Cefas

Radiological Habits Survey: Sellafield Review, 2007

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Radiological Habits Survey: Sellafield Review, 2007

Shellfish consumption and intertidal occupancy review

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The Centre for Environment, Fisheries & Aquaculture Science
Lowestoft Laboratory
Pakefield Road
Lowestoft
Suffolk
NR33 0HT

F.J. Clyne

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Peer reviewed by C.J. Garrod

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1. Introduction

This report describes a review of public radiation exposure pathways relating to liquid radioactive waste discharges from the Sellafield Ltd, and the United Kingdom Atomic Energy Authority (UKAEA) Windscale sites. It is also relevant to liquid discharges from the Drigg low-level waste repository site. The study was funded by the Food Standards Agency (FSA), the Environment Agency (EA) and the Health and Safety Executive (HSE), to support their roles in protecting the public from the effects of radiation.

The review specifically investigated the consumption of crustaceans and molluscs, and occupancy over intertidal substrates by members of the Sellafield Fishing Community. Reviews are conducted annually because of the importance of the shellfish consumption and intertidal occupancy pathways in the Sellafield area. Additionally, consumption and occupancy rates have been known to vary significantly from year to year with some people ceasing shellfish consumption, collection or fishing, and new individuals being identified. The last combined habits survey in the vicinity of Sellafield was conducted by the Centre for Environment, Fisheries & Aquaculture Science (Cefas) in 2003 (Clyne *et al*, 2004). Prior to this and in 2004, 2005 and 2006, annual reviews of shellfish consumption and occupancy over intertidal substrates have been conducted.

During 2007, in addition to the review, several of the higher rate consumers of shellfish logged their seafood consumption and intertidal occupancies for a two week period every three months. This logging data can be used to check the validity of the interview data if consumption rates are considered to be unreasonably high.

2. Survey area

The survey area, shown in Figure 1, extended from Parton to Tarn Bay, and 11 km offshore.

Figure 1. The Sellafield aquatic review area

3. Conduct of the survey

Prior to the fieldwork, individuals noted to have high rates of crustacean and mollusc consumption and/or intertidal occupancy in previous reviews were contacted and where possible interview times were arranged.

The fieldwork was carried out from 12th – 15th October 2007, by a team of three people. During the fieldwork, individuals were interviewed and asked to estimate crustacean and mollusc consumption rates, and occupancy rates over intertidal areas for themselves and members of their families. Interviewees were also asked to provide consumption rates for fish in order to determine valid combinations of pathways and to assess the dose to the Sellafield Fishing Community. Information was also obtained about the origins of the seafood being consumed and locations of intertidal occupancy.

There were several interviewees who were not available at the time of the fieldwork. Interviews with these individuals were conducted after the fieldwork by the Cefas team at Whitehaven and by phone interviews by the Cefas team at Lowestoft.

Observations for 38 adults and 4 children were recorded for the 2007 Sellafield review. Children were identified spending time on intertidal areas but not consuming seafood.

4. Methods of data analysis

4.1 Data recording

Consumption and occupancy data collected during interviews were recorded in logbooks. These data were examined and any notably high rates were double-checked, by means of a follow-up phone call. 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.

All consumption and occupancy data in the text of this report are rounded to two significant figures to reflect the author's judgement on the accuracy of the methods used. In the tables and annexes, the consumption rate data are presented to one decimal place. External exposure data are presented as integers.

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

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

4.2 Data analysis

The main outputs of the Sellafield review are the individuals' consumption and occupancy rates given in Annexes 1 and 2 for adults and children, respectively. These data can be used in dose assessments for the Sellafield area. It is only with the outcome of such assessments that the critical group can strictly be identified as those most exposed.

The consumption and occupancy data have been analysed in three ways. Firstly, the 'cut-off' method described by Hunt *et al.* (1982) was used. With the 'cut-off' method, the appropriate high rate was calculated by taking the arithmetic mean of the maximum observed rate and all observed rates within a factor of 3 of the maximum value (termed the lower threshold value). For ease of presentation in this report, the term 'critical group rate' is used to represent the data derived by the 'cut-off' method. Secondly, 97.5th percentile rates were calculated using the Excel mathematical function for calculating percentiles. Thirdly, data has been profiled using the 'cut-off' approach. This gives a complete view of the habits of the individuals that are used to assess total dose integrated across all pathways of exposure. The profiled habits matrix in this report contains data from the 2003 Sellafield combined habits survey which has been updated with the 2004, 2005, 2006 and 2007 Sellafield review data.

The calculated values in the tables (row totals, critical group consumption rates and 97.5th percentile rates) are based on un-rounded data.

