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Radiological Habits Survey: Sellafield Review, 2016

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Radiological Habits Survey: Sellafield Review, 2016

Review of shellfish and fish consumption, and intertidal occupancy

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2017

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1. INTRODUCTION

This report describes a review of the public's shellfish and fish consumption, and intertidal occupancy, relating to liquid radioactive waste discharges from the Sellafield Ltd nuclear site in Cumbria. It is also relevant to discharges from the Low Level Waste Repository (LLWR) near Drigg due to the proximity of the site, as well as the proposed Moorside nuclear power station adjacent to the Sellafield site. The information and data in this report are used in radiological dose assessments as reported in the Radioactivity in Food and the Environment (RIFE) series (e.g. EA, FSA, FSS, NRW, NIEA and SEPA, 2016). The study was funded by the Environment Agency (EA), the Food Standards Agency (FSA) and the Office for Nuclear Regulation (ONR) to support their roles in protecting the public from the effects of radiation.

Radiological protection of the public is based on the concept of a 'representative person'. This notional individual is defined as being representative of the more highly exposed members of the population. It follows that, if the dose to the representative person is acceptable when compared to dose limits and optimisation, then other members of the public will receive acceptable doses, and overall protection to the public is provided from the effects of radiation. This Sellafield Review specifically investigated the consumption of crustaceans, molluscs and fish, and occupancy over intertidal substrates, since these pathways are the major contributors to the dose of the representative person. Reviews are conducted annually, except in years when full surveys are undertaken, because consumption and occupancy rates have been known to vary from year to year, with some people ceasing seafood consumption, shellfish collection or intertidal activities, and new individuals being identified. The last full habits survey (encompassing aquatic, terrestrial and direct radiation pathways) in the vicinity of Sellafield was conducted by the Centre for Environment, Fisheries & Aquaculture Science (Cefas) in 2013 (Clyne *et al.*, 2014).

The consumption of fish has historically not been targeted for the Sellafield Reviews because fish have generally been of lower radiological significance around Sellafield than shellfish and intertidal occupancy. However, the people interviewed in relation to shellfish consumption and intertidal occupancy have been asked about their fish consumption. Prior to 2015, these fish consumption rates were used to update the total dose assessment of additive exposure but the fish consumption rates from the most recent full Sellafield habits surveys were used for the Sellafield source specific aquatic dose assessments. More recently, the relative contribution to doses arising from fish consumption has increased, and therefore, since 2015, a mean rate for the high-rate group for fish has been presented in these annual Sellafield Reviews, which can be used in the Sellafield source specific aquatic dose assessments. The fish consumption rates will also be used to update the total dose assessment. The adequacy of the inclusion of the mean rate for the high-rate group for fish in the Sellafield source specific aquatic dose assessments using the consumption rates from the Sellafield Review will be reviewed in future years.

Handling rates of sediment and fishing gear are not obtained during Sellafield Reviews, therefore, for assessments purposes, the mean handling rates for the high-rate groups for fishing gear and sediment will be retained from the 2013 full Sellafield habits survey.

In addition to the habits surveys undertaken in the vicinity of Sellafield, several of the higher rate consumers of shellfish keep a diary of their seafood consumption and intertidal occupancy for a two-week period every three months. These data can be used to check the validity of the interview data if extreme rates are recorded. This year it was not necessary to use the diaries to check the validity of the interview data used in this report because no extreme consumption or occupancy rates were recorded.

2. SURVEY AREA

The aquatic survey area, shown in Figure 1, extended from Parton to Tarn Bay. This included all intertidal areas and extended up to 11 km offshore.

Figure 1. The aquatic survey area

3. CONDUCT OF THE SURVEY

Prior to the fieldwork, individuals identified as having high rates of crustacean, mollusc or fish consumption and/or intertidal occupancy in previous Sellafield habits surveys were contacted and where possible interview times were arranged.

The fieldwork was carried out from 6th to 10th June 2016, by a team of two people. During the fieldwork, individuals were interviewed and asked to estimate consumption rates for crustaceans, molluscs and fish, as well as occupancy rates over intertidal areas, for themselves and members of their families. Information was obtained about the origins of the seafood being consumed and locations of intertidal occupancy. Investigations were also carried out in order to identify and interview any previously unknown individuals who might have high rates of fish or shellfish consumption or intertidal occupancy. This included visiting the beaches in the survey area.

Observations for 52 adults were recorded for the 2016 Sellafield Review. None of the interviewees had children or infants in their families who were consuming seafood or spending time in intertidal areas, so no data were collected for these age groups.

4. METHODS OF DATA ANALYSIS

4.1 Data recording and presentation

Consumption and occupancy data collected during interviews were recorded in logbooks. The raw data were entered into a purpose-built habits survey database where each individual for whom information was obtained was given a unique identifier (the Person ID number) to assist in maintaining data quality.

The consumption and occupancy data in the text of this report are rounded to two significant figures. This method of presentation reflects the authors' judgement on the accuracy of the methods used. In the tables and annexes, the consumption rate data are usually presented to one decimal place. Occasionally, this rounding process causes the computed values (row totals, mean rates and 97.5th percentiles), which are based on un-rounded data, to appear slightly erroneous. External exposure data are quoted as integer number of hours per year.

In habits surveys, data are structured into age groups because different dose coefficients (i.e. the factors which convert intakes of radioactivity into dose) can apply to different ages. The International Commission on Radiological Protection (ICRP) revised its recommendations for the age groupings to be used in radiological assessments and these recommendations were adopted in the 2010 and subsequent habits survey reports. Consequently, the age ranges used in the habits survey reports prior to 2010 differ from those used currently. The names used for the age groups, based on the

recommendations in ICRP 101 (ICRP, 2007), are shown in Table A below, together with those used in reports prior to 2010, for comparison. Although no data were collected for children or infants in the 2016 Sellafield Review the description of age groups is retained in this report for consistency within the Sellafield Review series.

Table A. Names of age groups and range of ages within each age group.

Age ranges used from 2010 onwards			Age ranges used prior to 2010	
Name of age group[a]	**Age range in group**		**Name of age group**	**Age range in group**
Infant	0 to 5-year-old		3-month-old	Under 1-year-old
			1-year-old	1-year-old
			5-year-old	2-year-old to 6-year-old
Child	6-year-old to 15-year-old		10-year-old	7-year-old to 11-year-old
			15-year-old	12-year-old to 16-year-old
Adult	16-year-old and over		Adult	17-year-old and over

[a] In the 2010 reports only, the infant age group was called the 1-year-old age group and the child age group was called the 10-year-old age group.

4.2 Approaches for the identification of high rates

The habits data have been analysed to identify high rates of consumption and occupancy, which are suitable for use in radiological assessments. Two approaches have been used:

Firstly, the 'cut-off' method described by Hunt *et al.* (1982) was used. With the 'cut-off' method, the appropriate high rate was calculated by taking the arithmetic mean of the values between the maximum observed rate and one third of the maximum observed rate. In this report, the term 'high-rate group' is used to represent the individuals derived by the 'cut-off' method. The mean of the high-rate group was calculated for each aquatic food group and intertidal substrate identified in the survey. In certain cases, using the 'cut-off' method resulted in only one person being in the high-rate group. In these cases, expert judgement was used to decide whether the high-rate group should remain as one individual or whether others should be included. If others were included, the second highest rate was divided by three and all observations above this were included in the high-rate group.

Secondly, the 97.5th percentile rate was calculated for each group. The use of percentiles accords with precedents used in risk assessments of the safety of food consumption. It should be noted that the interviewees in this study are often selected and, therefore, the calculated percentiles are not based on random data.

The results of the individuals' consumption and occupancy rates collected during the survey were grouped and presented in tables with the high-rate group members indicated in bold and with the calculated mean rates for the high-rate group and 97.5th percentile rates. The consumption rates and occupancy rates for all groups for adults are presented in Annex 1, with the high-rate group members indicated in bold.

5. INTERNAL EXPOSURE

Consumption data for aquatic foods for adults are presented in Tables 1, 2 and 3. The tables include the mean consumption rates for the high-rate groups, calculated as described in Section 4.2, and the observed 97.5th percentile rates. There were no children or infants that were consuming seafood in the families of the interviewees so no consumption rates were obtained for these age groups.

5.1 Crustaceans, molluscs and fish

The people consuming the greatest quantities of crustaceans, molluscs and fish from the aquatic survey area were commercial and hobby fishermen, shellfish collectors, anglers, and the families of these groups of people. Table B presents a summary of the adults' consumption rates of crustaceans, molluscs and fish for adults. The table includes the mean consumption rates for the high-rate groups and the observed 97.5th percentile rates.

Table B. Summary of consumption rates of foods from the aquatic survey area

Food group	Number of observations	Number of individuals in the high-rate group	Observed maximum for the high-rate group (kg y^{-1})	Observed minimum for the high-rate group (kg y^{-1})	Observed mean for the high-rate group (kg y^{-1})	Observed 97.5th percentile (kg y^{-1})
Adults						
Crustaceans	24	7	55.6	21.6	37.4	49.6
Molluscs	11	3	17.5	8.3	11.7	15.5
Fish	20	7	102.1	44.9	59.8	81.2

The species of crustaceans consumed by people in the adult high-rate group were brown crab, brown shrimp, common lobster, common prawn and *Nephrops*. The brown crab, common lobster and *Nephrops* were caught off-shore throughout the survey area. Brown crabs and common lobsters were also caught at Coulderton and Drigg by hooking them out from amongst the crevices at low water, and in pots set from the shore. Brown shrimps were caught at Seamill and Whitehaven north beach by wading out into shallow water and pushing a net, and also in pots set on the shore at Coulderton and Drigg. Small quantities of common prawns were caught as a by-catch in the pots set for other species both onshore and offshore, and also in shrimp nets.

