THE RADIOLOGICAL IMPACT OF FARMED FISH IN THE UK

by Bryan Smith

CEFAS
The Centre for Environment, Fisheries & Aquaculture Science

Objectives

To see whether eating farmed fish in the UK is radiologically significant.

To consider transfer processes for radioactivity from fish feed to farmed fish

Background

Farmed fish are raised throughout their lives on fishmeal-based feeds. A previous study by CEFAS on radioactivity in fishmeal indicated that farmed fish might contain enhanced levels of radioactivity.

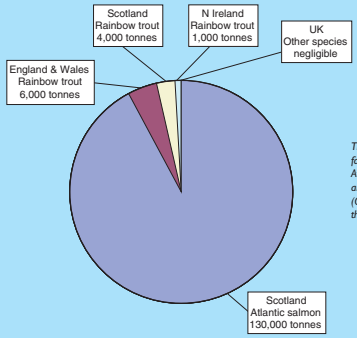
Atlantic salmon: *Typically, salmon are raised in seawater until 2 – 3 years old and weigh 4 – 5 kg*

Typical fish farm *© Marine Harvest*

Rainbow trout: *Typically, trout are raised in fresh water until 1 year old and weigh 0.3 kg*

UK farmed fish industry

Annual UK production of farmed fish



The species most commonly farmed and eaten are Atlantic salmon (Salmo salar) and rainbow trout (Oncorhynchus mykiss) so these were studied

Sampling

- The salmon farms were chosen so as to give a geographic spread around the coast.
- The trout farms were chosen so as to give different fresh water conditions.
- At each farm, samples of fish ready for consumption and fish feed on which the fish had been raised were collected.
- At some farms, sampling was repeated later in the year to check for variability.

Map of sampling locations in England and Wales

Map of sampling locations in Scotland

Analytical results

Table 1: Radioactivity in farmed fish and fish feed

Sample type	Sampling period	Radioactivity concentration (wet)[a], Bq kg^{-1}					Ratio
		^{14}C	^{99}Tc	^{137}Cs	^{210}Pb	^{210}Po	^{210}Po/^{210}Pb
Atlantic salmon	July 2001	17 - 50		0.35 - 0.53	0.053 - 0.16	0.016 - 0.13	0.13 - 1.7
	Oct - Dec 2001	10 - 15	0.24	0.34 - 0.42	<0.010 - <0.070	0.10 - 0.13	>1.4 - >13
Rainbow trout	July 2001	28 - 39		0.24 - 0.39	0.073 - 0.27	0.043 - 0.22	0.16 - 3.0
	Oct - Dec 2001	<16 - 20		0.23 - 0.25	<0.010	0.19 - 0.29	>19 - >29
Salmon feed	July 2001	47 - 130		0.35 - 0.50	0.83 - 3.6	2.8 - 20	3.1 - 11
	Oct - Dec 2001	37 - 49	1.3	<0.26 - 0.86	<0.040 - 1.7	8.2 - 25	12 - >200
Trout feed	July 2001	64 - 110		<0.27 - 0.44	0.98 - 2.3	5.4 - 13	3.1 - 8.5
	Oct - Dec 2001	30 - 36		0.36 - 0.58	0.72 - 1.4	8.8 - 20	6.1 - 28

[a] except for feed where dry concentrations apply

- Similar concentrations were found in salmon and trout.
- Similar concentrations were found in feeds for salmon and trout.
- Most gamma emitting radionuclides were below analytical limits of detection.
- Concentrations of ^{210}Pb and ^{210}Po were consistent with natural levels.
- Unusually, a number of fish samples had ^{210}Po / ^{210}Pb quotients less than 1.

Dose assessments

Doses were assessed using:

$$D_{ind} = \Sigma (C_R \times I_S \times DPUI_R)$$

where: D_{ind} is the individual dose due to consumption of farmed fish (mSv y^{-1}),

C_R is the activity concentration of radionuclide R in farmed fish (Bq kg^{-1}),

I_S is the consumption rate for farmed fish (kg y^{-1}),

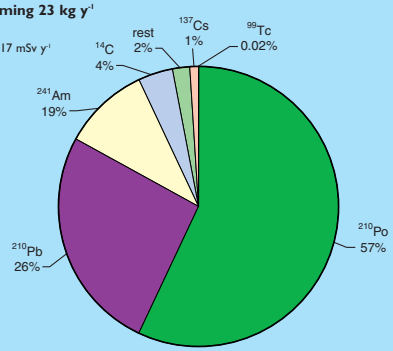
and

$DPUI_R$ is the dose per unit intake of radionuclide R (mSv Bq^{-1}).

Conservative assumptions were that concentrations were at the highest observed, that limit of detection values were positive and that no corrections were made for natural levels of ^{14}C, ^{210}Pb and ^{210}Po.

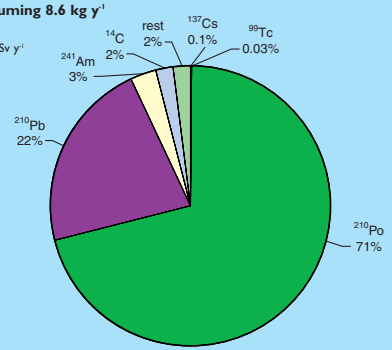
Dose to adult consuming 23 kg y^{-1} farmed fish

Total assessed dose was 0.017 mSv y^{-1}



Dose to 1-year old consuming 8.6 kg y^{-1} farmed fish

Total assessed dose was 0.038 mSv y^{-1}



Transfer from fish feed to farmed fish

Transfer factors are used in modelling and were calculated using:

$$TF = \frac{C_R}{C_{FF} \times I_D}$$

where: TF is the transfer factor (d kg^{-1}),

C_R is the activity concentration of radionuclide R in farmed fish (Bq kg^{-1}),

C_{FF} is the activity concentration of radionuclide R in fish feed (Bq kg^{-1}), and

I_D is the daily intake of fish feed (kg d^{-1}).

Table 2: Transfer factors for salmon and trout

Transfer factor (d kg^{-1})		
	Atlantic salmon	Rainbow trout
^{14}C	3.3 - 23	100 - 230
^{99}Tc	4.8	
^{137}Cs	12 - >33	170 - >370
^{210}Pb	<0.23 – 4.4	<2.8 - 48
^{210}Po	0.079 - 0.59	2.4 - 13

Trout were found to have much higher transfer factors than salmon.

Table 3: Ratios of radionuclide concentrations in farmed fish and fish feed

Concentration ratio				
		Atlantic salmon	Rainbow trout	Salmon and trout
^{14}C	range	0.13 - 0.91	<0.52 - 0.56	<0.52 - 0.91
	median	0.34	0.47	0.37
^{99}Tc		0.19		0.19
^{137}Cs	range	0.49 - >1.3	0.43 - >0.93	0.43 - >1.3
	median	0.82	0.56	0.76
^{210}Pb	range	<0.0093 - 0.17	<0.0070 - 0.12	<0.0070 - 0.17
	median	0.12	0.10	0.11
^{210}Po	range	0.0031 - 0.024	0.0061 - 0.033	0.0031 - 0.033
	median	0.0068	0.013	0.010

A ratio of 0.4 would imply equilibrium between radioactivity in fish feed and farmed fish. The median values suggest this is the case for ^{14}C, but for ^{137}Cs there may be some biomagnification between fish feed and farmed fish. For ^{99}Tc, ^{210}Pb and ^{210}Po, with ratios lower than 0.4, there would appear to be depletion between fish feed and salmon and trout.

The Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK. http://www.cefas.co.uk