5. Internal exposure

Adult consumption data for crustaceans and molluscs are presented in Tables 1 and 2, respectively. The consumption of seafood by children was not identified. The Sellafield review did not target fish consumers. However, fish consumption rates were collected during interviews with members of the Sellafield Fishing Community and these are presented in Annex 1.

5.1. Crustaceans

The main species of crustaceans consumed were crabs, lobsters and *Nephrops*, with a small amount of brown shrimps. The mean critical group consumption rate for crustaceans was 20 kg/y based on 11 observations (maximum rate 27 kg/y). The observed 97.5th percentile rate based on 24 observations was 26 kg/y.

Table 1. Adults' consumption rates of crustaceans in the Sellafield area (kg/y)

Observation number	Brown shrimp	Crab	Lobster	*Nephrops*	Total
9		**22.1**	**4.7**		**26.8**
7		**11.3**	**14.7**		**26.0**
8		**11.3**	**14.7**		**26.0**
34		**2.1**	**5.0**	**13.8**	**20.9**
35		**2.1**	**5.0**	**13.8**	**20.9**
38		**18.4**	**1.4**		**19.8**
10		**14.7**	**4.7**		**19.4**
36	**1.5**	**15.7**			**17.2**
24		**3.7**	**3.0**	**9.8**	**16.5**
30	**8.1**	**4.7**	**3.2**		**16.0**
11		**14.9**			**14.9**
37		7.9			7.9
23				7.3	7.3
32	0.4	2.4	3.7		6.5
31	0.4	2.4	3.7		6.5
22		4.5			4.5
29	4.4				4.4
33	0.4		3.7		4.1
39	0.7	2.0	0.8		3.6
40	0.7	2.0	0.8		3.6
20	0.5				0.5
21	0.5				0.5
41				0.3	0.3
42				0.3	0.3

Emboldened observations are the critical group members

5.2 Molluscs

The main species of molluscs consumed were winkles, mussels, whelks and cockles, with small amounts of clams, razor shells, Pacific oysters and limpets. The mean critical group consumption rate for molluscs was 29 kg/y based on seven observations (maximum rate 45 kg/y). The observed 97.5th percentile rate based on 19 observations was 45 kg/y.

Table 2. Adults' consumption rates of molluscs in the Sellafield area (kg/y)

Observation number	Clam	Cockle	Limpet	Mussel	Pacific oyster	Razor shell	Whelk	Winkle	Total
41			**0.1**	**11.9**				**32.7**	**44.7**
42				**11.9**				**32.7**	**44.6**
36		**2.9**				**1.0**	**29.4**		**33.2**
29	**1.4**	**13.3**		**13.6**	**0.4**		**2.5**	**1.7**	**32.8**
4								**15.6**	**15.6**
5								**15.6**	**15.6**
6								**15.6**	**15.6**
22				7.8				5.9	13.7
38		5.9		2.9				0.5	9.4
24		6.6		0.2		1.0			7.8
34				3.9		2.4			6.2
7		2.7							2.7
39				0.7		1.3		0.6	2.5
40				0.7		1.3		0.6	2.5
31		2.4							2.4
32		2.4							2.4
35						2.4			2.4
30		0.1		0.2				0.3	0.6
23		0.2		0.2					0.5

Emboldened observations are the critical group members

5.3 Species composition of the shellfish critical groups

The percentage composition for the predominant shellfish species consumed in the critical groups rounded to the nearest 10% are as follows:

- Crustacean mean critical group consumption rate 20 kg/y - 50% crab, 30% lobster and 20% *Nephrops*
- Mollusc mean critical group consumption rate 29 kg/y - 60% winkles and 40% other molluscs

The 2006 rates and percentage composition currently used for dose assessments are:

- Crustacean mean critical group consumption rate 20 kg/y - 50% crab, 30% *Nephrops and* 20% lobster
- Mollusc mean critical group consumption rate 40 kg/y - 50% winkles and 50% other molluscs

In 2007, the mean critical group consumption rate for crustaceans remained the same rate as in 2006. There was a decrease of 11 kg/y in the mean critical group consumption rate of molluscs

in 2007. The main species of crustaceans and molluscs consumed in 2007 remained the same as in 2006. The percentage breakdown of species changed in both groups in 2007. For crustaceans, there was an increase in lobster consumption and a decrease in *Nephrops* consumption, and for molluscs, there was an increase in winkle consumption and a decrease in the consumption of other molluscs.

5.4 Consumption trends

The mean critical group consumption rate trends for crustaceans and molluscs over ten years (1998 - 2007) are shown in Figures 2 and 3. The raw data are presented in Annex 3a.