The species of molluscs consumed by people in the adult high-rate group were limpets, mussels, razor shells and winkles. Limpets were collected from Nethertown and Braystones; mussels were collected from Whitey Rock (at the northern end of Whitehaven north beach); razor shells were collected from Whitehaven north beach; and winkles were collected from Coulderton, Nethertown and Braystones. The following mollusc species were consumed in small quantities but not by the people in the high-rate

group: cockles that were collected at Braystones; Pacific oysters that were collected at Drigg; and whelks that were caught incidentally in trawls and lobster pots offshore.

The species of fish consumed by people in the adult high-rate group were, bass, cod, Dover sole, grey mullet, herring, lemon sole, ling, mackerel, plaice, thornback ray and turbot. The fish were caught throughout the survey area. Small quantities of brill were also consumed, but not by the people in the high-rate group.

5.2 Composition of the food groups for crustaceans, molluscs and fish, for use in dose assessments, and comparison with 2015 data

In the Sellafield Review reports prior to 2014, the adult high-rate crustacean food group was presented as three species; crabs, lobsters and *Nephrops.* Any small quantities of brown shrimps and/or common prawns were included with the *Nephrops* for dose assessment purposes. However, in 2014, 2015, and 2016 brown shrimps represented a significant contribution to the consumption rates so, although the *Nephrops*, brown shrimps and common prawns have still been grouped together, since 2014 this group has been called 'other crustaceans'. The mollusc food group is presented in two parts, as before; winkles and all other molluscs combined.

The percentage composition for the predominant shellfish and fish species consumed by the adult high-rate groups from the 2016 Sellafield Review, rounded to the nearest 5% for use in dose assessments, are as follows:

- Crustaceans - 30% brown crab, 35% common lobster, 35% other crustaceans (including *Nephrops*, brown shrimps and common prawns) (mean consumption rate for the adult high-rate group, 37 kg y^{-1})
- Molluscs - 60% winkles and 40% other molluscs (including mussels, razor shells and limpets) (mean consumption rate for the adult high-rate group, 12 kg y^{-1})
- Fish - 25% cod and 75% other fish species (mainly thornback ray, plaice, bass, with smaller quantities of Dover sole, grey mullet, herring, lemon sole, ling, mackerel and turbot) (mean consumption rate for the adult high-rate group, 60 kg y^{-1})

By comparison, the percentage composition for the predominant shellfish and fish species consumed by the adult high-rate groups from the 2015 Sellafield Review, used in RIFE-21 (EA, FSA, FSS, NRW, NIEA and SEPA, 2016) for dose assessments, were:

- Crustaceans - 30% brown crab, 40% common lobster, 30% other crustaceans (including *Nephrops* and brown shrimps) (mean consumption rate for the adult high-rate group, 38 kg y^{-1})
- Molluscs - 55% winkles and 45% other molluscs (including mussels, razor shells and limpets) (mean consumption rate for the adult high-rate group, 12 kg y^{-1})

- Fish - 25% cod and 75% other fish species (mainly thornback ray, plaice, bass, with smaller quantities of Dover sole, grey mullet, herring, lemon sole and turbot) (mean consumption rate for the adult high-rate group, 64 kg y^{-1})

In 2016, compared to 2015, the mean consumption rate for the adult high-rate group for crustaceans decreased by 1 kg y^{-1}, and the mean consumption rate for the adult high-rate group for fish decreased by 4 kg y^{-1}. The consumption rate for molluscs was the same in both years.

The main species of crustaceans within the high-rate groups were similar in 2016 and 2015 except that there was no common prawn in the high-rate group in 2015. The main species of molluscs within the high-rate groups were the same in 2016 and 2015. The main species of fish within the high-rate groups were similar in 2016 and 2015 except that there were no ling or mackerel in the high-rate group in 2015. The percentage breakdown of species changed slightly for crustaceans and molluscs in 2016 compared with 2015, but remained the same for fish in both years. For crustaceans, there was a slight decrease in common lobster and a slight increase in other crustaceans. For molluscs, there was a slight increase in winkles and a slight decrease in other molluscs. Where there were differences in the species composition between 2016 and 2015 they were generally small and no specific reasons for the differences were identified, except that the difference for crustaceans was partly due to an increase in the availability of common prawn in 2016.

5.3 Consumption trends

The consumption rates for the adult high-rate groups for crustaceans and molluscs over the previous ten years (2007 - 2016) are shown in Figures 2 and 3, respectively. These figures were plotted using the adult means for the high-rate groups distributed according to the percentage breakdowns as described in Section 5.2. The raw data are presented in Annex 2a. 'Other crustaceans' includes *Nephrops*, brown shrimps and common prawns. Between 2015 and 2016 there was very little change in the consumption rates of either crustaceans or molluscs.

Figure 2. Consumption rates for the adult high-rate group for crustaceans, 2007 – 2016 (kg y^{-1})

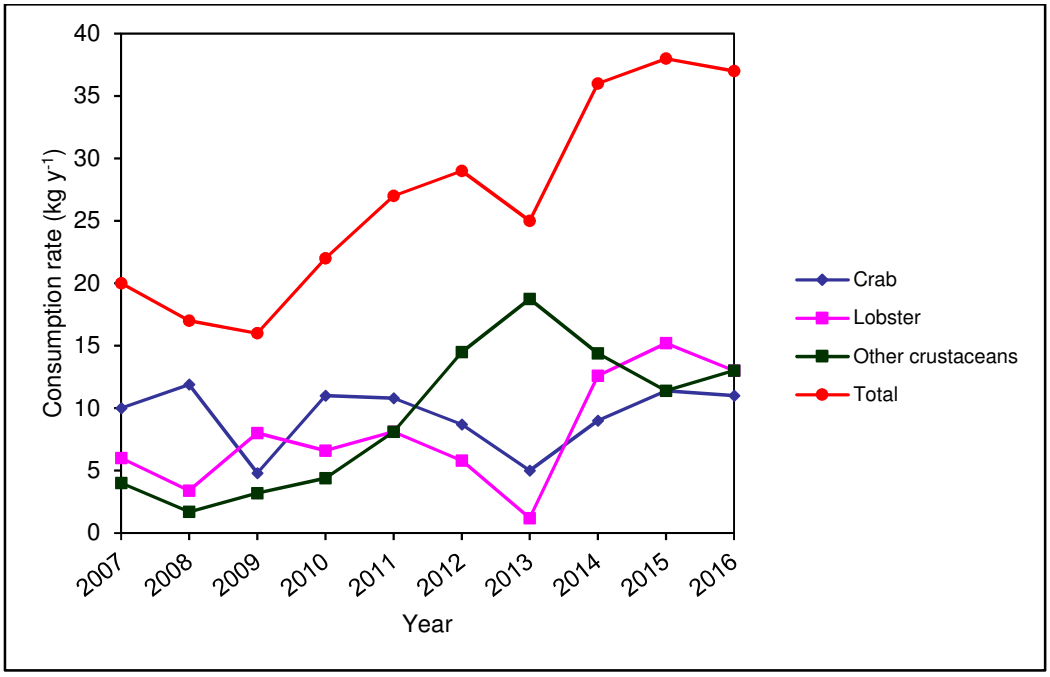
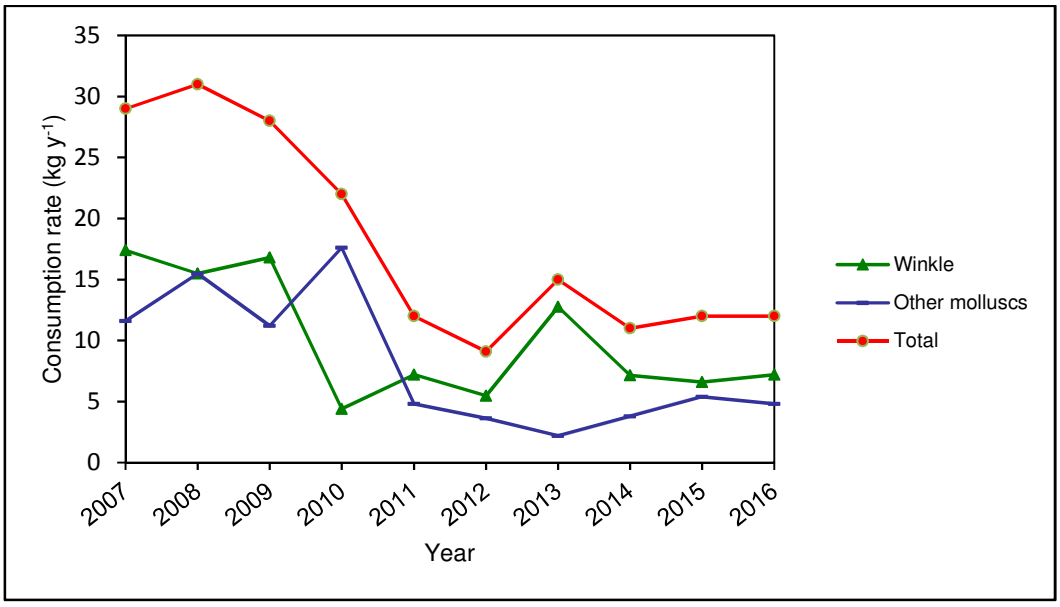


Figure 3. Consumption rates for the adult high-rate group for molluscs, 2007 – 2016 (kg y^{-1})



6. EXTERNAL EXPOSURE

Intertidal occupancy rates for adults are presented in Table 4. It should be noted that there are often more than one substrate at one named location and that substrates at a given location are liable to change over time. Activities were assigned to the predominant substrate over which they were taking place. There were no children or infants that were undertaking activities in intertidal areas in the families of the interviewees so no intertidal occupancy rates were obtained for these age groups.

