TECHNICAL REPORTS SERIES NO. 479

Handbook of Parameter Values for the Prediction of Radionuclide Transfer to Wildlife

IAEA
International Atomic Energy Agency

IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available on the IAEA Internet site

http://www-ns.iaea.org/standards/

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at: Vienna International Centre, PO Box 100, 1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

Other safety related IAEA publications are issued as **Emergency Preparedness and Response** publications, **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

HANDBOOK OF
PARAMETER VALUES FOR
THE PREDICTION OF
RADIONUCLIDE TRANSFER
TO WILDLIFE

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHAMAS
BAHRAIN
BANGLADESH
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BRUNEI DARUSSALAM
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
CANADA
CENTRAL AFRICAN REPUBLIC
CHAD
CHILE
CHINA
COLOMBIA
CONGO
COSTA RICA
CÔTE D'IVOIRE
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DEMOCRATIC REPUBLIC OF THE CONGO
DENMARK
DOMINICA
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ERITREA
ESTONIA
ETHIOPIA
FIJI
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GUATEMALA
HAITI
HOLY SEE
HONDURAS
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN, ISLAMIC REPUBLIC OF
IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LAO PEOPLE'S DEMOCRATIC REPUBLIC
LATVIA
LEBANON
LESOTHO
LIBERIA
LIBYA
LIECHTENSTEIN
LITHUANIA
LUXEMBOURG
MADAGASCAR
MALAWI
MALAYSIA
MALI
MALTA
MARSHALL ISLANDS
MAURITANIA, ISLAMIC REPUBLIC OF
MAURITIUS
MEXICO
MONACO
MONGOLIA
MONTENEGRO
MOROCCO
MOZAMBIQUE
MYANMAR
NAMIBIA
NEPAL
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PAPUA NEW GUINEA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
RWANDA
SAN MARINO
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWAZILAND
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
TOGO
TRINIDAD AND TOBAGO
TUNISIA
TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA, BOLIVARIAN REPUBLIC OF
VIET NAM
YEMEN
ZAMBIA
ZIMBABWE

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

TECHNICAL REPORTS SERIES No. 479

HANDBOOK OF PARAMETER VALUES FOR THE PREDICTION OF RADIONUCLIDE TRANSFER TO WILDLIFE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2014

Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 2600 29302
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
http://www.iaea.org/books

Printed by the IAEA in Austria
June 2014
STI/DOC/010/479

IAEA Library Cataloguing in Publication Data

Handbook of parameter values for the prediction of radionuclide transfer to wildlife.
— Vienna : International Atomic Energy Agency, 2014.
p. ; 24 cm. — (Technical reports series, ISSN 0074–1914 ; no. 479)
STI/DOC/010/479
ISBN 978–92–0–100714–8
Includes bibliographical references.

1. Radioisotopes — Migration — Mathematical models. 2. Radioisotopes — Environmenal aspects. 3. Radioactive pollution. I. International Atomic Energy Agency. II. Series: Technical reports series (International Atomic Energy Agency) ; 479.

IAEAL 14–00902

FOREWORD

For many years, the IAEA has published materials aimed at supporting the assessment of the impact of radioactive releases to the environment, including guidance on both the assessment of doses to members of the public and associated parameter values, and on potential impacts on other species.

In the context of dose assessments for members of the public, the IAEA published generic models and parameters for assessing the environmental transfer of radionuclides from routine releases in 1982 (IAEA Safety Series No. 57), followed by two major publications providing compilations of relevant parameter values: Sediment Kds and Concentration Factors for Radionuclides in the Marine Environment (Technical Reports Series No. 247, 1985) and Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments (Technical Reports Series No. 364, 1994). In recent years, these books have been updated and superseded by: Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment (Safety Reports Series No. 19, 2001), Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment (Technical Reports Series No. 422, 2004) and Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments (Technical Reports Series No. 472, 2010).

The IAEA has played an instrumental role in the development of policies and assessment methods for evaluating potential impacts of radioactive releases on species other than humans, dating back to the 1970s. In 1979, the IAEA published Methodology for Assessing Impacts of Radioactivity on Aquatic Ecosystems (Technical Reports Series No. 190), followed in 1988 by Assessing the Impact of Deep Sea Disposal of Low Level Radioactive Waste on Living Marine Resources (Technical Reports Series No. 288). The impacts of radionuclide releases to terrestrial and freshwater environments were subsequently assessed as part of a consideration of the potential effects of ionizing radiation on plants and animals at levels implied by radiation protection standards in 1992 (Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards, Technical Reports Series No. 332). The IAEA has continued to work in this area, within the framework of the Environmental Modelling for Radiation Safety (EMRAS) programme, in the context of its coordination of international organizations with interests in environmental radiation protection, and through its ongoing development of related safety standards and supporting guidance.

This publication focuses on ‘concentration ratios’, which are one of the key parameter values for evaluating the transfer of radionuclides from environmental media (soil, air, water and sediments) to wildlife groups, for the purpose of assessing potential radiation dose rates and effects on wildlife. It is, therefore, analogous to Technical Reports Series No. 472, which presents transfer parameter values for use in assessments of doses to members of the public. The present publication contains mean transfer parameters and associated statistical distribution information. It also describes the approaches used to derive and collate these data and the main components of the models in which these data are used. Guidance on the application of these data and approaches for dealing with data gaps are also discussed. The transfer data presented in this publication are based on a comprehensive review of the available literature, including many publications in Russian not available in English. This review may, therefore, be considered to supersede previous reviews published by other organizations.

The current publication was prepared by the members of Working Group 5 of the EMRAS programme, chaired by B. Howard (United Kingdom), and with contributions from many other individuals and organizations convened to this work by the IAEA. The IAEA wishes to express its gratitude to all of the experts and institutions that contributed to this handbook, in particular, the International Union of Radioecology for its support, and the Environment Agency (of England and Wales), the Natural Environment Research Council of the United Kingdom and the Norwegian Radiation Protection Authority for the development of the on-line database used to collate the data presented in this publication. The IAEA officers responsible for this publication were D. Telleria and G. Pröhl of the Division of Radiation, Transport and Waste Safety.

CONTENTS

1. INTRODUCTION

The potential impacts of releases of radionuclides to the environment are generally assessed by means of mathematical models that take account of the transfer of radionuclides through different compartments of the environment [1]. The reliability of the predictions of the models depends, among other things, on the quality of the data used to represent radionuclide transfer through the environment. Ideally, such data should be obtained by measurements made in the environment being assessed. However, this is often impracticable or overly costly and, thus, there is heavy reliance on data obtained from the literature.

The IAEA has, for many years, supported efforts to develop models for radiological assessments for members of the public [1, 2] and to assemble appropriate sets of transfer parameter data [3, 4]. In 2004, the IAEA published an updated collection of data relevant to transfer in the marine environment [5] and, in 2010, data for estimating radionuclide transfer in the terrestrial and freshwater environments [6]. These compilations draw upon data from many countries and have come to be regarded as providing international reference values.

The IAEA has also played an instrumental role in the development of policies and assessment methods for evaluating potential impacts of radioactive releases on species other than humans, dating back to the 1970s. In 1979, the IAEA published a methodology for assessing impacts of radioactivity in aquatic systems [7], followed by an assessment of the impact of deep sea disposal in 1988 [8]. The impacts of radionuclide releases to terrestrial and freshwater environments were subsequently assessed as part of a consideration of the potential effects of ionizing radiation on plants and animals at levels implied by radiation protection standards in 1992 [9]. More recently, the IAEA work in this area has involved cooperation with other international organizations with ongoing relevant programmes, notably the United Nations Scientific Committee on the Effects of Atomic Radiation, the International Commission on Radiological Protection (ICRP), the International Union of Radioecology and the European Commission. The IAEA has also established of a number of relevant working groups within the framework of the Environmental Modelling for Radiation Safety (EMRAS) programme.

The biota working group (BWG) was established during the first IAEA EMRAS Programme (2003–2007) to compare and improve the growing number of models and approaches used to estimate the exposure of wildlife (both plants and animals) to ionizing radiation. Through model testing and comparison using scenarios, the BWG demonstrated that the dosimetric components of the various models available gave broadly comparable results, but that differences in the transfer components used within the models resulted in large variations in predicted whole organism activity concentrations and resultant internal doses [10–15]. These conclusions were supported by the outcome of the EURATOM PROTECT project [16], which compared the approaches available at the time [12, 17], and by the IAEA Coordination Group on Radiation Protection of the Environment [18]. The IAEA EMRAS BWG recommended that an international handbook on estimating transfer of radionuclides to wildlife, similar to Ref. [6], should be developed. In response, working group 5 was created within the EMRAS II Programme (2009–2011) to prepare this handbook of readily available quantitative information on the transfer of radionuclides to wildlife.

The use of concentration ratio values as a parameter to assess the transfer of radionuclides from environmental media to wildlife is a common approach in existing environmental exposure assessment models. To ensure adequate transparency, this handbook discusses the limitations of the concentration ratio values and the applicability of the data.

1.1. BACKGROUND

There is a well developed system of radiological protection of humans which has been implicitly providing protection to the environment for most exposure scenarios [19]. A systematic framework for radiological protection of the environment specifically considering exposure of wildlife[1] has only begun to evolve in the past decade. Policies, principles and methodologies for environmental radiological protection have been and continue to be developed [21] to consider the radiological protection of the environment in more detail and, in some cases, to estimate the exposure of wildlife to ionizing radiation.

In 2007, the ICRP revised its recommendations and acknowledged the importance of protecting the environment and, in doing this, noted that the standards of environmental control in place for the general public in planned exposure situations would ensure that other species are not placed at risk [19]. However, the ICRP also acknowledged that some national authorities required direct, explicit demonstration that the environment is protected and proposed a framework based on the assessment of dose rates and effects to a number of

[1] The term used to refer to species other than humans has varied over the years in ionizing radiation protection and radioecology literature. The following have been used: 'plants and animals' [9], 'non-human species' [20], 'flora and fauna' and 'non-human biota'. These terms are rarely used in other areas of environmental protection. The term 'wildlife' is in general use and here refers to living species that are not domesticated and which exist in natural habitats.

reference organisms (reference animals and plants (RAPs)) [19, 22]. The ICRP's stated aim is now that of:

> "preventing or reducing the frequency of deleterious ionizing radiation effects in the environment to a level where they would have a negligible impact on the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities, and ecosystems" [19, 20].

The ICRP believes that its approach to environmental protection is commensurate with the overall level of risk, is compatible with other approaches being taken to protect the environment, and closely relates to the current system for human radiological protection [19, 20, 22].

The IAEA, in cooperation with a number of other international governmental organizations, has taken account of the revised recommendations of the ICRP in developing a revised version of the International Basic Safety Standards (BSS) [23]. The BSS also identify protection of the environment[2] as an issue necessitating assessment, while allowing for flexibility in incorporating the results of environmental assessments into decision making processes and ensuring that the approaches adopted are commensurate with the radiation risks. Further guidance on the practical interpretation of the BSS requirements is under development by the IAEA.

Some Member States and regional organizations have also developed a range of approaches to address requirements in national legislation to demonstrate that the environment is protected from anthropogenic releases of radioactive substances [24–30].

In general terms, the assessment of the exposure of wildlife to ionizing radiation requires an approach that contains the following model components: (i) transfer of radionuclides to wildlife (including the physical transfer from the source of radioactivity through the relevant environmental medium) and; (ii) dose conversion coefficients relating internal and media activity concentrations to estimate absorbed dose rates to wildlife. The radiological risk to wildlife is then considered using knowledge of the biological effects of ionizing radiation [20, 31, 32].

[2] Protection of the environment includes the protection and conservation of: non-human species, both animals and plants, and their biodiversity; environmental goods and services such as the production of food and feed; resources used in agriculture, forestry, fisheries and tourism; amenities used in spiritual, cultural and recreational activities; media such as soil, water and air; and natural processes such as carbon, nitrogen and water cycles.

The most common approach to estimate radionuclide transfer to wildlife is to use a 'concentration ratio' to predict the activity concentration of a radionuclide in the whole organism from the activity concentration in the soil, sediment, water or air. The assumption is that equilibrium exists between the activity concentrations in the organism as a whole and the environmental medium in which it resides. The validity of this assumption depends on factors such as the variation in the rate of release of radioactive substances from a given site, the biological half-life of the radionuclide in the organism and the exposure time.

In aquatic systems, sediment–water distribution coefficients (K_d) are used to predict concentrations in water or sediment from known concentrations in sediment or water, respectively. Previous IAEA publications have provided reviews of K_d values for marine [5] and freshwater ecosystems [6, 33]; thus, these values are not included in this handbook.

Commonly, the approach taken to address the wide range of different organisms is to use 'reference organisms', which have been defined as:

> "a series of entities that provide a basis for the estimation of radiation dose rate to a range of organisms which are typical, or representative, of a contaminated environment. These estimates, in turn, would provide a basis for assessing the likelihood and degree of radiation effects" [34].

Slightly different terms and definitions are used by various groups [17], but the approaches adopted are generally similar. The selection of reference organisms may consider the need to encompass protected species, and different trophic levels and exposure pathways [20, 31, 35]. Reference organisms have tended to be defined at a broad wildlife group level (e.g. soil invertebrate, predatory fish, terrestrial mammal). In some cases, consideration of specific species has been included [27, 36].

The ICRP has established a group of 12 standardized reference organisms known as RAPs[3] to relate exposure to dose and dose to effects within its framework [20]. Information on the ecological characteristics, dosimetry and radiation induced effects relevant to these RAPs is presented in ICRP Publication 108 [20].

In this handbook, the transfer of radionuclides to wildlife is quantified using a concentration ratio between the organism and its associated environmental

---

[3] RAPs are defined by the ICRP as "A hypothetical entity, with the assumed basic biological characteristics of a particular type of animal or plant, as described to the generality of the taxonomic level of Family, with defined anatomical, physiological, and life-history properties, that can be used for the purposes of relating exposure to dose, and dose to effects, for that type of living organism".

media. The term is defined more precisely in Section 2. Concentration ratios for the RAPs have been published recently [37] based on the same on-line database (Section 3) as that used for the $CR_{wo\text{-}media}$ tables presented here.

1.2. OBJECTIVES

This handbook is primarily intended to provide generic transfer parameters in the form of concentration ratio values for use in assessment of ionizing radiation exposure to wildlife as a consequence of the presence of radionuclides in the environment. These data are intended for use in situations in which site specific values are not available or are deemed not to be necessary. The generic concentration ratio values are based on the assumption that equilibrium exists between the activity concentrations in wildlife and the appropriate medium. This assumption does not apply directly to rapidly changing situations where an equilibrium has not been established and the limitations of their application would then need to be taken into account.

1.3. SCOPE

This handbook provides equilibrium concentration ratio values for wildlife groups in terrestrial, freshwater, marine and brackish[4] water environments.

To provide comprehensive information suitable for different assessment approaches and purposes, both geometric and arithmetic means of concentration ratios are provided, where appropriate, for different wildlife groups together with associated estimates of standard deviation and ranges in observed values. These values may not be appropriate for certain cases needing detailed site specific assessments for which the collection of locally relevant data may be required. For transparency, the approaches used to derive and collate these data are presented. Guidance on the application of these data and approaches for coping with data gaps are discussed.

Available activity concentrations and/or concentration ratios for many radionuclides are often reported for specific tissues and not the whole organism. To enable such data to be converted to appropriate values for the whole organism, for the purposes of wildlife assessment, tables of conversion values are provided

[4] Brackish water environments include situations with relatively low water salinity, such as estuaries and others.

to allow tissue specific activity concentrations (or concentration ratios) to be converted to whole organism values.

The data tables presented here relate to the whole organism and are, therefore, not appropriate for assessing the transfer of radionuclides to foods consumed by humans. For the human food chain, transfer parameter values are required that relate to the edible fraction only; these data are presented in other IAEA publications [5, 6, 33].

1.4. STRUCTURE

Section 2 provides an overview of transfer processes, exposure pathways, modelling approaches and the definition of concentration ratios. Section 3 describes how the data were collated and summarized. The data tables of generic wildlife radionuclide concentration ratio values are provided in Section 4 together with guidance on their application. Section 5 describes approaches used to provide concentration ratios when data for a given radionuclide and organism are not available. The appendices provide reference information applicable to different sections. They contain data tables which can be used to convert ash or dry weight to fresh weight, or tissue specific radionuclide activity concentrations to whole organism activity concentrations, respectively, and are relevant to Section 3. The Annex provides the source publications used to estimate the concentration ratios included in the tables in Section 4, which are derived directly from the on-line database (discussed later). These data source publications are independent of the references relevant to the text. Relevant concepts and terminology are given in the Definitions.

2. CONCEPTS AND QUANTIFICATION

2.1. TRANSFER PROCESSES AND EXPOSURE PATHWAYS

2.1.1. Physical and chemical processes

Most releases of radioactive substances entering the environment are either in suspended or dissolved forms in liquid effluents, or as gases or particulates in airborne effluents. Following their release into air or water, the behaviour of radionuclides will be influenced by their physical and chemical form in the same manner as other elements. For example, water chemistry and the oxidation states of some elements, including radionuclides, will determine the degree to which they interact with suspended particulate material in the water column. The interaction of radionuclides with solid material, such as soil and sediment particles, plankton, vegetation and other materials occurs by numerous mechanisms including weathering, electrostatic attraction and formation of chemical bonds. In most cases, solid materials accumulate higher concentrations of radionuclides than air or water with some notable exceptions, such as noble gases.

In the terrestrial environment, vegetation can intercept elements, including airborne radionuclides from wet, dry or occult (e.g. fog, low cloud) deposition [38]; if not intercepted, they may be deposited onto the ground surface directly. Biomass per unit area affects the interception fraction for all types of deposition, but other factors, including ionic form, precipitation intensity, vegetation maturity and leaf area index[5] are important. Radionuclide activity concentrations on vegetation surfaces are reduced by a number of physical processes, including wash-off by rain or irrigation, surface abrasion and losses from wind action, tissue senescence, leaf fall, herbivore grazing, growth, volatilization and evaporation [39].

Resuspension of contaminated particulate material, generally associated with soil or sediment, is a process that occurs in both aquatic and terrestrial systems. In aquatic systems, the turbulent action of water can suspend surface sediments and transport them considerable distances before they are once more lost from the water column by sedimentation. Resuspended particulates will be available for direct entry into aquatic food chains via ingestion by particle feeders. In terrestrial ecosystems, wind action and rain splash on the soil can suspend radionuclides in the air. Resuspended particulates can then be inhaled or, if deposited on vegetation, ingested by animals [40].

In soils and sediments, radionuclides deposited on the soil surface migrate to deeper soil depths to varying extents. Soil/sediment properties, such as water percolation rates, amount of water present, pH, presence of ionic species, redox potential, bacterial activity, and clay mineral and organic matter content are important factors in determining radionuclide mobility [41, 42]. Physical disturbance, including bioturbation, leads to the mixing of radionuclides. In aquatic ecosystems, the sedimentation of particulate material will lead to the burial of deposited radionuclides.

Fixation of radionuclides to different components of soils and sediments over time can reduce their availability for uptake into food chains [43–46].

[5] Leaf area index is defined as the one sided green leaf area per unit ground area in broad-leaf canopies, or as the projected needle-leaf area per unit ground area in needle canopies.

In addition, vertical relocation to deeper soil and sediment layers removes radionuclides to compartments with little biological activity which may then act as permanent sinks.

In addition to the above mentioned processes, radionuclides naturally decay with a determined half-life characteristic of each element [47]. In some cases, radionuclides are naturally transformed into other radioactive or non-radioactive elements.

2.1.2. Biological uptake

The transfer of elements (including radionuclides) into an organism often depends on the food web, a series of related food chains through which energy, nutrients and chemicals move through an ecosystem. In all aquatic and terrestrial food webs, radionuclides are transferred from primary producers in the first trophic level to primary consumers (herbivores) at the second trophic level and then to carnivores or omnivores at higher trophic levels.

Elements enter food webs by numerous processes, which can vary over the different life cycle stages of some species. The key pathways by which radionuclides can enter an organism include:

(a) Inhalation of (re)suspended particles or gaseous radionuclides by terrestrial animals and aquatic birds, mammals and herpetofauna: Gaseous exchange of radionuclides by plants occurs via stomata respiration and cuticular absorption of radionuclides in the atmosphere or of radionuclides deposited onto plant surfaces followed by foliar uptake.

(b) Root uptake of radionuclides from the soil solution by plants: Soil/sediment characteristics, such as pH, cation exchange capacity, stable element status, organic matter content, soil moisture regime and characteristics of litter (especially for forest plants), strongly influence the transfer of many radionuclides to plants [48, 49]. Another factor governing radionuclide transfer to plants is the distribution of root systems and associated mycelia in the soil relative to that of the elements [49].

(c) Ingestion of radionuclides via organisms and water in lower trophic levels: In aquatic systems, there are many different primary producers including microscopic free-floating phototrophs (algae, bacteria, protists, phytoplankton) as well as macrophytes (aquatic plants) and macroalgae. In lakes and rivers, terrestrial plant material is also an important food source for some bottom feeding organisms. The transfer of radionuclides from these basal trophic levels occurs largely through the ingestion of such organisms by protozoa and zooplankton, and subsequent transfer to higher trophic levels. In terrestrial systems, the ingestion of the primary producers, plants, is a major contributor to the contamination of herbivorous animals. Predation of herbivores transfers radionuclides to successively higher trophic levels.

(d) Intake of radionuclides via ingested soil and sediments takes place in many organisms. For instance, radionuclides in the soil are directly ingested by both herbivores (often adhered to plant surfaces) and carnivores, sometimes through intentional ingestion to acquire essential nutrients. Ingestion of sediment is also a potential source of exposure in aquatic systems, especially for benthic feeders. For radionuclides that are not readily taken up by plants, such as plutonium, soil or sediment ingestion often represents an important route of intake [50–52].

(e) Absorption of ingested radionuclides in the digestive tract and their subsequent distribution within the organism leads to internal exposure of tissues. Absorption from the gastrointestinal tract of higher animals is highly variable and depends on factors such as age, homeostatic control and the physicochemical form of the radionuclide [53, 54]. For example, caesium in ionic form within plants is absorbed in the gut of herbivores to a greater extent than that adsorbed to soil matrices. Radionuclides accumulate in particular organs or tissues (e.g. iodine in thyroid, strontium in bone or shell, plutonium in liver and bone) [55]. Ingestion is the dominant transfer process of some important environmentally mobile radionuclides, such as those of caesium, in both aquatic and terrestrial ecosystems.

(f) Major factors influencing element transfer to aquatic biota (e.g. fish, molluscs, crustaceans) include the degree of physicochemical equilibrium between organisms and their surrounding environment, age of organisms, physicochemical form of elements in the water, (taxonomic) species and variations in the properties of the aquatic environment (such as suspended load, stable analogue concentrations and salinity of water) [56]. Aquatic organisms at a higher trophic level may accumulate relatively more environmentally mobile radioisotopes, such as iodine, calcium, technetium and strontium, than those at a lower trophic level (i.e. a bioconcentration effect) [57, 58]. Uptake leads to direct irradiation of respiratory systems, such as gills and digestive systems, and internal exposure of other organs if radionuclides are absorbed. The importance of different uptake routes varies. For example, plutonium in some high trophic level organisms, such as predatory fish, is taken up mainly via direct adsorption from the water column [59], indicating a low trophic-level effect for plutonium.

The tissues of deceased organisms, as well as secretions and excretions from living organisms input radionuclides into the detritus pool in both terrestrial and aquatic ecosystems. Detritus food webs are important in the cycling of all elements, including radionuclides. During decomposition, insoluble organic material is broken down to simpler forms by microbes and detritivores releasing radionuclides for potential uptake by primary producers and other organisms.

2.1.3. Exposure routes

The extent of exposure of wildlife to ionizing radiation is dependent on the amount of the different radionuclides present in the various environmental media (soil, sediment, water and air) and the rates of transfer of radionuclides in the environment. The pathways leading to exposure of organisms in both aquatic and terrestrial ecosystems are subdivided into internal and external components. Ingestion of contaminated food and water leads to direct irradiation of the digestive tract.

External irradiation can occur from any source external to the organism, and the dose that is delivered varies with ionizing radiation type, energy, size of organism and location of the source relative to the organism, depending on the organism's ecological characteristics and habitat. For example, a benthic dwelling fish will be exposed to ionizing radiation from radionuclides present in the water column and deposited sediments, whereas a pelagic fish may only be exposed to the former.

For β and γ irradiation, the range of the β particles or γ rays increases as the ionizing radiation energy increases. The relative importance and absolute magnitude of internal and external absorbed doses depend on the size and shape of the organism and on the density of the medium in which it is located. Most of the species in the wildlife groups are sufficiently large that the β and α radiation present within the organism will be fully absorbed by the tissues. However, as the organism size increases, the penetration of β radiation from external sources will decrease, resulting in exposure to the surface layers (e.g. skin, fur, feathers or plant cuticle) only. As the γ radiation energy increases, the fraction of the energy that is absorbed in a given sized organism will decrease. For microscopic organisms, external irradiation from α particles is also possible. External exposure pathways are not considered further as they are beyond the scope of the handbook.

2.2. CURRENT APPROACHES TO ESTIMATE TRANSFERS AND EXPOSURES USED IN ASSESSMENT MODELS

There are a variety of tools used to estimate exposure of wildlife to ionizing radiation [11, 14], some of which are freely available as software packages to any user [27, 35, 60]. In these models, concentration ratios are often used to predict radionuclide activity concentrations in wildlife by assuming that there is an equilibrium between the whole organism and the medium in which it is located [61]. All approaches currently used to assess the exposure of wildlife to ionizing radiation estimate dose rates to the whole organism. This approach allows model outputs to be put into context with the available data on the effects of ionizing radiation, which are typically presented as dose rates to the whole organism [20, 31, 32, 62].

Concentration ratio values are used in this handbook to describe the transfer from media to organisms. The approach is justified because of: (i) its simplicity, transparency and user-friendliness; (ii) the relatively large amount of relevant information available for organisms, elements and ecosystems compared with other methods of quantifying transfer; (iii) the common use of (and, therefore, the need for) this parameter in the existing environmental exposure assessment models; and (iv) its compatability with the approach being used by the ICRP in its developing framework for non-human biota [20] and tools used for human exposure assessments [6, 63].

2.2.1. Equilibrium concentration ratios

Concentration ratios are defined in the handbook in a manner which makes them clearly distinguishable from human food chain modelling and which specifies the medium being considered to avoid confusion. The $CR_{\text{wo-media}}$ value is defined for terrestrial ecosystems as:

$$CR_{\text{wo-soil}} = \frac{\text{activity concentration in whole organism (Bq/kg, fresh weight)}}{\text{activity concentration in soil (Bq/kg, dry weight)}} \tag{1}$$

with exceptions, in some models, for chronic atmospheric releases of some gaseous radionuclides (such as ^{3}H and ^{14}C) (see Section 2.2.2), where:

$$CR_{\text{wo-air}} = \frac{\text{activity concentration in whole organism (Bq/kg, fresh weight)}}{\text{activity concentration in air (Bq/m}^3\text{)}} \tag{2}$$

For aquatic ecosystems, the majority of approaches calculate $CR_{wo\text{-}media}$ using water as follows:

$$CR_{wo\text{-}water} = \frac{\text{activity concentration in whole organism (Bq/kg, fresh weight)}}{\text{activity concentration in (filtered) water (Bq/L)}} \quad (3)$$

although a few organizations estimate $CR_{wo\text{-}media}$ relative to sediment:

$$CR_{wo\text{-}sed} = \frac{\text{activity concentration in whole organism (Bq/kg, fresh weight)}}{\text{activity concentration in sediment (Bq/kg, dry weight)}} \quad (4)$$

The $CR_{wo\text{-}media}$ approach has some limitations; in particular, it assumes equilibrium in the environment between the media and the exposed wildlife. Therefore, careful consideration needs to be given when applying $CR_{wo\text{-}media}$ values in circumstances where there is substantial temporal variation in radiological conditions (e.g. pulsed inputs of radionuclides or accidents). There are alternative methods of quantifying transfer, including dynamic models [64] but the data necessary to populate these models are not yet available for many situations. Equilibrium $CR_{wo\text{-}media}$ values are particularly appropriate for assessments of chronic exposure scenarios, including quasi-steady annual discharges from nuclear installations.

$CR_{wo\text{-}media}$ values are also used as part of wildlife food chain transfer models. For instance, the United States Department of Energy uses $CR_{wo\text{-}media}$ values for quantifying radionuclide transfer to dietary components (such as plants or insects) as part of their kinetic–allometric food chain model [60] (see Section 5.4).

$CR_{wo\text{-}media}$ values are empirically derived parameters which offer a pragmatic approach to predicting radionuclide concentrations in wildlife and similar approaches are used for human food chain assessment [6]. However, these values provide no insight into underlying transfer processes or rates (although these are integrated within the value). There are many environmental factors controlling the behaviour of some radionuclides (Section 2.1). However, as they amalgamate many biological–chemical–physical processes, they may have a high degree of associated uncertainty. Depending on the purposes of the assessment, or the radionuclide and exposure pathway considered, this uncertainty may be acceptable and such environmental factors are rarely considered in human food chain assessment models used for screening purposes. The need to include such factors depends on whether the radionuclide exposure scenario considered is likely to give rise to doses rates requiring more than an initial screening assessment. If the release rate of a radionuclide, under highly conservative assumptions, only requires a generic assessment [24, 34], then more complex models will not be justified.

