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Bioaccumulation factors in aquatic ecosystems

A critical review

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July 2002

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Keywords: Bioaccumulation factors, water chemistry, trophic level.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author(s) and do not necessarily coincide with those of the client.

Abstract

The calculated concentrations of radionuclides in organisms are often obtained by means of bioaccumulation factors (BAF) that describe the internal concentration relative to an external concentration e.g. in the abiotic environments at steady-state conditions. Such factors are often used when modelling the dose to man from radionuclides released to the biosphere. Values of bioaccumulation factors vary widely in magnitude among elements, organisms, and environmental conditions which is not always considered. In order to relate the bioaccumulation factors for some radionuclides to environmental conditions as well as to the trophic level of the organism of concern we have compiled an extensive database with bioaccumulation factors (about 5 500 values) together with information on some environmental conditions. The data for nine radionuclides has been extracted and examined. A comparison between the bioaccumulation factors found in this study and values given in literature by IAEA and NCRP shows that the ranges presented in this study are generally somewhat higher with the exception of BAF for molybdenum in freshwater fish which is of the same order of magnitude. This is startling and calls for a thorough research.

The amount of readily accessible and reliable values of BAF is limited, often because basic information such as e.g. units and part of organism examined, is not reported. This is surprising and also unfortunate for those who need such data for use in generic or specific models. A major update of recommended values appears to be necessary for many elements to account for the development of analytical methods and experiences from case studies over the past two decades.

Sammanfattning

Beräknade koncentrationer av radionuklider i organismer erhålls ofta via bioackumulationsfaktorer (BAF) vilka beskriver den interna koncentrationen relativt den externa, t ex i den abiotiska omgivningen under förutsättning att jämvikt råder i systemet. Dylika faktorer används ofta vid modellerandet av dos till människa från radionuklider utsläppta i biosfären. Värden på bioackumulationsfaktorer varierar mycket i storlek mellan element, organismer och miljöförhållanden vilket inte alltid tas hänsyn till. För att relatera bioackumulationsfaktorer för några element till miljöförhållanden och den aktuella organismens trofinivå har en omfattande databas med bioackumulationsfaktorer (cirka 5 500 värden) tillsammans med information om vissa miljöförhållanden sammanställts. Data för nio radionuklider har extraherats och undersökts. En jämförelse mellan de bioackumulationsfaktorer som presenteras i denna studie och värden som ges i litteratur av IAEA och NCRP visar att värdena i denna studie generellt sett ofta är något högre med undantag av BAF för molybden i sötvattensfisk vilka är av samma storleksordning. Detta är oroande och behöver undersökas närmare.

Mängden lätttillgängliga och tillförlitliga BAF-värden är begränsad ofta på grund av att basal information som t ex enheter och vilka delar av organismen som analyserats inte rapporterats. Detta är förvånande och också olyckligt för de som behöver dessa data för användande i generiska eller specifika modeller. För många element verkar en betydande uppdatering av rekommenderade värden nödvändig för att beakta utvecklingen av analytiska metoder och erfarenheter från studier genomförda under de senaste två decennierna.

Contents

1 Introduction

The concentration of chemicals in aquatic organisms can be calculated by two different factors; bioconcentration factors (BCF) and bioaccumulation factors (BAF). Both factors illustrate the partitioning of a chemical between water and aquatic organisms, often fish, at steady-state conditions. BCF refers to levels in organisms only due to uptake by the organism from the surrounding water while BAF also includes uptake from food. BCF in animals can therefore only be measured in laboratory studies, where uptake from food can be restricted, whereas the ratios measured in field are BAF. Bioaccumulation factors are commonly used in assessment models, as they provide a pollution-scale independent parameter. Bioaccumulation factors are easy to calculate (see equation below). In aquatic systems the factors are usually expressed in the unit L/kg based on concentrations measured as Bq/kg and Bq/L, respectively:

$$BAF = \frac{[X]_{organism}}{[X]_{water}}$$

where $[X]_{organism}$ is the concentration of the element X in the examined organism

$[X]_{water}$ is the concentration of X in the water.

Recent compilations of recommended BAF values show the wide variability among elements (Table 1-1).

Although it is known that bioaccumulation factors (BAF) for a given element vary widely among organisms as well as environments, they are often treated as spatially and temporally constants. A more appropriate approach is to formulate algorithms to express BAF as a function of basic environmental variables. This has been done successfully for cesium in fish /Rowan and Rasmussen, 1994/, but such models are not available for many nuclides. For this reason, Studsvik Eco & Safety AB compiled a detailed database during 1998–1999 focusing on reported bioaccumulation factors in aquatic environments, in particular those related to Nordic ecosystems including clear mountain lakes, humic forest lakes, clayey lowland lakes, the brackish Baltic Sea, and true marine environments. This report treats elements of particular relevance for nuclear waste repositories and some preliminary findings are presented.

Bioaccumulation is the result of uptake and retention of elements in organisms and the process is complex to describe. The uptake of elements depends primarily on environmental conditions whereas the retention is more dependent on biological features of the organisms (see Chapter 2). The complexity of these processes may be one of the reasons why the range of the reported values of BAF for a given element can be very large.

Table 1-1. Recommended or expected values for BAF in fish (edible parts).

Element			**BAF Marine** IAEA 57 1982	**BAF Marine** IAEA 247 1985	**BAF Marine** NCRP 123 1996	**BAF Freshw.** IAEA 364 1994	**BAF Freshw.** NCRP 123 1996
1	H	Hydrogen		1	1	1	1
2	He	Helium			0 **	1	0 **
3	Li	Lithium			1 *		1
4	Be	Beryllium			200 *	100	100
5	B	Boron			200 *		5
6	C	Carbon		20000	2000	50000	50000
7	N	Nitrogen			60000	200000	150000
8	O	Oxygen			1	1	1
9	F	Fluorine			4		10
10	Ne	Neon			0 **		0 **
11	Na	Sodium	1 *	0.1	10 *	20	20
12	Mg	Magnesium			1		50
13	Al	Aluminum			500 *		500
14	Si	Silicon			10 *		20
15	P	Phosphorus	10000 *		30000	50000	50000
16	S	Sulfur	1	2	5	800	1000
17	Cl	Chlorine		0.05	1 *		1000
18	Ar	Argon			0 **		0 **
19	K	Potassium			5000 *		10000
20	Ca	Calcium		2	1		1000
21	Sc	Scandium		1000 *	2	100	100
22	Ti	Titanium			1000		1000
23	V	Vanadium			400 *		200
24	Cr	Chromium	400	200	400	200	200
25	Mn	Manganese	500 *	400 *	500 *	400	500
26	Fe	Iron	1000 *	3000 *	3000 *	200	200
27	Co	Cobalt	100 *	1000	100 *	300	300
28	Ni	Nickel	500	1000	500	100 *	100 *
29	Cu	Copper			700 *	200 *	200 *
30	Zn	Zinc	2000 *	1000 *	2000 *	1000	1000
31	Ga	Gallium			700		400
32	Ge	Germanium			4000*		4000 *
33	As	Arsenic			1000		400
34	Se	Selenium		6000	4000		200 *
35	Br	Bromine			3	400	400
36	Kr	Krypton		1	0 **		0 **
37	Rb	Rubidium		10	10	2000	2000
38	Sr	Strontium	1	2	1	60	60
39	Y	Yttrium	10	20	10	30	30
40	Zr	Zirconium	100	20	100	300	300
41	Nb	Niobium	100 *	30 *	100 *	300 *	300 *
42	Mo	Molybdenum			10	10 *	10 *
43	Tc	Technetium	10	30	10	20	20
44	Ru	Ruthenium	1 *	2	1 *	10	10
45	Rh	Rhodium			100 *	10	300
46	Pd	Palladium		300	10 *		10
47	Ag	Silver	1000 *	500 *	1000 *	5 *	10 *
48	Cd	Cadmium		1000 *	3000 *		200 *
49	In	Indium		1000 *	10000 *		10000 *
50	Sn	Tin		50000 *	1000 *	3000 *	3000 *
51	Sb	Antimony	1000 *	400 *	1000 *	100 *	100 *
52	Te	Tellurium	1000 *	1000 *	1000 *	400 *	400 *
53	I	Iodine	10	10	10	40	40
54	Xe	Xenon		1	0 **		0 **

Table 1-1. Cont'd

Element			BAF Marine IAEA 57 1982	BAF Marine IAEA 247 1985	BAF Marine NCRP 123 1996	BAF Freshw. IAEA 364 1994	BAF Freshw. NCRP 123 1996
55	Cs	Cesium	50	100	50	2000	2000
56	Ba	Barium	10	10	10	4	4
57	La	Lanthanum	30		100	30	30
58	Ce	Cerium	10 *	50	10 *	30	30
59	Pr	Praseodymium			10	100	100
60	Nd	Neodymium			100	100	100
61	Pm	Promethium	100	500 *	100	30	30
62	Sm	Samarium		500	100		25
63	Eu	Europium		300	100	50 *	50 *
64	Gd	Gadolinium		500 *	25		30
65	Tb	Terbium		60	25		25
66	Dy	Dysprosium		500 *	100		25 *
67	Ho	Holmium			30		12000
68	Er	Erbium			30		12000
69	Tm	Thulium		500 *	25		25 *
70	Yb	Ytterbium		200	500		200
71	Lu	Lutetium			25		25 *
72	Hf	Hafnium		40	30		40 *
73	Ta	Tantalum		60 *	30 *	100 *	100 *
74	W	Tungsten		10	30	10 *	12000
75	Re	Rhenium			30		12000
76	Os	Osmium			100 *		35
77	Ir	Iridium		20	10		10
78	Pt	Platinum			100		35 *
79	Au	Gold			100		35 *
80	Hg	Mercury		20000	2000 *	1000 *	1000 *
81	Tl	Thallium		5000	10000		10000
82	Pb	Lead	300 *	200 *	300 *	300	300
83	Bi	Bismuth	20		20	10 *	15 *
84	Po	Polonium	2000	2000	2000	50 *	100 *
85	At	Astatine			10		15
86	Rn	Radon			0 **		0 **
87	Fr	Francium			10000 *		30 *
88	Ra	Radium	100	500	100	50	50
89	Ac	Actinium		50	10		15
90	Th	Thorium	10000	600 *	10000	100	100
91	Pa	Protactinium	1000 *	50 *	1000 *	10	10
92	U	Uranium	1 *	1 *	1 *	10 *	10 *
93	Np	Neptunium	10	10	10	30	30
94	Pu	Plutonium	1	40 *	1	30	30
95	Am	Americium	10	50	10	30	30
96	Cm	Curium	10	50	10	30	30
97	Bk	Berkelium		50	25		25
98	Cf	Californium		50	25		25
99	Es	Einsteinium			25		25
100	Fm	Fermium			10		10
101	Md	Mendelevium			10		10
102	No	Nobelium			10		10
103	Lr	Lawrencium			10		10
104	Rf	Rutherfordium			30		40
105	Ha	Hahnium			30		40
106	Sg	Seaborgium					
107	Ns	Nielsbohrium					
108	Hs	Hassium					
109	Mt	Meitnerium					

* 10-fold error likely according to other data; ** obvious error.

A comparison of recommended BAF values (Table 1-1) reveals that substantial deviations and even obvious errors occur in compilations of recommended values. Comparison of values given in the different compilations and also with other data reveal a difference of, in some cases, several orders of magnitude. For the noble gases the given values in NCRP's compilations (0) are obviously wrong. When inert gases occur in the environment the concentration within organisms is unlikely to be 0, but can instead be expected to be similar as in the ambient water, thus resulting in a BAF of about 1 ($=10^0$) as stated for some of the gases by IAEA /1985 and 1994/.

Because of the large amount of data found, a selection was made which is described in Chapter 3 and further discussed in Chapter 5. Chapter 2 deals with important factors contributing to variation in reported values. A compressed overview of the data can be seen in Chapter 4 whereas the whole data set is presented in Appendix. The whole database is available as a computer file at Studsvik Eco & Safety AB.

2 Important factors contributing to variations in reported values

The values of BAF found in the literature can vary within a wide range for the same element. The documentation of what the reported values represent is in many cases so shortcoming that values representing various conditions may be compared with each other. This leads of course to large variation and must be corrected for before variations depending on environmental conditions or differences between organism groups or species can be seen.

One apparently trivial but important issue is if the concentration in an organism is expressed per unit fresh weight, dry weight or ash weight. BAF based on dry weight are about 3–10 times higher than those based on wet weight, depending on the organism and sample preparation. Ash-weight based BAF values are 100 times higher than those based on wet weight /IAEA, 1985/.

The values of the BAF also depend on which parts or tissues of the organism are examined. In fish, different radionuclides accumulate in different tissues, e.g. strontium, radium, uranium and plutonium accumulates in bones whereas cesium is fairly evenly distributed in the soft tissues /Coughtrey et al., 1985; Rowan and Rasmussen, 1994/. If a BAF is used to predict doses to man from consumption of fish, the edible part of the fish must be used. Most commonly the muscle is consumed but for some species, e.g. herring, the whole fish, including skin and bone, may be eaten.

Radionuclides exist in a wide variety of physical-chemical forms in nature, and their different forms can have different availability to uptake in aquatic biota. Some radionuclides adsorb strongly to particulate material in the water column. Therefore it is important if the analysed water was filtered or not before the measurements were performed.