6.1 Intertidal occupancy

Table C presents a summary of the adults' intertidal occupancy rates in the aquatic survey area, by substrate. The table includes the mean occupancy rates for the high-rate groups and the observed 97.5th percentile rates.

Table C. Summary of adults' intertidal occupancy rates

Intertidal substrate	Number of observations	Number of people in the high-rate group	Maximum of the high-rate group (h y^{-1})	Mean of the high-rate group (h y^{-1})	97.5th percentile (h y^{-1})
Mud	4	3	75	75	75
Mud and sand	3	3	235	196	232
Mud, sand and stones	4	3	365	362	365
Rock	2	1	135	135	132
Salt marsh	9	5	320	228	320
Sand	22	17	948	557	946
Sand and stones	17	8	828	507	758

The following activities were undertaken by people in the adult high-rate groups for occupancy over intertidal substrates:

- For mud: wildfowling along the River Irt
- For mud and sand: bait digging at Whitehaven outer harbour; dog walking along the River Irt
- For mud, sand and stones: boat maintenance and walking at Ravenglass
- For rock: hooking crabs and lobsters at Coulderton and Drigg
- For salt marsh: dog walking and tending livestock along the River Irt; angling along the River Esk
- For sand: bait digging at Nethertown, Braystones, Drigg, Eskmeals and Tarn Bay; attending set nets at Nethertown, Braystones, Sellafield, Seascale and Drigg; collecting razor shells at Whitehaven north beach; angling at Drigg and Eskmeals; long-lining and collecting small quantities of cockles at Braystones; dog walking at Whitehaven north beach, St Bees, Sellafield, Seascale and Drigg

- For sand and stones: angling at Parton, St Bees, Coulderton, Nethertown, Braystones and Drigg; dog walking at Parton, Whitehaven north beach, St Bees, Braystones and Sellafield; attending crab/shrimp pots at Coulderton, Braystones and Drigg; collecting winkles at Coulderton; beachcombing at Braystones and Sellafield

Brown shrimps were also caught at Seamill and Whitehaven north beach but since this involved wading out into shallow water and pushing a net, it was not classed as an intertidal activity. Therefore, this activity does not appear in the intertidal occupancy table.

The adults' intertidal occupancy rates from the 2015 Sellafield Review are presented in Table D and a comparison between the 2015 and 2016 mean rates of the high-rate groups for occupancy over each intertidal substrate is shown in Figure 4.

Table D. Summary of adults' intertidal occupancy rates from the 2015 Sellafield Review

Intertidal substrate	Number of observations	Number of people in the high-rate group	Maximum of the high-rate group (h y^{-1})	Mean of the high-rate group (h y^{-1})	97.5th percentile (h y^{-1})
Mud	3	3	74	74	74
Mud and sand	2	2	176	176	176
Mud, sand and stones	4	3	365	365	365
Rock	2	1	105	105	103
Salt marsh	7	4	320	248	320
Sand	16	12	1040	612	1040
Sand and stones	14	7	828	485	752

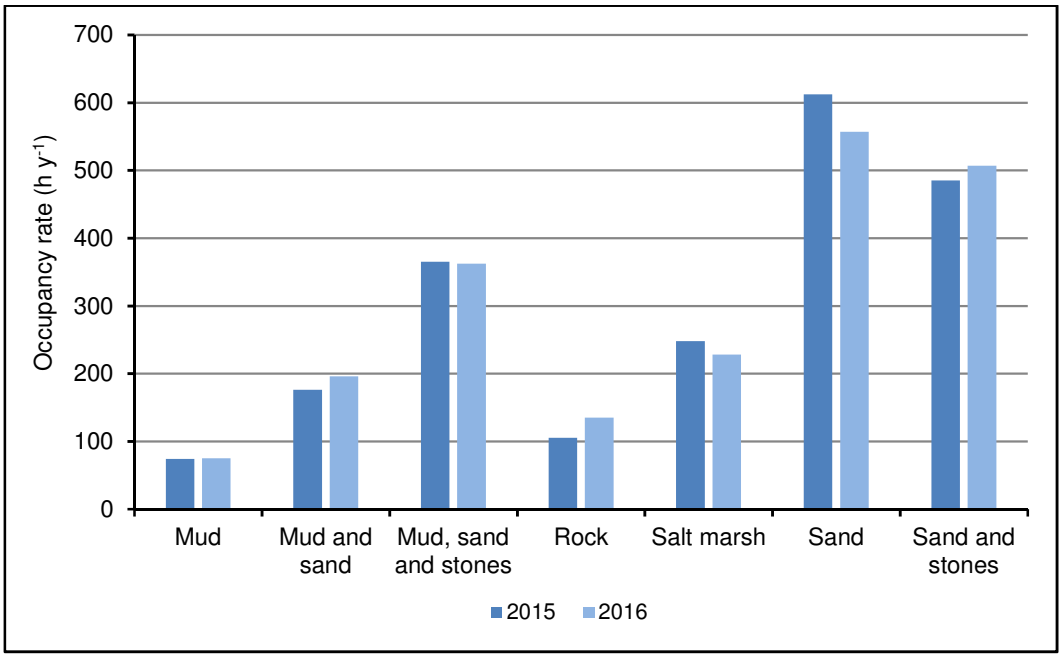
In 2016, compared with 2015, there were increases in the following mean intertidal occupancy rates for the high-rate groups (data rounded to two significant figures):

- For mud; from 74 h y^{-1} to 75 h y^{-1}
- For mud and sand; from 180 h y^{-1} to 200 h y^{-1}
- For rock; from 110 h y^{-1} to 140 h y^{-1}
- For sand and stones; from 490 h y^{-1} to 510 h y^{-1}

In 2016, compared with 2015, there were decreases in the following mean intertidal occupancy rates for the high-rate groups (data rounded to two significant figures):

- For mud, sand and stones; from 370 h y^{-1} to 360 h y^{-1}
- For salt marsh; from 250 h y^{-1} to 230 h y^{-1}
- For sand; from 610 h y^{-1} to 560 h y^{-1}

Figure 4. Comparison between the 2015 and 2016 mean rates of the high-rate groups for occupancy over each intertidal substrate



7. USE OF HABITS DATA FOR DOSE ASSESSMENTS

7.1 Aquatic combinations for adults in the Sellafield area

Table 5 presents the consumption rates and occupancy rates for people who appear in at least one of the high-rate groups for fish, crustaceans, molluscs or intertidal substrates. The table shows that several individuals are members of multiple high-rate groups. For example, Person ID number 1195/1/1 is in the high-rate group for fish, crustaceans, molluscs, and occupancy over sand, and over sand and stones. This supports the continuation of assessing the dose to the representative person based on a combination of internal and external pathways. Therefore, the Radioactivity in Food and the Environment (RIFE) Sellafield Fishing Community assessments for 2016 will be based on combinations of consumption and intertidal occupancy pathways.

As in previous years, since several individuals were undertaking activities over multiple substrates, the occupancy rates over five substrates (mud; mud and sand; mud, sand and stones; sand; sand and stones) have been combined into a single substrate called 'mud and sand'. Rock and salt marsh are not included in the combined substrate since rock is not assessed and salt marsh is assessed separately. The mean rate for the high-rate group for the reclassified 'mud and sand' substrate is 790 h y^{-1}. For comparison, the mean rate for the high-rate group for the reclassified 'mud and sand' substrate in 2015 was 1000 h y^{-1}.

7.2 Habits data for source specific assessments

Annexes 2a and 2b show the historic consumption and occupancy rates, updated with the 2016 data, for use in source specific assessments for the RIFE reports. Annex 2a shows the data for single year assessments and Annex 2b shows the data for the 5-year average assessments.

Prior to 2015, for Sellafield Reviews and full Sellafield habits surveys, the consumption rates of crustaceans and molluscs, and intertidal occupancy rates, were updated annually in these annexes using the Sellafield Review data or full survey data, as applicable. The fish consumption rates were only updated when a full habits survey was conducted. However, since 2015, the annexes have been updated with the consumption rates of fish from the current year's survey, since the relative contribution to doses arising from fish consumption has increased.

7.3 Profiled habits data for total dose assessments

The matrix for the 2016 Sellafield adults' profiled habits data is presented in Annex 3. It is based on data from the 2013 Sellafield full habits survey (aquatic, terrestrial and direct radiation pathways), which has been updated with data from the 2014, 2015 and 2016 annual Sellafield Reviews. All pathways and observations from the original 2013 profiled habits matrix were retained, and for the subsequent years' profiles, only data asked about during the subsequent years' reviews were updated; that is, intertidal occupancy and consumption of crustaceans, molluscs and fish. If data were collected for new interviewees, these were added as new observations, and if it was known that an individual who had been interviewed in previous years had stopped their activity, then their data was deleted. Because the profiles have been created using the data from the 2013, 2014, 2015 and 2016 surveys, the profiled data shown in Annex 3 are not comparable with the data presented in Annex 1.

8. SUMMARY AND RECOMMENDED DATA FOR USE IN RIFE-22 DOSE ASSESSMENTS

The survey investigated the consumption of shellfish and fish, and intertidal occupancy, relating to liquid discharges from the Sellafield nuclear site. The consumption and occupancy rates in this section are presented to two significant figures.