If sediment concentrations are known, but data for water are lacking, then distribution coefficient K_d values can be used to estimate concentrations of radionuclides in filtered water. The K_d can also be used to estimate radionuclide activity concentrations in sediment (which are needed to calculate external dose from sediment) from filtered water concentrations. The K_d, which is defined at equilibrium, is determined as:

$$K_d \text{ (L/kg)} = \frac{\text{activity concentration in sediment (Bq/kg, dry weight)}}{\text{activity concentration in (filtered) water (Bq/L)}} \quad (5)$$

The assumption of equilibrium between water and sediment activity concentrations is not always valid and the value of K_d is influenced by many water and sediment parameters [65].

To undertake wildlife dose assessment, the radionuclide activity concentration in bed sediments needs to be estimated to determine external dose rates to benthic organisms. Many K_d values presented in the general literature are for suspended sediments and are not directly applicable to bed sediments. It has been proposed that the apparent K_d for bed sediments is roughly 10% of that for suspended sediments [1]. These issues also apply to the estimation and application of $CR_{wo\text{-}sed}$ values.

2.2.2. Specific activity approaches for ^{14}C and ^{3}H

Values of $CR_{wo\text{-}media}$ are not presented for transfer of ^{3}H and ^{14}C in the $CR_{wo\text{-}media}$ tables because a specific activity approach is generally preferred (and is outlined below) and, furthermore, there are few observed $CR_{wo\text{-}media}$ values for either isotope. ^{3}H and ^{14}C are radionuclides of macroelements which are structural components of plant and animal tissues and, in the case of ^{3}H, water. In terrestrial environments, these radionuclides are primarily present as reversible gases ($^{14}CO_2$ and ^{3}HHO). It is common practice in human food chain modelling [6] and many wildlife assessment models [28, 35] to assume a constant air concentration and derive concentrations in foodstuff and wildlife relevant to this value. The equations presented below for estimating activity concentrations of ^{14}C and ^{3}H in wildlife are similar to those recommended in Ref. [6].

2.2.2.1. Terrestrial environments

For ^{14}C, a simple specific activity approach as that described in Ref. [66] can be used. Assuming a constant concentration of ^{14}C in air of 1 Bq/m^3, the specific activity in air SA_{air} (Bq/g · C) is:

$$SA_{air} = \frac{1}{0.20} \tag{6}$$

where 0.20 g/m^3 is the current carbon content of air [6].

The specific activity in herbage SA_{herb} will equal that in air:

$$\frac{1}{0.20} = \frac{^{14}C_{herb}}{C_{herb}} \tag{7}$$

where $^{14}C_{herb}$ (Bq/kg, fresh weight) and C_{herb} (g/kg, fresh weight) are the ^{14}C activity and stable carbon concentrations in herbage, fresh weight, respectively. Thus, the ^{14}C activity concentration in herbage, fresh weight, is:

$$^{14}C_{herb} = 5(C_{herb}) \tag{8}$$

Similarly, the ^{14}C activity concentration in animals $^{14}C_{anim}$ (Bq/kg, fresh weight) is:

$$^{14}C_{anim} = 5(C_{anim}) \tag{9}$$

where C_{anim} is the stable carbon concentration in animals (g/kg, fresh weight).

For ^{3}H in terrestrial ecosystems, a specific activity approach adapted for transfer to animals to take into account tritiated water (HTO) and organically bound tritium (OBT) can be applied [66, 67].

The tritium activity concentration in plant water is estimated according to Refs [68, 69] by:

$$C_{plantHTO} = 1.1\left(\frac{P_a}{P_v}\right) \cdot C_a + 1.17\left(1 - \frac{P_a}{P_v}\right) \cdot C_s \tag{10}$$

where

$C_{plantHTO}$	is the HTO concentration in leaf water (Bq/L);
C_a	is the HTO concentration in air moisture (Bq/L);
P_a	is the water vapour mass per unit air volume (average value for summer) (kg/m^3);
P_v	is the saturated water vapour mass per unit volume at leaf temperature (average value for summer) (kg/m^3);

and C_s is the HTO concentration in the routing depth of soil (Bq/L).

The HTO concentration in air moisture is estimated as:

$$C_a = \frac{C_{av}}{P_a} \tag{11}$$

where C_{av} is the HTO concentration in air volume (Bq/m^3).

In practice, the average leaf temperature is often considered equal to the average air temperature and the ratio in Eq. (10) is equal to the relative humidity (during the growing season). If FD is the plant dry matter fraction, then the HTO concentration in edible plant parts is simply:

$$C_{freshHTO} = (1 - \mathrm{FD}) \cdot C_{plantHTO} \tag{12}$$

The fresh weight OBT concentration fraction in plants is given by:

$$C_{OBT} = 0.6\mathrm{FD} \cdot C_{plantHTO} \tag{13}$$

The ^{3}H concentration in soil water C_s (rooting depth average) is estimated as the sum of wet and dry deposition:

$$C_s = \frac{D_w}{I_r} + 0.3C_a \tag{14}$$

The wet deposition contribution (D_w/I_r) is derived from the average HTO concentration in rainwater during the vegetation growing period, where D_w is the total wet deposition (Bq/m^2) during the growing period and I_r the average precipitation during the growing period (mm). D_w is given by:

$$D_w = C_{av} \cdot \lambda \cdot \text{MH} \cdot \Delta t \tag{15}$$

where

λ is the washout rate (h^{-1});
MH is the mixing height in neutral weather conditions (m);

and Δt is the total duration of rainfall (h) during the growing season.

The dry deposition component in Eq. (14) is defined by $0.3C_a$, where 0.3 is a conservative value suited to dry meteorological conditions [6].

The resultant ^{3}H activity concentrations in plant material are assumed to represent the diet of herbivorous animals. Subsequently, the activity concentrations estimated for herbivores are used to estimate the diet of carnivores. The transfer of ^{3}H to animals has been estimated using the approach presented in Refs [67, 70]. The ^{3}H activity concentration is estimated as the sum of the transfer of HTO and OBT calculated from the following equations:

$$\text{CR}_{\text{HTO}} = v_{bw} + \text{SAR}\frac{m_o}{0.111} \tag{16}$$

$$\text{CR}_{\text{OBT}} = v_{bw} + \text{FD}\frac{I_{dm}}{I_w} + \frac{m_o - \text{SAR} \cdot m_o}{C_{oh}} \tag{17}$$

where

CR_{HTO} is the ratio of the activity concentration of ^{3}H in the whole body to that ingested as HTO;
CR_{OBT} is the ratio of whole body ^{3}H activity concentration to that ingested as OBT;
v_{bw} is the body water fraction;
SAR is the ratio of the specific activity of OBT in the animal product to the specific activity of HTO in the body water (Ref. [67] assumes a value of 0.25 for SAR based on the results from small, monogastric animals);
m_o is the mass of organically bound hydrogen content (kg/kg, fresh weight);
0.111 is the mass of hydrogen in water (kg/kg);
FD is dry matter diet digestibility;

I_{dm} is the total dry matter (dm) intake (kg/d);
I_w is total water intake (including drinking water and water from food) (kg/d);

and C_{oh} is the concentration of organic hydrogen in the animal's diet (kg/kg dm)

2.2.2.2. Aquatic environments

Specific activity models for determining the ^{3}H and ^{14}C activity concentrations in the tissues of freshwater fish for human food chain assessments have been reported previously [6]. These models estimate whole organism activity concentrations in a range of freshwater wildlife with the provision of suitable input parameters. The ^{14}C model assumes that the fish is in equilibrium with the specific activity of dissolved inorganic carbon (DIC):

$$^{14}\mathrm{C} = C_{\mathrm{DIC}} \cdot S_{\mathrm{C}} \tag{18}$$

where

^{14}C is the ^{14}C activity concentration in the whole organism (Bq/kg, fresh weight);
C_{DIC} is the ^{14}C concentration in DIC in the water column ($Bq \cdot kg \cdot C^{-1}$);

and S_C is the stable carbon concentration in the whole organism (kg C/kg, fresh weight).

One caveat is that modelling ^{14}C in aquatic ecosystems is complicated by the presence of several carbon pools in different forms, including organic, inorganic, dissolved and particulate [6].

For HTO in freshwater ecosystems, there is an assumption that full equilibrium in specific activity concentrations will provide a good approximation for HTO in most compartments [6]. The HTO activity concentration in the whole organism (C_{HTO}) can, therefore, be estimated as:

$$C_{\mathrm{HTO}} = W_{\mathrm{C}} \cdot C_{\mathrm{W}} \tag{19}$$

where

W_C is the fractional water content of the organism (L/kg, fresh weight);

and C_W is the HTO concentration in the water column (Bq/L).

Where the organism is assumed to be exposed to a uniform concentration of HTO, then it is considered reasonable to assume that the concentration of OBT in the combustion water of the organism is the same as the concentration of HTO, apart from the need to account for isotopic fractionation [6]. This is achieved using a partition factor that takes account of the presence of exchangeable H in the combustion water and of isotopic effects arising both in the fish and in the different components of its food and water intakes. The OBT concentration in the organism, exposed to HTO, is given by:

$$C_{\mathrm{OBT}} = (1 - W_{\mathrm{C}}) \cdot \mathrm{WEQ} \cdot R_{\mathrm{f}} \cdot C_{\mathrm{w}} \tag{20}$$

where

WEQ is the water equivalent factor of the organism (kilogram of water produced per kilogram of dry weight combusted);

and R_{f} is the partition coefficient which accounts for isotopic fractionation.

However, this approach cannot be used when ^{3}H does not originate from an HTO source term (i.e. when ^{3}H enters the aquatic ecosystem as OBT). A more recent model includes an approach for considering OBT source terms [71].

3. COLLATION, TREATMENT AND EVALUATION OF DATA

3.1. THE WILDLIFE TRANSFER DATABASE

An on-line database[6] has been established to facilitate the collection of data for this handbook. This provides a structured way to collate data on the transfer of radionuclides to wildlife from the scientific community. This was a joint development with the ICRP, so that the same database is used to provide $CR_{\text{wo-media}}$ values for their developing framework [19]; the ICRP has adopted ‘hypothetical entities’, called RAPs, which refer to a specific set of conceptual and numerical models which can be used to estimate ionizing radiation exposures to living organisms from radionuclides.

[6] www.wildlifetransferdatabase.org.

The database compiles data on organism-media concentration ratios ($CR_{wo\text{-}media}$ values) as this is the parameter most often used in the currently available assessment models. The data are reported as whole organism $CR_{wo\text{-}media}$ values for a range of wildlife groups which live in different ecosystems (see Section 3.2). The database does not include recommended values based on reviews from previous publications as these are not original data.

The data compilations used within the ERICA project[7] to parameterize the ERICA tool[8] were used (following additional quality control) to initially populate the database [72, 73].

The on-line database is intended to be maintained in the future with periodic releases of revised $CR_{wo\text{-}media}$ tables which will provide a continuously improving source of $CR_{wo\text{-}media}$ information for conducting assessments and developing and/or maintaining assessment models. The frequency of the release of update tables has not been specified as it will depend on factors such as the extent of new data entries. A documented, referable publication procedure will be followed when updates are released.

3.2. STRUCTURE OF THE WILDLIFE TRANSFER DATABASE

The database collates data into three categories of information:

(a) Reference source information (e.g. authors, year, title, journal name).

(b) Study information such as the habitat or habitat subcategory (Table 1) and species name (common and Latin): Four generic ecosystem habitats are defined. In the database, these four generic ecosystem categories are terrestrial, freshwater, marine and estuarine. However, because the estuarine data used to compile the tables in Section 4 were comprised of two main sources, estuarine data from Japan and data for the Baltic Sea (which is a low salinity ecosystem), the term 'brackish' has been used in this handbook instead as it is more appropriate. The species is allocated to a broad wildlife group and to a subcategory of this group (Tables 2–4), and/or an ICRP RAP [20] category, if appropriate. The ICRP RAP category information is included to allow users to obtain up to date values for these organisms. Other information collected includes the life stage of the

[7] Environmental Risk from Ionizing Contaminants: Assessment and Management, EURATOM 6th Framework Programme project (https://wiki.ceh.ac.uk/display/rpemain/ERICA).

[8] A tool implementing the ERICA tiered approach for radiological assessment of wildlife in freshwater, terrestrial and marine ecosystems developed by a EURATOM 6th Framework Programme consortium.

organism, radionuclide or element, and general notes on the study design (e.g. soil type, sampling depth and sediment grain size). The database includes the elements relevant for all radioisotopes listed in Ref. [74]. For some wildlife groups listed in Tables 2–4, there are currently no data, so $CR_{wo\text{-}media}$ values are not reported in the tables in Section 4. Additionally, for some wildlife groups, only a few data values have been input into the database (e.g. fungi and ferns) and, thus, $CR_{wo\text{-}media}$ values have not been included in the $CR_{wo\text{-}media}$ tables. Summaries of these data are available in the on-line database.

(c) Media and wildlife radionuclide activity concentrations where the user also defines the media type (air, soil, sediment or water): If the wildlife or media radionuclide activity concentration is entered as a mean value, then the database entry template requests the number of data points N contributing to that mean and associated standard deviation. The media and wildlife radionuclide activity concentration values are used to calculate the concentration ratio. The mean value and the standard deviation of the wildlife and media activity concentration values are used to calculate the standard deviation of the calculated radionuclide concentration ratio (CRSD; see Eq. (21)). The CRSD and the wildlife N value are then used to weight the overall $CR_{wo\text{-}media}$ value when the data are summarized (see Section 3.3).

3.3. CALCULATION OF THE STANDARD DEVIATION OF THE CONCENTRATION RATIO

$$\mathrm{CRSD} = \mathrm{CR}_{\text{wo-media}} \times \sqrt{\left(\left(\frac{\mathrm{WildlifeSD}}{\mathrm{WildlifeActivityConcentration}}\right)^2 + \left(\frac{\mathrm{MediaSD}}{\mathrm{MediaActivityConcentration}}\right)^2\right)} \quad (21)$$

where

WildlifeSD is the standard deviation of the mean wildlife radionuclide activity concentration;

and MediaSD is the standard deviation of the mean media radionuclide activity concentration.

TABLE 1. HABITATS AVAILABLE IN THE ON-LINE TRANSFER DATABASE

Habitat	Definition
Terrestrial	Generic ecosystem including data from all terrestrial ecosystem types (with the exception of estuarine systems)
Terrestrial: semi-natural grassland	Includes: mountain and upland grasslands, heath and shrub lands, and some Arctic ecosystems
Terrestrial: forest	Land with tree crown cover of more than 10% over an area of more than 0.5 ha and with trees, which are able to reach a minimum in situ height of 5 m at maturity
Terrestrial: agricultural grassland	Managed grasslands
Terrestrial: coastal sand dunes	Coastal sand dunes (not to include marine organisms)
Terrestrial: wetland	Marsh, fen, peatland (not estuarine systems (e.g. saltmarshes))
Freshwater	Generic ecosystem including data from all freshwater ecosystem types
Freshwater: flowing	Rivers and streams
Freshwater: lake	Lakes and other static water bodies
Marine	Generic ecosystem including data from all marine ecosystem types
Marine: coastal	Water within 3 km of the coast (not estuaries)
Marine: open water	Water more than 3 km from the coast
Estuarine: water	Generic ecosystem including aquatic systems such as estuaries and low salinity water bodies
Estuarine: terrestrial[a]	'Terrestrial' components of estuarine ecosystems (including saltmarshes and mud flats, but not coastal sand dunes)

[a] Insufficient data were input into the database to present $CR_{wo\text{-}media}$ values for the terrestrial components of estuarine ecosystems, so no further details for this category are presented here. The wildlife groups included in the database for 'estuarine (terrestrial)' can be found under 'estuarine ecosystems' at http://www.wildlifetransferdatabase.org.

TABLE 2. WILDLIFE GROUPS LISTED IN THE ON-LINE TRANSFER DATABASE: TERRESTRIAL WILDLIFE GROUP LIST AND RELATIONSHIP TO INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP) REFERENCE ANIMALS AND PLANTS

Broad group	Available subcategories	Potential appropriate ICRP reference animal and plant
Amphibians	—	Frog
Arachnids	—	—
Arthropods		
	Arthropods: carnivorous	—
	Arthropods: detritivorous	—
	Arthropods: herbivorous	Bee
Birds		Duck
	Birds: carnivorous	Duck
	Birds: herbivorous	Duck
	Birds: omnivorous	Duck
Annelids	—	Earthworm
Ferns	—	—
Fungi		
	Fungi: mycorrhizal	—
	Fungi: parasitic	—
	Fungi: saprophytic	—
Grasses and herbs		—
	Grasses	Wild grass
	Herbs[a]	—
Lichens and bryophytes	—	—
Mammals		Rat or deer
	Mammals: carnivorous	Rat
	Mammals: herbivorous[b]	Rat or deer
	Mammals: omnivorous	Rat
	Mammals: marsupial[c]	—
	Mammals: *Rangifer* spp.	—
Molluscs	—	—
	Molluscs: gastropod	—
Reptiles		—
	Reptiles: carnivorous	—
	Reptiles: herbivorous	—
Shrubs	—	—

TABLE 2. WILDLIFE GROUPS LISTED IN THE ON-LINE TRANSFER DATABASE: TERRESTRIAL WILDLIFE GROUP LIST AND RELATIONSHIP TO INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP) REFERENCE ANIMALS AND PLANTS (cont.)

Broad group	Available subcategories	Potential appropriate ICRP reference animal and plant
Trees		—
	Trees: coniferous	Pine tree
	Trees: broad-leaf	—

[a] Herb refers to any non-woody plant which does not fall into one of the other categories.
[b] Does not include *Rangifer* spp. (reindeer and caribou); see text for justification.
[c] All marsupials regardless of feeding strategy.

TABLE 3. WILDLIFE GROUPS LISTED IN THE ON-LINE TRANSFER DATABASE: FRESHWATER WILDLIFE GROUP LIST AND RELATIONSHIP TO INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP) REFERENCE ANIMALS AND PLANTS

Broad group	Available subcategories	Potential appropriate ICRP reference animal and plant
Algae	—	—
Amphibians	—	Frog
Birds		Duck
	Birds: carnivorous	Duck
	Birds: herbivorous	Duck
	Birds: omnivorous	Duck
Crustaceans	—	—
Fish		—
	Fish: benthic feeding[a]	—
	Fish: piscivorous[b]	Salmonid
	Fish: forage[c]	—
Insects	—	—
Insect larvae[d]	—	—
Mammals		—
	Mammals: carnivorous	—
	Mammals: herbivorous	—
	Mammals: omnivorous	—

TABLE 3. WILDLIFE GROUPS LISTED IN THE ON-LINE TRANSFER DATABASE: FRESHWATER WILDLIFE GROUP LIST AND RELATIONSHIP TO INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP) REFERENCE ANIMALS AND PLANTS (cont.)

Broad group	Available subcategories	Potential appropriate ICRP reference animal and plant
Molluscs		—
	Molluscs: bivalve	—
	Molluscs: gastropod	—
Phytoplankton	—	—
Reptiles	—	—
Vascular plants	—	Wild grass
Zooplankton	—	—

[a] Fish feeding on benthic dwelling organisms.
[b] Fish consuming smaller fish, amphibians and/or birds.
[c] Fish feeding on primary producers and pelagic invertebrates and zooplankton.
[d] Insect larvae are included as the aquatic life phase is important for many species which are terrestrial as an adult.

TABLE 4. WILDLIFE GROUPS LISTED IN THE ON-LINE TRANSFER DATABASE: MARINE AND BRACKISH (WATER) WILDLIFE GROUP LIST AND RELATIONSHIP TO INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP) REFERENCE ANIMALS AND PLANTS

Broad group	Available subcategories	Potential appropriate ICRP reference animal and plant
Annelids[a]	—	—
Birds		Duck
	Birds: carnivorous	Duck
	Birds: herbivorous	Duck
	Birds: omnivorous	Duck
Crustaceans		—
	Crustaceans: large	Crab
	Crustaceans: small	—
Fish		
	Fish: benthic feeding[b]	Flat fish
	Fish: piscivorous[c]	Salmonid
	Fish: forage[d]	—

TABLE 4. WILDLIFE GROUPS LISTED IN THE ON-LINE TRANSFER DATABASE: MARINE AND BRACKISH (WATER) WILDLIFE GROUP LIST AND RELATIONSHIP TO INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP) REFERENCE ANIMALS AND PLANTS (cont.)

Broad group	Available subcategories	Potential appropriate ICRP reference animal and plant
Insects	—	—
Macroalgae	—	Brown seaweed
Mammals		—
	Mammals: carnivorous	—
	Mammals: herbivorous	—
	Mammals: planktivorous	—
Molluscs		—
	Molluscs: bivalve	—
	Molluscs: cephalopod[e]	—
	Molluscs: gastropod	—
Phytoplankton	—	—
Reptiles	—	—
Sea anemones/true corals	—	—
Vascular plants	—	—
Zooplankton	—	—

[a] Referred to as ‘polychaete worm’ in the on-line database.
[b] Fish feeding on benthic dwelling organisms.
[c] Fish consuming smaller fish, amphibians and/or birds.
[d] Fish feeding on primary producers and pelagic invertebrates and zooplankton.
[e] Squid, octopus, cuttlefish, etc.

If a measure of error is only available for either media or wildlife activity concentrations, this is carried through (proportionally) to give a standard deviation estimate for the calculated $CR_{wo\text{-}media}$ values.

The $CR_{wo\text{-}media}$ value generally refers to the whole organism. For some wildlife groups, further clarification is needed since some parts of the organism are not included. For aquatic ecosystems, the whole organism $CR_{wo\text{-}media}$ values for bivalve molluscs, large crustaceans and marine gastropods do not include shell to be consistent with commonly used dosimetry approaches. For vertebrate wildlife groups, whole organism $CR_{wo\text{-}media}$ values typically do not include the gastrointestinal tract contents, although there may be some exceptions such as when animals have been live monitored and in the case of small fish. Gastrointestinal tract contents tend to be removed as they will often contain comparatively high activity concentrations of unabsorbed elements. Similarly, pelt and feathers will typically not be included in the whole organism $CR_{wo\text{-}media}$ for mammals and birds, respectively, to remove external contamination. Vegetation $CR_{wo\text{-}media}$ values are typically based on only the above-ground parts of plants; to some extent, this is driven by the requirements of some of the existing dosimetric models which only consider above-ground plant parts [20, 35]. For some elements, roots contain a higher concentration of elements than above-ground plant parts [75, 76]. For instance, concentrations of uranium in the root have been reported to be much higher than in above-ground plant parts (with adherent external soil not explaining the difference) [77–79].

3.4. DATA ENTRY ISSUES

Where possible, weighted (with respect to sample numbers and reported standard deviations) mean $CR_{wo\text{-}media}$ values and standard deviations were estimated (and are presented in tables in Section 4). Ideally, media radionuclide activity concentrations for $CR_{wo\text{-}water}$ should be for filtered water and $CR_{wo\text{-}soil}$ should be for the 0–10 cm layer of soil. However, many of the source references of the data included in the $CR_{wo\text{-}media}$ tables do not conform to this specification, or do not present the relevant information.

In the derivation of the ERICA tool database, which was initially used to populate the on-line wildlife database [72, 73], some assumptions and compromises were used to address the lack of information in some source publications. These were:

(a) If information on replication was not given and no error term was reported in the source literature, a sample number of one was assumed;
(b) If a measure of error (e.g. standard deviation or standard error) was reported without a sample number, the sample number was assumed to be three;
(c) If a minimum and maximum were reported with no details of sample replication, a sample number of two was assumed.

However, any references which did not give all of the required information were rejected for wildlife group–radionuclide combinations for which there were many reported values [72, 73]. Only assumption (a) was applied for additional data entered into the database thereafter.

In the ERICA tool database, data for *Rangifer* spp. (e.g. reindeer, caribou) were treated separately from other mammals (and were defined as a separate wildlife category). This is because the air–lichen–reindeer pathway has a particularly high transfer of some radionuclides (e.g. caesium, polonium, lead), so the pathway is not representative of the uptake routes for most other terrestrial mammals [10].

Data collected during either the period of above-ground nuclear weapons testing fallout (assumed to be before 1970) or the year of the Chernobyl accident (1986) were not used to derive transfer parameter values for radionuclides of caesium, plutonium, strontium and americium to avoid effects such as the direct surface contamination of terrestrial vegetation.

Some $CR_{wo\text{-}media}$ values were derived using stable element data; in terrestrial ecosystems, these data were often associated with studies of heavy metal pollution, in which case only data from uncontaminated (control) sites were used.

Where a given dataset contains some measurements below detection limits, a value of 50% of the detection limit has been assumed if the number of values below the detection limit is less than 20% of the total number of measurements. The data have not been used where the number of undetectable measurements comprises a higher proportion of the overall dataset.

In some cases, data were available for specific tissues rather than for the whole organism, or the radionuclide activity concentrations were given for ashed or dried weights instead of fresh weight. In these cases, correction factors were applied as described in Section 3.3.

A significant amount of laboratory data have been entered into the on-line database. However, to estimate the $CR_{wo\text{-}media}$ values, only field data were used because of concerns that equilibrium would not have been reached in laboratory studies and the values would not accurately reflect food chain transfer. An exception is the use of some algae (freshwater), zooplankton, phytoplankton and sea anemone/coral data. The latter data were incorporated on the basis that water is likely to be the source of contamination, rather than food chain transfer. For algae and phyto/zooplankton, equilibration between water and organism radionuclide activity concentrations is likely to be rapid. As a consequence, many laboratory derived $CR_{wo\text{-}media}$ data for such organisms are in good agreement with estimates made from in situ investigations [5].

Where possible, data used to derive $CR_{wo\text{-}media}$ values are for radionuclide activity concentrations in wildlife and media measured at the same sites. However, some $CR_{wo\text{-}media}$ values for marine organisms have been calculated using observed concentrations of stable elements in organisms and generic data on global concentrations in seawater from publications such as Ref. [80]. This is thought to be acceptable as the major element, and some of the minor element, concentrations in open seawaters are relatively constant [81] compared with soil or freshwater concentrations. Marine values derived by this approach are identified in the $CR_{wo\text{-}water}$ table for marine organisms.

3.5. DATA TRANSFORMATIONS

It was often necessary to transform data into the appropriate format for entry into the database. The most common transformations were applied to take account of the fact that:

(a) Wildlife radionuclide activity concentrations were given on a dry weight or ash weight basis (when fresh weight $CR_{wo\text{-}media}$ values were required);
(b) Data were available for specific tissues (i.e. not whole organism);
(c) Soil radionuclide activity concentrations were given in becquerels per square metre. Where information was not given within the source publications, to enable manipulation of the data into the format required, a set of standard assumptions was followed. The conversion data used for the on-line database were based on those used for the ERICA tool and are given in Appendix I. Other sources of conversion factors which can be used for data presented on an ash or dry weight basis for terrestrial and aquatic ecosystems have been provided previously [6].

Many of the available radioecological data for wildlife groups originate from measurements made for human food chain assessments. These data are, therefore, for tissues consumed by humans (e.g. for animal muscle and milk). To utilize these data for the purposes of environmental assessment, tissue-specific data need to be converted into whole organism radionuclide activity concentrations. In some instances, this information is available from the source publications. Where this information is not available, Ref. [82] presents a series of look-up tables for a wide range of elements with conversion factors for tissue specific to whole organism concentrations for marine, freshwater and terrestrial animals (given in Appendix II). By multiplying the tissue specific radionuclide activity concentration by the conversion factor, an estimate of whole organism concentration is obtained. The compilation of conversion factors presented in Ref. [82] is considerably more comprehensive than those used in the derivation of the original ERICA tool database [72, 73]. The modified concentration ratio values in the ERICA tool which have been used here have not been recalculated to comply with the recent recommendations discussed in Ref. [82]. Following the recommendations in Ref. [82], where the conversion factors fall between 0.75 and 1.5, the values are given as 1.0 in Appendix II. For vascular plants, bryophytes and lichens, all parts of the organism were assumed to have the same concentrations.

Where the source publications for terrestrial wildlife groups lacked the required information to convert soil radionuclide activity concentrations from becquerel per square metre to becquerel per kilogram for a sampling depth of 10 cm, a dry weight soil bulk density of 1400 kg/m^3 was assumed [3]. Since bulk density varies with soil type, there will be an uncertainty associated with this assumption.

3.6. CALCULATION OF THE SUMMARY CONCENTRATION RATIOS

The individual $CR_{wo\text{-}media}$ values entered into the database have been used to calculate the weighted arithmetic mean (AM) (i.e. the mean for an individual study is given weight according to the number of observations in that study) and arithmetic mean standard deviation (AMSD) by ecosystem and wildlife groupings (see below), where:

$$\mathrm{AM} = \frac{\sum_i n_i \mathrm{CR}_i}{N} \tag{22}$$

and n_i is the number of observations in study i, CR_i is the mean $CR_{wo\text{-}media}$ for that study and N is the total number of observations in all studies.

The associated combined standard deviation ($\mathrm{AMSD}_{combined}$) accounting for within and between study variation is estimated as:

$$\mathrm{AMSD}_{combined} = \sqrt{\frac{\sum_i \left((n_i - 1)\mathrm{AMSD}_i^2 + n_i \mathrm{CR}_i^2\right) - \frac{\left(\sum_i n_i \mathrm{CR}_i\right)^2}{N}}{N-1}} \tag{23}$$

where AMSD_i is the AMSD for study i. Hence, the resultant $\mathrm{AMSD}_{combined}$ value is representative of variation over the whole dataset.