To obtain correct BAF values requires a focus on equilibrated systems. Year-to-year variations in releases from nuclear facilities and atmospheric fall-out would lead to slight or even severe disequilibration at the top of the food web, as a result of the time lag required for the radionuclide to be transmitted through the food web. Fish at low position in the food chain (plankton feeders) tend to track variations in the water concentrations more closely than e.g. piscivorous fish /Rowan and Rasmussen, 1994/.

The feeding strategies of an individual species can vary from ecosystem to ecosystem and influence the biouptake of radionuclides /Meili, 1991/. The age and size of the fish are also important because small ones usually prefer other food than larger ones.

The pathway of uptake of radionuclides differs between freshwater and marine fish. Because of the high salt concentration in sea water, marine fish drink large amounts of water whereas freshwater fish do not drink water even if intake of small amounts of water is unavoidable. Consequently radionuclides dissolved in the water column are more prone to absorption in the gastro-intestine in marine species than in freshwater species /Poston and Klopfer, 1986/. As a rule, however, uptake from the food dominates the total uptake of radionuclides in fish relevant to human exposure.

The temperature regime under which a fish lives exerts profound effects on all metabolic processes. Clearance rates of radiocesium are known to increase with temperature together with basal metabolism, but a corresponding increase in feeding rates could easily counteract this effect. It is therefore difficult to predict whether the values of BAFs would increase, decrease or be unaffected by temperature /Rowan and Rasmussen, 1994/.

As water temperature often varies during the year the season during which the organisms were collected can influence the radionuclide concentration. If average annual doses to man are to be calculated, sampling to estimate the bioaccumulation in fish should take place during the same time of the year as the fishing for consumption.

The chemical composition of the water influences the uptake of radionuclides in freshwater biota. Cesium for example is known to be quite similar to potassium in its chemical and biological behaviour, which makes the potassium concentration in the water and in organisms an important parameter to be considered /Rowan and Rasmussen, 1994/.

3 The database

3.1 Contents

The extensive database compiled at Studsvik Eco & Safety AB during 1998–1999 contains values (about 5 500) of bioaccumulation factors for most elements. Data for fish as well as other aquatic organisms are included. Since BAF values are dependent on factors related to the organism groups or species as well as factors related to water conditions, such data were included in the database whenever information was available. The following factors were registered if available:

- Organism data: Group and/or species name
  Part of organism analysed
  Size (length/weight)
  Trophic level
  Number of samples
  Dry or wet weight analysed
- Water data: Type of lake (e.g. oligotrophic, eutrophic)
  Water chemistry (concentrations of potassium, calcium, organic carbon, suspended matter, pH and conductivity)
  Salinity (as ppm or salt/fresh/brackish)
  Number of samples
  Filtered or unfiltered water analysed
- Sampling data: Average or occasional value
  Location of measurement
  Time of measurement (year, time of year)
- The physical/chemical form of the element

3.2 Selection of data

Since the literature dealing with the concentration of different radionuclides in different aquatic organisms and water is extensive, a selection had to be made for this compilation. One of the criteria set up when scanning the literature was that all information required to calculate bioaccumulation factors in a given organism and system should be collected at approximately the same time and the values reported in the same document, unless reasonable estimates could be obtained elsewhere.

The following nine elements were selected for this study: Cl, Ni, Se, Zr, Nb, Mo, I, Cs, and Np. These elements are considered to be of particular relevance in case of a leakage of radionuclides from a deep repository for spent nuclear fuel and other radioactive waste. Calculations suggest that these nine radionuclides can reach the biosphere earlier and in larger amounts than other nuclides /SR 97/. The reason why neptunium was considered the only actinide of interest is that the others all have a lower bioavailability and the small amounts taken up are concentrated in organs that are rarely consumed, i.a. bones and exoskeletons /Coughtrey et al., 1985; Poston and Klopfer, 1986/.

At first the literature usually used at Studsvik Eco & Safety AB when estimating bioaccumulation factors for modelling purposes was examined. Thereafter other literature, mostly that relevant to Scandinavian conditions and concerning the nine radionuclides mentioned above was examined.

An extensive amount of data is available for the concentrations of ^{137}Cs in aquatic biota (especially fish) after the Chernobyl accident in April 1986. Therefore only the most well documented data were included in the database. As bioaccumulation factors are only valid at equilibrium, data collected close in time after the accident were not used. Equilibrium between the concentration within an organism and the surrounding environment is reached at different time for different organisms. The following time periods were applied to ^{137}Cs data collected since the Chernobyl accident /based on i.a. Starodub et al., 1993; Rowan and Rasmussen, 1994/:

- Phytoplankton: equilibrium assumed to be established after days to weeks.
- Zooplankton and benthic invertebrates: days to months.
- Macroalgae: weeks to months.
- Macrophytes: weeks to years.
- Small fish: equilibrium assumed to be established since 1988 (after 2 years).
- Carnivorous fish: equilibrium assumed to be established since 1990 (after 4 years).

For other nuclides (Cl, Ni, Se, Zr, Nb, Mo, I, and Np) little information was found. Values for selenium, iodine and nickel also included data on the stable elements.

A quality evaluation of the data was done based on the amount of documentation available in connection to each value. The evaluation system used is shown in Table 3-1.

Table 3-1. Criteria set up for the evaluation system.

Criteria	Documentation index
Data for which statements about the units used are lacking	0
Data for which statements are lacking about whether values refer to fresh or dry weight of the organisms OR to which part of the organism the values refer to OR if values refer to fresh or salt water	1
Data for which statements about species are lacking at high trophic level (e.g. fish but not plankton) OR if water chemistry data apart from salinity are absent	2
Data passing all criteria above	3

Data given index 0 or 1 were excluded which reduced the number of eligible data from about 1 900 to 400. Of these about 100 values were excluded because of the small amount of data concerning that specific element and/or organism group. The values left were BAFs for selenium in plankton and fish, molybdenum in fish, and cesium in plankton, macroalgae, macrophytes, invertebrates and fish. The data are presented in the tables A-1 to A-8 in the Appendix and summarised in Table 4-1.

Transformation of values

The concentration of radionuclides within organisms was expressed as Bq/kg fresh or dry weight. It was surprising that no standardisation has been adopted during the years of research. Dry and fresh weight values were used for the same kind of organisms with the exception of plankton where only dry weight values were found. The difference between dry and fresh weight values was assumed to be approximately 5 based on the calculations done in IAEA /1985/ and values tabulated in Kautsky /1995/. A conversion to the unit Bq/g C was also performed. In this study the conversion factors tabulated in Kautsky /1995/ were used if the organism of interest or an organism resembling this one was listed there. If that was not the case the conversion factors in IAEA /1985/ were used.

4 Results

The selected data are presented in the Appendix while an overview is given in Table 4-1 below. The values of the BAF for cesium show very wide ranges whereas the BAF for selenium and molybdenum in fish vary within more narrow intervals. The data found for chlorine, iodine, niobium, nickel, neptunium and zirconium as well as data for selenium, molybdenum and cesium in some groups of organisms were too scarce to be used in the further analysis and are therefore not presented in the Appendix or in Table 4-1.

Table 4-1. A compressed overview of the data presented in Appendix. The BAF ranges include values given in L/kg (dw) or kg/kg (dw) without any conversion since the density of water is near 1 kg/L.

Element	Organism group	Water type	BAF range	Number of values	Number of references
Selenium	Plankton	Fresh water	218–149 000	11	3
	Fish	Fresh water	985–13 000	16	3
Molybdenum	Fish	Fresh/Brackish	8–45	8	2
Cesium	Microalgae, cyanobacteria and zooplankton	Fresh water	46–19 200	49	4
	Macroalgae	Fresh water	280–20 000	17	2
	Macrophytes	Fresh water	70–37 333	73	4
	Invertebrates	Fresh water	85–23 000	36	5
		Brackish water	15–75	9	1
		Salt water	1–2 943	14	1
	Fish	Fresh water	1 000–44 160	82	5
		Brackish water	915–1 230	2	1
		Salt water	150–860	9	1

5 Discussion

5.1 The selection of data

For this compilation a selection of data from the literature was made (see Chapter 3). In the following text the criteria on which the selection was based are discussed.

All values of BAFs expressed in the units L/kg, kg/kg and ppm/ppm were considered to be direct comparable. As the density of water is close to 1 kg/L in fresh as well as salt water the different units does not contribute to significant variation. The units kg/kg and or ppm/ppm are more common in older literature /e.g. Thompson et al., 1972; Vanderploeg et al., 1975/ whereas L/kg is the most common unit nowadays.

Some literature was excluded in this study because of uncertainties of units. If all values found for an element had varied within a rather narrow range, it would have been possible to make assumptions about the units used, but as the ranges were wide this could not be done and therefore these data were excluded.

Data from the literature without any information about whether dry or fresh weight was used were also excluded. An approximation often used is that 1 kg fresh weight is equivalent to 0.2 kg dry weight /e.g. IAEA, 1985/. This gives a 5-fold difference due to units, which can be corrected for if appropriate information is reported.

Concentrations or BAF values where no information on which tissues or parts of the organisms that was analysed could be found was also often excluded from the study. Because some elements tend to accumulate in certain organs, measurements on whole organisms or in only certain tissues can result in very different radionuclide concentrations. It is e.g. a well known fact that strontium accumulates within hard tissues like bones and shells while cesium tends to be quite evenly distributed in the soft tissues of organisms /Coughtrey et al., 1985/.

Values were also excluded if type of water (fresh, brackish or marine) was not given. For most elements, the salinity of the water has a strong influence on the uptake in aquatic organisms. The BAFs of many elements in a given type of organism are much lower in marine waters compared to freshwater environments, whereas the opposite is true for some elements /IAEA, 1985 and 1994/. For example, the BAF for cesium in freshwater fish is about 100-fold higher than for fish in marine environments /Rowan and Rasmussen, 1994/. Such differences are induced by the physiological regulation required for the acquisition of essential elements from media where concentrations differ, or where the bioavailability of elements differs due to the formation of organic (e.g. humus) or inorganic (e.g. chloride) complexes, or due to the abundance of competing or similar ions (e.g. cesium and potassium).

5.2 Analyses of data

The conversion from Bq/kg dry or fresh weight to Bq/kg C (here called normalisation) was performed to decrease the variation of BAF values. As can be seen below (compare Figure 5-1 and 5-2) that operation did not succeed because information about the carbon content of different species were not found in most cases and therefore assumed average values were used which brought in further uncertainties in the calculations. In reality the values increased by a factor of ten to twenty. Anyway, to express BAFs per g C is relevant if the factors will be used in ecological models based on the carbon flow within ecosystems and in the following text all bioaccumulation factor values referred to are normalised ones unless stated otherwise.

5.2.1 Molybdenum

The small set of data on molybdenum bioaccumulation in fish was taken from two references /Neumann, 1985; Saiki et al., 1993/. Most values referred to whole fish, while one value for bone tissues suggests a much lower accumulation of molybdenum in bone compared to the whole fish (see Figure 5-3).

The data from Saiki et al. /1993/ show somewhat higher values in spring compared to autumn values. Whether this is a seasonal trend can not be stated as the data is only for one year. Water chemistry data such as pH and conductivity do also vary between spring and autumn.

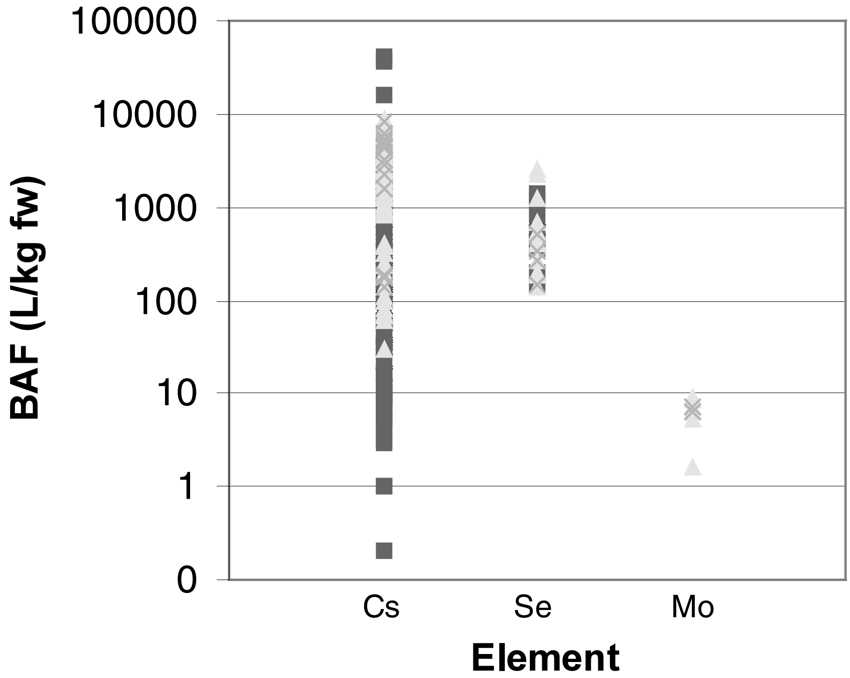

Figure 5-1. The ranges of BAFs for cesium, selenium and molybdenum before normalisation. The trophic levels 1–4 (primary producers, primary consumers, secondary consumers and tertiary consumers) are represented by different symbols (black diamond = trophic level 1, dark grey square = level 2, light grey triangle = level 3 and crosses = level 4).