Figure 2. Mean critical group consumption rates of crustaceans, 1998 – 2007 (kg/y)

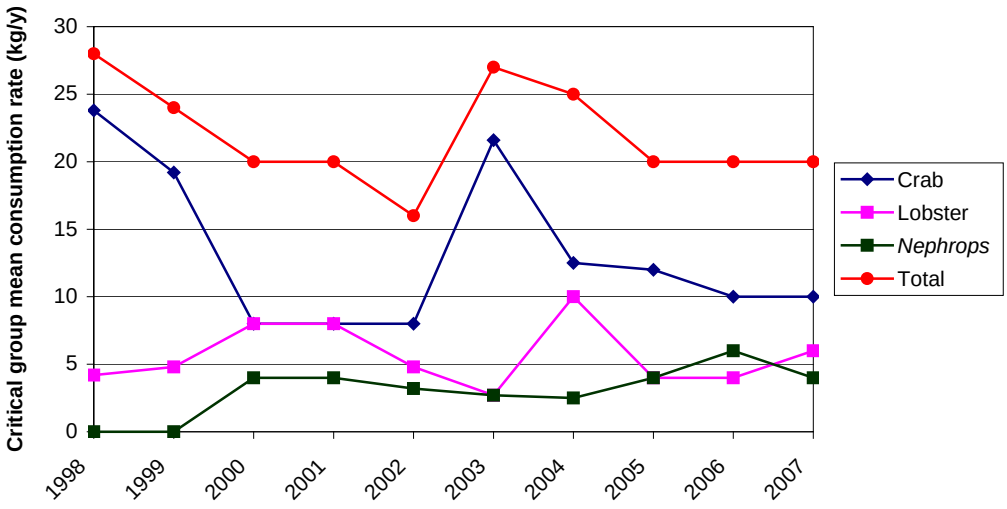
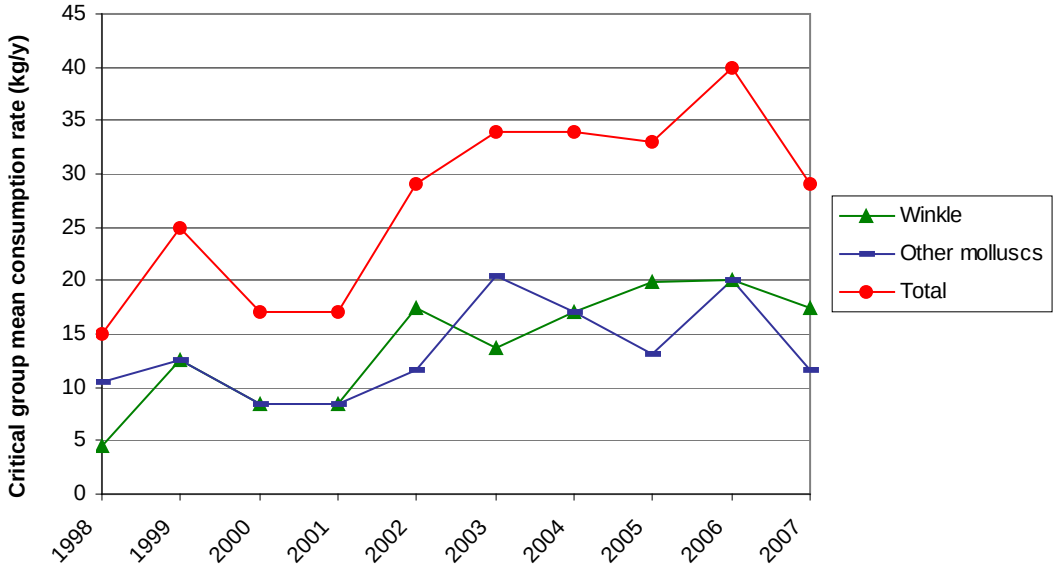


Figure 3. Mean critical group consumption rates of molluscs, 1998 – 2007 (kg/y)



5.5 Fish

The consumption of fish was not targeted during the Sellafield review; therefore there is insufficient data to calculate a valid new critical group rate. For dose assessments purposes, the mean critical group consumption rate of 41 kg/y for fish will be retained from the 2003 Sellafield combined habits survey.

6. External exposure

For external exposure pathways, the review targeted intertidal occupancy in the Sellafield area. Data were not collected for the handling of sediment or fishing gear.

