**	**40.4**	**23.8**	**43.6**	34.0	**85.5**								**11.3**														
1034	M	52	4.3	**21.2**	3.2					4.3	5.8	12.8	6.4								**9.0**		**4.5**		15		**365**			272			350		
1035	F	49	4.3	**21.2**	3.2					4.3	5.8	12.8	6.4										**4.5**												
1036	M	79	4.3							4.3	5.8	12.8	6.4										**4.5**												
1037	F	69	4.3							4.3	5.8	12.8	6.4										**4.5**												
1038	M	U	5.0																						40			425		120	465		120		
1039	M	U	U	**18.6**	0.6	**4.5**																											392		
1040	U	U	U	**18.6**	0.6	**4.5**																											392		
1041	U	U	U	**18.6**	0.6	**4.5**																											392		
1042	M	U	U			1.9																													
1043	M	U	U			1.9																													

Notes

Emboldened observations are rates included in the critical groups.

U = Unknown

Annex 2. Children's consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Milk	Eggs	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
15 year old age group																				
1015	M	16	8.0	0.9				0.1	**6.6**											
1026	M	16	5.3	**7.2**	0.2	0.5	1.8	**2.3**												
724	M	16	U	4.0																
121	M	16	4.0							**165.9**										
521	M	16	U																256	960
571	M	16	U																2350	
857	M	16	0.6																5477	156
794	M	15	12.5	0.9	1.0	0.4	**11.0**					50				50				
1029	F	15	U	**18.2**	**3.3**	**2.6**	**6.2**	**3.3**												
669	M	15	0.5																4765	400
999	F	15	4.0							**69.1**										
1016	M	14	8.0	0.9				0.1	**6.6**											
840	F	14	U			0.4														
1003	F	14	U	**11.8**																
986	M	14	U	3.0	0.3															
892	M	14	U	1.7														120		
154	F	14	3.6							**148.2**										
969	M	14	U											104			78			
10	F	13	U	**8.8**	**5.9**															
1017	M	12	8.0	0.9				0.1	**6.6**											
11	F	12	U	**8.8**	**5.9**															
688	M	12	0.2	**6.1**														240		
722	M	12	U	4.0									88							

Annex 2. Children's consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Heysham area

Observation number	Sex	Age in years	Distance of residence from site (km)	Fish	Crustaceans	Molluscs	Wildfowl	Marine plants/algae	Salt marsh grazed sheep	Milk	Eggs	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over sand	Intertidal occupancy over sand and stones	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy within 1 km of the site perimeter fence	Outdoor occupancy within 1 km of the site perimeter fence
10 year old age group																				
655	M	11	U								**10.5**									
658	F	11	U								**10.5**									
757	M	11	U											84						
1027	M	10	5.3	**7.2**	0.2	**0.5**	**1.8**	**2.3**												
1004	F	10	U	**11.8**																
725	F	10	U	**4.0**																
987	M	9	U	3.0	0.3															
51	F	8	U	**4.2**																
656	M	8	U								**10.5**									
657	M	8	U								**10.5**									
758	M	8	U											84						
12	F	7	U	**5.9**	**5.9**															
894	M	7	U	0.3									12	44	6	12				
852	M	7	0.6											144					5293	854
5 year old age group																				
846	M	6	0.5																7320	480
52	M	5	U	**2.9**																
853	M	4	0.6											144					5293	854
671	M	3	0.5																6996	156
1010	M	3	U	**6.4**																
53	M	2.5	U	**2.9**																
1 year old age group																				
854	F	1.5	0.6											144					6422	364
847	M	1	0.5											70					7474	500
1011	F	1	U	**6.4**																
3 month old age group																				
672	F	0.5	0.5																6901	156

Notes

Emboldened observations are rates included in the critical groups.

U = Unknown

Annex 3. Qualitative and estimated data for use in dose assessment

	Details of activity	Exposure pathways involved	Estimated rate	Other related exposure pathways potentially involved
1	Pig farming. It was not possible to interview the farmer at the only pig farm in the survey. Consumption of pig meat could have taken place there.	Consumption of pig meat	Insufficient data to estimate a rate.	
2	Cockle collection. Cockle collectors were interviewed during the 2006 Heysham survey and consumption rates of cockles were obtained. However, there were bed closures in Morecambe Bay in 2005/2006, which is reflected in the decrease in consumption from the 2001 habits survey. The two highest rate cockle consumers in 2001 were also the two highest rate consumers in 2006; their consumption in 2006 would have been higher if the beds were open for longer. In future years the cockle beds may re-open and the consumption of cockles may increase.	Consumption of cockles	Estimated rate for the two high rate consumers (See Table 5) is 0.9kg flesh weight of cockles per week in open season. If the cockle beds were open for the maximum period of 6 months in a year, the potential critical group consumption rate for molluscs would be 22kg/y based on the 2 highest consumers.	Occupany of intertidal areas and handling sediment.