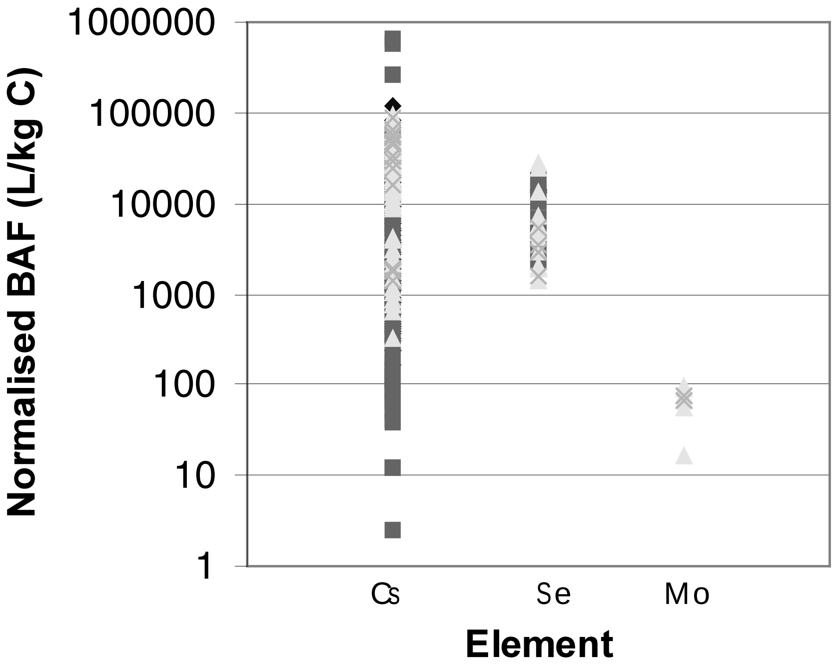

Figure 5-2. *The ranges of BAFs for cesium, selenium and molybdenum after normalisation. The trophic levels 1–4 (primary producers, primary consumers, secondary consumers and tertiary consumers) are represented by different symbols (black diamond = trophic level 1, dark grey square = level 2, light grey triangle = level 3 and crosses = level 4).*

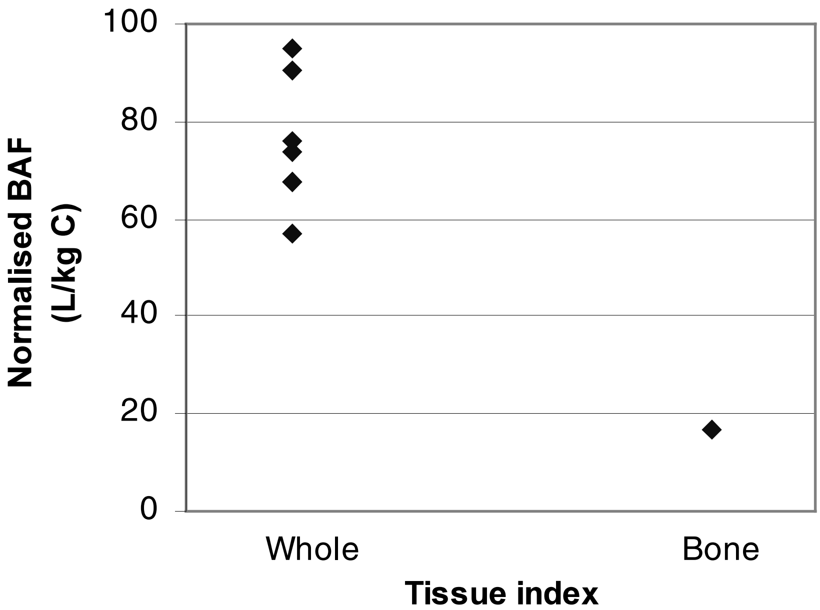

Figure 5-3. *Normalised BAFs of molybdenum in different fish tissues.*

5.2.2 Selenium

The data on selenium bioaccumulation in fish were taken from three references /Graham et al., 1992; Besser et al., 1996; Saiki et al., 1993/. As in the case of molybdenum, a seasonal difference was found in the data from Saiki et al. /1993/, with higher selenium BAF values in autumn than in spring.

Data on the bioaccumulation of selenium in phytoplankton were taken from one reference /Bowie et al., 1996/ whereas zooplankton data were taken from two /Saiki et al., 1993; Besser et al., 1993/. One of the latter is a laboratory study where the uptake of two different forms of selenium, seleno-methionine and selenite, was studied. The first is an organic form of selenium, which may be excreted by organisms. It seems to be effectively taken up in biota (BAFs of 14 800–149 000 L/kg dw) and is therefore probably present in negligible amounts in natural waters, in contrast to selenite which is a common form in nature and therefore ecologically more relevant. The bioaccumulation factors for selenite in zooplankton in the mentioned study varied (218–320 L/kg dw) but the range include both values from the third study which were based on field data.

5.2.3 Cesium

When a division of the fish data into piscivorous and non-piscivorous species was performed high correlation between the concentration of cesium in fish muscle and water were found (Figure 5-4 and 5-5). The high correlation (R = 0.82 and 0.87, respectively) in combination with the proportionality illustrates the suitability of the BAF concept for comparisons of cesium bioaccumulation in fish. Often adjustment to an exponential curve is most appropriate but for this data set adjustment to a potential curve gave the highest correlation coefficient.

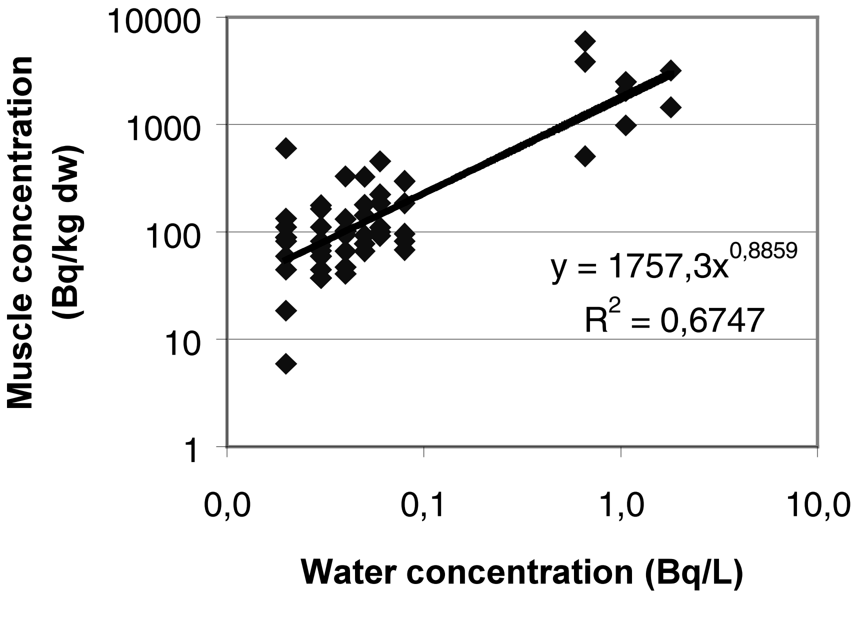

Figure 5-4. *Cesium concentrations in muscle of non-piscivorous fish (Bq/kg dw) versus cesium concentrations in water (Bq/L).*

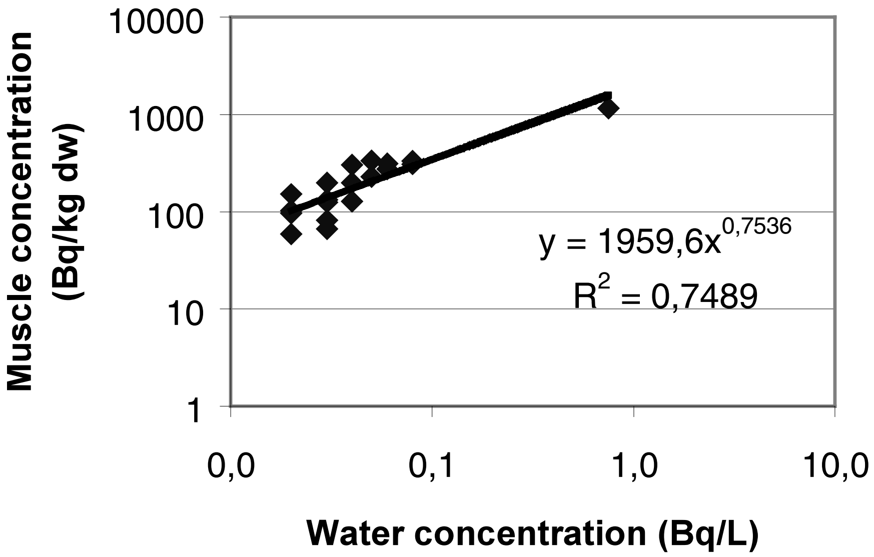

Figure 5-5. *Cesium concentrations in muscle of piscivorous fish (Bq/kg dw) versus cesium concentrations in water (Bq/L).*

That uptake and retention of cesium in fish is dependent on salinity is a well-known fact /see e.g. Rowan and Rasmussen, 1994/. Cesium BAF in fish decreases with increasing salinity, which is shown in Figure 5-6. The chemical conditions in fresh, brackish and marine waters are very different and therefore this is not surprising.

Rowan and Rasmussen /1994/ found that the water concentration of potassium was the chemical parameter which best explained the variation of BAFs for cesium. This has also been reported by others /e.g. Kolehmainen and Miettinen, 1968/. Other chemical parameters could also be used due to their strong correlation to the potassium concentration /Rowan and Rasmussen, 1994/. The normalised BAF for organisms of different trophic levels are plotted against potassium concentration in Figure 5-7 and 5-8. No pronounced pattern can be seen which may be explained by the few locations (and hence potassium concentrations) in the data set.

Two species of macrophytes (*Nuphar lutea, Scirpus lacustris)* were frequent enough to investigate separately. Both species were found in two Swedish lakes; Lake Sälgsjön and Lake Hillesjön. As can be seen in Figure 5-9 and 5-10 the ranges of normalised BAF for *Nuphar lutea* from Sälgsjön deviate from those from Hillesjön whereas this pattern is not found for *Scirpus lacustris*.

Rowan and Rasmussen /1994/ also found a relation between the bioaccumulation of cesium in fish and the length of the food chain. The length of the food chain was estimated as the ratio between piscivore yield (g C per m^2 and year) and primary production (g C per m^2 and year). This ratio decreased with increasing BAF, which indicates that fish from lakes with short food chains have lower radiocesium BAFs than those from lakes with longer food chains.

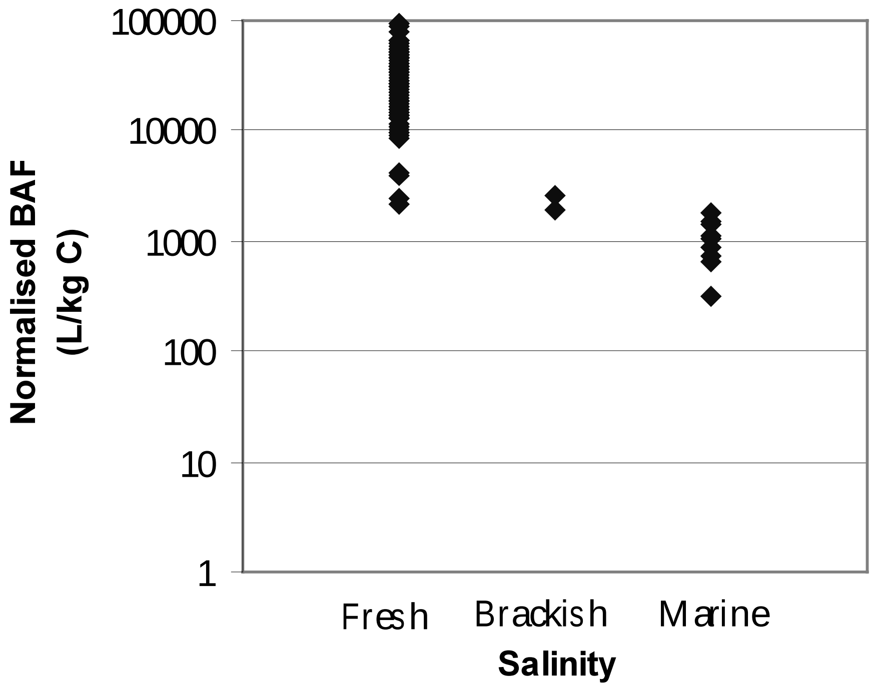

Figure 5-6. Cesium bioaccumulation in fish from waters with different salinity.

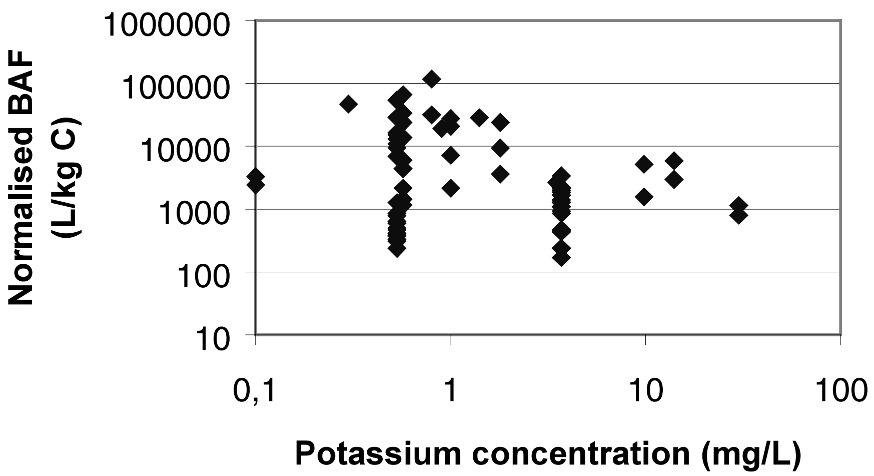

Figure 5-7. Normalised cesium BAFs for primary producers versus potassium concentration in water (mg/L).