6.1 Intertidal occupancy

In 2007, intertidal occupancy rates were noted for three different substrate types: mud and sand, rock, and sand and stones. These rates and substrates are shown in Tables 3 and 4 for adults and children, respectively. The review did not target intertidal occupancy over salt marsh. Therefore, for assessments purposes, the mean critical group rate of 400 h/y for occupancy over salt marsh will be retained from the 2003 Sellafield combined habits survey.

Adults

Three individuals undertaking bait digging, collecting cockles and winkles, angling and boat maintenance formed the critical group over mud and sand with a mean occupancy rate of 830 h/y. The maximum occupancy rate over mud and sand was 1300 h/y for an individual who was collecting winkles and bait digging. The observed 97.5th percentile rate based on 11 observations for mud and sand was 1100 h/y.

Two individuals undertaking angling, hooking for lobster, and collecting mussels and winkles formed the critical group over rock with a mean occupancy rate of 660 h/y. The maximum occupancy rate over rock was 800 h/y for an individual who was angling and hooking for lobster. The observed 97.5th percentile rate based on four observations for rock was 780 h/y.

Seven individuals undertaking angling, set-netting, collecting winkles and cockles, playing, dog walking and beach combing formed the critical group over sand and stones with a mean occupancy rate of 640 h/y. The maximum occupancy rate over sand and stones was 1100 h/y for an individual who was angling. The observed 97.5th percentile rate based on 15 observations for sand and stones was 1100 h/y.

These rates compare with the mean occupancy rates identified during the 2006 review of 580 h/y over mud and sand for four individuals (maximum rate 730 h/y) and 340 h/y over sand and stones for eight individuals (maximum rate 500 h/y). No occupancy over rock was identified in 2006.

Table 3. Adults' intertidal occupancy rates in the Sellafield area (h/y)

Observation number	Location	Activity	Mud and sand	Rock	Sand and stones
3	**Drigg and Braystones**	**Bait digging**	**1272**		
	Nethertown	**Collecting winkles**			
36	**Ravenglass**	**Collecting cockles**	**728**		
	Various locations	**Angling**			**416**
38	**Ravenglass beach**	**Boat maintenance**	**504**		
	Whitehaven harbour	**Bait digging**			
	Whitehaven beach	Collecting winkles			24
1	North of Whitehaven west pier	Bait digging	218		
	Braystones	Angling			
2	North of Whitehaven west pier	Bait digging	218		
	Braystones	Angling			
34	Ravenglass	Collecting mussels	146		
	Drigg	Bait digging			
	Various locations	**Angling**			**560**
42	Barrow Mouth and Whitehaven	Collecting winkles	132		
	Ravenglass beach	Collecting mussels			
	Whitehaven beach	Dog walking			220
29	Ravenglass	Collecting mussels and cockles	100		
	Whitriggs Scar	Collecting winkles		50	
	Various locations	Beach combing			312
23	Braystones	Bait digging	86		
	Ravenglass and Drigg	**Collecting mussels**		**527**	
	Parton to Drigg	**Collecting winkles**			
	St Bees to Drigg	**Angling**			
	Parton to Drigg	**Collecting winkles**			**1051**
	St Bees to Drigg	**Angling**			
	Ravenglass	**Collecting cockles**			
	Braystones	**Collecting winkles and setting nets**			
18	Seascale	Bait digging	31		
	Sellafield, Drigg and Seascale	Angling			310
20	Braystones	Bait digging	15		
	Braystones	Angling and long-lining			310
	Braystones to the River Ehen	Beach combing			24
30	**St Bees**	**Hooking**		**799**	
	Parton	**Angling**			
24	St Bees to Drigg	Angling		86	
	Braystones	**Setting nets and playing**			**414**
	St Bees to Drigg	**Angling**			
15	**Drigg beach**	**Dog walking**			**1095**
13	**Drigg beach**	**Angling**			**520**
39	**Braystones**	**Angling**			**416**
40	Braystones	Angling			208
16	Drigg beach	Walking			60
17	Drigg beach	Walking			60

Emboldened observations are the critical group members

Children

No children in the 15-year-old age group, the 1-year-old age group or the 3-month-old age group were identified spending time on intertidal substrates.

10-year-old age group

The only occupancy rate recorded over rock was 220 h/y for an individual who was angling and collecting winkles. No other individuals were identified spending time over rock, so the mean occupancy rate for this group was 220 h/y. The observed 97.5th percentile rate is not applicable for 1 observation.

The maximum occupancy rate recorded over sand and stones was 260 h/y for three individuals who were playing on the beach. No other individuals were identified spending time over sand and stones so the mean occupancy rate for this group was 260 h/y. The observed 97.5th percentile rate based on 3 observations for sand and stones was 260 h/y.