The mean rates for the adult high-rate groups from the 2016 Sellafield Review are as follows:

- Crustaceans 37 kg y^{-1}
- Molluscs 12 kg y^{-1}
- Fish 60 kg y^{-1}
- Occupancy over mud 75 h y^{-1}
- Occupancy over mud and sand 200 h y^{-1}
- Occupancy over mud, sand and stones 360 h y^{-1}
- Occupancy over rock 140 h y^{-1}
- Occupancy over salt marsh 230 h y^{-1}
- Occupancy over sand 560 h y^{-1}
- Occupancy over sand and stones 510 h y^{-1}

In 2016, compared to 2015, the mean consumption rate for the adult high-rate group for crustaceans decreased by 1 kg y^{-1}, and the mean consumption rate for the adult high-rate group for fish decreased by 4 kg y^{-1}. The consumption rate for molluscs was the same in both years. For occupancy over intertidal substrates, the mean rates for the adult high rate groups increased in 2016 compared to 2015 by 1 h y^{-1} for mud, by 20 h y^{-1} for mud and sand, by 30 h y^{-1} for rock and by 20 h y^{-1} for sand and stones; and decreased by 10 h y^{-1} for mud, sand and stones, by 20 h y^{-1} for salt marsh, and by 50 h y^{-1} for sand.

The following recommendations for data to be used in RIFE-22 dose assessments are for the adult age group only.

For the 'Sellafield Fishing Community' dose assessment, the mean consumption rates for the adult high-rate groups and species breakdown are:

- Fish 60 kg y^{-1}, comprising 25% cod and 75% other fish (including thornback ray, plaice, bass, Dover sole, grey mullet, herring, lemon sole, ling, mackerel and turbot)
- Crustaceans 37 kg y^{-1}, comprising 30% brown crab, 35% common lobster and 35% other crustaceans (including *Nephrops*, brown shrimps and common prawns)
- Molluscs 12 kg y^{-1}, comprising 60% winkles and 40% other molluscs (including mussels, razor shells and limpets)
- Occupancy over an intertidal substrate termed 'mud and sand' (mud; mud and sand; mud, sand and stones; sand; and sand and stones combined) 790 h y^{-1}

For the 'Sellafield Fishing Community 5-year average' dose assessments:

- Cod 17 kg y^{-1}
- Other fish 38 kg y^{-1}
- Crabs 9.0 kg y^{-1}
- Lobsters 9.6 kg y^{-1}
- Other crustaceans 14 kg y^{-1}
- Winkles 7.8 kg y^{-1}
- Other molluscs 4.0 kg y^{-1}
- Occupancy over an intertidal substrate termed 'mud and sand' (mud; mud and sand; mud, sand and stones; sand; and sand and stones combined) 900 h y^{-1}

For the 'Fisherman's Nets and Pots' dose assessment:

- Handling fishing gear 1100 h y^{-1} (mean rate for the high-rate group retained from the 2013 Sellafield habits survey)

For the 'Bait Digging and Mollusc Collection' dose assessment:

- Handling sediment 460 h y^{-1} (mean rate for the high-rate group retained from the 2013 Sellafield habits survey)

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Table 1. Adults' consumption rates of crustaceans from the Sellafield aquatic survey area (kg y^{-1})

Person ID number	Brown crab	Brown shrimp	Common lobster	Common prawn	*Nephrops*	Total
1195/1/1	**8.1**	**30.8**	**14.9**	**1.8**	**-**	**55.6**
1176/1/1	**17.7**	**2.0**	**13.3**	**-**	**12.0**	**45.1**
1176/2/1	**17.7**	**2.0**	**13.3**	**-**	**12.0**	**45.1**
1195/2/1	**8.1**	**23.6**	**7.4**	**1.8**	**-**	**40.9**
1195/3/1	**8.1**	**8.8**	**14.9**	**-**	**-**	**31.8**
1173/1/1	**6.6**	**-**	**13.9**	**0.3**	**0.9**	**21.6**
1173/2/1	**6.6**	**-**	**13.9**	**0.3**	**0.9**	**21.6**
1189/1/1	7.2	-	11.2	-	-	18.4
1189/2/1	7.2	-	11.2	-	-	18.4
1177/1/1	7.8	-	9.9	-	-	17.7
1196/2/1	3.6	-	5.6	1.4	-	10.6
1179/1/1	0.5	5.9	0.4	-	3.6	10.5
1179/2/1	0.5	5.9	0.4	-	3.6	10.5
1180/1/1	-	5.9	-	-	3.6	9.5
1180/2/1	-	5.9	-	-	3.6	9.5
1196/1/1	3.6	-	5.6	0.3	-	9.5
1196/3/1	3.6	-	5.6	-	-	9.2
1196/4/1	3.6	-	5.6	-	-	9.2
1185/1/1	2.9	-	1.0	-	0.3	4.3
1185/2/1	2.9	-	1.0	-	0.3	4.3
1188/1/1	1.0	-	1.5	-	-	2.6
1193/1/1	1.4	-	0.2	-	-	1.6
1193/2/1	1.4	-	0.2	-	-	1.6
1193/3/1	1.4	-	0.2	-	-	1.6

Notes

Emboldened observations are the high-rate consumers

The mean consumption rate of crustaceans for adults based on the 7 high-rate consumers is 37.4 kg y^{-1}

The observed 97.5th percentile rate based on 24 observations is 49.6 kg y^{-1}

Table 2. Adults' consumption rates of molluscs from the Sellafield aquatic survey area (kg y^{-1})

Person ID number	Cockle	Limpet	Mussel	Pacific oyster	Razor shell	Whelk	Winkle	Total
1195/1/1	**-**	**-**	**7.5**	**-**	**1.5**	**-**	**8.5**	**17.5**
1184/2/1	**-**	**1.4**	**-**	**-**	**-**	**-**	**8.0**	**9.4**
1195/3/1	**-**	**-**	**2.5**	**-**	**1.5**	**-**	**4.3**	**8.3**
1195/2/1	-	-	-	-	3.0	-	-	3.0
1176/1/1	-	-	0.3	-	-	1.9	-	2.3
1188/1/1	-	-	-	-	-	-	2.2	2.2
1179/2/1	0.5	-	-	0.2	0.2	-	-	0.9
1179/1/1	0.5	-	-	-	0.2	-	-	0.7
1184/1/1	-	-	-	-	-	-	0.4	0.4
1176/2/1	-	-	0.3	-	-	-	-	0.3
1173/1/1	-	-	-	-	-	0.3	-	0.3

Notes

Emboldened observations are the high-rate consumers

The mean consumption rate of molluscs for adults based on the 3 high-rate consumers is 11.7 kg y^{-1}

The observed 97.5th percentile rate based on 11 observations is 15.5 kg y^{-1}

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

Person ID number	Bass	Brill	Cod	Dover sole	Grey mullet	Herring	Lemon sole	Ling	Mackerel	Plaice	Thornback ray	Turbot	Total
1195/1/1	**13.6**	**-**	**31.8**	**4.5**	**-**	**-**	**-**	**-**	**-**	**16.8**	**31.8**	**3.6**	**102.1**
1179/1/1	**-**	**-**	**12.7**	**3.6**	**12.7**	**12.7**	**-**	**-**	**-**	**-**	**12.7**	**3.6**	**58.1**
1195/3/1	**9.1**	**-**	**20.9**	**3.6**	**-**	**-**	**-**	**-**	**-**	**-**	**20.9**	**2.7**	**57.2**
1191/1/1	**11.7**	**-**	**16.5**	**-**	**-**	**-**	**-**	**-**	**12.2**	**6.6**	**9.9**	**-**	**57.0**
1176/1/1	**-**	**-**	**8.9**	**-**	**-**	**-**	**3.4**	**2.0**	**-**	**17.7**	**17.7**	**-**	**49.8**
1176/2/1	**-**	**-**	**8.9**	**-**	**-**	**-**	**3.4**	**2.0**	**-**	**17.7**	**17.7**	**-**	**49.8**
1195/2/1	**4.5**	**-**	**10.4**	**1.8**	**-**	**-**	**-**	**-**	**-**	**16.3**	**10.4**	**1.4**	**44.9**
1179/2/1	4.5	-	4.5	2.7	4.5	4.5	-	-	-	4.5	4.5	2.7	32.7
1173/1/1	-	1.1	7.7	2.3	-	-	-	-	-	7.7	7.7	-	26.5
1173/2/1	-	1.1	7.7	2.3	-	-	-	-	-	7.7	7.7	-	26.5
1189/1/1	-	-	5.9	-	-	-	-	-	5.9	5.9	5.9	-	23.6
1189/2/1	-	-	5.9	-	-	-	-	-	5.9	5.9	5.9	-	23.6
1177/1/1	-	-	6.8	4.0	-	-	-	-	6.8	4.5	-	-	22.1
1185/1/1	-	-	2.5	-	-	-	-	-	-	9.1	9.1	-	20.6
1185/2/1	-	-	2.5	-	-	-	-	-	-	9.1	9.1	-	20.6
1185/3/1	-	-	2.5	-	-	-	-	-	-	9.1	9.1	-	20.6
1180/1/1	9.1	-	2.3	-	2.3	-	-	-	-	1.8	2.3	-	17.7
1180/2/1	9.1	-	2.3	-	2.3	-	-	-	-	1.8	2.3	-	17.7
1175/1/1	-	-	3.7	-	-	-	-	-	10.4	-	-	-	14.1
1175/2/1	-	-	3.7	-	-	-	-	-	10.4	-	-	-	14.1

Notes

Emboldened observations are the high-rate consumers

The mean consumption rate of fish for adults based on the 7 high-rate consumers is 59.8 kg y^{-1}