From the calculated weighted arithmetic mean and AMSD, approximate estimates of the geometric mean (GM) and geometric mean standard deviation (GMSD) were calculated:

$$\mathrm{GM} = \exp\left(-0.5\ln\left(\frac{\mathrm{AMSD}^2 + \mathrm{AM}^2}{\mathrm{AM}^4}\right)\right)$$

$$\mathrm{GMSD} = \exp\left(\sqrt{\ln\left(\frac{\mathrm{AMSD}^2 + \mathrm{AM}^2}{\mathrm{AM}^2}\right)}\right) \tag{24}$$

The resultant arithmetic mean, standard deviation, geometric mean and GMSD values along with the number of data N and the range are given in the tables presented in Section 4; it should be noted that the range here reflects the variation in individual mean values rather than the overall minimum and maximum of observed values. Geometric mean values are not given where $N < 3$. The estimated geometric mean and GMSD are approximations as their derivation using the above equations is dependent on the distribution of the underlying data.

Prior to the production of the tables presented in Section 4, the data were quality controlled to identify outlying values attributable to species within wildlife groups with especially high or low $CR_{wo\text{-}media}$ values. This resulted in the removal of some data for the transfer of selenium and uranium to terrestrial vegetation wildlife groups (summary $CR_{wo\text{-}media}$ values including these data are presented in the footnotes to Table 5 for comparison).

4. CONCENTRATION RATIO VALUES FOR WILDLIFE

4.1. CONCENTRATION RATIO TABLES FOR DIFFERENT ENVIRONMENTS

Concentration ratio values are provided for terrestrial ecosystems ($CR_{wo\text{-}soil}$) in Table 5, for freshwater ecosystems ($CR_{wo\text{-}water}$) in Table 6, for marine ecosystems ($CR_{wo\text{-}water}$) in Table 7 and for brackish ecosystems ($CR_{wo\text{-}water}$) in Table 8.

Source publications for the data within the concentration ratio tables are identified by their on-line identification (ID) number; the full reference for each ID number is provided in the Annex. Where possible, $CR_{wo\text{-}media}$ values are presented by wildlife subcategory. Subcategories were not considered for inclusion if the number of data were <10. If the number of data were in the range of 10–20, but originated from only one or two source references, the data were evaluated and some subcategory values were excluded from the summary tables if they represented a small proportion (typically <10%) of the overall dataset. Subcategories were not considered in brackish ecosystems because the data for brackish species originate from only two areas (Japanese estuaries or the Baltic Sea) and few references give subcategories.

The summary information for major wildlife groups presented in the tables contains data for all subcategories, with the exception of data for mammals; *Rangifer* spp. are not included in the values for mammals or mammals: herbivorous. Consideration was given to separating the reptile data into a subcategory of turtles, tortoises and terrapins (i.e. species with shells) and other species (predominantly lizards and snakes) because bone seeking elements will probably have higher $CR_{wo\text{-}media}$ values in shelled species. However, for terrestrial species, there were only two data entries for tortoises (one each for caesium and strontium); tortoises are herbivores. Thus, the data for carnivorous species in Table 5 are for snakes and lizards only. Although there were more data for freshwater turtles, they were insufficient to justify presenting separate values for the reptile groups. Reference [83] reports the same data as those included in the database used here, but subdivided for different orders of reptiles.

For some summary $CR_{wo\text{-}media}$ values where $N > 1$, no summary statistics are provided other than the arithmetic mean. This is where data are derived from a single source which only presents arithmetic mean and N values. The 'minimum' values presented in Tables 5–8 are, in a number of instances, higher than the estimated geometric mean. This is because the geometric mean derivation utilizes the overall AMSD value (see Eq. (24)) and, as noted above, the dataset contains a mixture of individual values and mean values with associated standard deviations. Hence, the minimum is not necessarily the true minimum of the constituent datasets. For instance, the dataset for iodine $CR_{wo\text{-}water}$ values for freshwater molluscs (see Table 6) is comprised of two data entries: (i) a mean and standard deviation of 80 ± 27 derived from six measurements and (ii) an individual entry of 102. Consequently, while the minimum value in Table 6 is 80, application of Eq. (24) results in a geometric mean estimate of 79.

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Ag (silver)								
Grasses and herbs	2.9E+0	3.7E+0	1.8E+0	2.7E+0	2.8E–3	9.8E+0	13	162, 212
Lichens and bryophytes	3.0E–2	3.4E–2	2.0E–2	2.5E+0	1.2E–2	1.3E–1	12	348
Shrubs	2.1E–2	9.1E–3	1.9E–2	1.5E+0	1.2E–2	3.3E–2	5	348
Al (aluminium)								
Lichens and bryophytes	1.1E–1	1.1E–1	7.1E–2	2.4E+0	1.0E–2	4.2E–1	32	348, 355
Shrubs	1.9E–2	1.8E–2	1.4E–2	2.2E+0	2.9E–3	1.2E–1	119	347, 348
Am (americium)								
Amphibians	1.3E–1	3.4E–2	1.3E–1	1.3E+0	1.0E–1	1.5E–1	22	486
Annelids	1.8E–1	3.0E–1	9.0E–2	3.2E+0	5.2E–2	1.1E+0	13	171, 486, 488
Arachnids	5.7E–2	6.2E–2	3.8E–2	2.4E+0	2.2E–2	1.3E–1	20	170, 488
Arthropods	1.1E–1	2.9E–1	4.0E–2	4.2E+0	1.3E–3	2.0E+0	82	170, 172, 223, 382, 407, 488
Arthropods: detritivorous	9.6E–2	7.5E–2	7.6E–2	2.0E+0	2.0E–2	2.2E–1	29	170, 172, 223, 488
Birds	3.2E–2	1.6E–2	2.8E–2	1.6E+0	1.9E–2	3.8E–2	3	486
Grasses and herbs	1.0E–1	2.9E–1	3.4E–2	4.4E+0	3.6E–3	3.0E–1	65	177, 250, 486
Grasses	1.0E–1	2.9E–1	3.5E–2	4.4E+0	3.6E–3	3.0E–1	63	177, 250, 486
Lichens and bryophytes	1.2E+0	1.7E+0	6.9E–1	2.9E+0	2.0E–1	3.2E+0	3	382, 486
Mammals	3.2E–2	1.0E–1	9.8E–3	4.7E+0	2.6E–4	1.7E–1	139	172, 184, 197, 221, 245, 407, 488
Mammals: herbivorous	5.4E–2	2.0E–1	1.4E–2	5.2E+0	2.6E–4	1.7E–1	27	184, 407, 488

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Mammals: omnivorous	3.0E–2	5.4E–2	1.5E–2	3.3E+0	3.7E–4	4.5E–2	84	221, 245, 488
Mammals: *Rangifer* spp.[b]	2.0E–1	2.4E–1	1.3E–1	2.6E+0	1.6E–1	2.2E–1	9	197
Molluscs: gastropod	1.4E–1	1.4E–1	1.0E–1	2.2E+0	5.1E–2	2.0E–1	13	486, 488
Reptiles: carnivorous[c]	6.4E–2	3.9E–2	5.5E–2	1.8E+0	1.0E–3	8.6E–2	16	407, 486
Shrubs	2.7E–2	3.3E–2	1.7E–2	2.6E+0	5.1E–5	9.5E–2	12	196, 486
As (arsenic)								
Annelids	3.5E–1	2.3E–1	2.9E–1	1.8E+0	6.1E–2	7.9E–1	383	344
Arthropods	2.2E–2	3.7E–2	1.1E–2	3.2E+0	4.8E–3	5.6E–1	257	344
Arthropods: detritivorous	2.9E–2	1.8E–2	2.5E–2	1.8E+0	9.3E–3	8.9E–2	38	344
Grasses[c]	1.3E–2						2	334
Lichens and bryophytes	1.1E+0	1.8E+0	6.1E–1	3.1E+0	7.1E–2	1.2E+1	93	342, 345, 348, 349, 355, 373, 467
Shrubs	4.6E–1	8.5E–1	2.2E–1	3.4E+0	5.5E–2	6.2E+0	127	342, 345, 347, 348
B (boron)								
Lichens and bryophytes	3.5E–1	6.0E–1	1.7E–1	3.3E+0	2.3E–2	2.4E+0	19	348
Shrubs	1.4E+0	1.7E+0	8.6E–1	2.7E+0	9.3E–2	6.8E+0	120	347, 348
Ba (barium)								
Arthropods	3.8E–2						1	518
Grasses and herbs	6.5E–2	4.4E–2	5.4E–2	1.8E+0	3.4E–2	7.2E–2	19	467, 518

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Lichens and bryophytes	1.8E–1	1.2E–1	1.5E–1	1.8E+0	2.1E–2	6.0E–1	37	348, 355, 467
Mammals: omnivorous[c]	4.9E–3	1.1E–3	4.8E–3	1.2E+0	4.3E–3	5.8E–3	18	518
Shrubs	2.7E+0	1.8E+0	2.2E+0	1.8E+0	1.3E–2	9.8E+0	131	347, 348, 467
Trees: coniferous[c]	1.9E–1	1.3E–1	1.6E–1	1.8E+0	6.2E–2	2.6E–1	3	467
Be (berylium)								
Lichens and bryophytes	1.6E–1	1.3E–1	1.2E–1	2.0E+0	3.8E–2	4.7E–1	19	348, 355
Shrubs	9.4E–2	3.9E–2	8.6E–2	1.5E+0	4.7E–2	1.6E–1	8	347, 348
Br (bromine)								
Grasses and herbs	7.3E–1	2.9E–1	6.8E–1	1.5E+0	6.3E–1	1.2E+0	6	467
Lichens and bryophytes	1.0E+0	5.3E–1	9.0E–1	1.6E+0	3.2E–1	1.7E+0	5	467
Shrubs	1.6E–1	4.4E–2	1.5E–1	1.3E+0	1.3E–1	2.2E–1	11	467
Trees	8.5E–2	4.9E–2	7.4E–2	1.7E+0	3.2E–2	1.2E–1	4	467
Cd (cadmium)								
Amphibians	1.5E–2	7.9E–3	1.3E–2	1.7E+0	5.0E–3	2.4E–2	5	213
Annelids	4.6E+0	3.6E+0	3.6E+0	2.0E+0	3.9E–1	2.1E+1	398	199, 229, 264, 344
Arachnids	1.9E+1	5.6E+0	1.8E+1	1.3E+0			30	158
Arthropods	2.7E+0	4.5E+0	1.4E+0	3.2E+0	2.1E–1	4.0E+1	679	158, 202, 204, 254, 344
Arthropods: carnivorous	3.1E+0	5.6E–1	3.0E+0	1.2E+0	3.0E+0	3.9E+0	167	158, 202

TABLE 5. CONCENTRATION RATIO ($CR_{wo-soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo-soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Arthropods: detritivorous	2.8E+0	4.9E+0	1.4E+0	3.3E+0	8.8E–1	4.0E+1	279	204, 254, 344
Grasses and herbs	2.1E+0	2.0E+0	1.5E+0	2.3E+0	3.5E–1	9.3E+0	530	158, 180, 202
Grasses	3.4E+0	2.2E+0	2.9E+0	1.8E+0	2.5E+0	9.3E+0	223	158, 202
Lichens and bryophytes	4.1E–1	1.2E–1	3.9E–1	1.3E+0	2.3E–1	7.3E–1	30	348
Mammals	1.6E+0	3.1E+0	7.2E–1	3.5E+0	8.5E–2	2.1E+1	415	158, 243
Mammals: carnivorous	1.3E+0	2.9E+0	5.4E–1	3.8E+0	8.5E–2	2.1E+1	395	158, 243
Mammals: herbivorous	6.8E+0	8.9E–1	6.7E+0	1.1E+0			20	158
Molluscs: gastropod	6.3E–1	3.7E–1	5.4E–1	1.7E+0	2.5E–1	1.3E+0	34	232
Shrubs	1.6E–1	1.0E–1	1.4E–1	1.8E+0	5.0E–2	4.0E–1	36	240, 347, 348, 354
Trees	7.1E–1	1.3E+0	3.5E–1	3.3E+0	5.4E–3	7.2E+0	228	180, 233
Ce (cerium)								
Annelids	3.7E–4						1	264
Grasses and herbs	4.7E–3	3.8E–3	3.6E–3	2.0E+0	3.9E–3	5.2E–3	6	467
Lichens and bryophytes	1.3E–2	8.8E–3	1.1E–2	1.8E+0	5.0E–3	2.8E–2	5	467
Shrubs	4.8E–2	2.3E–1	9.9E–3	5.9E+0	1.8E–3	3.2E–1	77	252, 467, 468
Trees: coniferous[c]	3.3E–3						2	467
Cl (chlorine)								
Annelids	1.8E–1	6.0E–2	1.7E–1	1.4E+0	1.7E–1	2.0E–1	17	238
Arthropods	3.0E–1	1.2E–1	2.8E–1	1.5E+0	2.5E–1	3.9E–1	31	238

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Arthropods: detritivorous	3.2E–1	1.2E–1	2.9E–1	1.5E+0	2.7E–1	3.9E–1	26	238
Grasses and herbs	2.1E+1	1.9E+1	1.5E+1	2.2E+0	1.9E–2	9.2E+1	56	251, 494, 498
Lichens and bryophytes	9.6E–1						1	251
Molluscs: gastropod	1.7E–1	1.0E–1	1.4E–1	1.8E+0	1.5E–1	2.0E–1	20	238
Shrubs	1.0E+0	2.1E+0	4.7E–1	3.5E+0	3.2E–1	1.0E+1	79	251
Trees	1.4E+0	1.2E+0	1.1E+0	2.1E+0	2.6E–1	3.9E+0	11	251
Cm (curium)								
Arthropods: detritivorous	1.4E–1				9.5E–2	1.8E–1	2	223
Grasses[c]	5.0E–4						1	491
Trees: broad-leaf[c]	9.4E–3				1.7E–3	1.7E–2	2	173
Co (cobalt)								
Arthropods	6.1E–3	5.1E–3	4.7E–3	2.1E+0	3.5E–3	6.2E–3	17	175, 234
Grasses and herbs	4.2E–3	1.5E–3	3.9E–3	1.4E+0	3.0E–3	5.3E–3	6	467
Lichens and bryophytes	2.4E–1	3.8E–1	1.3E–1	3.1E+0	1.6E–3	1.8E+0	37	348, 355, 467
Mammals: omnivorous[c]	3.0E–1	3.7E–1	1.8E–1	2.7E+0	5.9E–2	1.2E+0	29	161
Shrubs	7.2E–2	8.5E–2	4.7E–2	2.5E+0	1.4E–3	6.6E–1	128	347, 348, 467
Trees	8.7E–3	1.3E–2	4.9E–3	2.9E+0	3.8E–4	3.0E–2	7	174, 467

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Cr (chromium)								
Grasses and herbs	6.6E–3	3.6E–3	5.8E–3	1.7E+0	4.4E–3	8.6E–3	6	467
Lichens and bryophytes	1.3E–1	1.1E–1	1.0E–1	2.1E+0	3.8E–3	3.1E–1	17	348, 467
Shrubs	1.0E–1	1.4E–1	5.8E–2	2.9E+0	1.3E–3	4.9E–1	23	347, 348, 467
Trees: coniferous[c]	4.1E–3	1.8E–3	3.8E–3	1.5E+0	2.5E–3	4.9E–3	3	467
Cs (caesium)								
Amphibians	4.4E–1	8.1E–1	2.1E–1	3.4E+0	3.2E–2	2.1E+0	137	188, 205, 256, 486
Annelids	9.0E–2	1.6E–1	4.3E–2	3.4E+0	1.5E–2	6.9E–1	19	171, 207, 264, 488
Arachnids	3.0E–2	3.5E–2	1.9E–2	2.5E+0	2.0E–2	1.6E–1	20	170, 488
Arthropods	1.1E–1	4.7E–1	2.4E–2	5.7E+0	2.0E–3	1.7E+0	192	169, 170, 172, 175, 176, 195, 223, 257, 382, 388, 488
Arthropods: carnivorous	2.5E–1	4.7E–1	1.1E–1	3.5E+0	1.1E–2	1.7E+0	15	170, 195, 488
Arthropods: detritivorous	9.0E–2	2.9E–1	2.7E–2	4.7E+0	3.0E–3	1.4E+0	76	169, 170, 172, 176, 223, 257, 488
Arthropods: herbivorous	9.8E–3	1.8E–2	4.7E–3	3.4E+0	3.0E–3	7.1E–2	25	170, 176
Birds	6.7E–1	1.6E+0	2.7E–1	3.9E+0	1.4E–3	1.6E+1	180	163, 189, 190, 228, 258, 263, 405, 486
Birds: herbivorous	1.0E+0	1.5E+0	5.4E–1	3.0E+0	2.3E–2	5.8E+0	57	163, 190, 228, 258, 263, 405, 486
Birds: omnivorous	5.7E–1	1.8E+0	1.7E–1	4.8E+0	9.4E–3	1.6E+1	79	189, 190, 405, 486

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Grasses and herbs	1.2E+0	2.6E+0	5.1E–1	3.7E+0	1.9E–3	3.7E+1	2028	166, 193, 210, 236, 253, 257, 259, 272, 395, 400, 403, 404, 409, 413, 414, 432, 433, 434, 435, 437, 442, 443, 444, 448, 452, 453, 467, 486, 498, 500, 501, 510, 516, 519
Grasses	1.8E+0	3.2E+0	8.5E–1	3.4E+0	3.6E–3	3.7E+1	1081	210, 236, 253, 272, 395, 409, 413, 414, 448, 453, 486, 501, 510, 519
Herbs	1.1E+0	2.2E+0	5.0E–1	3.5E+0	3.0E–3	2.2E+1	155	253, 272, 400, 403, 409, 432, 452, 467, 500, 519
Lichens and bryophytes	4.1E+0	3.9E+0	3.0E+0	2.2E+0	3.0E–2	1.4E+1	142	163, 253, 272, 382, 435, 440, 467, 486, 519
Mammals	3.5E+0	8.3E+0	1.3E+0	4.0E+0	2.8E–3	1.4E+2	2463	163, 168, 172, 184, 190, 208, 209, 228, 230, 242, 268, 275, 289, 294, 405, 406, 486, 488
Mammals: carnivorous	5.4E–1	1.9E+0	1.4E–1	5.1E+0	2.8E–3	2.3E+1	231	190, 275, 405, 406, 486, 488
Mammals: herbivorous	3.9E+0	9.1E+0	1.5E+0	3.9E+0	1.0E–2	1.4E+2	1879	163, 184, 190, 208, 209, 228, 230, 242, 268, 294, 405, 486, 488
Mammals: omnivorous	3.2E+0	5.2E+0	1.7E+0	3.1E+0	1.7E–2	3.6E+1	335	168, 190, 268, 289, 405, 486, 488
Mammals: *Rangifer* spp.[b]	1.7E+1	1.6E+1	1.3E+1	2.2E+0	1.2E–1	8.1E+1	916	160, 163, 164, 218, 228, 241
Molluscs: gastropod	4.0E–2	3.1E–2	3.2E–2	2.0E+0	2.1E–2	6.5E–2	23	191, 486, 488
Reptiles	5.8E–1	1.0E+0	2.8E–1	3.3E+0	6.0E–4	3.0E+0	137	169, 267, 407, 486, 487

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Reptiles: carnivorous	5.2E–1	9.4E–1	2.5E–1	3.3E+0	6.0E–4	3.0E+0	125	169, 267, 407, 486, 487
Shrubs	2.3E+0	4.0E+0	1.1E+0	3.3E+0	9.8E–3	1.6E+1	354	164, 167, 210, 272, 468, 472, 486, 519
Trees	1.4E–1	2.4E–1	7.5E–2	3.1E+0	1.2E–3	1.8E+0	487	183, 190, 210, 265, 470, 471, 472, 473, 474, 475, 476, 477, 478, 484, 485, 519
Trees: broad-leaf	1.4E–1	2.2E–1	7.5E–2	3.1E+0	1.2E–3	1.3E+0	252	190, 210, 265, 470, 471, 472, 473, 474, 475, 477, 478, 484, 485, 519
Trees: coniferous	1.5E–1	2.5E–1	7.5E–2	3.2E+0	1.2E–3	1.8E+0	235	183, 472, 474, 475, 476, 484
Cu (copper)								
Annelids	2.2E–1	4.8E–2	2.1E–1	1.2E+0	1.3E–1	3.8E–1	383	344
Arthropods	7.5E–1	9.0E–1	4.8E–1	2.6E+0	1.7E–1	4.8E+0	254	344
Arthropods: detritivorous	2.5E+0	1.2E+0	2.3E+0	1.6E+0	8.0E–1	4.8E+0	35	344
Lichens and bryophytes	6.0E–1	5.4E–1	4.5E–1	2.1E+0	7.1E–2	2.5E+0	91	334, 342, 345, 348, 355
Reptiles: carnivorous[c]	3.2E–2	6.8E–1	1.5E–3	1.2E+1	1.3E–2	7.8E–2	44	487
Shrubs	3.8E+0	3.4E+0	2.8E+0	2.2E+0	2.7E–1	1.4E+1	239	342, 345, 347, 348
Eu (europium)								
Annelids	7.9E–4						1	264
Grasses and herbs	4.5E–3	3.3E–3	3.6E–3	1.9E+0	2.9E–3	5.9E–3	6	467

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Lichens and bryophytes	1.1E–2	7.5E–3	8.7E–3	1.9E+0	4.9E–3	2.4E–2	5	467
Shrubs	7.7E–3	8.0E–3	5.3E–3	2.4E+0	3.0E–3	2.7E–2	11	467
Trees	3.1E–3	1.9E–3	2.6E–3	1.8E+0	2.1E–3	5.1E–3	3	467
Fe (iron)								
Grasses and herbs	3.1E–3	1.3E–3	2.8E–3	1.5E+0	1.8E–3	4.2E–3	6	467
Lichens and bryophytes	4.9E–2	4.9E–2	3.4E–2	2.3E+0	1.7E–3	2.4E–1	37	348, 355, 467
Shrubs	1.1E–2	7.6E–3	8.8E–3	1.9E+0	6.8E–4	6.1E–2	131	347, 348, 467
Trees	9.2E–4	7.1E–4	7.3E–4	2.0E+0	1.4E–4	1.5E–3	4	467
Hf (hafnium)								
Grasses and herbs	3.5E–3	3.3E–3	2.5E–3	2.2E+0	2.3E–3	4.4E–3	6	467
Lichens and bryophytes	1.1E–2	8.0E–3	8.6E–3	1.9E+0	4.3E–3	2.4E–2	5	467
Shrubs	2.4E–3	2.7E–3	1.6E–3	2.5E+0	7.6E–4	5.8E–3	10	467
Trees: coniferous[c]	1.8E–3						2	467
Hg (mercury)								
Annelids	2.6E+0				2.1E+0	3.1E+0	2	398
I (iodine)								
Annelids	1.6E–1	6.7E–2	1.4E–1	1.5E+0	1.5E–1	1.6E–1	10	238
Arthropods	3.0E–1	1.3E–1	2.8E–1	1.5E+0	2.3E–1	4.8E–1	32	238

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Arthropods: detritivorous	3.2E–1	1.4E–1	2.9E–1	1.5E+0	2.3E–1	4.8E–1	27	238
Grasses[c]	1.4E–1	3.4E–1	5.3E–2	4.0E+0			39	179
Molluscs: gastropod	1.8E–1	5.6E–2	1.7E–1	1.4E+0	1.5E–1	2.2E–1	12	238
La (lanthanum)								
Grasses and herbs	6.3E–3	2.3E–3	6.0E–3	1.4E+0	4.1E–3	8.0E–3	6	467
Lichens and bryophytes	2.0E–2	1.2E–2	1.7E–2	1.8E+0	8.1E–3	4.0E–2	5	467
Shrubs	1.3E–2	1.0E–2	9.9E–3	2.0E+0	6.6E–3	3.7E–2	11	467
Trees	4.0E–3	1.8E–3	3.6E–3	1.5E+0	1.6E–3	5.5E–3	4	467
Lu (lutetium)								
Grasses and herbs	6.1E–3	8.6E–3	3.5E–3	2.8E+0	3.9E–3	7.6E–3	5	467
Lichens and bryophytes	1.4E–2	8.8E–3	1.1E–2	1.8E+0	6.4E–3	2.4E–2	3	467
Shrubs	1.1E–2	4.2E–3	1.0E–2	1.5E+0	8.7E–3	1.5E–2	5	467
Trees: coniferous[c]	4.0E–3						2	467
Mn (manganese)								
Annelids	1.6E–2	9.1E–3	1.3E–2	1.7E+0	1.1E–3	2.4E–2	5	199, 264
Lichens and bryophytes	1.5E+0	1.0E+0	1.3E+0	1.8E+0	6.7E–1	5.3E+0	32	348, 355
Mammals: carnivorous[c]	2.5E–3	8.2E–4	2.4E–3	1.4E+0	1.9E–3	3.6E–3	4	199
Molluscs: gastropod	4.6E–2	1.6E–2	4.4E–2	1.4E+0	3.9E–2	6.4E–2	7	191

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Reptiles: carnivorous[c]	1.0E–2						1	487
Shrubs	2.1E+1	2.5E+1	1.4E+1	2.5E+0	1.0E+0	1.1E+2	184	252, 347, 348
Trees: broad-leaf[c]	4.0E–2	5.2E–2	2.4E–2	2.7E+0	1.8E–3	1.0E–1	3	255
Mo (molybdenum)								
Lichens and bryophytes	1.9E+0	2.1E+0	1.3E+0	2.5E+0	4.3E–1	6.7E+0	18	348
Shrubs	1.1E+0	9.7E–1	8.7E–1	2.1E+0	2.9E–1	4.0E+0	23	347, 348
Na (sodium)								
Grasses and herbs	1.2E–2	2.8E–3	1.2E–2	1.3E+0	1.0E–2	1.4E–2	6	467
Lichens and bryophytes	3.4E–2	2.5E–2	2.8E–2	1.9E+0	1.7E–2	7.5E–2	5	467
Shrubs	1.3E–2	3.7E–3	1.2E–2	1.3E+0	1.0E–2	2.0E–2	11	467
Trees	6.2E–3	1.6E–3	6.0E–3	1.3E+0	5.4E–3	7.8E–3	3	467
Nb (niobium)								
Annelids	5.1E–4						1	264
Nd (neodymium)								
Lichens and bryophytes	3.4E–2				1.7E–2	5.1E–2	2	467
Shrubs	1.7E–2						1	467

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Ni (nickel)								
Annelids	7.4E–2	7.5E–2	5.2E–2	2.3E+0	5.7E–3	3.2E–1	77	165, 199, 219, 237, 264
Arthropods	8.6E–3						1	234
Grasses and herbs	2.0E–1	5.5E–1	6.7E–2	4.4E+0	1.3E–2	7.1E–1	169	180, 285, 286, 334
Grasses	2.2E–1	1.6E–1	1.8E–1	1.9E+0	1.3E–2	7.1E–1	58	285, 286, 334
Lichens and bryophytes	6.7E–1	1.6E+0	2.6E–1	4.0E+0	2.7E–2	1.1E+1	108	334, 342, 345, 348, 349, 355, 373, 467
Mammals: carnivorous[c]	7.2E–2				1.4E–3	1.4E–1	2	199
Molluscs: gastropod	1.8E–2	1.0E–2	1.5E–2	1.7E+0	1.7E–2	2.0E–2	7	191
Reptiles: carnivorous[c]	3.0E–1						1	487
Shrubs	4.3E–1	5.3E–1	2.7E–1	2.6E+0	1.1E–2	4.2E+0	301	252, 342, 345, 347, 348, 467
Trees: broad-leaf[c]	1.8E–2	4.2E–3	1.8E–2	1.3E+0	1.3E–2	2.1E–2	3	255
Pb (lead)								
Amphibians	1.2E–1	5.2E–1	2.7E–2	5.6E+0	8.8E–4	2.8E–1	24	206, 213
Annelids	5.2E–1	7.5E–1	2.9E–1	2.9E+0	2.3E–3	2.8E+0	647	159, 199, 229, 247, 264, 344
Arachnids	5.3E–2				4.3E–2	6.2E–2	2	262
Arthropods	4.0E–1	4.7E–1	2.6E–1	2.5E+0	4.6E–3	1.0E+0	561	159, 204, 244, 344
Arthropods: detritivorous	7.1E–1	4.2E–1	6.1E–1	1.7E+0	1.8E–2	1.0E+0	314	159, 204, 244, 344
Birds: carnivorous[c]	6.2E–2	1.7E–1	2.1E–2	4.4E+0			424	247