5-year-old age group

The only occupancy rate recorded over sand and stones was 260 h/y for an individual who was playing on the beach. No other individuals were identified spending time over sand and stones, so the mean occupancy rate for this group was 260 h/y. The observed 97.5th percentile rate is not applicable for 1 observation.

Table 4. Children's intertidal occupancy rates in the Sellafield area (h/y)

Observation number	Age	Location	Activity	Rock	Sand and stones
10-year-old age group					
28	**8**	**St Bees to Drigg**	**Angling**	**220**	
		Parton to Drigg	**Collecting winkles**		
		Braystones	**Playing**		**258**
25	**11**	**Braystones**	**Playing**		**258**
26	**9**	**Braystones**	**Playing**		**258**
5-year-old age group					
27	**4**	**Braystones**	**Playing**		**258**

Emboldened observations are the critical group members

6.2 Handling sediment and fishing gear

The Sellafield review did not target the handling of sediment and fishing gear, therefore, for assessments purposes, the mean critical group rates will be retained from the 2003 Sellafield combined habits survey. These were, 1000 h/y for handling sediment and 730 h/y for handling fishing gear.

7. Use of habits data for dose assessments

7.1 Aquatic combinations for the Sellafield Fishing Community

The Radioactivity in Food and the Environment (RIFE) Sellafield Fishing Community aquatic assessments for 2007 will be based on the combinations of consumption and occupancy pathways presented in Table 5. The pathways for each observation number have been combined to show all consumption and occupancy rates for each individual. This provides evidence of individuals' membership of multiple critical groups, supporting the continuation of assessing the critical group dose based on a combination of internal and external pathways. For example, observation number 36 is in the critical groups for crustaceans, molluscs and intertidal occupancy and also consumes significant amounts of fish. As the consumption of fish was not targeted during the Sellafield review, the mean critical group consumption rate for fish will be retained from the 2003 Sellafield combined habits survey for use in assessments. The fish consumption rates shown in Table 5 will not be used in assessments but are presented to highlight the combination of pathways for assessments purposes.

Table 5. Aquatic combinations for the Sellafield Fishing Community

	Internal exposure (kg/y)			External exposure (h/y)		
Observation number	Fish	Crustaceans	Molluscs	Mud and sand	Rock	Sand and stones
24	*80.7*	**16.5**	7.8		86	**414**
36	*59.0*	**17.2**	**33.2**	**728**		**416**
1	*31.7*			218		
22	*31.3*	4.5	13.7			
37	*29.5*	7.9				
23	*29.3*	7.3	0.5	86	**527**	**1051**
30	*19.7*	**16.0**	0.6		**799**	
34	*19.1*	**20.9**	6.2	146		**560**
35	*19.1*	**20.9**	2.4			
11	*14.3*	**14.9**				
38	*12.9*	**19.8**	9.4	**504**		24
7	*6.1*	**26.0**	2.7			
8	*6.1*	**26.0**				
13	*4.5*					**520**
4	*2.3*		**15.6**			
5	*2.3*		**15.6**			
3	*2.3*			**1272**		
9		**26.8**				
10		**19.4**				
29		4.4	**32.8**	100	50	312
39		3.6	2.5			**416**
41		0.3	**44.7**			
42		0.3	**44.6**	132		220
6			**15.6**			
15						

Emboldened observations are the critical group members

7.2 Sellafield 5-year average

Annex 3a presents the annual RIFE aquatic consumption and occupancy rates for the Sellafield Fishing Community and Annex 3b presents the 5-year rolling averages. The 5-year average (2003-2007) of the critical group rates (for fish, crustaceans, molluscs and intertidal occupancy) will be used in assessments and presented in RIFE 13 in order to provide a longer term trend of dose to members of the Sellafield Fishing Community group.

7.3 Profiled habits data

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 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 Sellafield are made using these profiles and reported in the RIFE reports (e.g. EA, EHS, FSA and SEPA, 2007).

The relevant matrix for the Sellafield adults' profiled habits data is presented in Annex 4. It is based on data from the 2003 Sellafield combined habits survey (aquatic and terrestrial pathways and direct radiation), which has been updated with subsequent Sellafield annual aquatic reviews from 2004, 2005, 2006 and 2007. All pathways and observations from the original 2003 profiled habits matrix were retained and for each new Sellafield review, only data relating to pathways asked about during the review were updated. Data for all other pathways not asked about during the review were retained. If data were collected for new interviewees, these were added as new observations. Because the profiles have been updated, the profiled data shown in Annex 4 are not comparable with data from Annex 1.