The observed 97.5th percentile rate based on 20 observations is 81.2 kg y^{-1}

Table 4. Adults' intertidal occupancy rates in the Sellafield aquatic survey area (h y^{-1})

Person ID number	Location	Activity	Mud	Mud and sand	Mud, sand and stones	Rock	Salt marsh	Sand	Sand and stones
1192/1/1	**River Irt**	**Wildfowling**	**75**	-	-	-	-	-	-
	River Irt	Walking	-	-	-	-	25	-	-
1192/2/1	**River Irt**	**Wildfowling**	**75**	-	-	-	-	-	-
	River Irt	Walking	-	-	-	-	25	-	-
1192/3/1	**River Irt**	**Wildfowling**	**75**	-	-	-	-	-	-
	River Irt	Walking	-	-	-	-	25	-	-
1190/1/1	Newbiggin Marsh	Wildfowling	9	-	-	-	-	-	-
	Newbiggin Marsh	Wildfowling and dog walking	-	-	-	-	16	-	-
1189/1/1	**Whitehaven outer harbour**	**Bait digging**	-	**235**	-	-	-	-	-
	Parton, St Bees, Braystones and Drigg	**Angling**	-	-	-	-	-	-	**652**
	Parton, Whitehaven north beach and St Bees	**Dog walking**	-	-	-	-	-	-	
1193/3/1	**River Irt**	**Dog walking**	-	**176**	-	-	**176**	-	-
1193/4/1	**River Irt**	**Dog walking**	-	**176**	-	-	**176**	-	-
1177/1/1	**Ravenglass**	**Boat maintenance and walking**	-	-	**365**	-	-	-	-
1196/1/1	**Ravenglass**	**Boat maintenance**	-	-	**360**	-	-	-	-
1196/3/1	**Ravenglass**	**Boat maintenance**	-	-	**360**	-	-	-	-
1185/1/1	Ravenglass	Walking	-	-	22	-	-	-	-
	St Bees and Drigg	Walking	-	-	-	-	-	80	-
	Parton and Coulderton	Walking	-	-	-	-	-	-	80
1195/3/1	**Coulderton and Drigg**	**Hooking**	-	-	-	**135**	-	-	-
	Parton and Seamill	Angling	-	-	-	-	-	-	156
1195/1/1	Whitey Rock	Collecting mussels	-	-	-	35	-	-	-
	Braystones	**Bait digging**	-	-	-	-	-	**598**	-
	Braystones and Seascale	**Setting nets**	-	-	-	-	-		-
	Whitehaven north beach	**Collecting razor shells**	-	-	-	-	-		-
	Coulderton, Nethertown and Braystones	**Angling**	-	-	-	-	-	-	**828**
	Coulderton and Drigg	**Potting**	-	-	-	-	-	-	
	Coulderton	**Collecting winkles**	-	-	-	-	-	-	
1193/1/1	**River Irt**	**Tending livestock**	-	-	-	-	**320**	-	-
1193/2/1	**River Irt**	**Tending livestock**	-	-	-	-	**320**	-	-
1191/1/1	**River Esk**	**Angling**	-	-	-	-	**150**	-	-
	Drigg and Eskmeals	**Angling**	-	-	-	-	-	**425**	-
	Drigg and Tarn Bay	**Bait digging**	-	-	-	-	-		-
	Tarn Bay	Angling and collecting peeler crab	-	-	-	-	-	-	242
1179/1/1	**Nethertown, Braystones, Sellafield, Seascale and Drigg**	**Setting nets**	-	-	-	-	-	**948**	-
	Braystones	**Long lining and collecting cockles**	-	-	-	-	-		-
	Braystones and Sellafield	**Dog walking and beach combing**	-	-	-	-	-	-	**570**
	Braystones	**Potting**	-	-	-	-	-	-	
1180/1/1	**Nethertown, Braystones, Sellafield, Seascale and Drigg**	**Setting nets**	-	-	-	-	-	**945**	-
	Braystones	**Long lining**	-	-	-	-	-		-
	Sellafield	Angling	-	-	-	-	-	-	213
	Braystones and Sellafield	Dog walking and beach combing	-	-	-	-	-	-	
1181/1/1	**Nethertown, Braystones, Sellafield, Seascale and Drigg**	**Setting nets**	-	-	-	-	-	**742**	-
1184/1/1	**Nethertown, Braystones, Drigg and Eskmeals**	**Bait digging**	-	-	-	-	-	**626**	-
	Braystones	Angling	-	-	-	-	-	-	208
	Nethertown and Braystones	Collecting winkles and limpets	-	-	-	-	-	-	
1186/1/1	**St Bees**	**Dog walking**	-	-	-	-	-	**548**	-
1186/2/1	**St Bees**	**Dog walking**	-	-	-	-	-	**548**	-

Table 4. Adults' intertidal occupancy rates in the Sellafield aquatic survey area (h y^{-1})

Person ID number	Location	Activity	Mud	Mud and sand	Mud, sand and stones	Rock	Salt marsh	Sand	Sand and stones
1197/1/1	**Seascale**	**Dog walking**	-	-	-	-	-	**548**	-
1197/2/1	**Seascale**	**Dog walking**	-	-	-	-	-	**548**	-
1182/1/1	**Whitehaven north beach, Seascale and Drigg**	**Dog walking**	-	-	-	-	-	**521**	-
1182/2/1	**Whitehaven north beach, Seascale and Drigg**	**Dog walking**	-	-	-	-	-	**521**	-
1181/3/1	**Nethertown, Braystones, Sellafield, Seascale and Drigg**	**Setting nets**	-	-	-	-	-	**495**	-
1183/1/1	**Seascale**	**Dog walking**	-	-	-	-	-	**365**	-
1198/1/1	**St Bees**	**Dog walking**	-	-	-	-	-	**365**	-
1198/2/1	**St Bees**	**Dog walking**	-	-	-	-	-	**365**	-
1196/2/1	**Seascale and Sellafield**	**Dog walking**	-	-	-	-	-	**355**	-
1181/2/1	Nethertown, Braystones, Sellafield, Seascale and Drigg	Setting nets	-	-	-	-	-	248	-
1180/2/1	Nethertown, Braystones, Sellafield, Seascale and Drigg	Setting nets	-	-	-	-	-	180	-
	Braystones and Sellafield	Dog walking	-	-	-	-	-	-	105
1171/1/1	St Bees, Seascale and Drigg	Dog walking	-	-	-	-	-	75	-
	Parton	**Dog walking**	-	-	-	-	-	-	**332**
1185/3/1	St Bees and Drigg	Walking	-	-	-	-	-	26	-
	Parton and Coulderton	Walking	-	-	-	-	-	-	26
1169/1/1	**Parton**	**Dog walking**	-	-	-	-	-	-	**548**
1168/1/1	**Parton**	**Dog walking**	-	-	-	-	-	-	**456**
1170/1/1	**Parton**	**Dog walking**	-	-	-	-	-	-	**365**
1172/1/1	**Parton**	**Dog walking**	-	-	-	-	-	-	**304**
1176/1/1	Parton	Collecting winkles and walking	-	-	-	-	-	-	114
1188/1/1	Nethertown and Braystones	Collecting winkles	-	-	-	-	-	-	39

Notes

Emboldened observations are the high-rate consumers

The mean intertidal occupancy rate over mud for adults based on 3 high-rate observations is 75 h y^{-1}

The observed 97.5th percentile rate based on 4 observations is 75 h y^{-1}

The mean intertidal occupancy rate over mud and sand for adults based on 3 high-rate observations is 196 h y^{-1}

The observed 97.5th percentile rate based on 3 observations is 232 h y^{-1}

The mean intertidal occupancy rate over mud, sand and stones for adults based on 3 high-rate observations is 362 h y^{-1}

The observed 97.5th percentile rate based on 4 observations is 365 h y^{-1}

The mean intertidal occupancy rate over rock for adults based on 1 high-rate observations is 135 h y^{-1}

The observed 97.5th percentile rate based on 2 observations is 132 h y^{-1}

The mean intertidal occupancy rate over salt marsh for adults based on 5 high-rate observations is 228 h y^{-1}

The observed 97.5th percentile rate based on 9 observations is 320 h y^{-1}

The mean intertidal occupancy rate over sand for adults based on 17 high-rate observations is 557 h y^{-1}

The observed 97.5th percentile rate based on 22 observations is 946 h y^{-1}

The mean intertidal occupancy rate over sand and stones for adults based on 8 high-rate observations is 507 h y^{-1}