Annex 4. Ratios for determining consumption and occupancy rates for children

Food group	Ratio child/adult[1]	
	1 yr old	10 yr old
Fish[2]	0.05	0.20
Crustaceans[2]	0.05	0.25
Molluscs[2]	0.05	0.25
Green vegetables	0.22	0.44
Other vegetables	0.20	0.50
Root vegetables	0.38	0.50
Potatoes	0.29	0.71
Domestic fruit	0.47	0.67
Milk	1.33	1.00
Cattle meat	0.22	0.67
Pig meat	0.14	0.63
Sheep meat	0.12	0.40
Poultry	0.18	0.50
Eggs	0.60	0.80
Wild/free foods[3]	0.11	0.49
Game[4]	0.14	0.50
Honey	0.79	0.79
Wild fungi	0.15	0.45
Freshwater fish[2]	0.05	0.25
Direct radiation	1.00	1.00
External exposure	0.50	0.03
Plume	1.00	1.00

Notes

1. The age groups suggested for assessment in this table are those relating to dose coefficients representing 1 to 2 yr olds (labelled 1 yr old) and 7 to 12 yr olds (labelled 10 yr old). Excepting notes 2 and 3, ratios were derived from Byrom et al., (1995) for 1yr old (6 - 12 months) and 10 yr old children (10 - 11 yrs).
2. Ratios were derived from Smith and Jones, (2003) which presented data for infants and children.
3. Ratios were derived from FSA data for wild fruit and nuts for infants and 10 yr old children.
4. Game includes rabbits/hares and venison.

Annex 5. Summary of adults' profiled habits data in the Heysham area

Profile Name	Number of individuals	Pathway Name	Crustacea	Direct[1]	Eggs	Fish - Sea	Fruit - Domestic	Fruit and Nuts - Wild	Gamma ext - Sediment[2]	Honey	Marine plants and algae	Meat - Cattle	Meat - Game[3]	Meat - Poultry	Meat - Salt marsh grazed sheep	Meat - Sheep	Milk	Mollusca	Mushrooms	Occupancy IN water	Occupancy ON water	Plume (IN; 0-0.25km)[4]	Plume (MID; 0.25-0.5km)[4]	Plume (OUT; 0.5-1km)[4]	Vegetables - Green	Vegetables - Other Domestic	Vegetables - Potatoes	Vegetables - Root
			kg	-	kg	kg	kg	kg	h	kg	kg	kg	kg	kg	kg	kg	l	kg	kg	h	h	h	h	h	kg	kg	kg	kg
Crustacean consumers	5		15.9			8.6			420									2.9			530							
Occupants for direct radiation	74			1		0.1									0.1	0.1	0.4					70	1440	290				
Egg consumers	17		0.2	0.1	12.5	1.1	0.2	1.1	30		0.1	3.1					73.1	0.5	0.6		120			1				
Sea fish consumers	22		1			25.2			120		0.5		2.5					1	0.4		260		100		0.4	0.5	0.6	1.2
Domestic fruit consumers	2					4.6	85.5			11.3															40.4	23.8	34	43.6
Wild fruit and nut consumers	7		0.4	0.3	5.1	4.1	0.1	3.8	80		0.1		2.4					1.3	1.4		330			2242		0.2		
Occupants for exposure - Sediment	40		0.4			1.3			2060									0.1			50							
Honey consumers	2					4.6	85.5			11.3															40.4	23.8	34	43.6
Marine plants/algae consumers	7		1	0.1		14.1			90		2.4		7.5					1.4			400		320					
Cattle meat consumers	5		0.1	0.2	7.1		0.5	0.2				10.4					219		0.2					2				
Game meat consumers	25		0.4			3.5		0.2	90		0.2		11.1					0.1	0.2		180				0.2	0.2	0.3	0.5
Meat - Poultry	1		0.3			0.9								2.8							240					5.3	34.7	
Meat - Salt marsh grazed sheep	11			1											5.4								1220					
Meat - Sheep	9			0.6												13.5	92.2						680				6.6	2.3
Milk consumers	21				1.7		0.1					2.5				2.2	195.2							1			2.8	1
Mollusc consumers	10		5.9	0.1	3.6	14		1.3	120		0.9		1.5					4.5	0.9		590		230					
Mushroom consumers	6		1.5		5.9	10.3		2.1	140		0.2		1.5					1.5	4.5		400				2.8	3.8	4.2	8.5
Occupants in water	3								30											130								
Occupants on water	21		4.2		1.7	9.6		0.6	340		0.2		1.9					1.3	0.4		890							
Occupants for plume pathways (inner area)	8			1																		3390						
Occupants for plume pathways (middle area)	9			1		1.3		0.2	20														6310					
Occupants for plume pathways (outer area)	19			1				0.5	190															7030		0.1		
Green vegetable consumers	10		0.1			0.9	24.7			2.3															32.4	20.9	56.2	33.4
Other domestic vegetable consumers	11		0.1			0.8	24.4			2.1															27.4	24.5	59.3	31.5
Potato consumers	11		0.2			1	9							0.3					0.1		20				16.9	15.6	62.6	21
Root vegetable consumers	11		0.1			0.8	22.6			2.1															28.7	20.2	49.4	32.9

Notes

1. Expressed as a proportion of the group who are present within 1km of site
2. Gamma ext - Sediment includes occupancy over mud, mud & sand, salt marsh, sand, and sand & stones
3. Game meat includes rabbits/hares and wildfowl
4. Plume times are the sums of individuals' indoor and outdoor times

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