TABLE 5. CONCENTRATION RATIO ($CR_{wo-soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo-soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Grasses and herbs	9.6E–2	2.3E–1	3.8E–2	3.9E+0	4.7E–3	1.0E+0	301	180, 215, 220, 235, 271, 293, 334
Grasses	1.3E–1	1.9E–1	7.5E–2	2.9E+0	4.7E–3	5.5E–1	74	220, 235, 293, 334
Lichens and bryophytes	4.6E+0	4.2E+0	3.4E+0	2.2E+0	2.0E–2	4.5E+1	351	163, 201, 258, 334, 342, 345, 348, 349, 355
Mammals	3.8E–2	3.6E–2	2.8E–2	2.2E+0	2.7E–4	2.0E–1	515	159, 181, 182, 185, 186, 187, 198, 211, 224, 225, 226, 227, 243, 429, 458
Mammals: carnivorous	4.7E–2	2.8E–2	4.0E–2	1.7E+0	8.8E–3	7.7E–2	368	159, 243
Mammals: herbivorous	2.0E–2	2.7E–2	1.2E–2	2.8E+0	1.9E–3	2.0E–1	92	159, 181, 182, 185, 186, 187, 198, 211, 224, 225, 226, 227, 429
Mammals: omnivorous	1.2E–2	6.3E–2	2.2E–3	6.3E+0	2.7E–4	3.9E–2	51	198, 211, 429
Mammals: *Rangifer* spp.[b]	3.6E+0	3.3E+0	2.7E+0	2.2E+0	4.0E–1	1.8E+1	270	163, 214, 218, 258
Molluscs: gastropod	7.3E–3	1.3E–2	3.6E–3	3.3E+0	6.1E–4	3.8E–2	47	191, 232
Reptiles	3.7E–1	1.0E+0	1.3E–1	4.3E+0	1.4E–3	1.2E+0	45	450, 487
Reptiles: carnivorous	3.8E–2	1.6E–1	8.7E–3	5.6E+0	1.4E–3	7.0E–2	32	450, 487
Shrubs	1.2E+0	1.9E+0	6.4E–1	3.1E+0	1.4E–3	1.5E+1	740	167, 220, 249, 252, 342, 345, 347, 348
Trees	7.6E–2	1.1E–1	4.3E–2	2.9E+0	6.5E–3	5.8E–1	42	220, 233, 255
Trees: broad-leaf	8.1E–2	1.2E–1	4.4E–2	3.0E+0	6.5E–3	5.8E–1	32	220, 233, 255

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Po (polonium)								
Annelids	1.0E–1	3.9E–2	9.6E–2	1.4E+0	1.0E–1	1.0E–1	7	384
Birds: herbivorous	1.0E–2	2.9E–3	9.6E–3	1.3E+0			5	384
Grasses and herbs	3.1E–1	4.9E–1	1.7E–1	3.0E+0	1.7E–2	1.9E+0	71	215, 220, 235, 277, 334
Grasses	3.8E–1	5.2E–1	2.3E–1	2.8E+0	1.7E–2	1.9E+0	49	220, 235, 277, 334
Lichens and bryophytes	6.7E+0	6.8E+0	4.7E+0	2.3E+0	5.4E–1	3.0E+1	166	163, 201, 334, 342, 348, 349, 355, 373
Mammals	8.6E–2	2.1E–1	3.3E–2	4.0E+0	2.4E–4	1.1E+0	67	61, 181, 182, 185, 186, 187, 196, 224, 225, 226, 227, 384, 423, 429, 450, 509
Mammals: carnivorous	1.2E–1	8.7E–2	9.7E–2	1.9E+0	1.9E–2	1.4E–1	11	61, 384
Mammals: herbivorous	2.9E–3	1.9E–3	2.4E–3	1.8E+0	2.4E–4	9.5E–3	38	181, 182, 185, 186, 187, 196, 224, 225, 226, 227, 429
Mammals: omnivorous	2.1E–1	1.2E–1	1.8E–1	1.7E+0	7.5E–4	2.6E–1	10	384, 429, 450
Mammals: *Rangifer* spp.[b]	2.5E+0	3.7E+0	1.4E+0	3.0E+0	5.9E–1	2.1E+1	199	163, 214, 258
Reptiles	9.5E+0	2.3E+1	3.6E+0	4.0E+0	1.9E–2	1.1E+1	15	450, 487
Shrubs	1.3E+0	1.2E+0	9.3E–1	2.2E+0	1.9E–3	8.0E+0	448	164, 220, 342, 345, 347, 348
Trees	3.8E–2	2.2E–2	3.3E–2	1.7E+0	1.3E–2	5.5E–2	20	220

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Pu (plutonium)								
Annelids	3.1E–2	3.2E–2	2.1E–2	2.4E+0			16	488
Arachnids	3.2E–2	3.5E–2	2.2E–2	2.4E+0	1.9E–2	3.6E–2	35	170, 488
Arthropods	3.1E–2	4.9E–2	1.6E–2	3.1E+0	4.2E–4	2.5E–1	150	170, 216, 223, 261, 382, 407, 488
Arthropods: detritivorous	3.6E–2	5.4E–2	2.0E–2	3.0E+0	1.6E–3	1.6E–1	68	170, 216, 223, 488
Birds	2.3E–3	4.8E–3	9.8E–4	3.7E+0	3.3E–5	1.5E–2	26	405, 486
Birds: omnivorous	2.9E–3	5.8E–3	1.3E–3	3.6E+0	3.3E–5	1.5E–2	16	405, 486
Grasses[c]	1.6E–2	2.3E–2	9.4E–3	2.8E+0	1.2E–2	4.3E–2	78	177, 250, 486
Lichens and bryophytes	1.3E–1				1.0E–1	1.6E–1	2	382
Mammals	5.0E–2	2.6E–1	9.3E–3	6.3E+0	1.6E–4	2.6E+0	219	172, 184, 197, 221, 222, 245, 261, 268, 405, 407, 488
Mammals: carnivorous	5.0E–3	6.1E–3	3.1E–3	2.6E+0	7.1E–4	2.2E–2	29	197, 405, 488
Mammals: herbivorous	5.3E–2	3.0E–1	9.2E–3	6.5E+0	1.6E–4	2.8E–1	56	184, 222, 268, 405, 407, 488
Mammals: omnivorous	5.9E–2	3.0E–1	1.1E–2	6.1E+0	2.2E–4	2.6E+0	113	221, 245, 268, 405, 488
Mammals: *Rangifer* spp.[b]	6.1E–3	8.8E–3	3.5E–3	2.9E+0	3.3E–3	7.6E–3	9	197
Molluscs: gastropod	1.2E–1	8.6E–2	9.7E–2	1.9E+0			16	488
Reptiles: carnivorous[c]	3.3E–3	6.5E–3	1.5E–3	3.6E+0	1.0E–5	2.0E–2	41	267, 407, 486, 487
Shrubs	8.9E–2	1.6E–1	4.3E–2	3.3E+0	4.4E–5	3.3E–1	4	196, 468

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Ra (radium)								
Arthropods	3.2E+0	3.6E+0	2.1E+0	2.5E+0	1.0E–2	8.9E+0	27	192, 239, 388
Birds	3.6E–2	5.1E–2	2.1E–2	2.8E+0	2.1E–3	2.0E–1	48	239, 260
Birds: carnivorous	5.2E–2	6.9E–2	3.1E–2	2.7E+0	2.7E–3	2.0E–1	16	239
Birds: herbivorous	3.3E–2	4.1E–2	2.1E–2	2.6E+0	2.1E–3	1.9E–1	25	239, 260
Grasses and herbs	1.9E–1	6.6E–1	5.4E–2	4.9E+0	5.1E–5	1.2E+1	464	215, 220, 239, 266, 270, 272, 273, 276, 278, 280, 287, 288, 290, 292, 293, 295, 296, 298, 334, 455, 459
Grasses	2.0E–1	7.2E–1	5.1E–2	5.1E+0	5.1E–5	1.2E+1	382	220, 239, 266, 270, 272, 273, 276, 278, 280, 287, 288, 290, 292, 293, 295, 298, 334, 459
Herbs	2.3E–1	3.1E–1	1.4E–1	2.8E+0	1.6E–2	1.3E+0	29	239, 266, 272, 459
Lichens and bryophytes	1.7E+0	3.4E+0	7.6E–1	3.6E+0	6.5E–2	2.3E+1	243	217, 272, 334, 342, 345, 348, 349, 355, 373, 459
Mammals	4.7E–2	1.2E–1	1.7E–2	4.1E+0	5.7E–5	7.6E–1	84	182, 185, 186, 187, 224, 225, 226, 227, 260, 423, 429, 458, 509
Mammals: carnivorous	4.6E–2	2.4E–2	4.1E–2	1.6E+0	1.5E–2	1.2E–1	25	260
Mammals: herbivorous	1.5E–2	3.4E–2	6.1E–3	3.8E+0	5.7E–5	2.0E–1	45	182, 185, 186, 187, 224, 225, 226, 227, 260, 429
Mammals: marsupial	2.2E–1	3.2E–1	1.3E–1	2.9E+0	5.5E–3	7.6E–1	9	423, 458, 509

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	N	
Molluscs: gastropod	4.8E–2	4.8E–2	3.4E–2	2.3E+0	2.5E–2	1.4E–1	10	191
Shrubs	1.0E+0	1.6E+0	5.4E–1	3.1E+0	2.4E–2	1.2E+1	504	220, 342, 345, 347, 348, 469
Trees	6.8E–4	7.5E–4	4.5E–4	2.5E+0	1.1E–4	2.4E–3	20	220
Rb (rubidium)								
Grasses and herbs	2.3E–1	1.4E–1	2.0E–1	1.8E+0	1.4E–1	4.5E–1	6	467
Lichens and bryophytes	7.2E–2	3.4E–2	6.6E–2	1.6E+0	3.3E–2	1.2E–1	5	467
Shrubs	1.2E–1	4.9E–2	1.1E–1	1.5E+0	9.4E–2	2.4E–1	11	467
Trees: coniferous[c]	3.1E–2	2.0E–1	4.5E–3	7.1E+0	6.0E–3	1.0E–1	100	467, 495
Ru (ruthenium)								
Arthropods	6.4E–3	7.6E–3	4.1E–3	2.6E+0			16	175
Shrubs	4.1E–1	3.2E–1	3.2E–1	2.0E+0	1.6E–1	7.7E–1	3	468
Sb (antimony)								
Annelids	6.0E–3						1	264
Lichens and bryophytes	3.9E–1	2.4E–1	3.4E–1	1.7E+0	1.9E–1	7.1E–1	4	467
Molluscs: gastropod	2.5E–1	2.4E–1	1.8E–1	2.2E+0	1.3E–1	5.7E–1	7	191
Shrubs	9.2E–2	5.5E–2	7.9E–2	1.7E+0			3	467

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Sc (scandium)								
Grasses and herbs	3.0E–3	1.4E–3	2.7E–3	1.6E+0	1.7E–3	4.3E–3	6	467
Lichens and bryophytes	4.3E–3	3.2E–3	3.4E–3	1.9E+0	1.3E–3	9.4E–3	5	467
Shrubs	1.8E–3	1.8E–3	1.3E–3	2.3E+0	5.8E–4	4.5E–3	11	467
Trees	7.4E–4	7.1E–4	5.4E–4	2.2E+0	1.3E–4	1.4E–3	4	467
Se (selenium)								
Annelids	1.5E+0						1	231
Grasses and herbs[d]	1.0E+0	2.1E+0	4.4E–1	3.6E+0	9.0E–3	1.2E+1	364	180, 492, 497, 498
Grasses	1.8E+0	1.6E+0	1.3E+0	2.1E+0	5.7E–1	5.4E+0	48	497
Herbs[e]	1.4E+0	2.2E+0	8.1E–1	2.9E+0	1.0E–1	1.2E+1	132	492, 497
Lichens and bryophytes	3.6E–1	2.0E–1	3.1E–1	1.7E+0	9.0E–2	1.1E+0	18	348, 467
Mammals	6.3E–2	3.8E–1	1.0E–2	6.7E+0			12	246
Molluscs: gastropod	3.5E–2	3.1E–2	2.6E–2	2.2E+0	2.0E–2	7.1E–2	7	191
Shrubs	1.5E+0	1.4E+0	1.1E+0	2.2E+0	1.7E–1	2.6E+0	94	248, 347, 348
Sm (samarium)								
Grasses and herbs	9.8E–4	2.4E–3	3.8E–4	4.0E+0	2.1E–7	7.6E–3	39	281, 467, 499
Herbs	3.3E–4	1.1E–3	9.2E–5	4.9E+0	2.1E–7	4.3E–3	35	467, 499
Lichens and bryophytes	1.4E–2	1.0E–2	1.2E–2	1.9E+0	6.1E–3	3.1E–2	5	467

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Shrubs	8.5E–3	9.5E–3	5.7E–3	2.5E+0	2.6E–3	3.0E–2	11	467
Trees	2.6E–3	1.7E–3	2.1E–3	1.8E+0	4.0E–4	4.1E–3	4	467
Sn (tin)								
Lichens and bryophytes	2.0E+0				1.0E+0	2.9E+0	2	355
Shrubs	2.0E–1	4.8E–2	1.9E–1	1.3E+0	1.3E–1	2.5E–1	8	347
Sr (strontium)								
Amphibians	1.2E+0	1.2E+0	7.9E–1	2.4E+0	1.4E–1	2.5E+0	22	188, 486
Annelids	9.0E–3						1	264
Arthropods	4.1E–1	1.9E+0	8.4E–2	5.9E+0	6.3E–2	1.9E+0	31	169, 176, 223
Birds	4.8E–1	8.9E–1	2.3E–1	3.4E+0	4.8E–3	7.2E+0	91	189, 190, 263, 405, 486
Birds: omnivorous	5.4E–1	9.7E–1	2.6E–1	3.3E+0	4.0E–2	7.2E+0	74	189, 190, 405
Grasses and herbs	9.8E–1	1.8E+0	4.7E–1	3.4E+0	6.7E–3	8.8E+0	519	163, 193, 404, 414, 432, 433, 434, 435, 437, 442, 444, 451, 467, 486, 498, 501
Grasses	1.8E+0	3.1E+0	9.5E–1	3.2E+0	5.0E–2	6.3E+0	48	163, 414, 451, 467, 486, 501
Herbs	2.6E+0	1.6E+0	2.2E+0	1.8E+0	3.2E–1	5.0E+0	89	414, 432, 433, 467
Lichens and bryophytes	4.8E+0	7.1E+0	2.7E+0	2.9E+0	4.4E–2	2.8E+1	104	163, 348, 355, 382, 440, 467
Mammals	1.6E+0	2.3E+0	9.5E–1	2.8E+0	9.9E–3	1.7E+1	474	163, 190, 228, 245, 268, 405, 406
Mammals: carnivorous	8.6E–1	1.5E+0	4.3E–1	3.2E+0	1.3E–2	9.8E+0	164	190, 405, 406

TABLE 5. CONCENTRATION RATIO ($CR_{wo-soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo-soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Mammals: herbivorous	2.5E+0	3.0E+0	1.6E+0	2.5E+0	9.9E–3	1.7E+1	108	163, 190, 228, 268, 405
Mammals: omnivorous	1.8E+0	2.2E+0	1.1E+0	2.6E+0	3.0E–2	1.0E+1	202	190, 245, 268, 405
Mammals: *Rangifer* spp.[b]	6.5E+0	4.1E+0	5.5E+0	1.8E+0	4.8E–3	1.5E+1	435	160, 163, 218, 228
Molluscs: gastropod	9.2E–2	3.1E–2	8.7E–2	1.4E+0	7.1E–2	1.0E–1	7	191
Reptiles	3.8E–1	6.1E–1	2.0E–1	3.1E+0	2.1E–2	2.2E+0	74	169, 267, 486, 487
Reptiles: carnivorous	3.6E–1	5.8E–1	1.9E–1	3.1E+0	2.1E–2	1.2E+0	70	169, 267, 486, 487
Shrubs	4.8E–1	7.8E–1	2.5E–1	3.1E+0	4.7E–3	6.7E+0	307	164, 252, 347, 348, 467, 468
Trees	4.9E–1	1.1E+0	2.0E–1	3.7E+0	1.2E–3	5.3E+0	191	190, 467, 473, 478, 479, 480, 482, 484, 485
Trees: broad-leaf	4.4E–1	7.1E–1	2.3E–1	3.1E+0	1.2E–3	3.1E+0	114	190, 467, 473, 478, 480, 482, 484, 485
Trees: coniferous	5.6E–1	1.4E+0	2.0E–1	4.1E+0	1.5E–3	5.3E+0	77	467, 479, 480, 482, 484
Ta (tantalum)								
Grasses[c]	5.3E–3	9.5E–3	2.6E–3	3.3E+0			3	467
Lichens and bryophytes	1.2E–2	7.2E–3	1.1E–2	1.7E+0	5.0E–3	2.0E–2	3	467
Shrubs	2.2E–3						1	467
Tb (terbium)								
Herbs	1.5E–3						1	467
Shrubs	2.6E–2				1.9E–2	3.4E–2	2	467

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	N	
Tc (technetium)								
Amphibians	3.9E–1	2.0E–1	3.5E–1	1.6E+0	3.2E–1	5.1E–1	5	486
Birds: omnivorous	1.7E–1						2	486
Grasses and herbs	1.4E+1	1.3E+1	1.0E+1	2.3E+0	6.2E–3	2.0E+1	28	250, 486, 493, 512
Grasses	1.6E+1	1.3E+1	1.3E+1	2.0E+0	8.3E–2	2.0E+1	24	250, 486, 493
Shrubs	1.2E–2	1.1E–2	8.4E–3	2.2E+0	6.3E–4	3.3E–2	8	512
Th (thorium)								
Birds: herbivorous	3.9E–4	9.4E–5	3.8E–4	1.3E+0	3.1E–4	5.4E–4	20	260
Grasses and herbs	2.4E–1	5.1E–1	9.9E–2	3.7E+0	2.2E–4	2.7E+0	341	215, 272, 274, 278, 281, 295, 296, 334, 390, 430, 455, 459, 467, 498
Grasses	3.6E–1	6.4E–1	1.7E–1	3.3E+0	1.6E–3	2.7E+0	193	272, 274, 278, 281, 295, 334, 430, 459, 467, 498
Herbs	5.1E–2	9.6E–2	2.4E–2	3.4E+0	2.2E–4	5.1E–1	49	272, 430, 459, 467
Lichens and bryophytes	9.7E–1	2.1E+0	4.1E–1	3.7E+0	1.2E–2	1.5E+1	228	217, 272, 334, 342, 345, 348, 349, 355, 459, 467
Mammals	1.4E–4	1.3E–4	1.0E–4	2.2E+0	1.3E–5	6.4E–4	36	181, 182, 185, 186, 187, 224, 225, 226, 227, 450
Mammals: herbivorous	1.4E–4	1.3E–4	1.0E–4	2.2E+0	1.3E–5	6.4E–4	35	181, 182, 185, 186, 187, 224, 225, 226, 227
Reptiles	2.0E–1	4.8E–1	7.6E–2	4.0E+0	9.4E–5	2.7E–1	18	450, 487

TABLE 5. CONCENTRATION RATIO ($CR_{wo-soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo-soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Shrubs	2.5E–1	5.6E–1	9.9E–2	3.9E+0	1.2E–3	3.9E+0	403	272, 342, 345, 347, 348, 467, 469
Trees	1.1E–3	1.1E–3	7.6E–4	2.3E+0	1.0E–5	3.1E–3	85	200, 249, 467
Ti (titanium)								
Lichens and bryophytes	3.3E–2	3.0E–2	2.4E–2	2.2E+0	5.9E–3	1.7E–1	32	348, 355
Shrubs	6.4E–3	5.0E–3	5.0E–3	2.0E+0	6.7E–4	3.6E–2	120	347, 348
U (uranium)								
Annelids	8.8E–3						1	264
Arthropods	1.8E–2	5.0E–3	1.7E–2	1.3E+0	1.0E–2	2.0E–2	4	382
Birds: herbivorous	5.0E–4	1.1E–4	4.9E–4	1.3E+0	4.1E–4	6.8E–4	20	260
Grasses and herbs	1.4E–1	4.4E–1	4.5E–2	4.6E+0	7.7E–5	5.5E+0	439	215, 220, 266, 269, 272, 274, 278, 279, 292, 295, 296, 298, 334, 390, 426, 430, 455, 457, 459, 489, 498
Grasses	1.3E–1	4.0E–1	3.7E–2	4.8E+0	7.7E–5	5.5E+0	280	220, 266, 269, 272, 274, 278, 279, 292, 295, 298, 334, 430, 457, 459, 489, 498
Herbs	2.1E–1	5.5E–1	7.6E–2	4.2E+0	2.2E–3	2.8E+0	64	266, 272, 430, 459
Lichens and bryophytes	2.5E+0	4.4E+0	1.3E+0	3.2E+0	2.0E–2	2.9E+1	237	272, 334, 342, 345, 348, 349, 355, 373, 382, 459
Mammals	5.8E–3	6.8E–3	3.7E–3	2.5E+0	1.5E–5	2.1E–2	22	61, 196, 423, 429, 450, 458, 509

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Mammals: marsupial	6.2E–3	7.9E–3	3.9E–3	2.6E+0	8.0E–4	2.1E–2	12	61, 423, 458, 509
Reptiles	1.5E+0	3.1E+0	6.7E–1	3.6E+0	1.3E–4	2.5E+0	21	450, 487
Shrubs[f]	2.3E–1	6.4E–1	8.1E–2	4.3E+0	1.4E–5	5.9E+0	970	220, 249, 342, 345, 347, 348, 469
Trees	6.8E–3	1.4E–2	2.9E–3	3.7E+0	1.4E–5	3.2E–2	521	200, 220, 249
V (vanadium)								
Lichens and bryophytes	2.0E–1	2.9E–1	1.1E–1	2.9E+0	2.2E–2	1.2E+0	32	348, 355
Shrubs	4.7E–2	6.9E–2	2.6E–2	2.9E+0	7.5E–3	3.4E–1	64	347, 348
W (tungsten)								
Trees: coniferous[c]	4.7E–1						1	467
Yb (ytterbium)								
Grasses and herbs	5.7E–3	8.5E–3	3.1E–3	3.0E+0	2.6E–4	7.5E–3	4	467
Lichens and bryophytes	9.8E–3	1.2E–2	6.3E–3	2.6E+0	3.3E–3	3.1E–2	5	467
Shrubs	8.4E–3	3.4E–3	7.8E–3	1.5E+0	6.0E–3	1.0E–2	5	467
Trees: coniferous[c]	3.2E–3						2	467
Zn (zinc)								
Annelids	4.0E+0	1.6E+0	3.7E+0	1.5E+0	1.9E+0	7.0E+0	383	344
Arthropods	1.1E+0	6.1E–1	9.7E–1	1.7E+0	3.0E–1	3.6E+0	257	344
Grasses and herbs	1.8E+0	2.8E+0	9.6E–1	3.1E+0	1.8E–2	8.7E+0	12	334, 467

TABLE 5. CONCENTRATION RATIO ($CR_{wo\text{-}soil}$) VALUES FOR WILDLIFE GROUPS IN TERRESTRIAL ECOSYSTEMS (cont.)

Wildlife group (terrestrial)	$CR_{wo\text{-}soil}$ (Bq/kg, fresh weight whole organism:Bq/kg, dry weight soil)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Lichens and bryophytes	1.8E+0	1.7E+0	1.3E+0	2.2E+0	2.9E–2	7.6E+0	100	334, 342, 345, 348, 355, 467
Reptiles: carnivorous[c]	2.0E–1	3.9E–1	9.2E–2	3.5E+0	1.6E–1	2.4E–1	30	487
Shrubs	4.5E+0	3.5E+0	3.5E+0	2.0E+0	4.0E–2	1.6E+1	250	342, 345, 347, 348, 467
Trees	3.1E–2	2.0E–2	2.6E–2	1.8E+0	8.4E–3	4.7E–2	4	467
Zr (zirconium)								
Shrubs	9.4E–5	8.1E–5	7.2E–5	2.1E+0			64	252

Note: AM: arithmetic mean; AMSD: arithmetic mean standard deviation; DW: dry weight; FW: fresh weight; GM: geometric mean; GMSD: geometric mean standard deviation; ID: identification; *N*: number of data.

[a] The publications corresponding to these ID numbers are given in the Annex.

[b] Not included in the mammals wildlife group value.

[c] All of the data for the wildlife group are for the subcategory presented.

[d] Including outlying values; $CR_{wo\text{-}soil}$ value for Se grasses and herbs (see Section 3.4) is AM ± SD = 83 ± 170, GM ± GSD = 37 ± 3.6, $n = 938$.

[e] Including outlying values; $CR_{wo\text{-}soil}$ value for Se herbs (see Section 3.4) AM ± SD = 110 ± 190, GM ± GSD = 59 ± 3.1, $n = 606$.

[f] Including outlying values; $CR_{wo\text{-}soil}$ value for U shrubs (see Section 3.4) AM ± SD = 0.4 ± 1.6, GM ± GSD = 0.095 ± 5.4, $n = 983$.

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Al (aluminium)								
Fish	7.9E+1	1.3E+2	4.1E+1	3.2E+0	1.0E+0	1.5E+3	250	333, 336, 340, 343, 346, 350, 355, 356, 357, 358, 359, 363, 364, 374, 376, 378, 517
Fish: benthic feeding	8.8E+1	1.1E+2	5.5E+1	2.6E+0	2.5E+0	6.5E+2	85	333, 336, 343, 346, 355, 356, 357, 358, 376, 378
Fish: piscivorous	7.5E+1	1.4E+2	3.4E+1	3.5E+0	1.9E+0	1.5E+3	157	333, 336, 340, 343, 350, 355, 356, 358, 359, 363, 364, 376, 378, 517
Vascular plants	1.6E+2	1.5E+2	1.2E+2	2.2E+0	6.6E+1	5.7E+2	18	343, 517
Am (americium)								
Algae	5.3E+2						8	309
Fish: forage[b]	7.6E+2	6.7E+2	5.7E+2	2.1E+0	2.4E+0	1.5E+3	17	309, 411
Insects	1.3E+2						7	309
Insect larvae	1.8E+3						15	309
Molluscs	1.0E+4	1.3E+4	6.6E+3	2.6E+0	1.2E+2	3.6E+4	60	309, 411
Molluscs: gastropod	6.3E+3	9.4E+3	3.5E+3	3.0E+0	1.2E+2	2.8E+4	50	309, 411
Reptiles	3.2E+3						1	487
Vascular plants	1.3E+3	2.6E+3	6.2E+2	3.5E+0	6.7E+0	7.5E+3	66	309, 410, 411

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
As (arsenic)								
Fish	3.6E+2	4.2E+2	2.3E+2	2.5E+0	1.4E+1	2.0E+3	148	339, 340, 355, 356, 357, 358, 359, 361, 363, 364, 376, 377, 378
Fish: benthic feeding	3.9E+2	4.4E+2	2.5E+2	2.5E+0	1.4E+1	2.0E+3	75	339, 355, 356, 357, 358, 361, 363, 364, 376, 377, 378
Fish: piscivorous	3.2E+2	3.9E+2	2.0E+2	2.6E+0	4.4E+1	1.5E+3	72	339, 340, 355, 358, 359, 361, 363, 376, 377, 378
Reptiles	2.6E+2	9.5E+1	2.5E+2	1.4E+0	7.2E+1	3.3E+2	9	487
Vascular plants	8.8E+1				5.2E+1	1.2E+2	2	333
B (boron)								
Reptiles	1.1E+1				1.1E+0	2.0E+1	2	487
Ba (barium)								
Fish	8.1E+1	1.3E+2	4.3E+1	3.1E+0	3.0E–1	8.8E+2	497	304, 333, 336, 339, 340, 343, 350, 355, 356, 357, 358, 359, 361, 363, 371, 376, 378, 517
Fish: benthic feeding	9.5E+1	1.3E+2	5.7E+1	2.8E+0	1.4E+0	6.6E+2	148	333, 336, 339, 343, 355, 356, 357, 358, 361, 363, 371, 376, 378
Fish: piscivorous	7.6E+1	1.3E+2	3.9E+1	3.2E+0	3.0E–1	8.8E+2	340	333, 336, 340, 350, 355, 356, 358, 359, 363, 376, 378, 517

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Reptiles	1.4E+2						1	487
Vascular plants	1.4E+3	1.2E+3	1.1E+3	2.1E+0	3.2E+2	4.4E+3	18	343, 517
Ca (calcium)								
Algae	5.5E+2	4.6E+2	4.2E+2	2.1E+0	1.0E+2	1.5E+3	14	333
Amphibians	1.2E+3	1.2E+3	8.7E+2	2.3E+0	2.8E+2	3.7E+3	9	333
Crustaceans	6.6E+2	1.8E+2	6.4E+2	1.3E+0	4.3E+2	8.1E+2	4	333
Fish	1.4E+3	1.8E+3	8.6E+2	2.7E+0	1.6E+1	1.6E+4	481	314, 322, 333, 339, 343, 350, 361, 363, 371, 517
Fish: benthic feeding	7.7E+2	1.3E+3	4.0E+2	3.2E+0	1.6E+1	6.0E+3	127	333, 339, 343, 361, 363, 371
Fish: forage	2.9E+3	4.5E+3	1.6E+3	3.0E+0	5.2E+1	1.6E+4	35	333, 517
Fish: piscivorous	1.5E+3	1.3E+3	1.1E+3	2.1E+0	8.3E+1	7.2E+3	318	322, 333, 339, 343, 350, 361, 363, 371, 517
Insects	7.4E+0				4.5E+0	1.0E+1	2	333
Insect larvae	4.3E+1	4.5E+1	3.0E+1	2.4E+0	1.1E+1	1.1E+2	4	333
Mammals: herbivorous[b]	3.9E+2				3.5E+2	4.3E+2	2	333
Molluscs: bivalve[b]	1.1E+3	1.9E+2	1.1E+3	1.2E+0			3	517
Phytoplankton	2.4E+2	3.5E+2	1.4E+2	2.9E+0	2.6E+1	8.2E+2	20	416
Reptiles	5.0E+2				1.2E+1	9.9E+2	2	487
Vascular plants	2.0E+2	1.3E+2	1.7E+2	1.8E+0	2.0E+1	4.4E+2	20	333, 343, 517