The observed 97.5th percentile rate based on 17 observations is 758 h y^{-1}

Table 5. Aquatic combinations for adults in the Sellafield area

Person ID number	Consumption rates (kg y^{-1})			Intertidal occupancy rates (h y^{-1})						
	Fish	Crustaceans	Molluscs	Mud	Mud and sand	Mud, sand and stones	Rock	Salt marsh	Sand	Sand and stones
1195/1/1	**102.1**	**55.6**	**17.5**	-	-	-	35	-	**598**	**828**
1179/1/1	**58.1**	10.5	0.7	-	-	-	-	-	**948**	**570**
1195/3/1	**57.2**	**31.8**	**8.3**	-	-	-	**135**	-	-	156
1191/1/1	**57.0**	-	-	-	-	-	-	**150**	**425**	242
1176/1/1	**49.8**	**45.1**	2.3	-	-	-	-	-	-	114
1176/2/1	**49.8**	**45.1**	0.3	-	-	-	-	-	-	-
1195/2/1	**44.9**	**40.9**	3.0	-	-	-	-	-	-	-
1173/1/1	26.5	**21.6**	0.3	-	-	-	-	-	-	-
1173/2/1	26.5	**21.6**	-	-	-	-	-	-	-	-
1189/1/1	23.6	18.4	-	-	**235**	-	-	-	-	**652**
1177/1/1	22.1	17.7	-	-	-	**365**	-	-	-	-
1180/1/1	17.7	9.5	-	-	-	-	-	-	**945**	213
1196/2/1	-	10.6	-	-	-	-	-	-	**355**	-
1196/1/1	-	9.5	-	-	-	**360**	-	-	-	-
1196/3/1	-	9.2	-	-	-	**360**	-	-	-	-
1193/3/1	-	1.6	-	-	**176**	-	-	**176**	-	-
1193/1/1	-	1.6	-	-	-	-	-	**320**	-	-
1193/2/1	-	1.6	-	-	-	-	-	**320**	-	-
1184/2/1	-	-	**9.4**	-	-	-	-	-	-	-
1184/1/1	-	-	0.4	-	-	-	-	-	**626**	208
1192/1/1	-	-	-	**75**	-	-	-	25	-	-
1192/2/1	-	-	-	**75**	-	-	-	25	-	-
1192/3/1	-	-	-	**75**	-	-	-	25	-	-
1193/4/1	-	-	-	-	**176**	-	-	**176**	-	-
1171/1/1	-	-	-	-	-	-	-	-	75	**332**
1181/1/1	-	-	-	-	-	-	-	-	**742**	-
1186/1/1	-	-	-	-	-	-	-	-	**548**	-
1186/2/1	-	-	-	-	-	-	-	-	**548**	-
1197/1/1	-	-	-	-	-	-	-	-	**548**	-
1197/2/1	-	-	-	-	-	-	-	-	**548**	-
1182/1/1	-	-	-	-	-	-	-	-	**521**	-
1182/2/1	-	-	-	-	-	-	-	-	**521**	-
1181/3/1	-	-	-	-	-	-	-	-	**495**	-
1183/1/1	-	-	-	-	-	-	-	-	**365**	-
1198/1/1	-	-	-	-	-	-	-	-	**365**	-
1198/2/1	-	-	-	-	-	-	-	-	**365**	-
1169/1/1	-	-	-	-	-	-	-	-	-	**548**
1168/1/1	-	-	-	-	-	-	-	-	-	**456**
1170/1/1	-	-	-	-	-	-	-	-	-	**365**
1172/1/1	-	-	-	-	-	-	-	-	-	**304**

Notes

Values in high-rate groups are emboldened

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

Person ID number	Gender	Age	Fish	Crustaceans	Molluscs	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud, sand and stones	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	Intertidal occupancy over sand	Intertidal occupancy over sand and stones
1168/1/1	F	55	-	-	-	-	-	-	-	-	-	**456**
1169/1/1	M	62	-	-	-	-	-	-	-	-	-	**548**
1170/1/1	F	30	-	-	-	-	-	-	-	-	-	**365**
1171/1/1	M	40	-	-	-	-	-	-	-	-	75	**332**
1172/1/1	F	59	-	-	-	-	-	-	-	-	-	**304**
1173/1/1	M	52	26.5	**21.6**	0.3	-	-	-	-	-	-	-
1173/2/1	F	52	26.5	**21.6**	-	-	-	-	-	-	-	-
1175/1/1	M	25	14.1	-	-	-	-	-	-	-	-	-
1175/2/1	F	24	14.1	-	-	-	-	-	-	-	-	-
1176/1/1	M	77	**49.8**	**45.1**	2.3	-	-	-	-	-	-	114
1176/2/1	F	78	**49.8**	**45.1**	0.3	-	-	-	-	-	-	-
1177/1/1	M	85	22.1	17.7	-	-	-	**365**	-	-	-	-
1179/1/1	M	69	**58.1**	10.5	0.7	-	-	-	-	-	**948**	**570**
1179/2/1	F	65	32.7	10.5	0.9	-	-	-	-	-	-	-
1180/1/1	M	34	17.7	9.5	-	-	-	-	-	-	**945**	213
1180/2/1	F	36	17.7	9.5	-	-	-	-	-	-	180	105
1181/1/1	M	U	-	-	-	-	-	-	-	-	**742**	-
1181/2/1	M	U	-	-	-	-	-	-	-	-	248	-
1181/3/1	U	U	-	-	-	-	-	-	-	-	**495**	-
1182/1/1	F	53	-	-	-	-	-	-	-	-	**521**	-
1182/2/1	M	54	-	-	-	-	-	-	-	-	**521**	-
1183/1/1	M	59	-	-	-	-	-	-	-	-	**365**	-
1184/1/1	M	U	-	-	0.4	-	-	-	-	-	**626**	208
1184/2/1	F	U	-	-	**9.4**	-	-	-	-	-	-	-
1185/1/1	M	74	20.6	4.3	-	-	-	22	-	-	80	80
1185/2/1	F	72	20.6	4.3	-	-	-	-	-	-	-	-
1185/3/1	F	43	20.6	-	-	-	-	-	-	-	26	26
1186/1/1	F	U	-	-	-	-	-	-	-	-	**548**	-
1186/2/1	F	U	-	-	-	-	-	-	-	-	**548**	-
1188/1/1	M	56	-	2.6	2.2	-	-	-	-	-	-	39
1189/1/1	M	62	23.6	18.4	-	-	**235**	-	-	-	-	**652**
1189/2/1	F	U	23.6	18.4	-	-	-	-	-	-	-	-
1190/1/1	M	73	-	-	-	9	-	-	-	16	-	-
1191/1/1	M	U	**57.0**	-	-	-	-	-	-	**150**	**425**	242
1192/1/1	M	U	-	-	-	**75**	-	-	-	25	-	-
1192/2/1	M	U	-	-	-	**75**	-	-	-	25	-	-
1192/3/1	M	U	-	-	-	**75**	-	-	-	25	-	-
1193/1/1	M	58	-	1.6	-	-	-	-	-	**320**	-	-
1193/2/1	M	35	-	1.6	-	-	-	-	-	**320**	-	-
1193/3/1	F	55	-	1.6	-	-	**176**	-	-	**176**	-	-
1193/4/1	F	24	-	-	-	-	**176**	-	-	**176**	-	-
1195/1/1	M	68	**102.1**	**55.6**	**17.5**	-	-	-	35	-	**598**	**828**
1195/2/1	F	67	**44.9**	**40.9**	3.0	-	-	-	-	-	-	-
1195/3/1	M	44	**57.2**	**31.8**	**8.3**	-	-	-	**135**	-	-	156
1196/1/1	M	57	-	9.5	-	-	-	**360**	-	-	-	-
1196/2/1	F	54	-	10.6	-	-	-	-	-	-	**355**	-

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

Person ID number	Gender	Age	Fish	Crustaceans	Molluscs	Intertidal occupancy over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud, sand and stones	Intertidal occupancy over rock	Intertidal occupancy over salt marsh	Intertidal occupancy over sand	Intertidal occupancy over sand and stones
1196/3/1	M	21	-	9.2	-	-	-	**360**	-	-	-	-
1196/4/1	M	19	-	9.2	-	-	-	-	-	-	-	-
1197/1/1	F	69	-	-	-	-	-	-	-	-	**548**	-
1197/2/1	M	72	-	-	-	-	-	-	-	-	**548**	-
1198/1/1	M	U	-	-	-	-	-	-	-	-	**365**	-
1198/2/1	F	U	-	-	-	-	-	-	-	-	**365**	-

Notes

U = Unknown

Emboldened observations are the high-rate individuals

Annex 2a. Sellafield Fishing Community consumption and intertidal occupancy data reported in AEMR and RIFE (kg y^{-1} and h y^{-1})