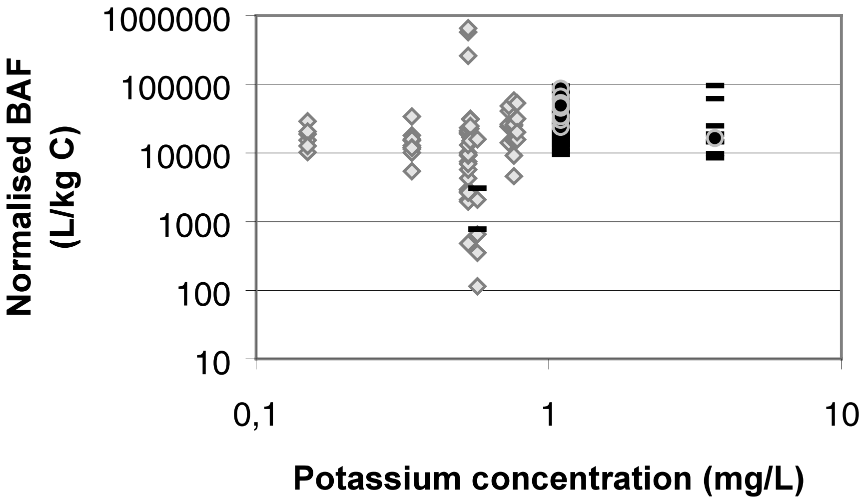

Figure 5-8. Normalised cesium BAFs versus potassium concentration in water (mg/L). The trophic levels 2–4 (primary, secondary and tertiary consumers) are represented by different symbols (grey diamond = trophic level 2, black line = level 3 and circle = level 4).

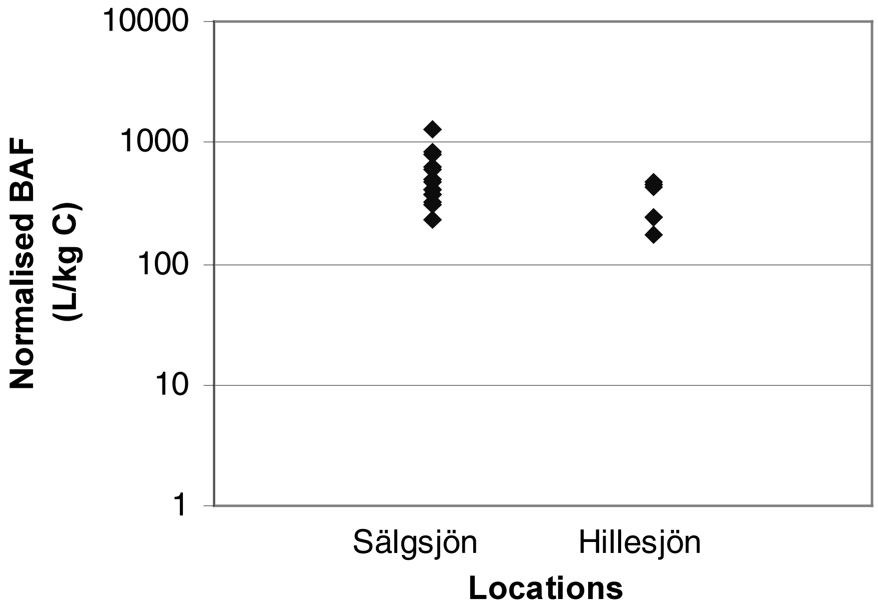

Figure 5-9. Cesium bioaccumulation in Scirpus lacustris *from two different Swedish lakes; Lake Sälgsjön and Lake Hillesjön.*

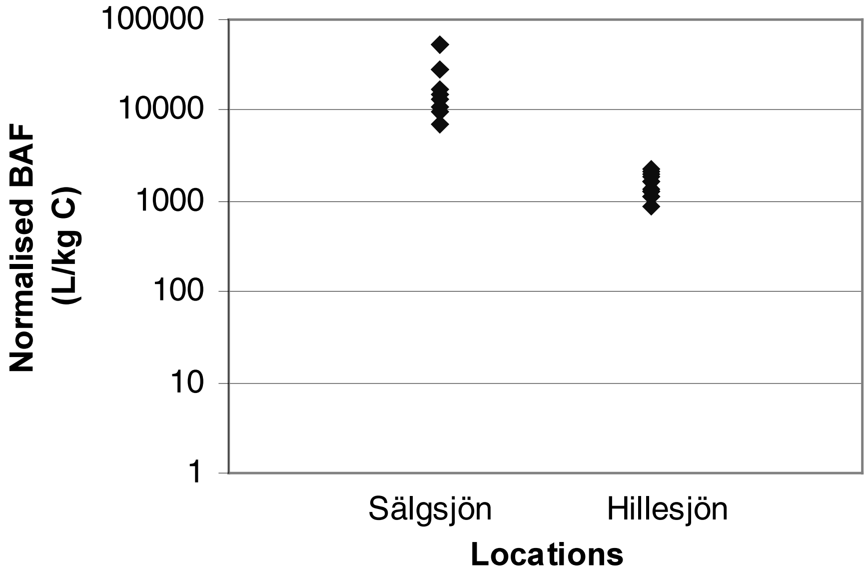

***Figure 5-10.** Cesium bioaccumulation in* Nuphar lutea *from two different Swedish lakes; Lake Sälgsjön and Lake Hillesjön.*

In the large data set analysed by Rowan and Rasmussen /1994/ the concentration of suspended matter ranged from 0.2 mg/L to 71 mg/L. They concluded that the suspended matter might play an important role in bioaccumulation by acting as a competitive matrix, although it is unclear how this should effect steady-state BAF since most cesium in water is dissolved.

5.2.4 Comparison with tabulated values

BAFs for different elements in edible portions of freshwater fish are given in IAEA /1994/ and NCRP /1996/. The expected values and ranges are presented in Table 5-1. Values from a compilation of bioaccumulation factors for different elements in some organisms made by Thompson et al. /1972/ are also presented together with the ranges found in this study. The former study treats stable elements and the units are ppm/ppm. For BAF of molybdenum in freshwater fish the values given by IAEA, NCRP and Thompson et al. are of the same order of magnitude as the range found in this study. The BAF for selenium in freshwater fish given by Thompson et al. is lower than the range presented here whereas the NCRP value is in the lower part of the range. For cesium the values given by IAEA, NCRP and Thompson et al. are all in the lower part of the range presented here. The BAF for cesium in marine fish found in this study are also higher than the values given by IAEA and Thompson et al.

Another classic compilation of bioaccumulation factors is the one made by Coughtrey et al. /1985/. Also in that study the BAF vary within very wide ranges; cesium BAF vary within the range 0.3–10 000 kg/kg for marine crustaceans and within the range 0.1–1 000 kg/kg for marine molluscs. BAF for cesium in marine fish vary within the range 0.5–10 000 kg/kg. All these ranges include the values found in this study.

Table 5-1. Expected values and ranges for BAF of molybdenum, selenium and cesium given in IAEA /1985 (marine fish) and 1994 (freshwater fish)/, NCRP /1996/ and Thompson et al. /1972/. The ranges found in this study are also shown for comparison. Unit = L/kg dw.

Element	IAEA[1]	NCRP[2]	Thompson et al., 1972[2,3]	This study
Freshwater fish				
Mo	10	50	50	8–45
Se	–	1 000	835	985–13 000
Cs	30–3 000 (2 000)	10 000	2 000	1 000–44 160
Marine fish				
Cs	10–300 (100)	250	150	150–860

[1]The values are said to be valid for fresh as well as dry weight
[2]Values converted from fresh weight to dry weight (i.e. multiplied with 5)
[3]Given in ppm/ppm

6 Conclusions

A comparison with BAFs given by IAEA /1985 and 1994/, NCRP /1996/ and Thompson et al. /1972/ shows that the ranges presented in this study are generally somewhat higher with the exception of BAF for molybdenum in freshwater fish which is of the same order of magnitude. The values of BAF for cesium in marine crustacean and molluscs as well as marine fish are all within the ranges presented in Coughtrey et al. /1985/.

It is startling that the recommended values given by authorities such as IAEA and NCRP are lower than values found in literature, which calls for a thorough research and update. Are the values presented here atypical or are the tabulated values too low?

One conclusion drawn from this study is that the amount of readily accessible and reliable values of BAF is limited, often because basic information such as e.g. units and part of organism examined, is not reported. This is surprising and also unfortunate for those who need such data for use in generic or specific models. However, BAF values can be obtained by synthesising information from an appropriate combination of studies from different fields. This is time-consuming and beyond the scope of this report, but appears to be the only way of generating BAF values for certain radionuclides that are potentially important but difficult to study. We therefore suggest that the work with the database should continue and be intensified. A specialisation on some important elements is preferable. Laboratory or field studies of the uptake and accumulation of some elements not often treated in the literature need to be performed.

Furthermore, a major update of recommended values appears to be necessary for many elements to account for the development of analytical methods and experiences from case studies over the past two decades.

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Appendix A

Data presentation

Abbreviations used in the tables

The following abbreviations are used in table A-1 to A-8:

Column	Abbreviation	Explanation
Documentation index	Numbers referring to the division described earlier in the text.	
Isotope/Chemical form	Numbers referring to the radioactive isotope	
Organism index	Al	Algae
	Cr	Crustacean
	Cy	Cyanobacteria
	D	Diatoms
	F	Fish
	GAl	Green algae
	I	Invertebrates
	Ins	Insects
	M	Macrophytes
	Mo	Molluscs
	P	Plankton
	PP	Phytoplankton
	ZP	Zooplankton
Trophic level	A rough estimate, only integer numbers used	
	1	Primary producers
	2	Primary consumers (plantivores, omnivores and detritivores)
	3	Secondary consumers (invertebrate feeders and parasites)
	4	Tertiary consumers (piscivores)
Tissue index	W	Whole
	M	Muscle/soft parts/feet (molluscs)
	B	Bone
	Sh	Shell/exoskeleton
	St	Stem
	R	Root
	L	Leaves
	Se	Seeds
Lake type index	D	Dystrophic
	O	Oligotrophic
	M	Mesotrophic
	E	Eutrophic
Salinity index	F	Fresh water
	B	Brackish water
	S	Salt water
Filtration index	f	Filtrated
	u	Unfiltrated
Weight index	d	Dry weight
	f	Fresh weight

Column	Abbreviation	Explanation
Com	gm	Geometrical average value
Reference	See the reference list	
Sampling site	1	Hyco Reservoir, North Carolina
	2	Ulkesjön, Sweden
	3	Sälgsjön, Sweden
	4	Hillesjön, Sweden
	5	Kytäjärvi, Finland
	6	Näsijärvi, Finland
	7	Suolijärvi, Finland
	8	Vuohijärvi, Finland
	9	Vähä-Valkjärvi, Finland
	10	Halsjärvi, Finland
	11	Iso Valkjärvi, Finland
	12	Mekkojärvi, Finland
	13	Rahtijärvi, Finland
	14	Valkea-Mustajärvi, Finland
	15	Research pond
	16	Pigeon Lake, near Lake Michigan
	17	San Joaquin River, California

Table A-1. Bioaccumulation factors for selenium in plankton

Element		Se	Se	Se	Se	Se	Se	Se	Se	Se	Se	Se
Documentation index		2	2	2	3	3	2	2	2	2	2	2
Isotope/Chemical form							seleno-methionine	seleno-methionine	seleno-methionine	selenite	selenite	selenite
Organism index		PP	PP	PP	ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP
English name												
Latin name							*Daphnia magna*	*Daphnia magna*	*Daphnia magna*	*Daphnia magna*	*Daphnia magna*	*Daphnia magna*
Trophic level		1	1	1	2	2	2	2	2	2	2	2
Tissue index		W	W	W	W	W	W	W	W	W	W	W
Org. size, weight (g)												
Org. size, length (mm)					>153microm	>153microm						
Lake type index												
Lab. study							*	*	*	*	*	*
Water chemistry	[K] (ppm=mg/l)											
	[Ca] (ppm=mg/l)											
	[TOC] (mg/cl)											
	[C] (mgPt/L)											
	[Fe] (ppm=mg/l)											
	pH				7.37	8.04	8	8	8	8	8	8
	Conductivity (mS/m)				59.4	43.6						
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index												
Weight index		d	d	d	d	d	d	d	d	d	d	d
Validity	Annual average	*	*	*								
	Occasional				*	*	*	*	*	*	*	*
Sampling date		-85	-86	-87	spring-87	fall-87						
BAF		3017	3178	2499	734	973	149000	102000	14800	3200	590	218
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm	gm	gm	gm	gm						
Reference		190)	190)	190)	189)	189)	192)	192)	192)	192)	192)	192)
Sampling site		1	1	1	17	17						