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	N	
Cd (cadmium)								
Fish	2.3E+2	1.8E+2	1.9E+2	2.0E+0	5.7E+0	1.0E+3	75	358, 391, 392, 427, 431, 441
Fish: benthic feeding	3.4E+2	7.9E+1	3.3E+2	1.3E+0	4.8E+1	3.6E+2	39	391, 441
Fish: forage	1.3E+2	2.0E+2	7.5E+1	2.9E+0	5.7E+0	1.0E+3	30	358, 391, 392, 427, 431
Molluscs: bivalve[b]	2.8E+5	2.4E+5	2.1E+5	2.1E+0			3	517
Phytoplankton	1.8E+3	1.2E+3	1.5E+3	1.8E+0	5.2E+2	3.4E+3	30	416
Reptiles	1.7E+3	1.4E+3	1.3E+3	2.0E+0	5.9E+0	2.4E+3	7	487
Vascular plants	6.3E+2	5.8E+2	4.6E+2	2.2E+0			3	517
Ce (cerium)								
Algae	1.9E+3	1.0E+3	1.7E+3	1.7E+0	9.0E+2	4.4E+3	10	320, 424
Fish	1.6E+2	3.6E+2	6.5E+1	3.8E+0	1.8E+0	2.3E+3	276	304, 314, 333
Fish: benthic feeding	5.1E+2	7.3E+2	2.9E+2	2.9E+0	3.4E+0	2.3E+3	44	333
Fish: piscivorous	9.4E+1	1.7E+2	4.5E+1	3.4E+0	1.8E+0	1.3E+3	225	333
Molluscs: bivalve[b]	1.0E+3	1.2E+3	6.6E+2	2.6E+0	2.5E+2	2.3E+3	8	456, 517
Phytoplankton	8.8E+3	7.8E+3	6.6E+3	2.1E+0	1.0E+3	2.6E+4	35	416, 419
Reptiles	6.3E+2				6.0E+2	6.5E+2	2	487
Vascular plants	1.2E+2	1.0E+2	9.0E+1	2.1E+0	6.7E+1	1.7E+2	6	517

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Cl (chlorine)								
Fish	1.3E+2						1	304
Vascular plants	2.6E+2	2.0E+2	2.1E+2	2.0E+0	1.1E+2	4.1E+2	6	517
Cm (curium)								
Algae	6.7E+1						8	309
Fish: forage[b,c]	2.4E–1						7	309
Insects	1.7E+1						7	309
Insect larvae	2.5E+2						15	309
Molluscs: gastropod[b]	1.7E+1						30	309
Reptiles	7.7E+1						1	487
Vascular plants	2.3E+0	8.0E+0	6.3E–1	5.0E+0	3.3E–1	4.2E+1	26	309
Co (cobalt)								
Algae	4.0E+2	4.6E+2	2.6E+2	2.5E+0	2.4E+1	1.0E+3	15	396, 445
Fish	1.4E+2	1.8E+2	8.2E+1	2.7E+0	2.4E–1	1.6E+3	381	300, 301, 314, 324, 331, 333, 359, 394, 431, 445, 449, 461, 462, 517
Fish: benthic feeding	7.7E+1	5.8E+1	6.2E+1	2.0E+0	7.4E–1	3.5E+2	100	324, 333, 394, 445, 461, 462
Fish: forage	4.3E+1	8.9E+1	1.9E+1	3.6E+0	2.4E–1	4.1E+2	87	300, 324, 331, 333, 394, 431, 449, 461, 517
Fish: piscivorous	2.0E+2	1.9E+2	1.5E+2	2.2E+0	2.6E+0	7.5E+2	192	324, 333, 359, 394, 517

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Molluscs: bivalve[b]	1.1E+3	7.6E+2	9.6E+2	1.8E+0			3	517
Phytoplankton	6.5E+2	1.2E+3	3.1E+2	3.4E+0	4.4E+1	3.5E+3	35	416, 419
Reptiles	1.2E+1	2.2E+1	5.9E+0	3.3E+0	4.7E+0	1.1E+2	28	487
Vascular plants	5.9E+2	8.4E+2	3.4E+2	2.9E+0	2.2E+1	4.0E+3	158	396, 445, 449, 461, 462, 463, 517
Cr (chromium)								
Algae	2.9E+2	2.5E+2	2.2E+2	2.1E+0	4.9E+1	5.3E+2	10	396
Amphibians	6.5E+1				4.9E+1	8.2E+1	2	333
Fish	1.6E+2	1.5E+2	1.1E+2	2.3E+0	2.2E–1	9.0E+2	377	304, 333, 343, 350, 358, 391, 427, 441, 449
Fish: benthic feeding	1.8E+2	1.2E+2	1.5E+2	1.9E+0	1.6E+0	3.2E+2	105	333, 343, 391, 441
Fish: forage	2.0E+1	6.9E+1	5.6E+0	4.9E+0	2.2E–1	2.9E+2	66	333, 391, 427, 449
Fish: piscivorous	1.9E+2	1.6E+2	1.4E+2	2.1E+0	1.7E+0	9.0E+2	205	333, 343, 350, 358, 391
Reptiles	1.3E+3	1.2E+3	9.7E+2	2.2E+0	6.0E+0	2.2E+3	9	487
Vascular plants	3.6E+2	4.1E+2	2.4E+2	2.5E+0	1.4E+1	1.1E+3	44	333, 343, 396, 449, 517
Cs (caesium)								
Algae	1.3E+3	2.6E+3	6.0E+2	3.5E+0	4.4E+0	1.1E+4	99	320, 402, 417, 419, 461, 464
Crustaceans	1.8E+3	1.2E+3	1.5E+3	1.8E+0	1.1E+2	4.9E+3	20	454, 490

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Fish	3.1E+3	5.1E+3	1.6E+3	3.1E+0	1.3E+1	8.2E+4	722	146, 153, 178, 300, 301, 302, 313, 314, 315, 319, 323, 326, 327, 331, 332, 333, 393, 394, 402, 408, 411, 415, 416, 418, 419, 445, 446, 454, 461, 462, 465
Fish: benthic feeding	1.0E+3	2.0E+3	4.6E+2	3.5E+0	1.8E+1	2.0E+4	156	146, 178, 302, 332, 333, 393, 394, 402, 411, 416, 418, 419, 445, 446, 461, 462, 465
Fish: forage	9.2E+2	1.6E+3	4.7E+2	3.2E+0	1.7E+1	8.6E+3	125	153, 300, 302, 313, 323, 331, 332, 333, 394, 402, 408, 411, 415, 418, 446, 454, 461, 465
Fish: piscivorous	4.5E+3	6.0E+3	2.7E+3	2.8E+0	1.3E+1	8.2E+4	439	146, 178, 302, 313, 315, 319, 326, 327, 332, 333, 393, 394, 402, 411, 415, 416, 418, 419, 446, 465
Insects	2.2E+3						1	490
Insect larvae	2.0E+3	2.1E+3	1.4E+3	2.4E+0	1.3E+2	5.9E+3	6	490
Molluscs	1.3E+2	1.0E+2	1.0E+2	2.0E+0	3.3E+1	3.8E+2	70	402, 408, 411
Molluscs: bivalve	1.1E+2	6.3E+1	9.8E+1	1.7E+0	4.7E+1	2.0E+2	20	402, 411
Molluscs: gastropod	1.4E+2	1.2E+2	1.0E+2	2.1E+0	3.3E+1	3.8E+2	50	408, 411
Phytoplankton	1.4E+2	1.9E+2	8.5E+1	2.7E+0	1.9E+1	6.6E+2	50	416, 419, 454
Reptiles	4.0E+3	7.0E+3	2.0E+3	3.3E+0	7.1E+1	1.0E+4	93	487

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Vascular plants	3.1E+2	1.3E+3	7.0E+1	5.6E+0	1.7E+1	2.4E+4	627	153, 178, 331, 393, 402, 408, 410, 411, 419, 420, 421, 422, 425, 445, 454, 461, 462, 464
Zooplankton	9.0E+1	6.4E+1	7.3E+1	1.9E+0	9.0E+0	3.3E+2	41	393, 490
Cu (copper)								
Fish	3.9E+2	3.6E+2	2.8E+2	2.2E+0	2.2E–1	2.8E+3	583	304, 333, 339, 340, 343, 346, 355, 356, 357, 358, 359, 361, 363, 391, 427, 431, 441, 449, 460, 517
Fish: benthic feeding	5.0E+2	4.0E+2	3.9E+2	2.0E+0	3.2E+0	2.8E+3	169	333, 339, 343, 346, 355, 356, 357, 358, 361, 391, 441
Fish: forage	7.3E+1	2.4E+2	2.1E+1	4.8E+0	2.2E–1	1.3E+3	78	333, 391, 427, 431, 449, 517
Fish: piscivorous	4.0E+2	3.3E+2	3.1E+2	2.0E+0	4.2E+0	1.6E+3	335	333, 339, 340, 343, 346, 355, 356, 358, 359, 361, 363, 391, 460, 517
Reptiles	1.5E+3	1.3E+3	1.1E+3	2.1E+0	2.4E+2	3.3E+3	9	487
Vascular plants	2.6E+2	3.1E+2	1.7E+2	2.6E+0	7.7E+1	8.5E+2	20	333, 343, 449, 517
Dy (dysprosium)								
Molluscs: bivalve[b]	7.7E+2	3.6E+2	7.0E+2	1.6E+0			3	517
Vascular plants	5.6E+1	3.6E+1	4.7E+1	1.8E+0	4.2E+1	6.9E+1	6	517

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Er (erbium)								
Molluscs: bivalve[b]	5.1E+2	2.5E+2	4.6E+2	1.6E+0			3	517
Vascular plants	4.9E+1	3.5E+1	4.0E+1	1.9E+0	3.6E+1	6.3E+1	6	517
Eu (europium)								
Fish	6.3E+1	4.2E+1	5.3E+1	1.8E+0	7.6E+0	2.3E+2	54	304, 333
Fish: piscivorous	6.8E+1	3.4E+1	6.1E+1	1.6E+0	7.6E+0	1.6E+2	43	333
Molluscs: bivalve[b]	1.5E+3	7.0E+2	1.4E+3	1.6E+0			3	517
Vascular plants	7.8E+1	5.0E+1	6.5E+1	1.8E+0	4.8E+1	1.1E+2	6	517
Fe (iron)								
Algae	1.1E+2	9.0E+1	8.7E+1	2.0E+0	2.6E+1	2.0E+2	10	396
Fish	5.2E+2	1.1E+3	2.3E+2	3.6E+0	6.4E–1	7.0E+3	764	314, 333, 336, 339, 340, 343, 350, 355, 356, 357, 358, 359, 361, 363, 364, 371, 376, 378, 431, 441, 449
Fish: benthic feeding	4.9E+2	1.0E+3	2.2E+2	3.6E+0	8.7E–1	5.3E+3	241	333, 336, 339, 343, 355, 356, 357, 358, 361, 363, 371, 376, 378, 441
Fish: forage	5.5E+2	1.3E+3	2.1E+2	4.0E+0	8.2E–1	5.7E+3	68	333, 431, 449
Fish: piscivorous	5.2E+2	1.0E+3	2.4E+2	3.5E+0	6.4E–1	7.0E+3	454	333, 336, 339, 340, 343, 350, 355, 356, 358, 359, 361, 363, 364, 371, 376, 378, 431

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Molluscs: bivalve[b]	1.8E+3	4.9E+2	1.8E+3	1.3E+0			3	517
Phytoplankton	4.4E+3	2.7E+3	3.7E+3	1.8E+0	1.8E+3	7.0E+3	10	419
Reptiles	1.0E+3	1.3E+3	6.3E+2	2.6E+0	1.3E+2	2.8E+3	4	487
Vascular plants	3.4E+2	3.8E+2	2.2E+2	2.5E+0	2.0E+1	1.9E+3	35	333, 343, 396, 449, 517
Gd (gadolinium)								
Molluscs: bivalve[b]	1.0E+3	4.9E+2	9.4E+2	1.6E+0			3	517
Vascular plants	5.1E+1	3.3E+1	4.2E+1	1.8E+0	3.9E+1	6.3E+1	6	517
Hf (hafnium)								
Vascular plants	1.2E+1	2.2E+1	5.4E+0	3.4E+0	1.1E+1	1.3E+1	6	517
Hg (mercury)								
Fish	3.5E+2	5.6E+2	1.9E+2	3.1E+0	2.7E+1	1.0E+3	3	304, 427
Phytoplankton	1.1E+4	4.1E+3	9.9E+3	1.5E+0	4.7E+3	1.5E+4	25	416
Reptiles	5.7E+3	6.5E+3	3.7E+3	2.5E+0	2.2E+1	1.3E+4	46	487
Ho (holmium)								
Molluscs: bivalve[b]	5.3E+2	2.5E+2	4.8E+2	1.6E+0			3	517
Vascular plants	5.3E+1	3.5E+1	4.4E+1	1.8E+0	4.0E+1	6.6E+1	6	517

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
I (iodine)								
Algae	1.2E+2	2.8E+1	1.1E+2	1.3E+0	1.0E+2	1.3E+2	9	401
Fish	3.7E+2	3.9E+2	2.6E+2	2.4E+0	9.0E+0	1.3E+3	135	301, 314, 329, 333, 401, 517
Fish: piscivorous	4.0E+2	3.9E+2	2.9E+2	2.3E+0	1.0E+1	1.3E+3	122	301, 329, 333, 401, 517
Molluscs	8.3E+1	2.6E+1	7.9E+1	1.4E+0	8.0E+1	1.0E+2	7	401
Vascular plants	5.0E+1	3.5E+1	4.0E+1	1.9E+0	2.2E+1	9.6E+1	33	401, 517
La (lanthanum)								
Fish	1.2E+2	2.1E+2	6.0E+1	3.2E+0	3.3E–1	1.3E+3	250	304, 333, 517
Fish: benthic feeding	3.0E+2	4.0E+2	1.8E+2	2.7E+0	3.8E+0	1.3E+3	44	333
Fish: piscivorous	8.1E+1	1.0E+2	5.0E+1	2.7E+0	7.3E–1	4.4E+2	197	333, 517
Molluscs: bivalve[b]	3.1E+3	1.4E+3	2.9E+3	1.5E+0			3	517
Reptiles	2.4E+2				2.1E+2	2.6E+2	2	487
Vascular plants	9.2E+1	6.0E+1	7.7E+1	1.8E+0	6.5E+1	1.2E+2	6	517
Lu (lutetium)								
Molluscs: bivalve[b]	2.5E+2	2.3E+2	1.8E+2	2.2E+0			3	517
Vascular plants	3.1E+1	3.3E+1	2.1E+1	2.4E+0	2.0E+1	4.1E+1	6	517

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	N	
Mg (magnesium)								
Amphibians	1.4E+1				6.7E+0	2.1E+1	2	333
Fish	1.4E+2	2.1E+2	7.9E+1	2.9E+0	4.1E+0	9.7E+2	153	333, 339, 343, 350, 361, 363, 371, 517
Fish: benthic feeding	9.3E+1	1.5E+2	4.8E+1	3.2E+0	4.1E+0	5.9E+2	65	333, 339, 343, 361, 363, 371
Fish: piscivorous	1.9E+2	2.5E+2	1.1E+2	2.8E+0	2.9E+1	9.7E+2	76	333, 339, 343, 350, 361, 363, 371, 517
Molluscs: bivalve[b]	2.5E+1	4.4E+0	2.5E+1	1.2E+0			3	517
Reptiles	6.0E+1				4.9E+1	7.1E+1	2	487
Vascular plants	1.5E+2	1.0E+2	1.3E+2	1.8E+0	1.2E+1	2.9E+2	20	333, 343, 517
Mn (manganese)								
Algae	1.5E+2	8.8E+1	1.3E+2	1.7E+0	6.5E+1	2.3E+2	10	396
Fish	2.0E+3	4.4E+3	8.6E+2	3.7E+0	3.3E+0	2.6E+4	670	314, 333, 336, 339, 340, 343, 350, 355, 356, 357, 358, 359, 361, 363, 364, 376, 378, 517
Fish: benthic feeding	2.6E+3	5.8E+3	1.0E+3	3.8E+0	3.3E+0	2.6E+4	201	333, 336, 339, 343, 355, 356, 357, 358, 361, 363, 376, 378
Fish: piscivorous	1.7E+3	3.6E+3	7.2E+2	3.7E+0	6.3E+0	1.8E+4	451	333, 336, 339, 340, 343, 350, 355, 356, 358, 359, 361, 363, 364, 376, 378, 517

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Mammals: omnivorous[b]	3.4E+2	7.2E+2	1.5E+2	3.7E+0	8.5E+0	1.8E+3	6	511
Molluscs: bivalve[b]	1.2E+4	6.9E+3	1.0E+4	1.7E+0			3	517
Reptiles	7.4E+2	3.0E+3	1.8E+2	5.4E+0	5.7E+1	1.5E+4	24	487
Vascular plants	2.3E+3	4.0E+3	1.1E+3	3.3E+0	6.0E+1	1.4E+4	50	333, 343, 396, 449, 517
Mo (molybdenum)								
Fish	1.5E+1	2.0E+1	8.9E+0	2.8E+0	1.8E–1	1.9E+2	289	333, 339, 356, 357, 358, 359, 376, 378, 517
Fish: benthic feeding	9.7E+0	1.5E+1	5.3E+0	3.0E+0	1.8E–1	9.8E+1	64	333, 339, 356, 357, 358, 376, 378
Fish: piscivorous	1.7E+1	2.2E+1	1.0E+1	2.7E+0	3.8E–1	1.9E+2	217	333, 359, 517
Molluscs: bivalve[b]	2.6E+2	5.1E+1	2.5E+2	1.2E+0			3	517
Reptiles	8.7E+2				2.1E+1	1.7E+3	2	487
Vascular plants	3.9E+2	4.3E+2	2.7E+2	2.4E+0	7.8E+1	7.1E+2	6	517
Na (sodium)								
Fish	1.9E+2	2.3E+2	1.2E+2	2.5E+0	2.0E+0	9.8E+2	380	304, 333, 339, 343, 350, 361, 363, 371, 517
Fish: benthic feeding	1.2E+2	1.1E+2	8.8E+1	2.2E+0	2.0E+0	5.4E+2	122	333, 339, 343, 361, 363, 371
Fish: piscivorous	2.4E+2	2.7E+2	1.6E+2	2.5E+0	2.0E+1	9.8E+2	240	333, 339, 343, 350, 361, 363, 371, 517
Molluscs: bivalve[b]	6.8E+1	1.2E+1	6.7E+1	1.2E+0			3	517

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Reptiles	4.0E+2						1	487
Vascular plants	4.6E+1	4.3E+1	3.4E+1	2.2E+0	6.9E+0	1.4E+2	20	333, 343, 517
Nd (neodymium)								
Molluscs: bivalve[b]	1.6E+3	7.2E+2	1.4E+3	1.5E+0			3	517
Vascular plants	6.5E+1	4.4E+1	5.4E+1	1.8E+0	4.8E+1	8.3E+1	6	517
Ni (nickel)								
Fish	2.3E+2	3.8E+2	1.2E+2	3.2E+0	1.6E+0	3.0E+3	207	333, 336, 340, 343, 355, 356, 357, 358, 359, 374, 391, 441
Fish: benthic feeding	3.6E+2	2.9E+2	2.8E+2	2.0E+0	6.6E+0	6.2E+2	68	333, 343, 355, 356, 357, 358, 391, 441
Fish: forage	6.1E+2	8.3E+2	3.6E+2	2.8E+0	4.5E+0	3.0E+3	23	358, 374, 391
Fish: piscivorous	7.5E+1	1.2E+2	4.0E+1	3.1E+0	1.6E+0	7.1E+2	116	333, 336, 340, 355, 356, 358, 359, 391
Molluscs: bivalve[b]	1.2E+2	3.2E+1	1.2E+2	1.3E+0			3	517
Reptiles	9.5E+2				2.2E+0	1.9E+3	2	487
Vascular plants	6.7E+1	6.1E+1	5.0E+1	2.2E+0	2.5E+1	2.8E+2	21	333, 343, 449, 517
Np (neptunium)								
Algae	3.0E+2						5	396
Vascular plants	2.2E+2	8.3E+1	2.1E+2	1.4E+0	1.2E+2	3.1E+2	15	396

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
P (phosphorous)								
Fish	6.8E+5	2.5E+5	6.4E+5	1.4E+0	3.5E+5	1.2E+6	163	333, 350
Fish: benthic feeding	7.1E+5	2.0E+5	6.9E+5	1.3E+0	4.6E+5	9.5E+5	45	333
Fish: piscivorous	6.6E+5	2.7E+5	6.1E+5	1.5E+0	3.5E+5	1.2E+6	113	333, 350
Phytoplankton	1.3E+3	1.9E+3	7.4E+2	2.9E+0	6.2E+1	5.8E+3	35	416
Pb (lead)								
Amphibians	5.3E+0				1.7E+0	8.9E+0	2	333
Crustaceans	3.9E+1	4.7E+1	2.5E+1	2.6E+0			5	507
Fish	2.5E+2	7.0E+2	8.7E+1	4.3E+0	2.0E+0	7.5E+3	379	333, 336, 340, 355, 356, 357, 358, 359, 361, 364, 383, 391, 402, 427, 431, 441, 507
Fish: benthic feeding	1.8E+2	6.3E+2	4.8E+1	5.0E+0	3.2E+0	7.5E+3	148	333, 336, 355, 356, 357, 358, 361, 364, 383, 391, 402, 441, 507
Fish: forage	2.6E+1	6.2E+1	9.9E+0	4.0E+0	2.0E+0	3.5E+2	30	333, 358, 391, 427, 431, 507
Fish: piscivorous	3.5E+2	7.8E+2	1.4E+2	3.8E+0	8.3E+0	5.7E+3	201	333, 336, 340, 356, 358, 359, 361, 364, 383, 391, 402, 507
Molluscs: bivalve[b]	6.0E+3	1.5E+4	2.3E+3	4.0E+0	1.1E+2	2.9E+4	32	383, 402, 505, 508, 517
Reptiles	4.4E+2	6.2E+2	2.5E+2	2.9E+0	1.3E+1	1.9E+3	12	487
Vascular plants	6.2E+1	7.0E+1	4.1E+1	2.5E+0	1.3E+1	1.9E+2	21	333, 343, 402, 517

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Pm (promethium)								
Phytoplankton	7.0E+3	4.8E+3	5.7E+3	1.9E+0	2.1E+3	1.5E+4	25	416
Po (polonium)								
Crustaceans	8.3E+3	7.0E+3	6.3E+3	2.1E+0	1.2E+3	1.6E+4	12	312, 328, 507
Fish	2.0E+3	6.6E+3	5.9E+2	4.8E+0	4.9E+1	3.7E+4	203	303, 311, 312, 328, 336, 339, 343, 346, 350, 355, 363, 383, 507
Fish: benthic feeding	1.6E+3	4.4E+3	5.7E+2	4.2E+0	6.3E+1	1.9E+4	90	303, 312, 328, 336, 339, 343, 346, 355, 383, 507
Fish: forage	7.6E+3	1.2E+4	4.2E+3	3.0E+0	1.3E+2	2.6E+4	18	311, 312, 328, 507
Fish: piscivorous	1.3E+3	6.7E+3	2.6E+2	6.1E+0	4.9E+1	3.7E+4	95	336, 343, 346, 350, 355, 363, 383, 507
Molluscs	1.2E+5	5.2E+4	1.1E+5	1.5E+0	1.7E+3	1.7E+5	147	311, 312, 328, 383, 504, 508
Molluscs: bivalve	1.3E+5	4.9E+4	1.2E+5	1.5E+0	1.7E+3	1.7E+5	141	311, 312, 328, 383, 504, 508
Reptiles	3.6E+3	2.3E+3	3.1E+3	1.8E+0	1.5E+3	7.3E+3	7	487
Vascular plants	2.0E+3	1.5E+3	1.6E+3	2.0E+0	5.5E+2	4.6E+3	31	311, 312, 328, 343
Pr (praseodymium)								
Molluscs: bivalve[b]	1.7E+3	7.2E+2	1.6E+3	1.5E+0			3	517
Vascular plants	7.2E+1	4.7E+1	6.0E+1	1.8E+0	5.2E+1	9.1E+1	6	517

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Pu (plutonium)								
Algae	1.3E+3						8	309
Fish	7.8E+1	1.4E+2	3.8E+1	3.3E+0	4.0E–2	7.0E+2	73	301, 306, 307, 308, 309, 321, 331, 411, 462
Fish: forage	6.8E+1	1.2E+2	3.4E+1	3.2E+0	1.5E+0	5.9E+2	60	301, 306, 307, 308, 309, 321, 331, 411
Insects	1.7E+2						7	309
Insect larvae	2.5E+3						15	309
Molluscs	5.5E+3	1.2E+4	2.3E+3	3.7E+0	1.7E+2	4.2E+4	60	309, 411
Molluscs: gastropod	1.4E+3	2.3E+3	7.4E+2	3.1E+0	1.7E+2	7.1E+3	50	309, 411
Reptiles	5.9E+3				3.8E+3	8.1E+3	2	487
Vascular plants	1.1E+3	1.7E+3	5.7E+2	3.0E+0	3.3E+0	4.7E+3	99	309, 410, 411, 461, 462
Ra (radium)								
Crustaceans	2.7E+2	4.4E+2	1.4E+2	3.1E+0			5	507
Fish	1.7E+2	5.0E+2	5.5E+1	4.5E+0	1.4E–1	4.8E+3	277	299, 301, 305, 318, 339, 340, 343, 346, 350, 355, 357, 361, 371, 507
Fish: benthic feeding	3.1E+2	8.1E+2	1.1E+2	4.2E+0	1.4E+1	4.8E+3	88	305, 339, 343, 346, 355, 357, 361, 371, 507
Fish: piscivorous	1.1E+2	2.1E+2	5.1E+1	3.5E+0	6.7E+0	8.5E+2	68	305, 339, 340, 343, 350, 355, 361, 371, 507

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Mammals: herbivorous[b]	2.1E–1	1.6E–1	1.7E–1	1.9E+0	1.0E–1	5.0E–1	45	513
Molluscs: bivalve[b]	2.4E+4	3.5E+4	1.4E+4	2.9E+0	1.2E+1	1.3E+5	43	397, 502, 505, 508
Phytoplankton	5.5E+2	7.3E+2	3.3E+2	2.7E+0	1.8E+2	2.4E+3	40	416
Reptiles	8.0E+2	1.5E+3	3.7E+2	3.4E+0	1.0E+2	4.0E+3	18	487
Vascular plants	2.2E+3	2.7E+3	1.4E+3	2.6E+0	4.0E+2	1.0E+4	73	318, 343
Rb (rubidium)								
Fish: piscivorous[b]	5.9E+3	1.2E+3	5.8E+3	1.2E+0			3	517
Molluscs: bivalve[b]	9.5E+1	1.0E+1	9.4E+1	1.1E+0			3	517
Phytoplankton	2.6E+2	3.5E+2	1.5E+2	2.8E+0	5.2E+1	1.0E+3	30	416
Reptiles	1.7E+3				1.6E+0	3.4E+3	2	487
Vascular plants	2.6E+3	1.7E+3	2.2E+3	1.8E+0	1.1E+3	4.1E+3	6	517
Ru (ruthenium)								
Algae	5.2E+2	6.3E+2	3.3E+2	2.6E+0	1.1E+2	1.6E+3	5	320
Fish	1.0E+2	3.5E+2	2.9E+1	4.9E+0	1.7E–1	1.4E+3	17	301, 394
Phytoplankton	1.3E+3	1.6E+3	8.0E+2	2.6E+0	1.9E+2	4.5E+3	30	416
S (sulphur)								
Phytoplankton	2.0E+2	2.9E+2	1.1E+2	2.9E+0	2.9E+1	7.6E+2	25	416

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Sb (antimony)								
Fish	3.3E+1	9.7E+1	1.1E+1	4.5E+0	2.4E–1	7.5E+2	141	304, 333, 399
Fish: benthic feeding	2.0E+1	2.1E+1	1.4E+1	2.4E+0	3.0E+0	7.8E+1	22	333
Fish: piscivorous	3.6E+1	1.1E+2	1.1E+1	4.6E+0	2.4E–1	7.5E+2	113	333, 399
Insect larvae	8.2E+1	6.9E+1	6.3E+1	2.1E+0	2.5E+0	2.4E+2	14	399
Molluscs: gastropod[b]	4.9E+1						1	399
Reptiles	2.3E+3				5.7E+1	4.5E+3	2	487
Vascular plants	2.5E+1	1.8E+1	2.0E+1	1.9E+0	1.3E+1	3.7E+1	6	517
Sc (scandium)								
Algae	1.8E+3	1.7E+3	1.4E+3	2.2E+0	2.5E+2	3.4E+3	10	396
Fish	6.9E+0	3.4E+0	6.2E+0	1.6E+0	6.3E+0	7.4E+0	6	517
Vascular plants	7.8E+1	3.4E+1	7.1E+1	1.5E+0	4.2E+1	1.2E+2	21	396, 517
Se (selenium)								
Algae	3.1E+3	1.3E+3	2.8E+3	1.5E+0			3	438
Fish	4.8E+3	3.3E+3	4.0E+3	1.9E+0	1.6E+2	1.4E+4	127	304, 310, 340, 356, 357, 359, 361, 371, 376, 378, 517
Fish: benthic feeding	6.2E+3	3.7E+3	5.4E+3	1.7E+0	1.7E+3	1.4E+4	51	356, 357, 361, 371, 376, 378
Fish: piscivorous	4.2E+3	2.7E+3	3.5E+3	1.8E+0	1.6E+2	1.1E+4	70	340, 356, 359, 361, 371, 376, 378, 517