8. Summary and recommendations

The survey investigated the consumption of shellfish, and intertidal occupancy, relating to liquid discharges from the Sellafield nuclear site. Fish consumption was not targeted during the survey but was collected during interviews with the Sellafield Fishing Community. Consumption and occupancy data were collected for 38 adults and occupancy data was collected for 4 children.

The mean critical group rates from the 2007 Sellafield review are as follows:

- Crustaceans 20 kg/y
- Molluscs 29 kg/y
- Occupancy over mud and sand 830 h/y
- Occupancy over rock 660 h/y
- Occupancy over sand and stones 640 h/y

In comparison to the 2006 Sellafield review, the critical group rates in 2007 remained unchanged for crustaceans, decreased by 11 kg/y for molluscs, increased by 250 h/y for occupancy over mud and sand and increased by 300 h/y for occupancy over sand and stones.

The mean critical group rates retained from the 2003 Sellafield combined habits survey are as follows:

- Fish 41 kg/y
- Occupancy over salt marsh 400 h/y
- Handling sediment 1000 h/y
- Handling fishing gear 730 h/y

The recommended 5-year averages for use in RIFE 13 dose assessments are as follows:

- Fish 41 kg/y
- Crabs 13 kg/y
- Lobsters 5.4 kg/y
- Nephrops 3.9 kg/y
- Winkles 18 kg/y
- Other molluscs 16 kg/y
- Occupancy over mud and sand 810 h/y

9. References

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

Observation number	Sex	Age (years)	Fish	Crustaceans	Molluscs	Intertidal occupancy over mud and sand	Intertidal occupancy over rock	Intertidal occupancy over sand and stones
1	M	U	31.7			218		
2	M	U				218		
3	M	U	2.3			**1272**		
4	F	U	2.3		**15.6**			
5	M	U	2.3		**15.6**			
6	F	U			**15.6**			
7	M	U	6.1	**26.0**	2.7			
8	F	U	6.1	**26.0**				
9	M	U		**26.8**				
10	F	U		**19.4**				
11	M	U	14.3	**14.9**				
12	F	U	14.3					
13	M	41	4.5					**520**
14	F	41	4.5					
15	M	U						**1095**
16	M	35						60
17	M	35						60
18	M	45	17.4			31		310
19	F	45	17.4					
20	M	76	15.0	0.5		15		334
21	F	U	4.1	0.5				
22	M	U	31.3	4.5	13.7			
23	M	U	29.3	7.3	0.5	86	**527**	**1051**
24	F	U	80.7	**16.5**	7.8		86	**414**
29	M	U		4.4	**32.8**	100	50	312
30	M	U	19.7	**16.0**	0.6		**799**	
31	M	U	6.8	6.5	2.4			
32	F	U		6.5	2.4			
33	F	U		4.1				
34	M	U	19.1	**20.9**	6.2	146		**560**
35	M	U	19.1	**20.9**	2.4			
36	M	U	59.0	**17.2**	**33.2**	**728**		**416**
37	F	U	29.5	7.9				
38	M	U	12.9	**19.8**	9.4	**504**		24
39	M	U		3.6	2.5			**416**
40	M	U		3.6	2.5			208
41	M	19		0.3	**44.7**			
42	M	49		0.3	**44.6**	132		220

Notes

Emboldened observations are the critical group members

U = unknown

Annex 2. Children's occupancy rates in the Sellafield area (h/y)

Observation number	Sex	Age (years)	Intertidal occupancy over rock	Intertidal occupancy over sand and stones
10-year-old age group				
25	M	11		**258**
26	M	9		**258**
28	M	8	**220**	**258**
5-year-old age group				
27	F	4		**258**

Notes

Emboldened observations are the critical group members

Annex 3a. Sellafield Fishing Community consumption and occupancy data reported in AEMR and RIFE (kg/y and h/y)