Table A-2. Bioaccumulation factors for selenium in fish

Element		Se	Se	Se	Se	Se	Se	Se	Se	Se	Se	Se
Documentation index		3	3	2	2	3	3	3	3	2	2	2
Isotope/Chemical form				Seleno-methionine	Selenite							
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Mosquitofish	Mosquitofish	Mosquitofish	Mosquitofish	Bluegill	Bluegill	Largemouth bass	Largemouth bass	Pike (Northern)	Pike (Northern)	Rock Bass
Latin name		*Gambusia affinis*	*Gambusia affinis*	*Gambusia affinis*	*Gambusia affinis*	*Lepomis macrochirus*	*Lepomis macrochirus*	*Micropterus salmoides*	*Micropterus salmoides*	*Esox lucius*	*Esox lucius*	*Ambloplites rupestris*
Trophic level		3	3	3	3	3	3	4	4	4	4	3
Tissue index		W	W	W	W	W	W	W	W	W	W	W
Org. size, weight (g)										551	1065	157
Org. size, length (mm)												
Lake type index												
Lab. study												
Water chemistry	[K] (ppm=mg/l)											
	[Ca] (ppm)											
	[TOC] (mg/cl)											
	[C] (mgPt/L)											
	[Fe] (ppm=mg/l)											
	pH	7.37	8.04			7.37	8.04	7.37	8.04			
	Conductivity (mS/m)	59.4	43.6			59.4	43.6	59.4	43.6			
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index												
Weight index		d	d	f	f	d	d	d	d	f	f	f
Validity	Annual average											
	Occasional	*	*	*	*	*	*	*	*	*	*	*
Sampling date		spring-87	fall-87			spring-87	fall-87	spring-87	fall-87	summer-94	summer-94	summer-94
BAF		919	2193	2600	2300	679	1364	728	1348	338	522	408
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm	gm			gm	gm	gm	gm			
Reference		189)	189)	186)	186)	189)	189)	189)	189)	187)	187)	187)
Sampling site		17	17	15	15	17	17	17	17	16	16	16

Table A-2. Cont'd

Element		Se	Se	Se	Se	Se
Documentation index		2	2	2	2	2
Isotope/Chemical form						
Organism index		F	F	F	F	F
English name		Spottail Shiner	Spottail Shiner	White Sucker	White Sucker	Yellow Perch
Latin name						
Trophic level		3	3	3	3	3
Tissue index		W	W	W	W	W
Org. size, weight (g)		0.77	0.5	716	1002	148
Org. size, length (mm)						
Lake type index						
Lab. study						
Water chemistry	[K] (ppm=mg/l)					
	[Ca] (ppm=mg/l)					
	[TOC] (mg/cl)					
	[C] (mgPt/L)					
	[Fe] (ppm=mg/l)					
	pH					
	Conductivity (mS/m)					
	Susp. matter (ppm=mg/l)					
	Salinity (per mil)					
Salinity index		F	F	F	F	F
Filtration index						
Weight index		f	f	f	f	f
Validity	Annual average					
	Occasional	*	*	*	*	*
Sampling date		summer-94	summer-94	summer-94	summer-94	summer-94
BAF		535	1261	197	696	521
Unit		L/kg	L/kg	L/kg	L/kg	L/kg
Com						
Reference		187)	187)	187)	187)	187)
Sampling site		16	16	16	16	16

Table A-3. Bioaccumulation factors for molybdenum in fish

Element		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo
Documentation index		3	3	3	3	3	3	2	2
Isotope/Chemical form									
Organism index		F	F	F	F	F	F	F	F
English name		Mosquitofish	Mosquitofish	Bluegill	Bluegill	Largemouth bass	Largemouth bass		
Latin name		*Gambusia affinis*	*Gambusia affinis*	*Lepomis macrochirus*	*Lepomis macrochirus*	*Micropterus salmoides*	*Micropterus salmoides*		
Trophic level		3	3	3	3	4	4	3	3
Tissue index		W	W	W	W	W	W	W	B
Org. size, weight (g)									
Org. size, length (mm)									
Lake type index									
Lab. study									
Water chemistry	[K] (ppm=mg/l)								
	[Ca] (ppm=mg/l)								
	[TOC] (mg/cl)								
	[C] (mgPt/L)								
	[Fe] (ppm=mg/l)								
	pH	7.37	8.04	7.37	8.04	7.37	8.04		
	Conductivity (mS/m)	59.4	43.6	59.4	43.6	59.4	43.6		
	Susp. matter (ppm=mg/l)								
	Salinity (per mil)								
Salinity index		F	F	F	F	F	F	F/B	F/B
Filtration index									
Weight index		d	d	d	d	d	d	f	f
Validity	Annual average								
	Occasional	*	*	*	*	*	*		
Sampling date		spring-87	fall-87	spring-87	fall-87	spring-87	fall-87		
BAF		45	32	43	27	36	32	7	2
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com									
Reference		189)	189)	189)	189)	189)	189)	106)	106)
Sampling site		17	17	17	17	17	17		

Table A-4. Bioaccumulation factors for cesium in planktontic and benthic microalgae and cyanobacteria, and zooplankton

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	2	3	2	3	3	2	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		Cy	Cy	Cy	D	GAl	GAl	GAl	GAl	P	P	P
English name			unknown	unknown		mixed multicell. sp.	mixed multicell. sp.	mixed multicell. sp.				
Latin name		*Plectonema boryanum*			*Navicula seminulum*				*Chlamydo-monas moewussi*			
Trophic level		1	1	1	1	1	1	1	1	2	2	2
Tissue index		W	W	W	W					W	W	W
Org. size, weight (g)												
Org. size, length (mm)										>70microm	>70microm	>70microm
Lake type index										D/O	D/O	D/O
Lab. study		*			*				*			
Water chemistry	[K] (ppm=mg/l)	3.6	1.4		14		1.8	1.8		0.53	0.53	0.53
	[Ca] (ppm=mg/l)									10	10	10
	[TOC] (mg/cl)											
	[C] (mgPt/L)									252	252	252
	[Fe] (ppm=mg/l)											
	pH									6.92	6.92	6.92
	Conductivity (mS/m)									2.89	2.89	2.89
	Susp. matter (ppm=mg/l)									4	4	4
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index		u	u	u	u	u	f	u	u	f	f	f
Weight index		f	f	f	f	f	f	f	f	d	d	d
Validity	Annual average											
	Occasional									*	*	*
Sampling date										1986-06-01	1986-08-01	1986-08-01
BAF		100	1200	3400	130	2449	600	230	219	6597	3176	6368
Unit		kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	L/kg	L/kg	L/kg
Com						gm			gm			
Reference		1)	1)	1)	1)	1)	1)	1)	1)	180)	180)	180)
Sampling site										3	3	3

Table A-4. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-134	-134	-134	-134	-137	-137	-137	-137	-134	-134
Organism index		P	P	P	P	P	P	P	P	P	ZP	ZP
English name												
Latin name											*Chaoborus*	*Holopedium gibberum*
Trophic level		2	2	2	2	2	2	2	2	2	2	2
Tissue index		W	W	W	W	W	W	W	W	W	W	W
Org. size, weight (g)												
Org. size, length (mm)		>70microm	>70microm	>70microm	>70microm	>70microm	>70microm	>70microm	>70microm	>70microm		
Lake type index		D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O		
Lab. study												
Water chemistry	[K] (ppm=mg/l)	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.57	0.57
	[Ca] (ppm=mg/l)	10	10	10	10	10	10	10	10	10		
	[TOC] (mg/cl)											
	[C] (mgPt/L)	252	252	252	252	252	252	252	252	252		
	[Fe] (ppm=mg/l)											
	pH	6.92	6.94	6.94	6.94	6.94	6.94	6.94	6.94	6.94		
	Conductivity (mS/m)	2.89	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04		
	Susp. matter (ppm=mg/l)	4	4	4	4	4	4	4	4	4		
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index		f	u	u	u	u	u	u	u	u		
Weight index		d	d	d	d	d	d	d	d	d	d	d
Validity	Annual average										*	*
	Occasional	*	*	*	*	*	*	*	*	*		
Sampling date		1986-10-01	1986-06-01	1986-08-01	1986-08-01	1986-10-01	1986-06-01	1986-08-01	1986-08-01	1986-10-01		
BAF		2365	7324	2889	6139	1792	4130	3000	6014	2194	46	260
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com											gm	gm
Reference		180)	180)	180)	180)	180)	180)	180)	180)	180)	162)	162)
Sampling site		3	3	3	3	3	3	3	3	3		

Table A-4. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-134	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP
English name												
Latin name												
Trophic level		2	2	2	2	2	2	2	2	2	2	2
Tissue index		W	W	W	W	W	W	W	W	W	W	W
Org. size, weight (g)												
Org. size, length (mm)			>200microm	>200microm	>200microm	>200microm						
Lake type index												
Lab. study												
Water chemistry	[K] (ppm=mg/l)	0.57	0.15	0.15	0.15	0.15	0.34	0.34	0.34	0.34	0.34	0.54
	[Ca] (ppm=mg/l)		0.79	0.79	0.79	0.79	1.19	1.19	1.19	1.19	1.19	2.86
	[TOC] (mg/cl)		2.4	2.4	2,4	2,4	8	8	8	8	8	7
	[C] (mgPt/L)											
	[Fe] (ppm=mg/l)		0.6	0.6	0.6	0.6	0.17	0.17	0.17	0.17	0.17	0.12
	pH		4.4	4.4	4.4	4.4	4.8	4.8	4.8	4.8	4.8	6.3
	Conductivity (mS/m)		2	2	2	2	1.3	1.3	1.3	1.3	1.3	2.2
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index			f	f	u	u	f	f	f	u	u	f
Weight index		d	d	d	d	d	d	d	d	d	d	d
Validity	Annual average	*										
	Occasional											
Sampling date			summer-88	summer-89	summer-88	summer-89	summer-87	summer-88	summer-89	summer-88	summer-89	summer-87
BAF		140	7563	11588	5042	8208	4732	4067	6389	2179	4792	6000
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm										
Reference		162)	183)	183)	183)	183)	183)	183)	183)	183)	183)	183)
Sampling site			9	9	9	9	11	11	11	11	11	14

Table A-4. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP	ZP
English name												
Latin name												
Trophic level		2	2	2	2	2	2	2	2	2	2	2
Tissue index		W	W	W	W	W	W	W	W	W	W	W
Org. size, weight (g)												
Org. size, length (mm)												
Lake type index												
Lab. study												
Water chemistry	[K] (ppm=mg/l)	0.54	0.54	0.54	0.54	0.73	0.73	0.73	0.73	0.73	0.76	0.76
	[Ca] (ppm=mg/l)	2.86	2.86	2.86	2.86	5.03	5.03	5.03	5.03	5.03	5.53	5.53
	[TOC] (mg/cl)	7	7	7	7	15.9	15.9	15.9	15.9	15.9	24.9	24.9
	[C] (mgPt/L)											
	[Fe] (ppm=mg/l)	0.12	0.12	0.12	0.12	0.52	0.52	0.52	0.52	0.52	0.79	0.79
	pH	6.3	6.3	6.3	6.3	6.1	6.1	6.1	6.1	6.1	5.4	5.4
	Conductivity (mS/m)	2.2	2.2	2.2	2.2	3.4	3.4	3.4	3.4	3.4	3.6	3.6
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index		f	f	u	u	f	f	f	u	u	f	f
Weight index		d	d	d	d	d	d	d	d	d	d	d
Validity	Annual average											
	Occasional											
Sampling date		summer-88	summer-89	summer-88	summer-89	summer-87	summer-88	summer-89	summer-88	summer-89	summer-88	summer-89
BAF		12333	12600	9867	9000	10500	19200	16333	9600	9800	3667	10333
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com												
Reference		183)	183)	183)	183)	183)	183)	183)	183)	183)	183)	183)
Sampling site		14	14	14	14	13	13	13	13	13	12	12

Table A-4. Cont'd

Element		Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137
Organism index		ZP	ZP	ZP	ZP	ZP
English name						
Latin name						
Trophic level		2	2	2	2	2
Tissue index		W	W	W	W	W
Org. size, weight (g)						
Org. size, length (mm)						
Lake type index						
Lab. study						
Water chemistry	[K] (ppm=mg/l)	0.76	0.76	0.78	0.78	0.78
	[Ca] (ppm=mg/l)	5.53	5.53	5.83	5.83	5.83
	[TOC] (mg/cl)	24.9	24.9	14.7	14.7	14.7
	[C] (mgPt/L)					
	[Fe] (ppm=mg/l)	0.79	0.79	0.82	0.82	0.82
	pH	5.4	5.4	6	6	6
	Conductivity (mS/m)	3.6	3.6	3.9	3.9	3.9
	Susp. matter (ppm=mg/l)					
	Salinity (per mil)					
Salinity index		F	F	F	F	F
Filtration index		u	u	f	f	u
Weight index		d	d	d	d	d
Validity	Annual average					
	Occasional					
Sampling date		summer-88	summer-89	summer-87	summer-88	summer-88
BAF		1833	6200	8000	12500	6250
Unit		L/kg	L/kg	L/kg	L/kg	L/kg
Com						
Reference		183)	183)	183)	183)	183)
Sampling site		12	12	10	10	10

Table A-5. Bioaccumulation factors for cesium in macroalgae (cm - m)