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Insect larvae	2.4E+3	1.9E+3	1.8E+3	2.0E+0	8.1E+2	3.9E+3	9	438
Molluscs: gastropod[b]	3.2E+3	2.9E+3	2.4E+3	2.1E+0			3	438
Reptiles	2.7E+3	2.5E+3	1.9E+3	2.2E+0	3.3E+1	5.2E+3	11	487
Vascular plants	2.2E+2	5.7E+1	2.2E+2	1.3E+0			3	517
Zooplankton	6.6E+3	3.9E+3	5.7E+3	1.7E+0			3	438
Si (silicon)								
Vascular plants	8.4E+2	9.7E+2	5.5E+2	2.5E+0	5.5E+1	1.6E+3	6	517
Sm (samarium)								
Molluscs: bivalve[b]	1.4E+3	6.7E+2	1.3E+3	1.6E+0			3	517
Vascular plants	6.2E+1	4.2E+1	5.1E+1	1.9E+0	4.5E+1	7.9E+1	6	517
Sn (tin)								
Fish	9.9E+2	7.0E+1	9.9E+2	1.1E+0	9.2E+2	1.1E+3	3	340, 358
Sr (strontium)								
Algae	4.9E+2	7.6E+2	2.7E+2	3.0E+0	1.6E+1	3.5E+3	99	320, 402, 417, 419, 445, 456, 461, 464
Crustaceans	6.5E+2						1	454

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Fish	8.9E+2	5.2E+3	1.5E+2	6.6E+0	3.8E+0	1.2E+5	789	178, 314, 317, 324, 331, 332, 333, 336, 339, 340, 350, 355, 356, 357, 358, 359, 361, 363, 371, 376, 389, 394, 411, 415, 416, 418, 419, 446, 454, 461, 462, 517
Fish: benthic feeding	1.2E+3	4.5E+3	3.3E+2	5.1E+0	3.8E+0	4.8E+4	224	178, 324, 333, 336, 339, 355, 356, 357, 358, 361, 363, 371, 376, 389, 394, 416, 418, 419, 446, 462
Fish: forage	4.7E+2	5.9E+2	2.9E+2	2.6E+0	1.7E+1	2.8E+3	73	317, 324, 331, 333, 394, 411, 416, 446, 454, 461, 517
Fish: piscivorous	7.9E+2	5.8E+3	1.1E+2	7.4E+0	5.3E+0	1.2E+5	491	178, 317, 324, 332, 333, 336, 339, 340, 350, 355, 356, 358, 359, 361, 363, 371, 376, 389, 394, 415, 416, 418, 419, 446, 517
Molluscs	4.6E+2	6.1E+2	2.8E+2	2.7E+0	3.8E+1	2.7E+3	83	402, 408, 411, 517
Molluscs: bivalve	3.8E+2	1.6E+2	3.5E+2	1.5E+0	2.1E+2	6.6E+2	23	402, 411, 517
Molluscs: gastropod	4.9E+2	7.0E+2	2.8E+2	2.9E+0	3.8E+1	2.7E+3	60	402, 408, 411
Phytoplankton	1.3E+2	1.2E+2	9.0E+1	2.3E+0	2.1E+1	3.7E+2	50	416, 419, 454, 456
Reptiles	1.2E+4	4.9E+4	2.8E+3	5.5E+0	8.9E+0	2.8E+4	40	487

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Vascular plants	1.8E+2	4.7E+2	6.1E+1	4.3E+0	1.7E+1	4.4E+3	533	153, 331, 402, 410, 411, 412, 419, 420, 421, 422, 425, 445, 449, 454, 456, 461, 462, 464, 517
Zooplankton	3.7E+3	7.4E+2	3.6E+3	1.2E+0	3.0E+3	4.4E+3	10	412
Tc (technetium)								
Fish: forage[b]	9.9E+1	9.6E+1	7.1E+1	2.3E+0	5.3E+0	2.0E+2	3	301
Te (tellurium)								
Fish: piscivorous[b]	3.3E+2	2.1E+2	2.8E+2	1.8E+0	9.6E+1	8.9E+2	15	333
Th (thorium)								
Fish	6.7E+2	4.6E+3	9.8E+1	7.1E+0	3.3E+1	3.7E+4	64	304, 318, 339, 507
Phytoplankton	1.2E+4	1.0E+4	8.7E+3	2.1E+0	2.1E+2	2.9E+4	30	416, 428
Reptiles	1.0E+3	6.4E+2	8.7E+2	1.8E+0	2.4E+2	1.5E+3	7	487
Vascular plants	1.1E+5	3.6E+5	3.1E+4	4.8E+0	7.1E+1	4.7E+5	84	318, 517
Ti (titanium)								
Fish	8.0E+2	1.6E+3	3.6E+2	3.6E+0	3.0E+1	6.1E+3	146	336, 340, 355, 356, 357, 358, 359, 376
Fish: benthic feeding	1.7E+2	1.1E+2	1.4E+2	1.8E+0	3.0E+1	3.8E+2	43	336, 355, 356, 357, 358
Fish: piscivorous	1.1E+3	1.9E+3	5.8E+2	3.2E+0	3.5E+1	6.1E+3	93	336, 340, 355, 356, 358, 359, 376

TABLE 6. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Tl (thallium)								
Fish: piscivorous[b]	1.0E+2						2	359
Tm (thulium)								
Molluscs: bivalve[b]	3.4E+2	1.5E+2	3.1E+2	1.5E+0			3	517
Vascular plants	4.6E+1	3.1E+1	3.8E+1	1.8E+0	3.4E+1	5.7E+1	6	517
U (uranium)								
Crustaceans	2.0E+2	3.1E+2	1.1E+2	3.1E+0			5	507
Fish	3.1E+1	1.0E+2	9.1E+0	4.8E+0	5.0E–2	7.6E+2	1294	299, 301, 303, 318, 339, 340, 350, 357, 358, 361, 371, 376, 377, 378, 507, 517
Fish: benthic feeding	7.5E+1	2.1E+2	2.6E+1	4.3E+0	6.0E–1	7.6E+2	99	303, 339, 357, 358, 361, 371, 376, 377, 378, 507
Fish: piscivorous	2.2E+1	4.0E+1	1.1E+1	3.4E+0	5.1E–1	1.7E+2	84	301, 340, 350, 358, 361, 371, 377, 378, 507
Molluscs: bivalve[b]	5.6E+2	1.3E+2	5.4E+2	1.3E+0			3	517
Phytoplankton	7.1E+1	4.7E+1	5.9E+1	1.8E+0	4.0E+1	1.8E+2	40	416
Reptiles	1.2E+2	9.6E+1	9.0E+1	2.1E+0	4.5E+1	1.9E+2	8	487
Vascular plants	3.7E+2	9.9E+2	1.3E+2	4.2E+0	2.9E+1	2.7E+3	386	318, 517

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
V (vanadium)								
Fish: forage[b]	9.4E+0	7.1E+0	7.5E+0	2.0E+0			3	517
Molluscs: bivalve[b]	5.9E+2	2.0E+2	5.6E+2	1.4E+0			3	517
Reptiles	1.1E+3				9.3E+2	1.2E+3	2	487
Vascular plants	5.2E+1	3.2E+1	4.4E+1	1.8E+0	3.4E+1	7.0E+1	6	517
Y (yttrium)								
Fish	3.1E–1	1.6E–1	2.8E–1	1.6E+0	2.5E–1	3.7E–1	6	517
Molluscs: bivalve[b]	2.3E+3	1.1E+3	2.1E+3	1.6E+0			3	517
Phytoplankton	6.8E+3	5.4E+3	5.3E+3	2.0E+0	2.5E+2	1.7E+4	45	416, 419, 456
Reptiles	5.0E+2						1	487
Vascular plants	6.3E+1	4.1E+1	5.2E+1	1.8E+0	4.8E+1	7.7E+1	6	517
Yb (ytterbium)								
Molluscs: bivalve[b]	4.5E+2	2.1E+2	4.0E+2	1.6E+0			3	517
Vascular plants	4.2E+1	3.0E+1	3.4E+1	1.9E+0	3.0E+1	5.5E+1	6	517
Zn (zinc)								
Algae	8.6E+1	5.5E+1	7.2E+1	1.8E+0	3.3E+1	1.4E+2	10	396
Amphibians	7.3E+2				2.0E+2	1.3E+3	2	333

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Fish	7.6E+3	6.0E+3	6.0E+3	2.0E+0	1.6E+1	3.4E+4	522	314, 333, 336, 339, 340, 346, 355, 356, 357, 358, 359, 363, 392, 431, 460, 517
Fish: benthic feeding	6.8E+3	6.7E+3	4.9E+3	2.3E+0	2.2E+2	3.4E+4	136	333, 336, 339, 346, 355, 356, 357, 358, 363
Fish: forage	3.0E+3	4.2E+3	1.7E+3	2.8E+0	1.6E+1	1.1E+4	20	333, 392, 431, 517
Fish: piscivorous	8.1E+3	5.7E+3	6.7E+3	1.9E+0	3.9E+2	2.4E+4	365	333, 336, 339, 340, 346, 355, 356, 358, 359, 363, 460, 517
Mammals: omnivorous[b]	1.6E+3						1	511
Phytoplankton	4.5E+3	3.9E+3	3.4E+3	2.1E+0	1.6E+2	1.1E+4	35	416
Reptiles	2.3E+4	2.3E+4	1.6E+4	2.3E+0	2.7E+3	5.3E+4	6	487
Vascular plants	5.7E+2	1.4E+3	2.2E+2	4.0E+0	4.5E+1	4.5E+3	38	333, 396, 449, 517
Zr (zirconium)								
Fish	1.1E+2	1.8E+2	5.4E+1	3.2E+0	9.2E+0	6.9E+2	31	333, 517
Fish: piscivorous	1.2E+2	2.0E+2	6.3E+1	3.1E+0	1.2E+1	6.9E+2	20	333
Phytoplankton	1.9E+3	8.0E+2	1.7E+3	1.5E+0	1.1E+3	2.7E+3	10	416

TABLE 6. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN FRESHWATER ECOSYSTEMS (cont.)

Wildlife group (freshwater)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Reptiles	1.2E+3				7.5E+2	1.7E+3	2	487
Vascular plants	4.1E+1	3.5E+1	3.1E+1	2.1E+0	4.0E+1	4.2E+1	6	517

Note: AM: arithmetic mean; AMSD: arithmetic mean standard deviation; FW: fresh weight; GM: geometric mean; GMSD: geometric mean standard deviation; ID: identification; *N*: number of data.

[a] The publications corresponding to these ID numbers are given in the Annex.

[b] All of the data for the wildlife group are for the subcategory presented.

[c] This value is from a single study and is low compared with those for Pu and Am for which there are considerably larger datasets.

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Ag (silver)								
Annelids[b]	2.7E+4						1	21
Fish[b]	1.1E+4	9.5E+3	8.1E+3	2.1E+0	7.2E+2	2.4E+4	5	8, 21, 31
Macroalgae[b]	3.9E+3	6.0E+3	2.1E+3	3.0E+0	2.0E+2	1.5E+4	20	7, 10, 16, 21, 149
Mammals: carnivorous[b,c]	2.2E+4	2.1E+4	1.6E+4	2.2E+0			10	154
Molluscs[b]	3.6E+4	7.2E+4	1.6E+4	3.6E+0	3.3E+2	1.0E+5	19	8, 10, 15, 21, 31, 149
Phytoplankton[b]	6.9E+4	8.2E+4	4.4E+4	2.6E+0	1.3E+4	2.0E+5	10	7, 21, 44
Sea anemones/true corals	1.3E+2				8.2E+1	1.7E+2	2	48
Zooplankton[b]	6.0E+3	9.6E+3	3.2E+3	3.1E+0	4.7E+2	1.7E+4	3	10, 21
Am (americium)								
Crustaceans: large[c]	5.0E+2						5	133
Fish: benthic feeding[c]	3.2E+2	4.2E+2	1.9E+2	2.7E+0	1.7E+1	1.5E+3	23	55, 78, 116
Macroalgae	4.3E+2	7.8E+2	2.1E+2	3.3E+0	3.9E+1	3.8E+3	47	16, 55, 60, 100, 106, 133, 381
Molluscs	9.9E+3	1.1E+4	6.7E+3	2.4E+0	2.0E+2	2.0E+4	33	52, 55, 78, 133
Molluscs: gastropod	8.7E+3	1.1E+4	5.4E+3	2.7E+0			26	78
Phytoplankton	2.1E+5	2.1E+5	1.5E+5	2.3E+0	7.0E+3	6.9E+5	15	41, 42, 44
Sea anemones/true corals	4.5E+1	4.2E+1	3.3E+1	2.2E+0	6.0E+0	1.2E+2	6	48
Ca (calcium)								
Fish: benthic feeding[c]	6.2E+0	5.5E+0	4.6E+0	2.2E+0	4.0E–1	1.1E+1	3	333

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Cd (cadmium)								
Annelids	1.5E+3						1	53
Crustaceans: large[c]	9.6E+3	5.0E+3	8.5E+3	1.6E+0	7.6E+2	1.2E+4	5	53, 514
Fish	2.9E+4	5.9E+4	1.3E+4	3.6E+0	3.0E+1	1.5E+5	6	10, 31, 36, 87
Macroalgae	8.4E+2	8.4E+2	5.9E+2	2.3E+0	1.6E+1	4.7E+3	63	10, 32, 40, 84, 87, 97
Mammals[b]	4.7E+3	5.0E+3	3.2E+3	2.4E+0			529	39
Molluscs	9.0E+4	4.3E+5	1.9E+4	5.9E+0	1.0E+1	2.3E+6	80	10, 31, 32, 36, 40, 53
Molluscs: bivalve	1.3E+5	5.0E+5	3.4E+4	5.2E+0	2.2E+2	2.3E+6	21	32, 36, 53
Molluscs: gastropod	5.7E+3	2.1E+4	1.5E+3	5.2E+0	1.0E+1	1.5E+5	50	32, 36, 40
Phytoplankton	8.1E+2	1.1E+3	4.7E+2	2.8E+0	2.2E+1	3.2E+3	56	10, 44, 150, 152
Zooplankton	5.0E+4						2	10
Ce (cerium)								
Crustaceans	1.0E+2				8.5E+1	1.2E+2	2	83
Fish: forage[c]	3.9E+2	6.2E+2	2.1E+2	3.1E+0	2.1E+1	1.1E+3	3	83, 141
Macroalgae	2.1E+3	3.2E+3	1.2E+3	2.9E+0	1.4E+1	1.1E+4	40	10, 83, 93, 114, 141, 145
Molluscs	2.2E+3	3.5E+3	1.1E+3	3.1E+0	6.0E+1	1.0E+4	9	10, 27, 83, 141
Phytoplankton	1.1E+4	2.2E+4	4.8E+3	3.6E+0	3.4E+2	4.5E+4	11	10, 120
Sea anemones/true corals	1.3E+2	5.4E+1	1.2E+2	1.5E+0	4.9E+1	1.7E+2	4	11, 119, 120
Vascular plants	1.6E+2				1.3E+2	1.8E+2	2	119, 120

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Cl (chlorine)								
Crustaceans[b]	5.6E–2						1	21
Fish[b]	5.6E–2						1	21
Macroalgae[b]	8.2E–1	4.3E–1	7.3E–1	1.6E+0	4.4E–2	1.0E+0	36	21, 65
Molluscs[b]	4.7E–2						1	21
Cm (curium)								
Macroalgae	1.2E+4	1.2E+4	8.2E+3	2.3E+0	1.3E+3	5.2E+4	23	35, 60
Molluscs	3.2E+4	2.7E+4	2.4E+4	2.1E+0	1.2E+4	5.7E+4	10	35
Phytoplankton	2.7E+5	2.2E+5	2.1E+5	2.0E+0	1.2E+5	6.4E+5	5	44
Co (cobalt)								
Annelids	8.3E+3	1.0E+4	5.3E+3	2.6E+0	1.0E+3	2.0E+4	3	120
Crustaceans	3.5E+3	6.4E+3	1.7E+3	3.3E+0	2.2E+2	2.2E+4	11	8, 67, 72, 120, 147, 149
Fish	5.3E+3	1.5E+4	1.8E+3	4.3E+0	2.8E+1	7.8E+4	99	8, 10, 20, 67, 72, 74, 120, 123, 140, 147
Fish: benthic feeding	4.8E+2	6.8E+2	2.8E+2	2.8E+0	5.3E+1	3.3E+3	24	67, 72, 120, 147
Fish: forage	1.1E+3	2.8E+3	3.8E+2	4.2E+0	3.5E+1	1.0E+4	12	67, 72, 120, 147
Fish: piscivorous	1.1E+4	2.0E+4	5.0E+3	3.4E+0	2.8E+1	7.8E+4	46	67, 72, 74, 120, 147
Macroalgae	1.7E+3	3.2E+3	7.8E+2	3.5E+0	9.0E+0	1.4E+4	130	8, 10, 26, 72, 98, 100, 108, 120, 140, 147, 149, 381
Mammals: carnivorous[b,c]	5.0E+2	1.4E+3	1.7E+2	4.4E+0			10	154

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Molluscs	5.3E+3	1.5E+4	1.7E+3	4.5E+0	1.7E+2	4.1E+4	42	8, 10, 15, 20, 67, 72, 120, 140, 147, 148, 149
Molluscs: bivalve	5.5E+3	1.6E+4	1.8E+3	4.5E+0	1.7E+2	4.1E+4	26	10, 20, 67, 72, 120, 147, 148, 149
Phytoplankton	3.1E+3	4.3E+3	1.8E+3	2.9E+0	1.0E+2	1.2E+4	22	9, 10, 17, 44, 58
Sea anemones/true corals	3.3E+2	5.2E+2	1.7E+2	3.1E+0	2.0E+1	1.1E+3	4	48, 120
Vascular plants	5.2E+1	5.9E+1	3.4E+1	2.5E+0	1.8E+1	1.2E+2	3	18, 120
Zooplankton	4.8E+3	6.5E+3	2.9E+3	2.8E+0	2.0E+2	2.6E+4	24	10, 120, 147
Cs (caesium)								
Annelids	1.8E+2	1.6E+2	1.3E+2	2.2E+0	1.0E+1	5.1E+2	40	6, 120, 125
Birds	4.8E+2	6.4E+2	2.9E+2	2.8E+0	5.0E+1	3.5E+3	66	43, 63, 91, 125
Crustaceans	5.3E+1	1.2E+2	2.1E+1	3.9E+0	5.5E–1	1.3E+3	287	6, 24, 43, 51, 67, 78, 83, 90, 91, 99, 108, 110, 111, 120, 125, 133, 139, 147
Crustaceans: large	5.6E+1	1.4E+2	2.1E+1	4.0E+0	1.3E+1	1.3E+3	225	24, 43, 51, 78, 90, 91, 110, 120, 125, 133, 139, 147
Crustaceans: small	4.4E+1	3.8E+1	3.4E+1	2.1E+0	5.5E–1	1.2E+2	54	24, 51, 67, 91, 99, 108, 110, 111, 120, 125, 139

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Fish	8.4E+1	1.2E+2	4.8E+1	2.9E+0	5.0E+0	1.8E+3	1812	5, 6, 14, 20, 24, 43, 49, 51, 62, 67, 74, 76, 78, 79, 83, 90, 91, 92, 99, 103, 106, 107, 108, 109, 110, 111, 113, 117, 120, 125, 131, 132, 137, 143, 145, 146, 147, 385, 386
Fish: benthic feeding	7.1E+1	1.5E+2	3.1E+1	3.6E+0	5.0E+0	1.8E+3	515	24, 51, 62, 67, 78, 90, 99, 106, 107, 110, 111, 117, 120, 125, 132, 137, 143, 145, 147, 385, 386
Fish: forage	1.2E+2	1.8E+2	6.8E+1	2.9E+0	1.2E+1	1.0E+3	92	14, 49, 62, 67, 91, 99, 106, 107, 110, 111, 113, 117, 125, 146, 147, 385, 386
Fish: piscivorous	7.9E+1	6.9E+1	5.9E+1	2.1E+0	7.4E+0	3.6E+2	903	6, 14, 24, 62, 67, 74, 78, 90, 91, 92, 99, 106, 108, 109, 110, 111, 113, 117, 120, 125, 131, 132, 137, 143, 146, 147, 385
Macroalgae	9.6E+1	3.7E+2	2.4E+1	5.3E+0	3.7E+0	4.8E+3	654	10, 12, 43, 51, 62, 63, 65, 78, 83, 90, 91, 93, 95, 100, 106, 107, 108, 109, 110, 111, 113, 114, 120, 125, 133, 144, 145, 146, 147, 381, 386

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Mammals[b]	2.2E+2	5.1E+2	8.4E+1	3.9E+0	8.7E+0	8.2E+2	717	1, 5, 12, 14, 30, 33, 43, 54, 63, 77, 91, 111, 128, 133, 154, 156
Molluscs	5.0E+1	5.1E+1	3.5E+1	2.3E+0	2.0E+0	2.1E+2	336	6, 20, 24, 43, 51, 67, 78, 83, 90, 91, 94, 95, 103, 113, 120, 125, 133, 140, 147, 385
Molluscs: bivalve	6.3E+1	5.9E+1	4.6E+1	2.2E+0	2.0E+0	1.7E+2	191	6, 20, 24, 43, 67, 78, 90, 91, 94, 95, 103, 113, 125, 133, 147, 385
Molluscs: gastropod	3.7E+1	2.8E+1	3.0E+1	2.0E+0	3.0E+0	1.3E+2	102	20, 78, 94, 95, 113, 120, 125, 147
Phytoplankton	8.5E+0	1.8E+1	3.6E+0	3.7E+0	1.0E+0	7.3E+1	15	19, 51, 120
Sea anemones/true corals	2.3E+2	3.2E+2	1.3E+2	2.8E+0	1.0E+0	8.0E+2	9	48, 51, 119, 125
Vascular plants	1.0E+1	7.2E+0	8.5E+0	1.9E+0	2.0E+0	1.5E+1	3	18, 119
Zooplankton	1.3E+2	2.2E+2	6.7E+1	3.2E+0	2.9E+0	9.9E+2	23	88, 147
Cu (copper)								
Fish	2.1E+3	1.2E+3	1.9E+3	1.7E+0	1.1E+3	4.2E+3	9	333
Eu (europium)								
Fish: forage[c]	7.3E+2						1	141
Macroalgae	1.4E+3	1.0E+3	1.1E+3	1.9E+0	3.0E+2	2.6E+3	4	141
Molluscs: bivalve[c]	6.9E+3						1	141

TABLE 7. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo-water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Hg (mercury)								
Crustaceans: large[c]	1.6E+4	5.7E+3	1.5E+4	1.4E+0			4	514
I (iodine)								
Macroalgae[b]	4.2E+3	1.1E+4	1.4E+3	4.3E+0	1.6E+2	8.5E+4	61	10, 21, 62, 65, 120
Mammals: carnivorous[b,c]	6.8E–1	2.3E–1	6.4E–1	1.4E+0			8	154
Molluscs[b]	8.8E+3	1.8E+4	3.8E+3	3.6E+0	1.4E+1	5.0E+4	8	10, 21, 120
Phytoplankton[b]	9.5E+2						1	21
Vascular plants	2.4E+1						1	18
Zooplankton	3.1E+3						2	10
Mg (magnesium)								
Fish: benthic feeding[c]	1.6E–1	4.1E–2	1.6E–1	1.3E+0	1.2E–1	1.9E–1	3	333
Mn (manganese)								
Annelids	3.2E+3						1	53
Crustaceans	4.5E+4	9.8E+4	1.9E+4	3.7E+0	4.5E+2	1.3E+5	9	10, 53, 85, 120, 147
Fish	2.6E+3	1.5E+4	4.4E+2	6.6E+0	2.0E+1	5.0E+4	57	10, 31, 85, 87, 115, 120, 123, 147, 333
Macroalgae	8.6E+3	1.0E+4	5.6E+3	2.5E+0	3.0E+2	5.2E+4	44	10, 47, 56, 85, 87, 120, 147
Mammals: carnivorous[b,c]	4.5E+3	1.1E+4	1.7E+3	4.0E+0			10	154
Molluscs	1.2E+4	2.0E+4	5.9E+3	3.2E+0	2.4E+2	8.5E+4	41	10, 31, 53, 85, 120, 147
Molluscs: bivalve	5.8E+3	9.2E+3	3.1E+3	3.1E+0	4.0E+2	3.5E+4	21	53, 85, 120, 147

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	N	
Phytoplankton	3.5E+3	3.5E+3	2.5E+3	2.3E+0	2.0E+1	5.0E+3	6	10, 120
Sea anemones/true corals	1.0E+1						1	48
Vascular plants	3.0E+4				8.9E+3	5.2E+4	2	56, 85
Zooplankton	2.5E+3	3.4E+3	1.5E+3	2.8E+0	2.0E+2	1.1E+4	18	10, 120, 147
Na (sodium)								
Fish: benthic feeding[c]	2.0E–1	6.4E–2	1.9E–1	1.4E+0	1.3E–1	2.4E–1	3	333
Nb (niobium)								
Crustaceans	1.0E+2						1	10
Macroalgae	4.9E+2	5.6E+2	3.2E+2	2.5E+0	2.0E+1	1.7E+3	15	10, 120
Molluscs	8.8E+2						2	10
Ni (nickel)								
Annelids[b]	4.2E+3						1	21
Fish	2.5E+2	1.9E+2	2.0E+2	2.0E+0	5.5E+1	6.7E+2	16	10, 31, 333
Macroalgae	9.5E+2	9.0E+2	6.9E+2	2.2E+0	2.5E+2	2.8E+3	14	10, 47
Molluscs	6.4E+3	1.3E+4	2.8E+3	3.6E+0	5.5E+1	2.1E+4	12	10, 31
Phytoplankton[b]	5.7E+2	7.4E+2	3.5E+2	2.7E+0	1.6E+2	1.4E+3	3	10, 21
Zooplankton	5.0E+2						2	10

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Np (neptunium)								
Crustaceans: large[c]	1.1E+2						1	515
Macroalgae	5.2E+1	2.2E+1	4.8E+1	1.5E+0	1.5E+1	6.6E+1	53	35, 86, 515
Molluscs	3.8E+2	3.7E+2	2.7E+2	2.3E+0	1.1E+1	8.9E+2	14	35, 515
Molluscs: gastropod	4.3E+2	4.1E+2	3.1E+2	2.2E+0	1.1E+1	8.9E+2	11	35, 515
Phytoplankton	1.4E+2	6.2E+1	1.3E+2	1.5E+0	3.0E+1	2.4E+2	12	41
Zooplankton	1.7E+1						2	51
P (phosphorous)								
Annelids[b]	2.6E+4						1	21
Fish	9.9E+4	3.0E+4	9.5E+4	1.3E+0			21	75
Macroalgae[b]	9.8E+3	1.9E+3	9.6E+3	1.2E+0	8.4E+3	1.2E+4	3	21
Mammals[b]	3.8E+4	1.1E+5	1.3E+4	4.4E+0	2.3E+4	1.9E+5	11	21, 154
Molluscs[b]	2.0E+4						1	21
Phytoplankton[b]	3.3E+4						2	21
Zooplankton[b]	2.3E+4						1	21
Pb (lead)								
Crustaceans	3.1E+4	9.1E+4	1.0E+4	4.5E+0	2.0E+2	2.9E+5	10	4, 31, 59
Fish	9.4E+3	2.6E+4	3.1E+3	4.4E+0	6.3E+1	1.2E+5	21	4, 31, 87, 333
Macroalgae	8.8E+2	1.3E+3	5.0E+2	2.9E+0	1.0E+1	6.1E+3	80	4, 32, 40, 84, 87, 95, 97
Mammals[b]	1.9E+4	1.5E+4	1.5E+4	2.0E+0			452	39