	FISH					CRUSTACEANS					MOLLUSCS				OCCUPANCY		Source of habits data	
Year (report)	**Species**	**Total**	**Cod**	**Plaice**	**Other fish**	**Species**	**Total**	**Crab**	**Lobster**	***Nephrops***	**Species**	**Total**	**Winkles**	**Other molluscs**	**Substrate**	**h/y**	**Consumption**	**Occupancy**
1994 (AEMR 45)	Plaice and cod (50%:50%)	26.0	13.0	13.0	0.0	Crab and lobster (65%:35%)	12.0	7.8	4.2	0.0	Winkles and other molluscs (85%:15%)	9.7	8.2	1.5	-	-	1993/94 Survey	-
1995 (RIFE 1)	Plaice and cod (50%:50%)	26.0	13.0	13.0	0.0	Crab and lobster (75%:25%)	8.6	6.5	2.2	0.0	Winkles and other molluscs (50%:50%)	12.0	6.0	6.0	-	-	1995 Review (crust and moll) and 1993/4 survey (fish)	-
1996 (RIFE 2)	Plaice and cod (50%:50%)	25.0	12.5	12.5	0.0	Crab and lobster (60%:40%)	12.0	7.2	4.8	0.0	Winkles and other molluscs (60%:40%)	12.0	7.2	4.8	-	-	1995 Review (crust and moll) and 1996 logging data (fish)	-
1997 (RIFE 3)	Plaice and cod (25%:75%)	37.0	27.8	9.3	0.0	Crab, lobster and *Nephrops* (50%:40%:10%)	17.0	8.5	6.8	1.7	Winkles and other molluscs (40%:60%)	4.2	1.7	2.5	-	-	1997 Review	-
1998 (RIFE 4)	Plaice and cod (50%:50%)	45.0	22.5	22.5	0.0	Crab and lobster (85%:15%)	28.0	23.8	4.2	0.0	Winkles and other molluscs (30%:70%)	15.0	4.5	10.5	Sand and mollusc beds	1100	1998 Survey	1998 Survey
1999 (RIFE 5)	Plaice and cod (50%:50%)	43.0	21.5	21.5	0.0	Crab and lobster (80%:20%)	24.0	19.2	4.8	0.0	Winkles and other molluscs (50%:50%)	25.0	12.5	12.5	Sand and mollusc beds	1000	1999 Review	1999 Review
2000 (RIFE 6)	Cod and other fish (40%:60%)	31.0	12.4	0.0	18.6	Crab, lobster and *Nephrops* (40%:40%:20%)	20.0	8.0	8.0	4.0	Winkles and other molluscs (50%:50%)	17.0	8.5	8.5	Sand and mollusc beds	1000	2000 Review	2000 Review
2001 (RIFE 7)	Cod and other fish (40%:60%)	31.0	12.4	0.0	18.6	Crab, lobster and *Nephrops* (40%:40%:20%)	20.0	8.0	8.0	4.0	Winkles and other molluscs (50%:50%)	17.0	8.5	8.5	Sand and mollusc beds	900	2000 Review	2000 Review
2002 (RIFE 8)	Cod and other fish (40%:60%)	51.0	20.4	0.0	30.6	Crab, lobster and *Nephrops* (50%:30%:20%)	16.0	8.0	4.8	3.2	Winkles and mussels (60%:40%)	29.0	17.4	11.6	Mud and sand	1200	2002 Review	2002 Review
2003 (RIFE 9)	Cod and other fish (60%:40%)	41.0	24.6	0.0	16.4	Crab, lobster and *Nephrops* (80%:10%:10%)	27.0	21.6	2.7	2.7	Winkles and other molluscs (40%:60%)	34.0	13.6	20.4	Mud and sand	870	2003 Survey	2003 Survey
2004 (RIFE 10)	Cod and other fish (60%:40%)	41.0	24.6	0.0	16.4	Crab, lobster and *Nephrops* (50%:40%:10%)	25.0	12.5	10.0	2.5	Winkles and other molluscs (50%:50%)	34.0	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%)	41.0	24.6	0.0	16.4	Crab, lobster and *Nephrops* (60%:20%:20%)	20.0	12.0	4.0	4.0	Winkles and other molluscs (60%:40%)	33.0	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%)	41.0	24.6	0.0	16.4	Crabs, lobsters and *Nephrops* (50%:20%:30%)	20.0	10.0	4.0	6.0	Winkles and other molluscs (50%:50%)	40.0	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%)	41.0	24.6	0.0	16.4	Crab, lobster 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

Annex 3b. Sellafield Fishing Community 5-year average data (kg/y and h/y)

	FISH				CRUSTACEANS				MOLLUSCS			EXTERNAL
5-year period	**Total fish**	**Cod**	**Plaice**	**Other fish**	**Total crustaceans**	**Crab**	**Lobster**	***Nephrops***	**Total molluscs**	**Winkles**	**Other molluscs**	**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

Annex 4. Summary of adults' profiled consumption data (kg/y or l/y) and occupancy data (h/y) in the Sellafield area (2003 - 2007)