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	2	3	3	3	3	2	3	2
Isotope/Chemical form		-134	-134	-137	-137	-137	stable	-137	-137	-137	-137
Organism index		AI	AI	GAI	GAI	GAI	GAI	GAI	GAI	GAI	GAI
English name											
Latin name				*Chara fragilis*	*Cladophora glomerata*	*Cladophora glomerata*	*Mougeotia sp.*	*Mougeotia sp.*	*Nitella hialina*	*Oedogonium sp.*	*Oedogonium sp.*
Trophic level		1	1	1	1	1	1	1	1	1	1
Tissue index		W	W								
Org. size, weight (g)											
Org. size, length (mm)											
Lake type index											
Lab. study					*	*					
Water chemistry	[K] (ppm=mg/l)	0.57	0.57		0.1	30	9.8	9.8		0.3	
	[Ca] (ppm=mg/l)										
	[TOC] (mg/cl)										
	[C] (mgPt/L)										
	[Fe] (ppm=mg/l)										
	pH										
	Conductivity (mS/m)										
	Susp. matter (ppm=mg/l)										
	Salinity (per mil)										
Salinity index		F	F	F	F	F	F	F	F	F	F
Filtration index				u	u	u	u	u	u	u	u
Weight index		d	d	f	f	f	d	f	f	f	f
Validity	Annual average	*	*								
	Occasional										
Sampling date											
BAF		10100	20000	1000	170	59	500	330	170	3000	1200
Unit		L/kg	L/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg
Com		gm	gm								
Reference		162)	162)	1)	1)	1)	1)	1)	1)	1)	1)
Sampling site											

Table A-5. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	2	3	2	3	2	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137
Organism index		GAI	GAI	GAI	GAI	GAI	GAI	GAI
English name								
Latin name		*Pithophora oedogonia*	*Pithophora oedogonia*	*Spirogyra sp.*	*Spirogyra sp.*	*Stigeoclo-nium lubricum*	*Tollipellposis stelligera*	*Vaucheria walzii*
Trophic level		1	1	1	1	1	1	1
Tissue index								
Org. size, weight (g)								
Org. size, length (mm)								
Lake type index								
Lab. study		*	*	*		*		*
Water chemistry	[K] (ppm=mg/l)	0.1	30	1		14		1
	[Ca] (ppm=mg/l)							
	[TOC] (mg/cl)							
	[C] (mgPt/L)							
	[Fe] (ppm=mg/l)							
	pH							
	Conductivity (mS/m)							
	Susp. matter (ppm=mg/l)							
	Salinity (per mil)							
Salinity index		F	F	F	F	F	F	F
Filtration index		u	u	u	u	u	u	u
Weight index		f	f	f	f	f	f	f
Validity	Annual average							
	Occasional							
Sampling date								
BAF		170	56	150	380	89	220	500
Unit		kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg
Com								
Reference		1)	1)	1)	1)	1)	1)	1)
Sampling site								

Table A-6. Bioaccumulation factors for cesium in macrophytes

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		2	2	2	2	3	3	3	3	2
Isotope/Chemical form		-134	-134	-134	-134	-137	-137	-137	-137	-134
Organism index		M	M	M	M	M	M	M	M	M
English name		Wolly sedge	Wolly sedge	Dulichium	Dulichium	Horsetail	Horsetail	Horsetail	Horsetail	
Latin name		*Carex laguninosa*	*Carex laguninosa*	*Dulichium arundinaceum*	*Dulichium arundinaceum*	*Equisetum fluviatile*	*Equisetum fluviatile*	*Equisetum fluviatile*	*Equisetum fluviatile*	*Eriocaulon septangulare/Lobelia dortmanna*
Trophic level		1	1	1	1	1	1	1	1	1
Tissue index		St	R	W	R	St,L	St,L	St,L	St,L	W
Org. size. weight (g)										
Org. size. length (mm)										
Lake type index						O	D/O	D/O	E	
Lab. study										
Water chemistry	[K] (ppm=mg/l)	0.57	0.57	0.57	0.57	0.8	0.9	1	1.8	0.57
	[Ca] (ppm=mg/l)					3.4	4.4	6	7.4	
	[TOC] (mg/cl)									
	[C] (mgPt/L)									
	[Fe] (ppm=mg/l)									
	pH									
	Conductivity (mS/m)									
	Susp. matter (ppm=mg/l)									
	Salinity (per mil)									
Salinity index		F	F	F	F	F	F	F	F	F
Filtration index										
Weight index		d	d	d	d	d	d	d	d	d
Validity	Annual average	*	*	*	*					*
	Occasional					*	*	*	*	
Sampling date										
BAF		370	690	460	1900	37333	6125	8900	7667	1400
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm	gm	gm	gm					gm
Reference		162)	162)	162)	162)	182)	182)	182)	182)	162)
Sampling site						8	7	6	5	

Table A-6. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-134	-134	-137	-137	-137	-134	-137	-137	-134
Organism index		M	M	M	M	M	M	M	M	M
English name		Spiked water-milfoil	Spiked water-milfoil	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily
Latin name		*Myriophyllum spicatum*	*Myriophyllum spicatum*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*
Trophic level		1	1	1	1	1	1	1	1	1
Tissue index		W	W	W	St	L	W	W	W	St
Org. size. weight (g)										
Org. size. length (mm)										
Lake type index		M	M	D/O	D/O	D/O	D/O	D/O	D/O	D/O
Lab. study										
Water chemistry	[K] (ppm=mg/l)	3.7	3.7	0.53	0.53	0.53	0.53	0.53	0.53	0.53
	[Ca] (ppm=mg/l)	53	53	10	10	10	10	10	10	10
	[TOC] (mg/cl)									
	[C] (mgPt/L)	70	70	252	252	252	252	252	252	252
	[Fe] (ppm=mg/l)									
	pH	7.56	7.56	6.92	6.92	6.92	6.94	6.94	6.94	6.94
	Conductivity (mS/m)	7.35	7.35	2.89	2.89	2.89	3.04	3.04	3.04	3.04
	Susp. matter (ppm=mg/l)	3	3	4	4	4	4	4	4	4
	Salinity (per mil)									
Salinity index		F	F	F	F	F	F	F	F	F
Filtration index		u	u	f	f	f	u	u	u	u
Weight index		f	f	f	f	f	f	f	f	f
Validity	Annual average									
	Occasional	*	*	*	*	*	*	*	*	*
Sampling date		1986-06-01	1986-08-01	1986-10-01	1986-06-01	1986-06-01	1987-06-01	1986-06-01	1987-06-01	1986-06-01
BAF		217	59	1850	704	971	3451	441	3497	835
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com										
Reference		180)	180)	180)	180)	180)	180)	180)	180)	180)
Sampling site		4	4	3	3	3	3	3	3	3

Table A-6. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-134	-137	-134	-134	-134	-134	-137	-137
Organism index		M	M	M	M	M	M	M	M	M
English name		Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily
Latin name		*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*
Trophic level		1	1	1	1	1	1	1	1	1
Tissue index		St	L	L	St	St	L	L	St	St
Org. size. weight (g)										
Org. size. length (mm)										
Lake type index		D/O	D/O	D/O	M	M	M	M	M	M
Lab. study										
Water chemistry	[K] (ppm=mg/l)	0.53	0.53	0.53	3.7	3.7	3.7	3.7	3.7	3.7
	[Ca] (ppm=mg/l)	10	10	10	53	53	53	53	53	53
	[TOC] (mg/cl)									
	[C] (mgPt/L)	252	252	252	70	70	70	70	70	70
	[Fe] (ppm=mg/l)									
	pH	6.94	6.94	6.94	7.56	7.56	7.56	7.56	7.56	7.56
	Conductivity (mS/m)	3.04	3.04	3.04	7.35	7.35	7.35	7.35	7.35	7.35
	Susp. matter (ppm=mg/l)	4	4	4	3	3	3	3	3	3
	Salinity (per mil)									
Salinity index		F	F	F	F	F	F	F	F	F
Filtration index		u	u	u	u	u	u	u	f	f
Weight index		f	f	f	f	f	f	f	f	f
Validity	Annual average									
	Occasional	*	*	*	*	*	*	*	*	*
Sampling date		1986-06-01	1986-06-01	1986-10-01	1986-06-01	1986-10-01	1986-06-01	1986-10-01	1986-06-12	1986-10-07
BAF		608	1065	1850	55	81	82	89	70	126
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com										
Reference		180)	180)	180)	180)	180)	180)	180)	180)	180)
Sampling site		3	3	3	4	4	4	4	4	4

Table A-6. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		M	M	M	M	M	M	M	M	M
English name		Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily	Yellow water-lily
Latin name		*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*	*Nuphar lutea*
Trophic level		1	1	1	1	1	1	1	1	1
Tissue index		St	St	L	L	L	L	St,L	St,L	St,L
Org. size. weight (g)										
Org. size. length (mm)										
Lake type index		M	M	M	M	M	M	O	D/O	E
Lab. study										
Water chemistry	[K] (ppm=mg/l)	3.7	3.7	3.7	3.7	3.7	3.7	0.8	1	3.5
	[Ca] (ppm=mg/l)	53	53	53	53	53	53	3.4	6	8.8
	[TOC] (mg/cl)									
	[C] (mgPt/L)	70	70	70	70	70	70			
	[Fe] (ppm=mg/l)									
	pH	7.56	7.56	7.56	7.56	7.56	7.56			
	Conductivity (mS/m)	7.35	7.35	7.35	7.35	7.35	7.35			
	Susp. matter (ppm=mg/l)	3	3	3	3	3	3			
	Salinity (per mil)									
Salinity index		F	F	F	F	F	F	F	F	F
Filtration index		u	u	f	f	u	u			
Weight index		f	f	f	f	f	f	d	d	d
Validity	Annual average									
	Occasional	*	*	*	*	*	*	*	*	*
Sampling date		1986-06-12	1986-10-07	1986-06-12	1986-10-07	1986-06-12	1986-10-07			
BAF		70	120	107	142	107	134	10167	6620	850
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com										
Reference		180)	180)	180)	180)	180)	180)	182)	182)	182)
Sampling site		4	4	4						

Table A-6. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		2	2	2	2	2	2	2	3	3
Isotope/Chemical form		-134	-137	-137	-137	-134	-137	-137	-137	-137
Organism index		M	M	M	M	M	M	M	M	M
English name		Yellow pond-lily	Pale Persicaria	Persicaria	Persicaria				Bulrush	Bulrush
Latin name		*Nuphar variegatum*	*Polygonum lapathifolium*	*Polygonum persicaria*	*Polygonum persicaria*	*Potamogeton amplifolium*	*Scirpus americanus*	*Scirpus americanus*	*Scirpus lacustris*	*Scirpus lacustris*
Trophic level		1	1	1	1	1	1	1	1	1
Tissue index		W	Se	L	Se	W	Se		W	W
Org. size. weight (g)										
Org. size. length (mm)										
Lake type index									D/O	D/O
Lab. study										
Water chemistry	[K] (ppm=mg/l)	0.57				0.57			0.53	0.53
	[Ca] (ppm=mg/l)								10	10
	[TOC] (mg/cl)									
	[C] (mgPt/L)								252	252
	[Fe] (ppm=mg/l)									
	pH								6.92	6.92
	Conductivity (mS/m)								2.89	2.89
	Susp. matter (ppm=mg/l)								4	4
	Salinity (per mil)									
Salinity index		F	F	F	F	F	F	F	F	F
Filtration index			u	u	u		u	u	f	f
Weight index		d	f	f	f	d	f	f	f	f
Validity	Annual average	*				*				
	Occasional								*	*
Sampling date									1986-06-01	1986-07-01
BAF		4400	240	400	600	7700	300	50	48	40
Unit		L/kg	kg/kg	kg/kg	kg/kg	L/kg	kg/kg	kg/kg	L/kg	L/kg
Com		gm				gm				
Reference		162)	1)	1)	1)	162)	1)	1)	180)	180)
Sampling site									3	3

Table A-6. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-134	-137	-137	-137	-137	-134
Organism index		M	M	M	M	M	M	M	M	M
English name		Bulrush	Bulrush	Bulrush	Bulrush	Bulrush	Bulrush	Bulrush	Bulrush	Bulrush
Latin name		*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*
Trophic level		1	1	1	1	1	1	1	1	1
Tissue index		W	St,L	St,R,L	W	W	W	W	W	St,L
Org. size. weight (g)										
Org. size. length (mm)										
Lake type index		D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O
Lab. study										
Water chemistry	[K] (ppm=mg/l)	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
	[Ca] (ppm=mg/l)	10	10	10	10	10	10	10	10	10
	[TOC] (mg/cl)									
	[C] (mgPt/L)	252	252	252	252	252	252	252	252	252
	[Fe] (ppm=mg/l)									
	pH	6.92	6.92	6.92	6.94	6.94	6.94	6.94	6.94	6.94
	Conductivity (mS/m)	2.89	2.89	2.89	3.04	3.04	3.04	3.04	3.04	3.04
	Susp. matter (ppm=mg/l)	4	4	4	4	4	4	4	4	4
	Salinity (per mil)									
Salinity index		F	F	F	F	F	F	F	F	F
Filtration index		f	f	f	u	u	u	u	u	u
Weight index		f	f	f	f	f	f	f	f	f
Validity	Annual average									
	Occasional	*	*	*	*	*	*	*	*	*
Sampling date		1986-10-01	1986-08-01	1986-08-01	1986-06-01	1987-06-01	1986-06-01	1986-07-01	1986-10-01	1986-08-01
BAF		68	32	26	51	101	30	37	63	33
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com										
Reference		180)	180)	180)	180)	180)	180)	180)	180)	180)
Sampling site		3	3	3	3	3	3	3	3	3