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	N	
Molluscs	1.4E+3	7.4E+3	2.7E+2	6.2E+0	1.1E+1	6.1E+4	68	31, 32, 40, 59, 95
Molluscs: bivalve	1.0E+3	1.9E+3	4.9E+2	3.4E+0	3.0E+1	7.4E+3	16	32, 95
Molluscs: gastropod	3.6E+2	9.9E+2	1.2E+2	4.3E+0	1.1E+1	6.9E+3	48	32, 40, 95
Phytoplankton	4.8E+5	8.9E+5	2.2E+5	3.4E+0	1.2E+3	2.6E+6	36	42, 45, 51, 59
Zooplankton	2.6E+4	3.0E+4	1.7E+4	2.5E+0	2.4E+1	9.1E+4	12	51, 59, 73
Po (polonium)								
Annelids	2.0E+4				1.7E+4	2.3E+4	2	135
Crustaceans	4.7E+4	5.8E+4	3.0E+4	2.6E+0	3.5E+3	2.2E+5	20	4, 28, 46, 59, 133, 135
Crustaceans: small	5.9E+4	5.1E+4	4.5E+4	2.1E+0	1.0E+4	1.5E+5	10	28, 59, 135
Fish	3.8E+4	1.1E+5	1.2E+4	4.5E+0	8.5E+2	6.9E+5	89	4, 28, 29, 46, 51
Macroalgae	1.3E+3	2.0E+3	7.1E+2	3.0E+0	7.0E+1	5.0E+3	38	4, 28, 29, 46, 95, 133
Mammals	8.8E+4	1.2E+5	5.2E+4	2.8E+0	8.0E+3	2.5E+5	7	29, 46
Molluscs	3.7E+4	3.2E+4	2.8E+4	2.1E+0	1.0E+3	1.7E+5	83	28, 29, 46, 52, 59, 94, 95, 130, 133, 135, 138
Molluscs: bivalve	4.4E+4	3.3E+4	3.5E+4	1.9E+0	2.2E+3	1.7E+5	62	28, 46, 94, 95, 130, 133, 135, 138
Molluscs: gastropod	1.2E+4	9.1E+3	9.5E+3	2.0E+0	1.7E+3	3.2E+4	11	94, 95
Phytoplankton	5.3E+4	8.2E+4	2.9E+4	3.0E+0	2.8E+3	2.4E+5	23	29, 42, 51, 59, 134, 387
Zooplankton	6.2E+4	7.9E+4	3.8E+4	2.7E+0	6.0E+2	3.3E+5	49	28, 29, 51, 59, 73, 134

TABLE 7. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo-water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	N	
Pu (plutonium)								
Annelids	1.5E+3	2.2E+3	8.4E+2	3.0E+0	1.0E+2	4.1E+3	3	51, 104
Crustaceans	1.2E+2	7.6E+1	9.7E+1	1.8E+0	3.8E+1	2.7E+2	14	51, 133
Fish	1.5E+3	6.0E+3	3.6E+2	5.4E+0	1.0E+0	4.5E+4	124	20, 29, 43, 51, 55, 78, 106, 107, 108, 111, 120, 125, 126, 145, 146, 385, 386
Fish: benthic feeding	2.5E+3	8.1E+3	7.3E+2	4.8E+0	2.0E+0	2.7E+4	34	51, 55, 78, 106, 120, 125, 126, 145, 386
Fish: forage	6.9E+2	1.2E+3	3.4E+2	3.3E+0	2.0E+2	4.8E+3	14	55, 106, 107, 126, 146, 385, 386
Fish: piscivorous	1.9E+2	1.7E+2	1.4E+2	2.2E+0	1.0E+0	5.5E+2	19	51, 108, 111, 126, 146
Macroalgae	4.1E+3	8.6E+3	1.7E+3	3.7E+0	8.5E+1	4.9E+4	308	43, 50, 51, 55, 60, 63, 64, 68, 91, 95, 100, 104, 106, 107, 108, 111, 127, 133, 146, 381, 385, 386
Mammals	1.3E+3	1.4E+3	9.2E+2	2.4E+0	1.0E+2	4.0E+3	24	30, 63, 126, 128, 133
Molluscs	1.1E+3	1.4E+3	6.6E+2	2.7E+0	1.8E+0	9.2E+3	169	20, 50, 51, 52, 55, 78, 94, 95, 104, 126, 133, 142, 385
Molluscs: bivalve	6.5E+2	8.2E+2	4.0E+2	2.7E+0	2.0E+1	4.8E+3	61	20, 51, 55, 94, 95, 104, 126, 133, 385
Molluscs: gastropod	1.7E+3	1.7E+3	1.2E+3	2.3E+0	7.0E+1	9.2E+3	81	20, 50, 51, 78, 94, 95, 104, 126, 142
Phytoplankton	1.3E+5	1.5E+5	8.3E+4	2.5E+0	4.0E+2	6.3E+5	55	29, 41, 51, 155, 387

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Sea anemones/true corals	4.9E+2						1	105
Zooplankton	7.8E+3	1.1E+4	4.5E+3	2.9E+0	2.0E+3	2.8E+4	5	29, 51
Ra (radium)								
Crustaceans	8.6E+1	5.4E+1	7.3E+1	1.8E+0			14	96
Fish	1.9E+2	4.2E+2	7.5E+1	3.8E+0	3.0E+1	1.9E+3	55	29, 74, 96, 121
Fish: benthic feeding	9.4E+1	1.0E+2	6.3E+1	2.4E+0	4.2E+1	1.2E+2	24	96, 121
Fish: piscivorous	3.3E+2	5.4E+2	1.7E+2	3.1E+0	3.0E+1	1.9E+3	21	74, 96
Macroalgae	9.0E+1	1.6E+2	4.4E+1	3.3E+0	8.0E–1	1.3E+2	8	18, 29
Molluscs	6.5E+1	6.3E+1	4.7E+1	2.3E+0	4.0E+1	1.7E+2	20	3, 96
Molluscs: bivalve	6.7E+1	6.7E+1	4.7E+1	2.3E+0	4.0E+1	1.7E+2	18	3, 96
Phytoplankton	1.1E+3	1.1E+4	1.2E+2	8.3E+0	3.0E+2	1.7E+3	7	29, 45
Zooplankton	8.1E+1	1.6E+2	3.6E+1	3.6E+0	4.9E+0	1.0E+2	5	29, 51
Ru (ruthenium)								
Fish	2.9E+1	4.4E+1	1.6E+1	3.0E+0	5.5E+0	1.0E+2	8	10
Macroalgae	1.2E+3	1.1E+3	8.8E+2	2.2E+0	1.5E+2	3.9E+3	48	10, 62, 114
Molluscs	1.6E+3	1.3E+3	1.3E+3	2.0E+0	1.0E+3	2.2E+3	9	10
Phytoplankton	6.7E+3	8.5E+3	4.1E+3	2.7E+0	5.4E+1	1.0E+4	3	10, 80
Sea anemones/true corals	2.9E+1				1.3E+1	4.4E+1	2	11

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
S (sulphur)								
Annelids	1.8E+0						1	21
Crustaceans: large[c]	2.0E+0	7.2E–1	1.8E+0	1.4E+0			4	514
Macroalgae[b]	3.0E+0	2.3E+0	2.4E+0	2.0E+0	1.5E+0	4.4E+0	4	21
Mammals: carnivorous[b,c]	1.5E+0	1.3E–1	1.5E+0	1.1E+0			10	154
Molluscs	3.2E+0						1	21
Phytoplankton	9.0E–1						2	21
Sb (antimony)								
Macroalgae	2.2E+2	4.9E+2	9.4E+1	3.8E+0	5.0E+1	3.0E+3	44	10, 65, 89, 147, 149
Molluscs	4.7E+2	8.6E+2	2.2E+2	3.4E+0	1.5E+1	2.4E+3	7	10, 15, 31, 147, 149
Sea anemones/true corals	9.0E+1						1	120
Zooplankton	1.3E+3	2.5E+3	6.1E+2	3.5E+0	1.3E+1	8.7E+3	13	147
Se (selenium)								
Annelids	4.5E+3						1	53
Macroalgae	4.3E+2	7.9E+2	2.0E+2	3.4E+0	2.9E+2	4.7E+3	36	65, 87
Mammals[b]	8.3E+3	2.7E+3	7.9E+3	1.4E+0			720	39
Molluscs	6.7E+3	4.6E+3	5.5E+3	1.9E+0	1.3E+3	1.2E+4	4	15, 31, 53
Phytoplankton	3.6E+3	1.3E+4	9.7E+2	5.1E+0	1.1E+1	1.1E+5	94	44, 150, 151, 152, 157
Sea anemones/true corals	1.0E+1						1	48

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Sr (strontium)								
Annelids[b]	4.6E–1						1	21
Crustaceans	4.9E+1	7.7E+1	2.7E+1	3.0E+0	1.5E–1	2.3E+2	36	13, 22, 51, 83, 110, 120, 133, 145, 514
Crustaceans: large	7.8E+1	1.1E+2	4.5E+1	2.9E+0	1.4E+0	2.3E+2	15	51, 120, 133, 145, 514
Crustaceans: small	3.0E+1	2.8E+1	2.2E+1	2.2E+0	1.5E–1	7.0E+1	18	13, 22, 51, 110, 120
Fish	2.5E+1	3.9E+1	1.4E+1	3.0E+0	1.5E–1	1.9E+2	118	6, 13, 43, 49, 51, 76, 83, 91, 110, 111, 120, 145, 146, 385
Fish: benthic feeding	1.1E+1	1.3E+1	7.4E+0	2.5E+0	3.0E+0	6.0E+1	25	13, 51, 91, 110, 145
Fish: forage	4.4E+1	4.0E+1	3.3E+1	2.2E+0	1.5E–1	1.4E+2	25	13, 49, 110, 120, 146, 385
Fish: piscivorous	3.8E+1	5.9E+1	2.0E+1	3.0E+0	2.0E–1	1.9E+2	30	91, 110, 111, 120
Macroalgae	2.9E+1	5.4E+1	1.4E+1	3.4E+0	2.0E–1	3.3E+2	385	10, 13, 43, 51, 65, 82, 83, 106, 107, 108, 111, 118, 120, 133, 145, 146, 381
Mammals	1.6E+2	3.6E+2	6.8E+1	3.8E+0	1.4E+0	1.0E+3	33	1, 43, 128, 133, 154
Molluscs	1.5E+2	1.5E+2	1.1E+2	2.3E+0	1.0E–1	5.0E+2	32	13, 51, 83, 120, 133
Molluscs: bivalve	8.8E+1	5.0E+1	7.7E+1	1.7E+0	2.0E–1	1.3E+2	12	13, 120, 133
Molluscs: gastropod	2.3E+2	1.6E+2	1.9E+2	1.9E+0	1.0E–1	3.9E+2	12	13, 120
Phytoplankton	1.9E+2	3.2E+2	9.6E+1	3.2E+0	4.0E+0	1.6E+3	30	19, 34, 51, 118, 124
Sea anemones/true corals	9.5E+1	1.0E+2	6.6E+1	2.4E+0	1.0E+0	2.0E+2	6	48, 51, 105, 119

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Vascular plants	3.0E+0						1	119
Zooplankton	6.8E+1	6.7E+1	4.8E+1	2.3E+0	1.1E+1	1.5E+2	19	13, 88
Tc (technetium)								
Crustaceans	1.7E+4	2.2E+4	1.1E+4	2.7E+0	5.0E+1	9.1E+4	235	23, 24, 25, 78, 81, 110, 112, 129, 133, 136
Crustaceans: large	1.8E+4	2.2E+4	1.1E+4	2.6E+0	5.0E+1	9.1E+4	226	23, 24, 25, 78, 81, 110, 112, 129, 133, 136
Macroalgae	5.3E+4	6.2E+4	3.5E+4	2.5E+0	8.3E+2	4.3E+5	174	12, 23, 38, 66, 78, 89, 109, 110, 112, 133, 381
Molluscs	8.2E+3	9.1E+3	5.5E+3	2.5E+0	1.2E+2	2.0E+4	63	23, 24, 25, 78, 112, 133, 136
Molluscs: bivalve	1.1E+4	1.0E+4	7.7E+3	2.2E+0	1.2E+2	2.0E+4	44	23, 24, 25, 78, 112, 133, 136
Molluscs: gastropod	2.7E+3	2.1E+3	2.1E+3	2.0E+0	1.5E+2	3.1E+3	19	25, 78
Phytoplankton	4.9E+0	5.4E+0	3.3E+0	2.4E+0	5.0E–1	1.7E+1	10	51
Te (tellurium)								
Phytoplankton	1.3E+4	1.6E+4	8.4E+3	2.6E+0	1.0E+3	4.5E+4	12	102
Th (thorium)								
Fish	1.3E+3						1	29
Macroalgae	4.6E+3	7.3E+3	2.4E+3	3.1E+0	2.3E+2	2.0E+4	7	29, 64, 100

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Molluscs	1.7E+3	2.6E+3	9.0E+2	3.0E+0	9.0E+1	6.3E+3	5	3, 29, 52
Phytoplankton	7.3E+5	7.6E+5	5.1E+5	2.4E+0	7.5E+3	2.0E+6	25	29, 45
Zooplankton	7.2E+3	7.5E+3	5.0E+3	2.4E+0	2.0E+1	1.5E+4	6	29, 51
U (uranium)								
Fish	8.8E+0	6.1E+0	7.3E+0	1.9E+0	2.0E+0	1.8E+1	9	122
Macroalgae	8.3E+1	9.9E+1	5.4E+1	2.6E+0	2.1E+1	5.1E+2	47	2, 29, 64, 95, 100, 381
Molluscs	3.2E+1	3.0E+1	2.4E+1	2.2E+0	4.0E+0	9.7E+1	22	3, 95
Molluscs: bivalve	3.5E+1	3.5E+1	2.5E+1	2.3E+0	4.0E+0	9.7E+1	13	3, 95
Phytoplankton	2.2E+2	2.3E+2	1.5E+2	2.4E+0	1.0E+1	6.0E+2	10	29, 45
Sea anemones/true corals	9.9E+2	4.4E+2	9.1E+2	1.5E+0	4.2E+2	1.8E+3	38	2, 29
Vascular plants	2.4E+2				1.7E+2	3.0E+2	2	2
Zooplankton	3.7E+0	4.8E+0	2.3E+0	2.7E+0	1.7E–1	5.5E+0	3	29, 51
Zn (zinc)								
Fish	2.5E+4	5.5E+3	2.4E+4	1.2E+0	1.9E+4	3.8E+4	9	333
Zr (zirconium)								
Crustaceans	4.9E+1						2	83
Fish	8.5E+1	6.9E+1	6.6E+1	2.0E+0	3.7E+1	2.0E+2	5	10, 83, 123
Macroalgae	1.7E+3	2.5E+3	9.3E+2	2.9E+0	2.3E+1	1.0E+4	44	10, 37, 83, 93, 114
Molluscs	3.3E+3	7.4E+3	1.3E+3	3.8E+0	4.4E+1	2.0E+4	7	10, 83
Phytoplankton	3.3E+4	5.4E+4	1.7E+4	3.1E+0	1.1E+4	5.5E+4	4	10

TABLE 7. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN MARINE ECOSYSTEMS (cont.)

Wildlife group (marine)	$CR_{wo\text{-}water}$ (Bq/kg, freshweight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Sea anemones/true corals	1.3E+2						1	120
Vascular plants	1.1E+3						1	120
Zooplankton	2.2E+4	2.5E+4	1.4E+4	2.5E+0	2.0E+4	2.5E+4	3	10, 37

Note: AM: arithmetic mean; AMSD: arithmetic mean standard deviation; FW: fresh weight; GM: geometric mean; GMSD: geometric mean standard deviation; ID: identification; *N*: number of data.

[a] The publications corresponding to these ID numbers are given in the Annex.

[b] All of the data for the wildlife group are for the subcategory presented.

[c] Based on a single generic concentration for sea water.

TABLE 8. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS

Wildlife group (brackish)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Al (aluminium)								
Crustaceans	9.2E+4						2	506
Fish	1.0E+2	2.1E+2	4.4E+1	3.7E+0	2.8E+0	3.9E+2	17	506, 517
Macroalgae	1.8E+5	1.4E+5	1.4E+5	2.0E+0	1.0E+5	2.6E+5	6	506
Molluscs	1.3E+5	5.1E+4	1.2E+5	1.5E+0	6.2E+4	1.7E+5	7	506
Phytoplankton	8.0E+4	2.1E+4	7.7E+4	1.3E+0			3	506
Vascular plants	1.2E+5	1.3E+5	7.7E+4	2.5E+0	7.1E+3	2.2E+5	6	506, 517
Zooplankton	1.8E+4						1	506
Am (americium)								
Fish	3.1E+2	3.4E+2	2.0E+2	2.5E+0	6.5E+1	7.0E+2	3	57
Molluscs	6.8E+2	1.0E+3	3.7E+2	3.0E+0	5.0E+2	1.2E+3	5	57
As (arsenic)								
Fish	3.5E+2	3.8E+2	2.3E+2	2.4E+0	5.0E+1	7.5E+2	8	517
Vascular plants	2.4E+2	1.0E+2	2.2E+2	1.5E+0			3	517
Ba (barium)								
Crustaceans	8.0E+2						2	506
Fish	1.2E+1	8.1E+0	9.6E+0	1.9E+0	4.4E+0	2.0E+1	15	506, 517
Macroalgae	1.9E+3	1.1E+3	1.6E+3	1.7E+0	4.6E+2	2.9E+3	9	506, 517
Molluscs	4.8E+2	1.7E+2	4.6E+2	1.4E+0	2.5E+2	5.8E+2	7	506

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	N	
Phytoplankton	5.1E+1	8.8E+0	5.0E+1	1.2E+0			3	506
Vascular plants	1.9E+2	7.5E+1	1.7E+2	1.5E+0	1.3E+2	2.4E+2	6	506, 517
Zooplankton	2.4E+1						1	506
Br (bromine)								
Fish	1.7E–1	8.2E–2	1.5E–1	1.6E+0	8.3E–2	2.4E–1	6	506
Macroalgae	2.5E+0	1.2E+0	2.3E+0	1.6E+0	1.3E+0	3.6E+0	7	506, 517
Molluscs	1.4E+0	1.0E+0	1.2E+0	1.9E+0	6.3E–1	2.3E+0	4	506
Phytoplankton	1.6E+0						2	506
Vascular plants	2.0E+0	4.9E–1	2.0E+0	1.3E+0			3	517
Zooplankton	6.6E+0						1	506
Ca (calcium)								
Crustaceans	4.4E+1	8.8E+1	2.0E+1	3.6E+0	8.2E–1	2.5E+2	14	101, 439, 506
Fish	1.2E+2	1.2E+2	8.6E+1	2.3E+0	2.6E+1	3.8E+2	23	506, 517
Macroalgae	7.5E+0	1.3E+1	3.8E+0	3.2E+0	5.6E–2	5.5E+1	71	101, 439, 506, 517
Molluscs	2.5E+2	4.9E+2	1.1E+2	3.5E+0	5.5E–1	1.3E+3	34	101, 439, 506, 517
Phytoplankton	8.7E–1	5.1E–2	8.7E–1	1.1E+0			3	506
Vascular plants	2.9E+1	1.1E+1	2.6E+1	1.5E+0	2.6E+1	3.1E+1	6	506, 517
Zooplankton	9.1E+0						1	506

TABLE 8. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Cd (cadmium)								
Crustaceans	2.2E+4	3.1E+4	1.3E+4	2.8E+0	3.3E+2	1.2E+5	14	101, 439, 506
Fish	1.2E+2	6.5E+1	1.0E+2	1.7E+0	8.7E+1	1.8E+2	9	506
Macroalgae	5.9E+3	1.4E+4	2.4E+3	3.9E+0	7.0E+1	5.6E+4	52	101, 439, 506
Molluscs	8.8E+4	1.4E+5	4.7E+4	3.1E+0	8.2E+2	5.2E+5	32	101, 439, 506
Phytoplankton	2.8E+2	7.6E+1	2.7E+2	1.3E+0			3	506
Vascular plants	5.5E+3	1.4E+3	5.3E+3	1.3E+0			3	506
Zooplankton	2.2E+3						1	506
Ce (cerium)								
Crustaceans	2.4E+4	2.9E+4	1.6E+4	2.6E+0	4.7E+2	9.5E+4	9	101, 439
Macroalgae	3.1E+4	4.4E+4	1.8E+4	2.9E+0	1.1E+3	2.3E+5	46	101, 439
Molluscs	3.5E+4	4.7E+4	2.1E+4	2.8E+0	4.9E+2	2.1E+5	25	101, 439
Vascular plants	4.5E+3	9.6E+3	1.9E+3	3.7E+0			3	517
Cl (chlorine)								
Fish	6.7E–2	2.9E–2	6.2E–2	1.5E+0	3.0E–2	8.7E–2	6	506
Macroalgae	1.2E+0	4.3E–1	1.1E+0	1.4E+0	6.8E–1	1.6E+0	7	506, 517
Molluscs	2.8E–1	7.5E–2	2.7E–1	1.3E+0	2.2E–1	3.4E–1	4	506
Phytoplankton	4.6E–1						2	506
Vascular plants	1.4E+0	3.3E–1	1.3E+0	1.3E+0			3	517

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Co (cobalt)								
Crustaceans	4.0E+3	2.2E+3	3.5E+3	1.7E+0	3.6E+2	8.4E+3	10	101, 439
Fish	1.3E+1	1.0E+1	1.0E+1	2.0E+0	8.0E+0	1.8E+1	8	517
Macroalgae	8.4E+3	1.2E+4	4.8E+3	2.9E+0	1.7E+2	6.4E+4	46	101, 439
Molluscs	8.1E+3	7.0E+3	6.1E+3	2.1E+0	2.7E+2	2.8E+4	27	57, 101, 439
Vascular plants	1.9E+3	1.6E+3	1.4E+3	2.1E+0			3	517
Cr (chromium)								
Crustaceans	2.8E+2						2	506
Macroalgae	4.4E+2	3.3E+2	3.5E+2	2.0E+0	2.8E+2	6.1E+2	6	506
Molluscs	2.0E+2	8.1E+1	1.8E+2	1.5E+0	1.2E+2	2.7E+2	7	506
Phytoplankton	2.0E+2	5.6E+1	2.0E+2	1.3E+0			3	506
Vascular plants	7.3E+2	5.8E+2	5.7E+2	2.0E+0	5.3E+2	9.3E+2	6	506, 517
Zooplankton	1.3E+2						1	506
Cs (caesium)								
Annelids	1.1E+2						1	70
Birds	1.1E+2	9.5E+1	8.6E+1	2.1E+0	4.0E+1	2.5E+2	4	70
Crustaceans	9.1E+1	8.3E+1	6.7E+1	2.2E+0	1.5E+1	2.3E+2	66	57, 70
Fish	1.5E+2	7.4E+1	1.3E+2	1.6E+0	6.7E+1	3.9E+2	86	57, 70
Macroalgae	1.2E+2	6.0E+1	1.1E+2	1.6E+0	6.2E+1	2.0E+2	4	70

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Mammals	3.5E+2	4.0E+2	2.3E+2	2.5E+0	5.5E+1	7.9E+2	8	69, 71
Molluscs	3.5E+1	3.7E+1	2.4E+1	2.4E+0	5.2E+0	1.5E+2	84	57, 70
Phytoplankton	2.7E+2	2.1E+2	2.1E+2	2.0E+0	4.0E+0	7.0E+2	38	57, 70
Vascular plants	2.7E+1	1.4E+1	2.4E+1	1.6E+0	1.0E+1	4.6E+1	6	70
Zooplankton	9.8E+0				7.6E+0	1.2E+1	2	70
Cu (copper)								
Crustaceans	6.6E+4	7.1E+4	4.5E+4	2.4E+0	1.2E+4	2.9E+5	14	101, 439, 506
Fish	3.9E+2	2.8E+2	3.1E+2	1.9E+0	2.3E+2	8.4E+2	17	506, 517
Macroalgae	5.6E+3	8.2E+3	3.2E+3	2.9E+0	3.2E+2	4.5E+4	52	101, 439, 506
Molluscs	7.7E+4	1.8E+5	3.1E+4	3.9E+0	6.8E+2	9.8E+5	32	101, 439, 506
Phytoplankton	6.0E+2	1.5E+2	5.8E+2	1.3E+0			3	506
Vascular plants	1.1E+3	3.9E+2	9.9E+2	1.4E+0	1.1E+3	1.1E+3	6	506, 517
Zooplankton	2.1E+3						1	506
Dy (dysprosium)								
Crustaceans	5.2E+3	4.9E+3	3.8E+3	2.2E+0	6.0E+2	1.4E+4	8	101, 439
Macroalgae	5.2E+3	5.3E+3	3.7E+3	2.3E+0	2.7E+2	2.2E+4	46	101, 439
Molluscs	5.6E+3	4.7E+3	4.3E+3	2.1E+0	2.4E+2	1.7E+4	24	101, 439

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Er (erbium)								
Crustaceans	4.8E+3	5.5E+3	3.1E+3	2.5E+0	5.4E+2	1.6E+4	10	101, 439
Macroalgae	5.3E+3	5.9E+3	3.6E+3	2.4E+0	1.9E+2	3.0E+4	46	101, 439
Molluscs	6.5E+3	8.4E+3	4.0E+3	2.7E+0	5.7E+2	4.0E+4	24	101, 439
Eu (europium)								
Crustaceans	2.1E+4	3.1E+4	1.2E+4	2.9E+0	1.8E+3	7.9E+4	9	101, 439
Macroalgae	1.3E+4	1.5E+4	8.8E+3	2.5E+0	6.5E+2	6.4E+4	46	101, 439
Molluscs	1.9E+4	2.2E+4	1.2E+4	2.5E+0	1.1E+3	9.0E+4	23	101, 439
Fe (iron)								
Crustaceans	8.4E+4	1.0E+5	5.3E+4	2.6E+0	3.6E+3	4.1E+5	13	101, 439, 506
Fish	1.3E+3	4.9E+2	1.2E+3	1.4E+0	1.0E+3	1.5E+3	9	506
Macroalgae	2.9E+5	7.4E+5	1.1E+5	4.1E+0	3.2E+3	5.1E+6	52	101, 439, 506
Molluscs	4.3E+5	7.5E+5	2.1E+5	3.3E+0	5.2E+3	3.1E+6	32	101, 439, 506
Phytoplankton	3.2E+4	7.9E+3	3.2E+4	1.3E+0			3	506
Vascular plants	9.7E+4	2.9E+4	9.3E+4	1.3E+0			3	506
Zooplankton	7.0E+3						1	506

TABLE 8. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Gd (gadolinium)								
Crustaceans	5.9E+3	5.9E+3	4.2E+3	2.3E+0	4.0E+2	1.7E+4	9	101, 439
Macroalgae	7.0E+3	7.3E+3	4.8E+3	2.4E+0	3.9E+2	3.4E+4	46	101, 439
Molluscs	8.2E+3	7.7E+3	6.0E+3	2.2E+0	3.3E+2	2.8E+4	25	101, 439
Ho (holmium)								
Crustaceans	1.4E+4	1.8E+4	8.6E+3	2.7E+0	1.1E+3	4.1E+4	7	101, 439
Macroalgae	6.9E+3	7.0E+3	4.9E+3	2.3E+0	2.1E+2	2.7E+4	46	101, 439
Molluscs	1.3E+4	2.3E+4	6.3E+3	3.3E+0	2.9E+2	1.1E+5	23	101, 439
I (iodine)								
Fish	1.0E+1	5.0E+0	9.1E+0	1.6E+0	7.0E+0	1.3E+1	7	506, 517
Macroalgae	1.2E+3	1.0E+3	9.2E+2	2.1E+0	1.7E+2	2.1E+3	7	506, 517
Molluscs	6.7E+1	5.4E+1	5.3E+1	2.0E+0	2.2E+1	1.1E+2	4	506
Phytoplankton	1.3E+1						2	506
Vascular plants	1.5E+2	1.2E+2	1.2E+2	2.0E+0			3	517
Zooplankton	2.5E+1						1	506
La (lanthanum)								
Crustaceans	6.5E+3	7.3E+3	4.3E+3	2.5E+0	2.9E+2	2.7E+4	12	101, 439
Fish	5.3E+0	1.1E+1	2.3E+0	3.6E+0			3	517

TABLE 8. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Macroalgae	1.0E+4	1.5E+4	5.9E+3	2.9E+0	6.5E+2	7.9E+4	46	101, 439
Molluscs	1.4E+4	1.6E+4	8.8E+3	2.5E+0	4.7E+2	6.3E+4	25	101, 439
Vascular plants	4.1E+3	7.9E+3	1.9E+3	3.5E+0			3	517
Li (lithium)								
Crustaceans	9.2E+0						2	506
Fish	1.6E+0	6.1E–1	1.5E+0	1.4E+0	9.4E–1	2.2E+0	9	506
Macroalgae	1.1E+1	7.5E+0	9.0E+0	1.9E+0	2.7E+0	1.9E+1	9	506, 517
Molluscs	5.2E+0	8.5E–1	5.1E+0	1.2E+0	4.4E+0	5.7E+0	7	506
Phytoplankton	6.6E+0	1.6E+0	6.4E+0	1.3E+0			3	506
Vascular plants	1.2E+1	4.2E+0	1.1E+1	1.4E+0	8.4E+0	1.5E+1	6	506, 517
Zooplankton	3.0E+0						1	506
Lu (lutetium)								
Crustaceans	3.0E+4	3.8E+4	1.8E+4	2.7E+0	9.0E+2	8.8E+4	6	101, 439
Macroalgae	9.1E+3	1.0E+4	6.1E+3	2.5E+0	1.4E+2	4.3E+4	46	101, 439
Molluscs	2.1E+4	3.8E+4	1.0E+4	3.3E+0	6.1E+2	1.6E+5	20	101, 439
Mg (magnesium)								
Crustaceans	1.3E+0	2.3E+0	6.5E–1	3.2E+0	1.7E–1	6.6E+0	14	101, 439, 506
Fish	2.1E+0	9.6E–1	1.9E+0	1.6E+0	8.1E–1	3.3E+0	23	506, 517