Year (report)	FISH					CRUSTACEANS					MOLLUSCS				INTERTIDAL OCCUPANCY		Source of habits data	
	Species Composition	Total	Cod	Plaice	Other fish	Species Composition	Total	Crab	Lobster	*Nephrops or other crustaceans*	Species Composition	Total	Winkles	Other molluscs	Substrate	h y^{-1}	Consumption	Occupancy
1994 (AEMR 45)	Plaice and Cod (50%:50%)	26	13.0	13.0	0	Crabs and Lobsters (65%:35%)	12	7.8	4.2	0	Winkles and other molluscs (85%:15%)	9.7	8.2	1.5	-	0	1993/94 Survey	-
1995 (RIFE 1)	Plaice and Cod (50%:50%)	26	13.0	13.0	0	Crabs and Lobsters (75%:25%)	8.6	6.5	2.2	0	Winkles and other molluscs (50%:50%)	12	6.0	6.0	-	0	1995 Review (crust and moll) and 1993/4 survey (fish)	-
1996 (RIFE 2)	Plaice and Cod (50%:50%)	25	12.5	12.5	0	Crabs and Lobsters (60%:40%)	12	7.2	4.8	0	Winkles and other molluscs (60%:40%)	12	7.2	4.8	-	0	1995 Review (crust and moll) and 1996 logging data (fish)	-
1997 (RIFE 3)	Plaice and Cod (25%:75%)	37	27.8	9.3	0	Crabs, Lobsters and *Nephrops* (50%:40%:10%)	17	8.5	6.8	1.7	Winkles and other molluscs (40%:60%)	4.2	1.7	2.5	-	0	1997 Review	-
1998 (RIFE 4)	Plaice and Cod (50%:50%)	45	22.5	22.5	0	Crabs and Lobsters (85%:15%)	28	23.8	4.2	0	Winkles and other molluscs (30%:70%)	15	4.5	10.5	Sand and mollusc beds	1100	1998 Survey	1998 Survey
1999 (RIFE 5)	Plaice and Cod (50%:50%)	43	21.5	21.5	0	Crabs and Lobsters (80%:20%)	24	19.2	4.8	0	Winkles and other molluscs (50%:50%)	25	12.5	12.5	Sand and mollusc beds	1000	1999 Review	1999 Review
2000 (RIFE 6)	Cod and other fish (40%:60%)	31	12.4	0	18.6	Crabs, Lobsters and *Nephrops* (40%:40%:20%)	20	8.0	8.0	4.0	Winkles and other molluscs (50%:50%)	17	8.5	8.5	Sand and mollusc beds	1000	2000 Review	2000 Review
2001 (RIFE 7)	Cod and other fish (40%:60%)	31	12.4	0	18.6	Crabs, Lobsters and *Nephrops* (40%:40%:20%)	20	8.0	8.0	4.0	Winkles and other molluscs (50%:50%)	17	8.5	8.5	Sand and mollusc beds	900	2000 Review	2000 Review
2002 (RIFE 8)	Cod and other fish (40%:60%)	51	20.4	0	30.6	Crabs, Lobsters and *Nephrops* (50%:30%:20%)	16	8.0	4.8	3.2	Winkles and mussels (60%:40%)	29	17.4	11.6	Mud and sand	1200	2002 Review	2002 Review
2003 (RIFE 9)	Cod and other fish (60%:40%)	41	24.6	0	16.4	Crabs, Lobsters and *Nephrops* (80%:10%:10%)	27	21.6	2.7	2.7	Winkles and other molluscs (40%:60%)	34	13.6	20.4	Mud and sand	870	2003 Survey	2003 Survey
2004 (RIFE 10)	Cod and other fish (60%:40%)	41	24.6	0	16.4	Crabs, Lobsters and *Nephrops* (50%:40%:10%)	25	12.5	10.0	2.5	Winkles and other molluscs (50%:50%)	34	17.0	17.0	Mud and sand	1000	2004 Review (crust and moll) and 2003 Survey (fish)	2004 Review
2005 (RIFE 11)	Cod and other fish (60%:40%)	41	24.6	0	16.4	Crabs, Lobsters and *Nephrops* (60%:20%:20%)	20	12.0	4.0	4.0	Winkles and other molluscs (60%:40%)	33	19.8	13.2	Mud and sand	790	2005 Review (crust and moll) and 2003 Survey (fish)	2005 Review
2006 (RIFE 12)	Cod and other fish (60%:40%)	41	24.6	0	16.4	Crabs, Lobsters and *Nephrops* (50%:20%:30%)	20	10.0	4.0	6.0	Winkles and other molluscs (50%:50%)	40	20.0	20.0	Mud and sand	580	2006 Review (crust and moll) and 2003 Survey (fish)	2006 Review
2007 (RIFE 13)	Cod and other fish (60%:40%)	41	24.6	0	16.4	Crabs, Lobsters and *Nephrops* (50%:30%:20%)	20.4	10.2	6.1	4.1	Winkles and other molluscs (60%:40%)	28.9	17.3	11.6	Mud and sand	830	2007 Review (crust and moll) and 2003 Survey (fish)	2007 Review
2008 (RIFE 14)	Cod and other fish (25%:75%)	40	10.0	0	30.0	Crabs, Lobsters and *Nephrops* (70%:20%:10%)	16.8	11.8	3.4	1.7	Winkles and other molluscs (50%:50%)	31.4	15.7	15.7	Mud and sand	930	2008 Survey	2008 Survey
2009 (RIFE 15)	Cod and other fish (25%:75%)	40	10.0	0	30.0	Crabs, Lobsters and *Nephrops* (30%:50%:20%)	16	4.8	8	3.2	Winkles and other molluscs (60%:40%)	28	16.8	11.2	Mud and sand	960	2009 Review (crust & moll) 2008 Survey (fish)	2009 Review
2010 (RIFE 16)	Cod and other fish (25%:75%)	40	10.0	0	30.0	Crabs, Lobsters and *Nephrops* (50%:30%:20%)	22	11.0	6.6	4.4	Winkles and other molluscs (20%:80%)	22	4.4	17.6	Mud and sand	870	2010 Review (crust & moll) 2008 Survey (fish)	2010 Review
2011 (RIFE 17)	Cod and other fish (25%:75%)	40	10.0	0	30.0	Crabs, Lobsters and *Nephrops* (40%:30%:30%)	27	10.8	8.1	8.1	Winkles and other molluscs (60%:40%)	12	7.2	4.8	Mud and sand	840	2011 Review (crust & moll) 2008 Survey (fish)	2011 Review

Annex 2a. Sellafield Fishing Community consumption and intertidal occupancy data reported in AEMR and RIFE (kg y^{-1} and h y^{-1})

Year (report)	FISH					CRUSTACEANS					MOLLUSCS				INTERTIDAL OCCUPANCY		Source of habits data	
	Species Composition	Total	Cod	Plaice	Other fish	Species Composition	Total	Crab	Lobster	*Nephrops or other crustaceans*	Species Composition	Total	Winkles	Other molluscs	Substrate	h y^{-1}	Consumption	Occupancy
2012 (RIFE 18)	Cod and other fish (25%:75%)	37	9.3	0	27.8	Crabs, Lobsters and *Nephrops* (30%:20%:50%)	29	8.7	5.8	14.5	Winkles and other molluscs (60%:40%)	9.1	5.5	3.6	Mud and sand	850	2012 LLWR Habits Survey	2012 LLWR Habits Survey
2013 (RIFE 19)	Cod and other fish (40%:60%)	56	22.4	0	33.6	Crabs, Lobsters and *Nephrops* (20%:5%:75%)	25	5.0	1.2	18.8	Winkles and other molluscs (85%:15%)	15	12.8	2.2	Mud and sand	760	2013 Survey	2013 Survey
2014 (RIFE 20)	Cod and other fish (40%:60%)	56	22.4	0	33.6	Crabs, Lobsters and other crustaceans (25%:35%:40%)	36	9.0	12.6	14.4	Winkles and other molluscs (65%:35%)	11	7.2	3.8	Mud and sand	1100	2014 Review (crust and moll) 2013 Survey (fish)	2014 Review
2015 (RIFE 21)	Cod and other fish (25%:75%)	64	16.0	0	48.0	Crabs, Lobsters and other crustaceans (30%:40%:30%)	38	11.4	15.2	11.4	Winkles and other molluscs (55%:45%)	12	6.6	5.4	Mud and sand	1000	2015 Review	2015 Review
2016 (RIFE 22)	Cod and other fish (25%:75%)	60	15.0	0	45.0	Crabs, Lobsters and other crustaceans (30%:35%:35%)	37	11.0	13.0	13.0	Winkles and other molluscs (60%:40%)	12	7.2	4.8	Mud and sand	790	2016 Review	2016 Review

Annex 2b. Sellafield Fishing Community 5-year average consumption and intertidal occupancy rates (kg y^{-1} and h y^{-1})

5-year period	FISH				CRUSTACEANS				MOLLUSCS			EXTERNAL
	Total fish	Cod	Plaice	Other fish	Total crustaceans	Crab	Lobster	*Nephrops* or other crustaceans	Total molluscs	Winkles	Other molluscs	Intertidal occupancy
1994-98	31.8	17.8	14.1	0.0	15.5	10.8	4.4	0.3	10.6	5.5	5.1	1100
1995-99	35.2	19.5	15.8	0.0	17.9	13.0	4.6	0.3	13.6	6.4	7.3	1050
1996-00	36.2	19.3	13.2	3.7	20.2	13.3	5.7	1.1	14.6	6.9	7.8	1033
1997-01	37.4	19.3	10.7	7.4	21.8	13.5	6.4	1.9	15.6	7.1	8.5	1000
1998-02	40.2	17.8	8.8	13.6	21.6	13.4	6.0	2.2	20.6	10.3	10.3	1040
1999-03	39.4	18.3	4.3	16.8	21.4	13.0	5.7	2.8	24.4	12.1	12.3	994
2000-04	39.0	18.9	0.0	20.1	21.6	11.6	6.7	3.3	26.2	13.0	13.2	994
2001-05	41.0	21.3	0.0	19.7	21.6	12.4	5.9	3.3	29.4	15.3	14.1	952
2002-06	43.0	23.8	0.0	19.2	21.6	12.8	5.1	3.7	34.0	17.6	16.4	888
2003-07	41.0	24.6	0.0	16.4	22.5	13.3	5.4	3.9	34.0	17.5	16.4	814
2004-08	40.8	21.7	0.0	19.1	20.4	11.3	5.5	3.7	33.5	18.0	15.5	826
2005-09	40.6	18.8	0.0	21.8	18.6	9.8	5.1	3.8	32.3	17.9	14.3	818
2006-10	40.4	15.8	0.0	24.6	19.0	9.6	5.6	3.9	30.1	14.8	15.2	834
2007-11	40.2	12.9	0.0	27.3	20.4	9.7	6.4	4.3	24.5	12.3	12.2	886
2008-12	39.4	9.9	0.0	29.6	22.2	9.4	6.4	6.4	20.5	9.9	10.6	890
2009-13	42.6	12.3	0.0	30.3	23.8	8.1	5.9	9.8	17.2	9.3	7.9	856
2010-14	45.8	14.8	0.0	31.0	27.8	8.9	6.9	12.0	13.8	7.4	6.4	884
2011-15	50.6	16.0	0.0	34.6	31.0	9.0	8.6	13.4	11.8	7.8	4.0	910
2012-16	54.6	17.0	0.0	37.6	33.0	9.0	9.6	14.4	11.8	7.8	4.0	900