Table A-6. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-134	-137	-134	-134	-134	-137	-137	-137
Organism index		M	M	M	M	M	M	M	M	M
English name		Bulrush	Bulrush	Bulrush	Bulrush	Bulrush	Bulrush	Bulrush	Bulrush	Bulrush
Latin name		*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*	*Scirpus lacustris*
Trophic level		1	1	1	1	1	1	1	1	1
Tissue index		St,L	St,R,L	St,R,L	W	St,L	St,R,L	St,L	St,L	St,R,L
Org. size. weight (g)										
Org. size. length (mm)										
Lake type index		D/O	D/O	D/O	M	M	M	M	M	M
Lab. study										
Water chemistry	[K] (ppm=mg/l)	0.53	0.53	0.53	3.7	3.7	3.7	3.7	3.7	3.7
	[Ca] (ppm=mg/l)	10	10	10	53	53	53	53	53	53
	[TOC] (mg/cl)									
	[C] (mgPt/L)	252	252	252	70	70	70	70	70	70
	[Fe] (ppm=mg/l)									
	pH	6.94	6.94	6.94	7.56	7.56	7.56	7.56	7.56	7.56
	Conductivity (mS/m)	3.04	3.04	3.04	7.35	7.35	7.35	7.35	7.35	7.35
	Susp. matter (ppm=mg/l)	4	4	4	3	3	3	3	3	3
	Salinity (per mil)									
Salinity index		F	F	F	F	F	F	F	F	F
Filtration index		u	u	u	u	u	u	f	u	f
Weight index		f	f	f	f	f	f	f	f	f
Validity	Annual average									
	Occasional	*	*	*	*	*	*	*	*	*
Sampling date		1986-08-01	1986-08-01	1986-08-01	1986-06-01	1986-08-01	1986-08-01	1986-08-13	1986-08-13	1986-08-13
BAF		30	19	25	14	19	19	36	35	37
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com										
Reference		180)	180)	180)	180)	180)	180)	180)	180)	180)
Sampling site		3	3	3	4	4	4	4	4	4

Table A-6. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	2	2	2	2	2	2	2
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137
Organism index		M	M	M	M	M	M	M	M
English name		Bulrush						Cat-tail	Cat-tail
Latin name		*Scirpus lacustris*	*Scirpus lacutus*	*Scirpus lacutus*	*Scirpus lacutus*	*Scirpus lacutus*	*Scirpus lacutus*	*Typha latifolia*	*Typha latifolia*
Trophic level		1	1	1	1	1	1	1	1
Tissue index		St,R,L	R	L	Se	Se		R	L
Org. size. weight (g)									
Org. size. length (mm)									
Lake type index		M							
Lab. study									
Water chemistry	[K] (ppm=mg/l)	3.7							
	[Ca] (ppm=mg/l)	53							
	[TOC] (mg/cl)								
	[C] (mgPt/L)	70							
	[Fe] (ppm=mg/l)								
	pH	7.56							
	Conductivity (mS/m)	7.35							
	Susp. matter (ppm=mg/l)	3							
	Salinity (per mil)								
Salinity index		F	F	F	F	F	F	F	F
Filtration index		u	u	u	u	u	u	u	u
Weight index		f	f	f	f	f	f	f	f
Validity	Annual average								
	Occasional	*							
Sampling date		1986-08-13							
BAF		36	400	100	400	70	90	250	250
Unit		L/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg
Com									
Reference		180)	1)	1)	1)	1)	1)	1)	1)
Sampling site		4							

Table A-6. Cont'd

Element		Cs	Cs
Documentation index		2	2
Isotope/Chemical form		-137	-134
Organism index		M	M
English name		Cat-tail	
Latin name		*Typha latifolia*	
Trophic level		1	1
Tissue index		Se	W
Org. size. weight (g)			
Org. size. length (mm)			
Lake type index			
Lab. study			
Water chemistry	[K] (ppm=mg/l)		0.57
	[Ca] (ppm=mg/l)		
	[TOC] (mg/cl)		
	[C] (mgPt/L)		
	[Fe] (ppm=mg/l)		
	pH		
	Conductivity (mS/m)		
	Susp. matter (ppm=mg/l)		
	Salinity (per mil)		
Salinity index		F	F
Filtration index		u	
Weight index		f	d
Validity	Annual average		*
	Occasional		
Sampling date			
BAF		100	1400
Unit		kg/kg	L/kg
Com			gm
Reference		1)	162)
Sampling site			

Table A-7. Bioaccumulation factors for cesium in invertebrates

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	2	2	2
Isotope/Chemical form		-137	-137	-137	-134	-134	-137	-137	-137	-137	-137	-137
Organism index		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo
English name		Swan mussel	Swan mussel	Swan mussel	Swan mussel	Swan mussel	Swan mussel	Swan mussel	Swan mussel	Swan mussel	Swan mussel	Swan mussel
Latin name		*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*	*Anodonta cygnea*
Trophic level		2	2	2	2	2	2	2	2	2	2	2
Tissue index		M	M	M	M	M	M	M	M	M	M	Sh
Org. size, weight (g)												
Org. size, length (mm)		62-84			62-84		62-84					
Lake type index		D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O			
Lab. study												
Water chemistry	[K] (ppm=mg/l)	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53			
	[Ca] (ppm=mg/l)	10	10	10	10	10	10	10	10			
	[TOC] (mg/cl)											
	[C] (mgPt/L)	252	252	252	252	252	252	252	252			
	[Fe] (ppm=mg/l)											
	pH	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92			
	Conductivity (mS/m)	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89			
	Susp. matter (ppm=mg/l)	4	4	4	4	4	4	4	4			
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index		f	f	f	u	u	u	u	u			
Weight index		f	f	f	f	f	f	f	f	d	f	d
Validity	Annual average											
	Occasional	*	*	*	*	*	*	*	*			
Sampling date		1986-06-01	1986-07-01	1986-08-01	1986-06-01	1986-08-01	1986-06-01	1986-07-01	1986-08-01			
BAF		340	167	234	39	238	213	157	221	300	30	60
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com												
Reference		180)	180)	180)	180)	180)	180)	180)	180)	106)	106)	106)
Sampling site		3	3	3	3	3	3	3	3			

Table A-7. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		2	2	2	2	2	2	2	2	2	2	2
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-134	-137	-137	-137	-137
Organism index		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo
English name		Swan mussel	Commom cockle	Commom cockle	Commom cockle	Commom cockle						
Latin name		*Anodonta cygnea*	*Cardium edule*	*Cardium edule*	*Cardium edule*	*Cardium edule*	*Rangia cuneata*	*Rangia cuneata*	*Rangia cuneata*	*Rangia cuneata*	*Rangia cuneata*	*Rangia cuneata*
Trophic level		2	2	2	2	2	2	2	2	2	2	2
Tissue index		Sh	M	M	Sh	Sh	M	M	M	M	M	M
Org. size, weight (g)												
Org. size, length (mm)												
Lake type index												
Lab. study							*	*				
Water chemistry	[K] (ppm=mg/l)											
	[Ca] (ppm=mg/l)											
	[TOC] (mg/cl)											
	[C] (mgPt/L)											
	[Fe] (ppm=mg/l)											
	pH											
	Conductivity (mS/m)											
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)								1	5	10	20
Salinity index		F	S	S	S	S	F/B	S	B	B	B	B
Filtration index												
Weight index		f	d	f	d	f	f	f	f	f	f	f
Validity	Annual average											
	Occasional											
Sampling date												
BAF		60	60	10	1	1	17	6	7	5	4	3
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com												
Reference		106)	106)	106)	106)	106)	106)	106)	106)	106)	106)	106)
Sampling site												

Table A-7. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		2	2	2	2	2	2	2	2	2	2	2
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo	Mo
English name						Blue mussel	Blue mussel	Blue mussel	Blue mussel	Baltic tellin	mussel	mussel
Latin name		*Rangia cuneata*	*Rangia cuneata*	*Rangia cuneata*	*Rangia cuneata*	*Mytilus edulis*	*Mytilus edulis*	*Mytilus edulis*	*Mytilus edulis*	*Macoma balthica*		
Trophic level		2	2	2	2	2	2	2	2	2	2	2
Tissue index		M	M	M	M	W	W	M	M	W	M	Sh
Org. size, weight (g)												
Org. size, length (mm)												
Lake type index												
Lab. study							*				*	*
Water chemistry	[K] (ppm=mg/l)											
	[Ca] (ppm=mg/l)											
	[TOC] (mg/cl)											
	[C] (mgPt/L)											
	[Fe] (ppm=mg/l)											
	pH											
	Conductivity (mS/m)											
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)	1	5	10	20							
Salinity index		B	B	B	B	F/B	S	S	B	F/B	S	S
Filtration index												
Weight index		f	f	f	f	f	f	f	f	f	f	f
Validity	Annual average											
	Occasional											
Sampling date												
BAF		15	9	7	5	100	3	9	13	60	10	1
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com												
Reference		106)	106)	106)	106)	106)	106)	106)	106)	106)	106)	106)
Sampling site												

Table A-7. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		2	2	2	2	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		Mo	Mo	Mo	Mo	Cr	Cr	Cr	Cr	Cr	Cr	Cr
English name		mussel	molluscs	mussels	mussels	Water-slater	Water-slater	Water-slater	Water-slater	Water-slater	Water-slater	Water-slater
Latin name						*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*
Trophic level		2	2	2	2	2	2	2	2	2	2	2
Tissue index		W	M	M	Sh	W	W	W	W	W	W	W
Org. size, weight (g)												
Org. size, length (mm)												
Lake type index												
Lab. study				*	*							
Water chemistry	[K] (ppm=mg/l)					0.15	0.15	0.34	0.34	0.34	0.34	0.34
	[Ca] (ppm=mg/l)					0.79	0.79	1.19	1.19	1.19	1.19	1.19
	[TOC] (mg/cl)					2.4	2.4	8	8	8	8	8
	[C] (mgPt/L)											
	[Fe] (ppm=mg/l)					0.6	0.6	0.17	0.17	0.17	0.17	0.17
	pH					4.4	4.4	4.8	4.8	4.8	4.8	4.8
	Conductivity (mS/m)					2	2	1.3	1.3	1.3	1.3	1.3
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F/B	S	F/B	F/B	F	F	F	F	F	F	F
Filtration index						f	u	f	f	f	u	u
Weight index		f	f	f	f	d	d	d	d	d	d	d
Validity	Annual average											
	Occasional											
Sampling date						summer-89	summer-89	summer-87	summer-88	summer-89	summer-88	summer-89
BAF		100	9	30	60	6125	4083	5122	13467	6056	7214	4542
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com												
Reference		106)	106)	106)	106)	183)	183)	183)	183)	183)	183)	183)
Sampling site						9	9	11	11	11	11	11

Table A-7. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	2	2	2	2
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-134	-137
Organism index		Cr	Cr	Cr	Cr	Cr	Cr	Cr	Cr	Cr	Cr	Cr
English name		Water-slater	Water-slater	Water-slater	Water-slater	Water-slater	Water-slater	Water-slater	crabs	crabs	crustacean	crustacean
Latin name		*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*	*Asellus aquaticus*				
Trophic level		2	2	2	2	2	2	2	2	2	2	2
Tissue index		W	W	W	W	W	W	W	M	Sh	W	M
Org. size, weight (g)												
Org. size, length (mm)												
Lake type index												
Lab. study											*	
Water chemistry	[K] (ppm=mg/l)	0.54	0.73	0.76	0.76	0.76	0.76	0.78				
	[Ca] (ppm=mg/l)	2.86	5.03	5.53	5.53	5.53	5.53	5.83				
	[TOC] (mg/cl)	7	15.9	24.9	24.9	24.9	24.9	14.7				
	[C] (mgPt/L)											
	[Fe] (ppm=mg/l)	0.12	0.52	0.79	0.79	0.79	0.79	0.82				
	pH	6.3	6.1	5.4	5.4	5.4	5.4	6				
	Conductivity (mS/m)	2.2	3.4	3.6	3.6	3.6	3.6	3.9				
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	S	S	S	S
Filtration index		f	f	f	f	u	u	f				
Weight index		d	d	d	d	d	d	d	f	f	f	f
Validity	Annual average											
	Occasional											
Sampling date		summer-87	summer-87	summer-88	summer-89	summer-88	summer-89	summer-87				
BAF		6762	5643	23000	10000	11500	6000	21200	435	588	9	20
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com												
Reference		183)	183)	183)	183)	183)	183)	183)	106)	106)	106)	106)
Sampling site		14	13	12	12	12	12	10				

Table A-7. Cont'd

Element		Cs	Cs	Cs	Cs
Documentation index		3	3	3	3
Isotope/Chemical form		-134	-134	-134	-134
Organism index		Ins	Ins	Ins	I
English name		Midge-larvae			leeches
Latin name		*Chirono-midae*	*Leptophle-bia*	*Odonata*	
Trophic level		2	2	3	3
Tissue index		W	W	W	W
Org. size, weight (g)					
Org. size, length (mm)					
Lake type index					
Lab. study					
Water chemistry	[K] (ppm=mg/l)	0.57	0.57	0.57	0.57
	[Ca] (ppm=mg/l)				
	[TOC] (mg/cl)				
	[C] (mgPt/L)				
	[Fe] (ppm=mg/l)				
	pH				
	Conductivity (mS/m)				
	Susp. matter (ppm=mg/l)				
	Salinity (per mil)				
Salinity index		F	F	F	F
Filtration index					
Weight index		d	d	d	d
Validity	Annual average	*	*	*	*
	Occasional				
Sampling date					
BAF		1100	8300	1600	340
Unit		L/kg	L/kg	L/kg	L/kg
Com		gm	gm	gm	gm
Reference		162)	162)	162)	162)
Sampling site					