		Pathway Name																								
Profile Name	**Number of individuals**	Crustacea	Direct[a]	Eggs	Fish - Freshwater	Fish - Sea	Fruit - Domestic	Fruit and nuts - Wild	Gamma ext - Sand/Mud[b]	Gamma ext - Saltmarsh[c]	Honey	Meat - Cow	Meat - Game[d]	Meat - Poultry	Meat - Sheep	Milk	Mollusca	Mushrooms	Occupancy in water	Occupancy on water	Plume (IN; 0-0.25km)[e]	Plume (MID; 0.25-0.5km)[e]	Plume (OUT; 0.5-1km)[e]	Vegetables - Green	Vegetables - Other Domestic	Vegetables - Potatoes	Vegetables - Root
Crustacean consumers	16	18				25.4			220				1				7.4			180						
Occupants for direct radiation	74		1	3.7		0.6	0.8	0.5	50			6	0.1	0.5	1.6	46.8		0.1		10	890	910	1660	0.8	1	7.2	1
Egg consumers	58		0.4	13.1		0.6	4.8	0.8	10			10.9		1.9	3.1	92		0.2			1020	870	500	6.2	4.7	30.2	6
Freshwater fish consumers	10			1.2	0.2	1.4			30				0.3	2				0.1								33.3	
Sea fish consumers	24	5.7				43.8			360				0.6				3.5			90							
Domestic fruit consumers	13			6.4			32.1	0.3	20		1.5			3.1	1.6			0.1		10				15.3	25.5	65.9	21.4
Wild fruit and nut consumers	13		0.6	10		0.1	3.7	3.4				7.3	0.2	1	2	8		0.4			2170	1810	8.7	3.7	36	10.9
Occupants for exposure - Sand/Mud	63	1.4				6.9			740				0.2				1			10		10					
Occupants for exposure - Saltmarsh	3	4.8				9.4			380	170			3.4				0.1										
Honey consumers	4						42.1	0.7	80		5			2.8						40				3.5	12.9	12.3	19
Cattle meat consumers	28		0.3	5.2		0.1	1.4	0.5				46.3	0.1	2.4	6.4	113.9		0.2			820	460	1010	0.1	2	28.8	2.8
Game meat consumers	3												25.7	6.1													
Poultry meat consumers	24		0.3	6.2		0.2	10.2	0.6	10		0.3	17.7	3.4	6.6	6.3	57.8		0.3		10	690	530	500	2.5	6.9	31.9	6.4
Sheep meat consumers	6		0.7	8.9			5.4	2				49.8	0.5	3.9	23.6	139		0.4				2130	2020	0.3	2.4	1.5	1.9
Milk consumers	35		0.4	4.8		0.4	1.7	0.4	20			12.7		0.9	2	260					1360	1030	470	0.7	0.2	16.4	3.6
Mollusc consumers	8	3.9				9.6			240								29.9										
Mushroom consumers	9		0.2	6.6			11.1	1.3	10		0.1			0.6	1.7	46.1	0.1	2.1				1620	12	7.6	35.3	15.1
Occupancy in water	13																		90								
Occupants on water	11	9.7	0.1			20.6			80								1.2			590							
Occupants for plume pathways (inner area)	8		1	10.8		0.2		0.4	30			14.2		1.3	2.8	165.9					7370					3.2	
Occupants for plume pathways (middle area)	9		1	11.5			4.3	1.6	10			15.7		1.2	7.9	156.2		0.1				7140				36.8	1.1
Occupants for plume pathways (outer area)	19		1	3.4		0.6	1.1	0.9				10	0.1	0.9	1.3	38.2		0.5					6310	0.1	2.3	0.5	0.2
Green vegetable consumers	14		0.1	11.7		1.2	17.8	0.6						0.7	1.5			0.3					70	35.8	26.3	81.3	31.4
Other domestic vegetable consumers	9		0.1	9.3			21.4	0.1						1	2.3			0.2					110	32.8	38.4	93.2	35
Potato consumers	36		0.1	6.4		0.6	5.5	0.3				10.5		2.4	0.9	43.1		0.2			400		30	10.5	9.6	109	11.4
Root vegetable consumers	21			7.8		0.8	16.5	1.2	10		0.3	4.5		1	1	29.6		0.2					50	25.5	19.8	65.4	30.9

Notes

[a]Direct radiation is expressed as a proportion of the group who are present within 1km of the site perimeter

[b]Gamma ext - sand/mud represents occupancy over all substrates except rock and saltmarsh

[c]Gamma ext - saltmarsh represents occupancy over saltmarsh only

[d]Game meat includes venison, rabbits/hares and wildfowl

[e]Plume times are the sum of individuals' indoor and outdoor times

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Head office
Centre for Environment,
Fisheries & Aquaculture Science
Pakefield Road, Lowestoft,
Suffolk NR33 0HT UK

Tel +44 (0) 1502 56 2244
Fax +44 (0) 1502 51 3865
Web www.cefas.co.uk

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