Annex 3. Summary of profiles for adults in the Sellafield area for use in the assessment of total dose

Profile Name	Number of individuals	Pathway Name: Crustacea	Direct	Eggs	Fish - Freshwater	Fish - Sea	Fruit - Domestic	Fruit and nuts - Wild	Gamma ext - saltmarsh	Gamma ext - sediments	Honey	Marine plants/algae	Meat - Cow	Meat - Game	Meat - Pig	Meat - Poultry	Meat - salt marsh grazed sheep	Meat - Sheep	Meat - Wildfowl	Milk	Mollusca	Mushrooms	Occupancy IN water	Occupancy ON water	Plume (IN; 0-0.25 km)	Plume (MID; >0.25-0.5 km)	Plume (OUT; <0.5-1 km)	Vegetables - Green	Vegetables - Other Domestic	Vegetables - Potatoes	Vegetables - Root
Notes:			1						2	3				4										5	5	5				
Units:		kg	-	kg	kg	kg	kg	kg	h	h	kg	kg	kg	kg	kg	kg	kg	kg	kg	l	kg	kg	h	h	h	h	h	kg	kg	kg	kg
Crustacean consumers	**18**	29.8	-	-	-	27.3	-	-	-	94	-	-	-	-	-	-	-	-	-	-	1.8	-	-	840	-	-	-	-	-	-	-
Occupants for direct radiation	**79**	0.39	1.00	1.8	-	1.8	1.1	0.37	-	66	-	-	1.7	-	0.28	0.25	-	0.61	-	3.8	0.02	-	-	4	240	740	2090	1.9	3.8	9.8	2.3
Egg consumers	**25**	0.04	0.40	15.3	0.23	3.8	6.9	2.4	-	22	-	-	5.7	3.6	-	2.6	-	3.2	0.95	-	<0.01	0.17	2	<1	640	1420	530	4.7	6.5	50.4	5.5
Freshwater fish consumers	**4**	-	-	17.8	1.4	3.3	2.3	6.8	-	-	-	-	-	0.23	-	0.68	-	-	-	-	-	0.23	-	-	-	-	-	2.9	-	165.1	8.8
Sea fish consumers	**12**	21.2	0.08	-	-	53.1	-	-	-	330	-	-	-	-	-	-	-	-	-	-	3.6	-	-	220	-	-	23	-	-	-	-
Domestic fruit consumers	**8**	-	0.25	3.9	-	-	32.7	0.99	-	<1	-	-	17.7	-	-	8.9	-	1.4	-	64.8	0.07	0.43	-	-	-	-	210	14.1	21.3	55.5	17.7
Wild fruit and nut consumers	**11**	0.09	0.36	14.3	0.51	7.3	4.0	5.3	-	28	-	-	6.1	8.1	-	4.5	-	3.9	2.2	-	0.02	0.08	4	-	-	1470	1260	3.0	2.4	63.3	3.2
Occupants over saltmarsh	**4**	1.2	-	-	-	-	-	-	250	88	-	-	-	-	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Occupants over sediment	**32**	3.1	0.13	-	-	7.9	0.09	0.02	-	680	-	-	-	-	-	-	-	-	-	3.2	0.67	-	-	20	19	-	25	1.1	1.4	0.88	1.5
Honey consumers	**4**	-	-	3.4	-	-	7.3	0.79	-	3	0.23	-	-	-	-	0.68	-	-	-	182.5	-	-	-	-	-	-	-	13.8	6.8	-	3.6
Marine plants and algae consumers	**2**	0.70	-	-	-	-	-	-	-	120	-	0.11	-	-	-	-	-	-	-	-	0.12	-	<1	-	-	-	-	-	-	-	-
Cattle meat consumers	**17**	-	0.24	4.5	-	-	5.1	0.47	-	1	-	-	38.1	-	8.9	0.82	-	4.5	0.16	30.5	0.03	-	-	-	1080	-	-	1.3	-	59.0	2.5
Game meat consumers	**3**	0.32	-	17.6	-	22.3	11.8	5.2	-	100	-	-	11.8	29.3	-	15.4	-	2.8	8.0	-	0.08	-	13	-	-	-	-	7.0	8.9	11.8	-
Pig meat consumers	**14**	-	0.14	-	-	-	-	0.06	-	-	-	-	13.5	-	17.3	0.50	-	3.1	0.19	-	-	-	-	-	-	-	920	1.3	-	1.3	2.1
Poultry meat consumers	**6**	0.16	-	8.8	-	11.2	12.6	3.1	-	52	-	-	5.9	14.7	-	20.5	-	1.4	4.0	-	0.04	-	7	-	-	-	-	9.3	7.9	40.1	4.8
Salt marsh grazed sheep consumers	**6**	0.80	-	-	-	-	-	-	170	59	-	-	-	-	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sheep meat consumers	**26**	-	0.08	3.0	-	-	3.9	0.78	-	1	-	-	19.4	-	5.8	0.54	-	9.4	0.10	19.9	0.02	0.04	-	-	-	620	-	0.86	0.55	7.5	1.7
Wildfowl consumers	**4**	0.24	-	13.2	-	16.7	8.8	3.9	4	80	-	-	8.9	22.3	-	12.3	-	2.1	10.2	-	0.06	-	10	-	-	-	-	5.3	6.7	8.8	-
Milk consumers	**15**	-	0.13	1.8	-	0.48	8.9	0.87	-	43	0.06	-	9.5	-	-	0.68	-	0.75	-	184.9	0.03	-	-	-	40	-	230	8.5	7.9	13.0	8.2
Mollusc consumers	**3**	29.1	-	-	-	53.1	-	-	-	530	-	-	-	-	-	-	-	-	-	-	11.7	-	-	52	-	-	-	-	-	-	-
Mushroom consumers	**2**	-	-	8.9	-	-	49.9	0.45	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7	-	-	-	-	-	39.6	58.9	82.8	46.7
Occupants IN Water	**2**	-	-	-	-	-	-	-	-	260	-	-	-	-	-	-	-	-	-	-	-	-	79	7	-	-	-	-	-	-	-
Occupants ON Water	**18**	12.9	-	-	-	10.9	-	-	-	40	-	-	-	-	-	-	-	-	0.31	-	0.02	-	-	1670	-	-	-	-	-	-	-
Occupants for plume pathways (0 - 0.25 km)	**2**	-	1.00	20.8	-	-	1.0	2.0	-	8	-	-	24.9	-	-	-	-	3.0	-	-	-	-	-	-	7070	-	-	-	-	131.6	-
Occupants for plume pathways (>0.25 - 0.5 km)	**6**	-	1.00	8.2	-	1.1	3.2	1.4	-	75	-	-	5.2	-	-	-	-	5.7	-	-	-	-	-	-	-	7770	-	4.1	4.5	4.2	0.44
Occupants for plume pathways (>0.5 - 1 km)	**18**	-	1.00	1.4	-	0.86	0.48	0.89	-	16	-	-	-	-	1.2	1.1	-	0.14	-	11.1	-	-	-	<1	-	-	6800	1.6	2.8	7.4	2.7
Green vegetable consumers	**15**	-	0.33	2.1	-	0.48	11.1	0.40	-	44	0.06	-	-	-	-	0.96	-	-	-	62.5	-	0.23	-	-	40	-	1050	21.6	28.0	27.2	24.1
Other domestic vegetable consumers	**6**	-	0.50	3.0	-	1.2	18.7	0.32	-	110	-	-	-	-	-	-	-	-	-	34.6	-	0.57	-	-	100	-	160	31.1	59.0	41.1	42.4
Potato consumers	**16**	-	0.25	9.5	0.35	0.82	9.1	2.2	-	<1	-	-	10.9	0.06	-	4.2	-	1.3	-	-	-	0.27	-	-	1150	-	-	6.3	8.7	124.3	9.7
Root vegetable consumers	**10**	-	0.50	1.8	-	0.73	13.2	0.28	-	64	-	-	-	-	-	-	-	-	-	20.7	-	0.34	-	-	61	-	1570	24.4	39.3	38.6	33.9

Notes:

1. Expressed as the proportion of the profile members who are exposed to direct radiation.
2. Gamma ext - saltmarsh only includes occupancy over saltmarsh.
3. Gamma ext - sediments represents occupancy over mud; mud and sand; mud, sand and stones; sand; sand and stones.
4. Game meat includes venison and rabbits/hares.
5. Plume times are the sums of individuals' indoor and outdoor times.

The data used for these profiles is the 2013 Sellafield Habits Survey data updated with the 2014, 2015 and 2016 Sellafield Review data.
The means of the high-rate groups are determined by the 'cut-off' method and are highlighted on the diagonal.

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Customer focus

We offer a range of multidisciplinary bespoke scientific programmes covering a range of sectors, both public and private. Our broad capability covers shelf sea dynamics, climate effects on the aquatic environment, ecosystems and food security. We are growing our business in overseas markets, with a particular emphasis on Kuwait and the Middle East.

Our customer base and partnerships are broad, spanning Government, public and private sectors, academia, non-governmental organisations (NGOs), at home and internationally.

We work with:

- a wide range of UK Government departments and agencies, including Department for the Environment Food and Rural Affairs (Defra) and Department for Energy and Climate and Change (DECC), Natural Resources Wales, Scotland, Northern Ireland and governments overseas.
- industries across a range of sectors including offshore renewable energy, oil and gas emergency response, marine surveying, fishing and aquaculture.
- other scientists from research councils, universities and EU research programmes.
- NGOs interested in marine and freshwater.
- local communities and voluntary groups, active in protecting the coastal, marine and freshwater environments.

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