Table A-8. Bioaccumulation factors for cesium in fish

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		2	2	2	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Cod	Cod	Cod	Perch	Perch	Perch	Perch	Perch	Perch	Perch	Perch
Latin name		*Gadidae*	*Gadidae*	*Gadidae*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*
Trophic level		4	4	4	3	3	3	3	3	3	3	3
Tissue index		M	M	M	M	M	M	M	M	M	M	M
Org. size, weight (g)												
Org. size, length (mm)					>200	<=200	>200	<=200	>200	<=200	>200	<=200
Lake type index					D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O
Lab. study												
Water chemistry	[K] (ppm=mg/l)				1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	[Ca] (ppm=mg/l)				5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	[TOC] (mg/cl)											
	[C] (mgPt/L)				60	60	60	60	60	60	60	60
	[Fe] (ppm=mg/l)				0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	pH				6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	Conductivity (mS/m)				8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		S	S	B	F	F	F	F	F	F	F	F
Filtration index												
Weight index		f	f	f	d	d	d	d	d	d	d	d
Validity	Annual average				*	*	*	*	*	*	*	*
	Occasional											
Sampling date					1964	1964	1965	1965	1966	1966	1967	1967
BAF		135	172	183	19630	19830	36670	17980	30430	16720	44160	17750
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com					gm	gm	gm	gm	gm	gm	gm	gm
Reference		106)	106)	106)	179)	179)	179)	179)	179)	179)	179)	179)
Sampling site					2	2	2	2	2	2	2	2

Table A-8. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Perch	Perch	Perch	Perch	Perch	Perch	Perch	Perch	Perch	Perch	Perch
Latin name		*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*
Trophic level		3	3	3	3	3	3	3	3	3	3	3
Tissue index		M	M	M	M	M	M	M	M	M	M	M
Org. size, weight (g)												
Org. size, length (mm)		>200	<=200	>200	<=200	>200	<=200	>200	<=200	>200	<=200	<100
Lake type index		D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	M
Lab. study												
Water chemistry	[K] (ppm=mg/l)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	3.7
	[Ca] (ppm=mg/l)	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	53
	[TOC] (mg/cl)											
	[C] (mgPt/L)	60	60	60	60	60	60	60	60	60	60	70
	[Fe] (ppm=mg/l)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
	pH	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	7.56
	Conductivity (mS/m)	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	7.35
	Susp. matter (ppm=mg/l)											3
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index												u
Weight index		d	d	d	d	d	d	d	d	d	d	f
Validity	Annual average	*	*	*	*	*	*	*	*	*	*	
	Occasional											*
Sampling date		1968	1968	1969	1969	1971	1971	1972	1972	1974	1974	1988-02-01
BAF		22200	12660	27690	18400	28570	11690	18750	12500	24000	16000	5821
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	
Reference		179)	179)	179)	179)	179)	179)	179)	179)	179)	179)	180)
Sampling site		2	2	2	2	2	2	2	2	2	2	4

Table A-8. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Perch	Perch	Perch	Perch	Pike	Pike	Pike	Pike	Pike	Pike	Pike
Latin name		*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Perca fluviatilis*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*
Trophic level		3	3	3	3	4	4	4	4	4	4	4
Tissue index		M	M	M	M	M	M	M	M	M	M	M
Org. size, weight (g)						>300	<=300	>300	<=300	>300	<=300	>300
Org. size, length (mm)		10-20	10-20	10-20								
Lake type index		M	M	M	M	D/O	D/O	D/O	D/O	D/O	D/O	D/O
Lab. study												
Water chemistry	[K] (ppm=mg/l)	3.7	3.7	3.7	3.7	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	[Ca] (ppm=mg/l)	53	53	53	53	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	[TOC] (mg/cl)											
	[C] (mgPt/L)	70	70	70	70	60	60	60	60	60	60	60
	[Fe] (ppm=mg/l)					0.8	0.8	0.8	0.8	0.8	0.8	0.8
	pH	7.56	7.56	7.56	7.56	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	Conductivity (mS/m)	7.35	7.35	7.35	7.35	8.1	8.1	8.1	8.1	8.1	8.1	8.1
	Susp. matter (ppm=mg/l)	3	3	3	3							
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index		u	u	u	u							
Weight index		f	f	f	f	d	d	d	d	d	d	d
Validity	Annual average					*	*	*	*	*	*	*
	Occasional	*	*	*	*							
Sampling date		1989-10-01	1988-02-01	1988-09-01	1989-10-01	1964	1964	1965	1965	1966	1966	1967
BAF		1394	9011	1768	2352	23170	22150	25120	21850	31550	21520	40990
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com						gm	gm	gm	gm	gm	gm	gm
Reference		180)	180)	180)	180)	179)	179)	179)	179)	179)	179)	179)
Sampling site		4	4	4	4	2	2	2	2	2	2	2

Table A-8. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Pike	Pike	Pike	Pike	Pike	Pike	Pike	Pike	Pike	Pike	Pike
Latin name		*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*	*Esox lucius*
Trophic level		4	4	4	4	4	4	4	4	4	4	4
Tissue index		M	M	M	M	M	M	M	M	M	M	M
Org. size, weight (g)		<=300	>300	<=300	>300	<=300	>300	<=300	>300	<=300	>300	<=300
Org. size, length (mm)												
Lake type index		D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O
Lab. study												
Water chemistry	[K] (ppm=mg/l)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	[Ca] (ppm=mg/l)	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	[TOC] (mg/cl)											
	[C] (mgPt/L)	60	60	60	60	60	60	60	60	60	60	60
	[Fe] (ppm=mg/l)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	pH	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	Conductivity (mS/m)	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index												
Weight index		d	d	d	d	d	d	d	d	d	d	d
Validity	Annual average	*	*	*	*	*	*	*	*	*	*	*
	Occasional											
Sampling date		1967	1968	1968	1969	1969	1971	1971	1972	1972	1974	1974
BAF		26870	24850	16040	31530	21320	22080	14290	22500	11250	26000	16000
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm
Reference		179)	179)	179)	179)	179)	179)	179)	179)	179)	179)	179)
Sampling site		2	2	2	2	2	2	2	2	2	2	2

Table A-8. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Pike	Roach	Roach	Roach	Roach	Roach	Roach	Roach	Roach	Roach	Roach
Latin name		*Esox lucius*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*
Trophic level		4	3	3	3	3	3	3	3	3	3	3
Tissue index		M	M	M	M	M	M	M	M	M	M	M
Org. size, weight (g)												
Org. size, length (mm)		<100				>200	<=200	>200	<=200	>200	<=200	<=200
Lake type index		M	M	M	M	D/O	D/O	D/O	D/O	D/O	D/O	D/O
Lab. study												
Water chemistry	[K] (ppm=mg/l)	3.7	3.7	3.7	3.7	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	[Ca] (ppm=mg/l)	53	53	53	53	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	[TOC] (mg/cl)											
	[C] (mgPt/L)	70	70	70	70	60	60	60	60	60	60	60
	[Fe] (ppm=mg/l)					0.8	0.8	0.8	0.8	0.8	0.8	0.8
	pH	7.56	7.56	7.56	7.56	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	Conductivity (mS/m)	7.35	7.35	7.35	7.35	8.1	8.1	8.1	8.1	8.1	8.1	8.1
	Susp. matter (ppm=mg/l)	3	3	3	3							
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index		u	u	u	u							
Weight index		f	f	f	f	d	d	d	d	d	d	d
Validity	Annual average					*	*	*	*	*	*	*
	Occasional	*	*	*	*							
Sampling date		1992-09-05	1988-02-01	1988-09-01	1989-10-01	1964	1964	1965	1965	1966	1966	1967
BAF		1542	1368	800	927	5420	4520	8040	8900	8670	7280	12650
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com						gm	gm	gm	gm	gm	gm	gm
Reference		180)	180)	180)	180)	179)	179)	179)	179)	179)	179)	179)
Sampling site		4	4	4	4	2	2	2	2	2	2	2

Table A-8. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Roach	Roach	Roach	Roach	Roach	Roach	Roach	Rudd	Rudd	Rudd	Rudd
Latin name		*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Rutilus rutilus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*
Trophic level		3	3	3	3	3	3	3	3	3	3	3
Tissue index		M	M	M	M	M	M	M	M	M	M	M
Org. size, weight (g)												
Org. size, length (mm)		<=200	>200	<=200	>200	<=200	<=200	<=200	<=200	<=200	<=200	<=200
Lake type index		D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O
Lab. study												
Water chemistry	[K] (ppm=mg/l)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	[Ca] (ppm=mg/l)	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	[TOC] (mg/cl)											
	[C] (mgPt/L)	60	60	60	60	60	60	60	60	60	60	60
	[Fe] (ppm=mg/l)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	pH	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	Conductivity (mS/m)	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index												
Weight index		d	d	d	d	d	d	d	d	d	d	d
Validity	Annual average	*	*	*	*	*	*	*	*	*	*	*
	Occasional											
Sampling date		1968	1969	1969	1971	1971	1972	1974	1966	1966	1967	1967
BAF		5070	16920	9230	10390	6490	6250	5000	13320	6210	20000	6320
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm
Reference		179)	179)	179)	179)	179)	179)	179)	179)	179)	179)	179)
Sampling site		2	2	2	2	2	2	2	2	2	2	2

Table A-8. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	3	3	3	3	3	3	3	3
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	-137	-137	-137	-137	-137
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Rudd	Rudd	Rudd	Rudd	Rudd	Rudd	Rudd	Rudd	Rudd	Rudd	Rudd
Latin name		*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*	*Scardinus erythroph-talmus*
Trophic level		3	3	3	3	3	3	3	3	3	3	3
Tissue index		M	M	M	M	M	M	M	M	M	M	M
Org. size, weight (g)												
Org. size, length (mm)		<=200	<=200	<=200	<=200	<=200	<=200	<=200	<=200	<=200	<=200	<=200
Lake type index		D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O	D/O
Lab. study												
Water chemistry	[K] (ppm=mg/l)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	[Ca] (ppm=mg/l)	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	[TOC] (mg/cl)											
	[C] (mgPt/L)	60	60	60	60	60	60	60	60	60	60	60
	[Fe] (ppm=mg/l)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	pH	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	Conductivity (mS/m)	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F	F	F	F	F	F	F	F
Filtration index												
Weight index		d	d	d	d	d	d	d	d	d	d	d
Validity	Annual average	*	*	*	*	*	*	*	*	*	*	*
	Occasional											
Sampling date		1968	1968	1969	1969	1971	1971	1972	1972	1964	1964	1965
BAF		12830	8280	23080	12310	10390	6490	13750	6250	12320	6400	14920
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm	gm	gm	gm	gm	gm	gm	gm	gm	gm	gm
Reference		179)	179)	179)	179)	179)	179)	179)	179)	179)	179)	179)
Sampling site		2	2	2	2	2	2	2	2	2	2	2

Table A-8. Cont'd

Element		Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs	Cs
Documentation index		3	3	3	2	2	2	2	2	2	2	2
Isotope/Chemical form		-137	-137	-137	-137	-137	-137	stable		-137	-137	-137
Organism index		F	F	F	F	F	F	F	F	F	F	F
English name		Rudd	Rudd	Rudd								
Latin name		*Scardinus erythroph- talmus*	*Scardinus erythroph- talmus*	*Scardinus erythroph- talmus*								
Trophic level		3	3	3	3	3	3	3	3	3	3	3
Tissue index		M	M	M	W	W	W	W	M	M	M	M
Org. size, weight (g)												
Org. size, length (mm)		<=200	<=200	<=200								
Lake type index		D/O	D/O	D/O								
Lab. study												
Water chemistry	[K] (ppm=mg/l)	1.1	1.1	1.1								
	[Ca] (ppm=mg/l)	5.7	5.7	5.7								
	[TOC] (mg/cl)											
	[C] (mgPt/L)	60	60	60								
	[Fe] (ppm=mg/l)	0.8	0.8	0.8								
	pH	6.5	6.5	6.5								
	Conductivity (mS/m)	8.1	8.1	8.1								
	Susp. matter (ppm=mg/l)											
	Salinity (per mil)											
Salinity index		F	F	F	F/B	S	S	S	F	F/B	F/B	S
Filtration index												
Weight index		d	d	d	f	f	f	f	d	f	f	f
Validity	Annual average	*	*	*								
	Occasional											
Sampling date		1965	1974	1974								
BAF		7410	24000	10000	383	108	83	71	2000	200	231	100
Unit		L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg	L/kg
Com		gm	gm	gm	gm	gm						
Reference		179)	179)	179)	106)	106)	106)	106)	90)	106)	106)	106)
Sampling site		2										

Table A-8. Cont'd

Element		Cs	Cs	Cs	Cs	Cs
Documentation index		2	2	2	2	2
Isotope/Chemical form		stable	-137	stable	-137	
Organism index		F	F	F	F	F
English name						
Latin name						
Trophic level		3	3	3	3	3
Tissue index		M	M	M	M	
Org. size, weight (g)						
Org. size, length (mm)						
Lake type index						
Lab. study						
Water chemistry	[K] (ppm=mg/l)					
	[Ca] (ppm=mg/l)					
	[TOC] (mg/cl)					
	[C] (mgPt/L)					
	[Fe] (ppm=mg/l)					
	pH					
	Conductivity (mS/m)					
	Susp. matter (ppm=mg/l)					
	Salinity (per mil)					
Salinity index		S	S	S	B	F
Filtration index						
Weight index		f	f	f	f	d
Validity	Annual average					
	Occasional					
Sampling date						
BAF		60	30	140	245	4330
Unit		L/kg	L/kg	L/kg	L/kg	L/kg
Com					gm	gm
Reference		106)	106)	106)	106)	162)
Sampling site						

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