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Macroalgae	2.5E+0	3.8E+0	1.4E+0	3.0E+0	1.4E–1	1.4E+1	55	101, 439, 506, 517
Molluscs	7.0E–1	4.0E–1	6.1E–1	1.7E+0	2.9E–1	2.1E+0	34	101, 439, 506, 517
Phytoplankton	8.3E–1	2.5E–2	8.3E–1	1.0E+0			3	506
Vascular plants	7.6E+0	3.4E+0	7.0E+0	1.5E+0	5.1E+0	1.0E+1	6	506, 517
Zooplankton	1.2E+0						1	506
Mn (manganese)								
Crustaceans	2.6E+3	2.6E+3	1.8E+3	2.3E+0	7.5E+1	7.0E+3	14	101, 439, 506
Fish	4.1E+2	1.7E+2	3.7E+2	1.5E+0	3.6E+2	4.9E+2	9	506
Macroalgae	5.0E+4	1.6E+5	1.5E+4	4.7E+0	1.7E+2	1.1E+6	52	101, 439, 506
Molluscs	1.0E+4	1.5E+4	5.7E+3	3.0E+0	2.1E+2	5.2E+4	32	101, 439, 506
Phytoplankton	4.6E+3	7.1E+2	4.5E+3	1.2E+0			3	506
Vascular plants	4.2E+4	1.5E+4	4.0E+4	1.4E+0			3	506
Zooplankton	7.0E+2						1	506
Mo (molybdenum)								
Crustaceans	1.8E+1	1.6E+1	1.3E+1	2.1E+0	4.3E+0	6.1E+1	13	101, 439, 506
Fish	1.7E+0	5.8E–1	1.6E+0	1.4E+0	1.3E+0	2.4E+0	23	506, 517
Macroalgae	1.8E+1	1.4E+1	1.4E+1	2.0E+0	1.4E+0	4.8E+1	55	101, 439, 506, 517
Molluscs	5.2E+1	4.9E+1	3.8E+1	2.2E+0	9.1E+0	1.8E+2	34	101, 439, 506, 517
Phytoplankton	4.1E+0	3.1E–1	4.1E+0	1.1E+0			3	506

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Vascular plants	8.5E+1	2.2E+1	8.3E+1	1.3E+0	8.5E+1	8.5E+1	6	506, 517
Zooplankton	1.3E+1						1	506
Na (sodium)								
Crustaceans	5.0E–1	4.5E–1	3.7E–1	2.2E+0	1.9E–1	1.5E+0	14	101, 439, 506
Fish	4.0E–1	1.2E–1	3.8E–1	1.4E+0	1.8E–1	5.2E–1	23	506, 517
Macroalgae	5.8E–1	8.8E–1	3.2E–1	3.0E+0	8.3E–3	2.8E+0	39	101, 506, 517
Molluscs	5.0E–1	4.0E–1	3.9E–1	2.0E+0	1.1E–1	1.5E+0	34	101, 439, 506, 517
Phytoplankton	6.6E–1	3.4E–2	6.6E–1	1.1E+0			3	506
Vascular plants	1.8E+0	5.3E–1	1.8E+0	1.3E+0	1.6E+0	2.1E+0	6	506, 517
Zooplankton	1.1E+0						1	506
Nd (neodymium)								
Crustaceans	5.3E+3	5.9E+3	3.6E+3	2.5E+0	2.2E+2	2.0E+4	14	101, 439, 506
Macroalgae	8.9E+3	1.2E+4	5.1E+3	2.8E+0	1.0E+2	6.6E+4	52	101, 439, 506
Molluscs	9.7E+3	1.1E+4	6.3E+3	2.5E+0	3.3E+2	5.1E+4	32	101, 439, 506
Phytoplankton	6.8E+0	2.1E+0	6.5E+0	1.4E+0			3	506
Vascular plants	3.0E+2	1.6E+2	2.6E+2	1.7E+0			3	506
Zooplankton	1.2E+3						1	506

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Ni (nickel)								
Crustaceans	1.0E+3	7.1E+2	8.7E+2	1.9E+0	2.8E+2	2.4E+3	14	101, 439, 506
Fish	1.1E+1	8.1E+0	8.7E+0	1.9E+0	8.1E–1	1.7E+1	11	506, 517
Macroalgae	2.7E+3	3.1E+3	1.7E+3	2.5E+0	2.7E+2	1.5E+4	55	101, 439, 506, 517
Molluscs	2.5E+3	3.1E+3	1.6E+3	2.6E+0	1.8E+2	1.5E+4	34	101, 439, 506, 517
Phytoplankton	1.3E+2	4.5E+1	1.3E+2	1.4E+0			3	506
Vascular plants	6.5E+2	3.3E+2	5.8E+2	1.6E+0	4.7E+2	8.3E+2	6	506, 517
Zooplankton	1.1E+2						1	506
P (phosphorous)								
Crustaceans	1.5E+5	8.6E+4	1.3E+5	1.7E+0	7.9E+4	2.3E+5	4	506
Fish	3.4E+5	2.9E+5	2.5E+5	2.1E+0	7.6E+3	1.0E+6	32	506, 517
Macroalgae	3.3E+4	1.4E+4	3.1E+4	1.5E+0	1.3E+4	5.2E+4	15	506, 517
Molluscs	5.0E+4	4.7E+4	3.7E+4	2.2E+0	1.1E+4	1.2E+5	14	506
Phytoplankton	6.7E+3	2.4E+3	6.3E+3	1.4E+0	4.9E+3	8.5E+3	6	506
Vascular plants	2.7E+4	2.5E+4	2.0E+4	2.2E+0	2.2E+2	5.6E+4	9	506, 517
Zooplankton	5.3E+4				1.4E+4	9.2E+4	2	506
Pb (lead)								
Birds	1.9E+2						1	383
Crustaceans	9.6E+2	1.1E+3	6.5E+2	2.4E+0	7.6E+1	3.6E+3	15	101, 383, 439, 506

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Fish	1.3E+1	2.4E+1	6.3E+0	3.4E+0	4.1E+0	8.4E+1	11	383, 506
Macroalgae	4.9E+3	7.4E+3	2.7E+3	3.0E+0	9.1E+1	3.6E+4	52	101, 439, 506
Molluscs	3.5E+3	4.7E+3	2.0E+3	2.8E+0	3.9E+1	2.2E+4	32	101, 439, 506
Phytoplankton	1.2E+2	1.2E+2	8.9E+1	2.3E+0			3	506
Vascular plants	1.8E+2	1.8E+2	1.3E+2	2.3E+0			3	506
Zooplankton	7.9E+1						1	506
Po (polonium)								
Fish	3.0E+3				6.7E+2	5.3E+3	2	383
Mammals	1.0E+4						2	69
Pr (praseodymium)								
Crustaceans	1.0E+4	9.3E+3	7.8E+3	2.1E+0	7.8E+2	2.6E+4	10	101, 439
Macroalgae	1.2E+4	1.5E+4	7.3E+3	2.6E+0	6.1E+2	7.5E+4	46	101, 439
Molluscs	1.4E+4	1.4E+4	1.0E+4	2.2E+0	3.7E+2	5.8E+4	25	101, 439
Pu (plutonium)								
Crustaceans	5.4E+3	1.0E+4	2.5E+3	3.5E+0	3.5E+3	9.0E+3	11	57
Fish	2.6E+2	4.5E+2	1.3E+2	3.3E+0	4.3E+1	1.4E+3	8	57
Molluscs	1.4E+3	1.0E+3	1.1E+3	1.9E+0	8.0E+2	2.5E+3	3	57

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Rb (rubidium)								
Crustaceans	1.1E+1	9.1E+0	8.9E+0	2.0E+0	5.1E+0	3.2E+1	14	101, 439, 506
Fish	6.8E+1	3.4E+1	6.1E+1	1.6E+0	2.9E+1	1.2E+2	20	506, 517
Macroalgae	3.1E+1	4.1E+1	1.9E+1	2.7E+0	1.5E+0	1.4E+2	55	101, 439, 506, 517
Molluscs	1.2E+1	7.4E+0	1.0E+1	1.8E+0	5.1E+0	3.0E+1	34	101, 439, 506, 517
Phytoplankton	1.4E+1	2.8E+0	1.4E+1	1.2E+0			3	506
Vascular plants	4.5E+1	1.8E+1	4.2E+1	1.5E+0	3.1E+1	5.9E+1	6	506, 517
Zooplankton	1.8E+1						1	506
S (sulphur)								
Crustaceans	1.1E+1						2	506
Fish	9.3E+0	2.4E+0	9.1E+0	1.3E+0	6.5E+0	1.2E+1	9	506
Macroalgae	2.7E+1	2.3E+1	2.1E+1	2.1E+0	6.5E+0	4.8E+1	6	506
Molluscs	2.8E+0	1.3E+0	2.6E+0	1.6E+0	1.3E+0	3.8E+0	7	506
Phytoplankton	1.1E+0	3.3E–2	1.1E+0	1.0E+0			3	506
Vascular plants	6.5E+0	1.1E+0	6.4E+0	1.2E+0			3	506
Zooplankton	2.9E+0						1	506
Sb (antimony)								
Molluscs	1.6E+2						1	57

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Se (selenium)								
Fish	2.3E+3	2.9E+2	2.3E+3	1.1E+0	2.0E+3	2.5E+3	8	517
Vascular plants	4.2E+2	1.0E+2	4.0E+2	1.3E+0			3	517
Si (silicon)								
Crustaceans	2.5E+3						2	506
Fish	8.6E+1	1.3E+2	4.7E+1	3.0E+0	1.7E+1	1.5E+2	9	506
Macroalgae	5.9E+3	6.3E+3	4.0E+3	2.4E+0	7.5E+2	1.4E+4	9	506, 517
Molluscs	1.7E+3	8.0E+2	1.5E+3	1.6E+0	7.8E+2	2.6E+3	7	506
Phytoplankton	7.4E+3	8.3E+2	7.4E+3	1.1E+0			3	506
Vascular plants	1.1E+4	2.0E+3	1.1E+4	1.2E+0			3	506
Zooplankton	2.1E+3						1	506
Sm (samarium)								
Crustaceans	9.8E+3	1.0E+4	6.8E+3	2.3E+0	6.2E+2	2.8E+4	9	101, 439
Macroalgae	1.0E+4	1.2E+4	6.5E+3	2.5E+0	4.9E+2	5.7E+4	46	101, 439
Molluscs	1.2E+4	1.1E+4	9.1E+3	2.2E+0	1.2E+3	4.0E+4	24	101, 439
Sr (strontium)								
Crustaceans	1.7E+2	2.3E+2	1.0E+2	2.8E+0	1.1E–1	4.7E+2	38	57, 101, 439
Fish	1.9E+1	3.5E+1	9.2E+0	3.4E+0	1.1E+0	1.2E+2	42	57, 517

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Macroalgae	2.1E+1	4.6E+1	8.4E+0	3.8E+0	9.3E–2	1.9E+2	49	101, 439, 517
Molluscs	1.8E+2	2.1E+2	1.1E+2	2.5E+0	7.9E–2	6.5E+2	60	57, 101, 439, 517
Phytoplankton	1.7E+1	1.1E+1	1.4E+1	1.8E+0	7.1E+0	2.9E+1	3	57
Vascular plants	2.4E+1	5.9E+0	2.4E+1	1.3E+0			3	517
Tb (terbium)								
Crustaceans	2.9E+4	4.0E+4	1.7E+4	2.8E+0	1.6E+3	9.0E+4	7	101, 439
Macroalgae	1.1E+4	1.3E+4	7.2E+3	2.6E+0	3.4E+2	5.2E+4	46	101, 439
Molluscs	2.2E+4	3.4E+4	1.2E+4	3.1E+0	7.3E+2	1.3E+5	22	101, 439
Ti (titanium)								
Crustaceans	8.0E+4						2	506
Fish	1.9E+3	1.9E+3	1.4E+3	2.3E+0	8.5E+2	3.8E+3	9	506
Macroalgae	1.6E+5	1.3E+5	1.3E+5	2.1E+0	9.3E+4	2.3E+5	6	506
Molluscs	8.3E+4	4.1E+4	7.4E+4	1.6E+0	4.5E+4	1.1E+5	7	506
Phytoplankton	6.8E+4	2.8E+4	6.3E+4	1.5E+0			3	506
Vascular plants	1.9E+5	8.4E+4	1.7E+5	1.5E+0			3	506
Zooplankton	1.6E+4						1	506

TABLE 8. CONCENTRATION RATIO ($CR_{wo-water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo-water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Tm (thulium)								
Crustaceans	3.5E+4	4.4E+4	2.1E+4	2.7E+0	2.0E+3	9.7E+4	6	101, 439
Macroalgae	1.0E+4	1.2E+4	6.5E+3	2.6E+0	1.6E+2	5.1E+4	46	101, 439
Molluscs	2.9E+4	5.9E+4	1.3E+4	3.6E+0	5.2E+2	2.5E+5	19	101, 439
U (uranium)								
Crustaceans	3.5E+0	2.3E+0	3.0E+0	1.8E+0	8.3E–1	7.6E+0	9	101, 439
Fish	4.6E–1	1.7E–1	4.4E–1	1.4E+0	4.0E–1	5.6E–1	9	517
Macroalgae	3.9E+1	7.8E+1	1.7E+1	3.6E+0	8.6E–1	3.3E+2	49	101, 439, 517
Molluscs	2.6E+1	2.5E+1	1.9E+1	2.2E+0	3.7E+0	9.1E+1	27	101, 439, 517
Vascular plants	1.4E+2	4.6E+1	1.3E+2	1.4E+0			3	517
V (vanadium)								
Crustaceans	3.9E+2	5.7E+2	2.2E+2	2.9E+0	9.6E+0	1.6E+3	13	101, 439, 506
Fish	1.2E+2	1.9E+2	5.9E+1	3.2E+0	1.6E+1	2.9E+2	9	506
Macroalgae	9.3E+2	1.3E+3	5.4E+2	2.8E+0	7.6E+1	4.5E+3	55	101, 439, 506, 517
Molluscs	6.7E+2	6.5E+2	4.8E+2	2.2E+0	1.1E+1	2.1E+3	34	101, 439, 506, 517
Phytoplankton	1.1E+3	2.8E+2	1.1E+3	1.3E+0			3	506
Vascular plants	3.0E+3	1.6E+3	2.6E+3	1.7E+0	1.9E+3	4.0E+3	6	506, 517
Zooplankton	2.5E+2						1	506

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Y (yttrium)								
Crustaceans	1.5E+3	1.0E+3	1.2E+3	1.8E+0	2.7E+2	3.1E+3	9	101, 439
Fish	1.1E+0						2	517
Macroalgae	2.7E+3	2.7E+3	1.9E+3	2.3E+0	1.3E+2	1.2E+4	46	101, 439
Molluscs	2.6E+3	2.4E+3	1.9E+3	2.2E+0	1.1E+2	9.7E+3	25	101, 439
Vascular plants	2.8E+3	4.8E+3	1.5E+3	3.2E+0			3	517
Yb (ytterbium)								
Crustaceans	5.5E+3	6.5E+3	3.5E+3	2.6E+0	1.1E+3	1.9E+4	9	101, 439
Macroalgae	4.7E+3	5.0E+3	3.2E+3	2.4E+0	1.7E+2	2.3E+4	46	101, 439
Molluscs	6.4E+3	8.4E+3	3.8E+3	2.7E+0	2.4E+2	4.0E+4	25	101, 439
Zn (zinc)								
Crustaceans	6.5E+3						2	506
Fish	6.5E+3	5.0E+3	5.1E+3	2.0E+0	1.6E+3	1.0E+4	17	506, 517
Macroalgae	1.8E+4	1.8E+4	1.3E+4	2.3E+0	2.7E+3	3.3E+4	6	506
Molluscs	5.3E+3	4.0E+3	4.2E+3	2.0E+0	1.5E+3	8.9E+3	7	506

TABLE 8. CONCENTRATION RATIO ($CR_{wo\text{-}water}$) VALUES FOR WILDLIFE GROUPS IN BRACKISH ECOSYSTEMS (cont.)

Wildlife group (brackish)	$CR_{wo\text{-}water}$ (Bq/kg, fresh weight whole organism:Bq/L water)							ID number[a]
	AM	AMSD	GM	GMSD	Minimum	Maximum	*N*	
Phytoplankton	5.5E+3	2.1E+3	5.2E+3	1.4E+0			3	506
Vascular plants	3.8E+3	3.5E+3	2.8E+3	2.2E+0	9.4E+2	6.7E+3	6	506, 517
Zooplankton	5.9E+3						1	506

Note: AM: arithmetic mean; AMSD: arithmetic mean standard deviation; FW: fresh weight; GM: geometric mean; GMSD: geometric mean standard deviation; ID: identification; *N*: number of data.

[a] The publications corresponding to these ID numbers are given in the Annex.

4.2. APPLICATION OF THE $CR_{wo\text{-}media}$ VALUES

The $CR_{wo\text{-}media}$ values can be used to calculate the whole organism radionuclide activity concentration of wildlife in environmental risk assessments in three ways depending on the requirements of the assessment:

(a) Generic average value using either the geometric mean or arithmetic mean;
(b) Conservative estimate using either the maximum value or the standard deviation to derive an upper percentile (e.g. 95th percentile);
(c) Probabilistic assessment using the mean and associated standard deviation.

The use of the generic average $CR_{wo\text{-}media}$ value does not account for uncertainties in the estimation of radionuclide activity concentrations in the whole organism in contrast to both the conservative and probabilistic approaches. The conservative approach, often used within screening assessments [84], aims to provide an upper estimate of radionuclide activity concentration and should be an overestimate for a population. In some approaches [24, 35], a conservative $CR_{wo\text{-}media}$ value may be applied together with other conservative assumptions (e.g. of media radionuclide activity concentration, exposure pathway). The maximum (and minimum) values presented in the $CR_{wo\text{-}media}$ tables are often the maximum mean value from any individual study entered into the database and not the maximum individual measurement. Consequently, if the user were to estimate, for example, a 95th percentile from the arithmetic mean and standard deviation values presented here, the resultant estimated 95th percentile value may be greater than the maximum value that appears in Tables 5–8.

To estimate the uncertainty within the end-points of an exposure assessment, the uncertainties in the inputs and parameters must be propagated through the model, often using a probabilistic approach such as Monte Carlo analysis [85]. In the Monte Carlo method, point estimates in a model equation are replaced with probability distributions, samples are taken from each distribution, and the results aggregated, usually in the form of a probability density function or cumulative distribution. For much radioecological data, including the $CR_{wo\text{-}media}$ values presented here, the most appropriate probability density function is log-normal. Where the number of data used to derive a $CR_{wo\text{-}media}$ value is low, then the assumption of a log-normal probability density function may be inappropriate and other distributions, such as exponential, might be more relevant. The most defensible approach to selecting distributions is one in which all available information (subjective and objective) is examined [86]. In undertaking such evaluations, it is necessary to consider whether there are sufficient data to conduct a probabilistic analysis or more data should be obtained. A sensitivity analysis may help to determine whether additional data are needed.

Suitable radionuclide activity concentrations in media are required when applying the $CR_{wo\text{-}media}$ values to estimate those in the whole body of organisms. Deriving such suitable media concentrations for use within an assessment requires consideration of spatial and temporal averaging which will depend on the aims of the assessment. For conservative assessments, the maximum activity concentrations of a radionuclide in media close to the facility or habitat of the wildlife group (or species) under assessment may be used. For more realistic assessments, the area over which radionuclide activity concentrations in media are averaged should reflect the home range of the wildlife group (or species) considered. Similarly, it may be reasonable to assume that an organism is present in a contaminated area for 100% of its time in a conservative assessment, whereas in a more realistic assessment the length of time the organism is likely to be present in the contaminated area (occupancy) will be taken into account. Appropriate temporal averaging of radionuclide activity concentrations in media may be required when considering facilities making pulsed discharges. Estimation (and applications) of $CR_{wo\text{-}media}$ values for migratory species (e.g. some species of birds or salmonids) is particularly difficult because whole organism concentrations may not reflect media concentrations in the area in which the animals were sampled. The lack of equilibrium between concentrations in the whole organism and the surrounding media will depend on the biological half-life and the duration of occupancy. It is, therefore, necessary to use caution when applying $CR_{wo\text{-}media}$ values to migratory species. As the values presented in Section 4 are intended to reflect equilibrium conditions, their application to migratory species is likely to be conservative.

The $CR_{wo\text{-}media}$ values presented in this handbook are intended for application when site specific data are not available. However, site specific data based on few measurements may not provide a better estimate of radionuclide activity concentrations in the whole organism than that provided by a generic $CR_{wo\text{-}media}$ value as provided in the tables below (see Ref. [87] for a discussion). It will be necessary to take this issue into account when deciding upon inputs to assessments. However, where site specific data are available, it is useful to compare them with estimates using the $CR_{wo\text{-}media}$ values presented here. The effort used in assessments should be commensurate with the risks and some assessments may require a better site specific understanding and prediction of radionuclide transfer [23].

4.3. LIMITATIONS OF THE EXISTING DATABASE

The data included for many organisms were predominantly from Europe, Japan, North America and Australasia, and originate in temperate or arctic ecosystems. This is because the need for radioecological information has been linked to nuclear power industries (as well as other nuclear facilities) which tend to be focused in Europe, Japan and North America. Little analysis is available of the applicability of transfer values from these regions to other areas of the world. It is, therefore, not possible to comment on whether the $CR_{wo\text{-}media}$ values are appropriate for wildlife groups and ecosystems in other areas of the world.

There are many data for the transfer of some radionuclides (e.g. caesium and strontium isotopes) and few, if any, for others (e.g. technetium). The considerable variation in availability of data needs to be borne in mind when applying the $CR_{wo\text{-}media}$ values in assessments. Some of the $CR_{wo\text{-}media}$ values are based on few data (345 of 946 $CR_{wo\text{-}media}$ values for the generic wildlife groups are derived from three or fewer observations). Such low replication may not provide a reliable estimate and will not reflect likely variations. It is, therefore, necessary to use caution when applying such values in assessments. While all of the available data have been quality controlled, such values need to be judged against more numerous data for biogeochemically similar elements or similar organism types. It may be helpful to consider the use of alternative approaches to provide $CR_{wo\text{-}media}$ values, discussed in Section 5, rather than the $CR_{wo\text{-}media}$ value in the table in these instances. An example where such a decision may be taken is the curium $CR_{wo\text{-}water}$ value for freshwater fish which originates from a single study and is 3–4 orders of magnitude lower than those for americium and plutonium which are based on larger datasets. Furthermore, the source study for the value also reports some of the lowest americium and plutonium $CR_{wo\text{-}media}$ values although they are not outliers.

Bayesian inference provides a mechanism for using prior knowledge to improve statistical parameters in cases where limited observational data are available. For example, the methods outlined in Section 5 (on filling knowledge gaps) have the potential to provide suitable $CR_{wo\text{-}media}$ values and probability distribution functions, which can subsequently be refined using Bayesian updating [88, 89] when empirical data for a specific $CR_{wo\text{-}media}$ become available.

Many of the $CR_{wo\text{-}media}$ values are derived from stable element data. This will result in a conservative estimate for radionuclides with short physical half-lives (e.g. isotopes of phosphorus), especially if an element has a comparatively long biological half-life. The uptake of some of the elements included within the tables will be subject to homeostatic control (e.g. calcium, phosphorus, sodium and magnesium are major essential elements). Nevertheless, the derived values for such elements are likely to be a reasonable estimate of those relevant for the organism when based upon comparatively large datasets from a range of sources. However, mean values are unlikely to be representative of areas with especially low or high bioavailable concentrations of these elements.

The source of the data, e.g. specific sampling areas or certain species, influences some wildlife $CR_{wo\text{-}media}$ values. For example, the large amount of data from post-Chernobyl studies for radiocaesium is probably dominated by data from areas with a comparatively high transfer to wildlife. Similarly, data from Canada dominates in some cases, for example: (i) the freshwater database for a number of radionuclide–organism combinations; and (ii) the data for natural radionuclide transfer to shrubs (which are largely for two species). The $CR_{wo\text{-}water}$ values for technetium transfer to marine crustaceans are dominated by data for European lobster (*Homarus gammarus*) and Norwegian lobster (*Nephrops norvegicus*) which accumulate relatively high activity concentrations of technetium compared with other crustaceans such as the edible crab (*Cancer pagarus*) [90]. All brackish ecosystem data are from Japanese estuaries or the Baltic Sea.

Almost all of the $CR_{wo\text{-}media}$ values presented here are for the adult life stages. Many organisms have different characteristics at different stages in their life cycle, including environment and feeding habits (e.g. amphibians, some flying insects which have aquatic larvae). While the ICRP [20] has identified life stages for their RAPs, there are few relevant data [8] and the ICRP compilation of transfer values does not provide $CR_{wo\text{-}media}$ values for life stages other than the adult.

The $CR_{wo\text{-}media}$ values for plants refer only to the part of the plant that is above ground because a number of assessment approaches currently only consider dose rates to that part of the plant. For radionuclides which accumulate in roots, such as uranium, the $CR_{wo\text{-}media}$ values presented here will underestimate the total internal dose rate. For certain assessments, it may be necessary to decide whether the root content of radionuclides needs to be considered separately and whether the lack of a dosimetric approach for roots in some models is likely to lead to significant errors in estimating dose (e.g. for elements with a low root to shoot transfer or for subsoil source terms [91]).

The $CR_{wo\text{-}media}$ values are based on the whole organism but excluding gut contents and parts of organisms which are likely to be contaminated by soil and sediment. However, when considering food chain modelling, these parts of organisms may be ingested by predators. Thus, if $CR_{wo\text{-}media}$ values are used for food chain modelling, they may underestimate the extent of transfer to higher trophic levels for some radionuclides. For instance, a study shows that >95% of the plutonium found in the whole body of rodents was in the pelt and gastrointestinal tract [92]. Similarly, a modelling study concluded that the cadmium intake of predators could be underestimated by up to a factor of ten if the gastrointestinal tract contents of wood mice (*Apodemus sylvaticus*) were neglected [93]. Conversely, in some circumstances, the $CR_{wo\text{-}media}$ values presented here would overestimate transfer. For instance, the majority of ^{90}Sr is located in the bones of vertebrates which are not generally consumed by predators, so applying whole organism $CR_{wo\text{-}media}$ values for the prey species would overestimate ^{90}Sr intake.

A number of limitations in the availability of $CR_{wo\text{-}media}$ values are discussed here. However, before defining future research requirements, it is important to critically determine whether current models are fit for the purposes to which they are being applied. This should include an evaluation of which radionuclides need to be assessed in different scenarios and their probable relative importance in contributing to total internal exposure of different wildlife groups.

5. APPROACHES FOR FILLING DATA GAPS

A large number of transfer parameter values for radionuclide–wildlife group combinations are required to enable assessments to be made of the radiation exposure of wildlife. Even when concentration ratio values for radionuclides are collated at the level of broad wildlife group, as presented in this handbook, there are many radionuclide–wildlife group combinations with no reported $CR_{wo\text{-}media}$ values. Thus, this handbook does not contain all of the $CR_{wo\text{-}media}$ values which may be required in generic assessments.

If the relevant data are not available in the $CR_{wo\text{-}media}$ tables, the first response would be to consider whether appropriate sampling is necessary to provide the required $CR_{wo\text{-}media}$ values (or site specific whole organism radionuclide activity concentrations). Before carrying out environmental sampling programmes to fill these data gaps, it is important to consider which radionuclides contribute most to the overall dose and to focus data gathering efforts accordingly. Such data collection also needs to take account of the ethical justification for sampling of each wildlife group. If such data are collected, it is recommended that the values be entered into the on-line Wildlife Transfer Parameter Database[9] to increase the overall available data underpinning the $CR_{wo\text{-}media}$ values in the future.

Existing models use a number of approaches to overcome the lack of $CR_{wo\text{-}media}$ values [24, 27, 66, 72, 73, 94]. Approaches considered to be the most appropriate for deriving missing $CR_{wo\text{-}media}$ values are described below. They are not presented in order of preference as the availability of data on which to base decisions will differ. If more than one option is available, it is often useful to compare the resultant values. The choice of approach may be dependent on the purpose of the assessment, any assumptions used and whether the derived $CR_{wo\text{-}media}$ values

[9] http://www.wildlifetransferdatabase.org.

are likely to be conservative or realistic. Most of the techniques outlined in this section are already being used in assessments [27, 72, 73, 95]. However, this does not necessarily mean that their validity has been rigorously tested; rather, it reflects the need for a pragmatic approach to provide a value in assessments when there are no directly relevant data available.

5.1. SURROGATE ORGANISMS

When a $CR_{wo\text{-}media}$ value is missing, a surrogate value for a similar organism, defined by factors such as taxonomy, physiology and trophic level may be used [27, 72, 73]. For example, suitable surrogates include:

— Macroalgae $CR_{wo\text{-}media}$ value for a marine vascular plant;
— Piscivorous fish $CR_{wo\text{-}media}$ value for a benthic feeding fish;
— Detritivorous arthropod $CR_{wo\text{-}media}$ value for an arachnid;
— Mammalian $CR_{wo\text{-}media}$ value for a bird.

The approach is supported by the study presented in Ref. [96] which demonstrated that data for leafy vegetables could be used as a surrogate for tree leaves. Furthermore, data given in Ref. [6] show that, in many instances, $CR_{wo\text{-}soil}$ values for crops are broadly similar to those for grass. The available data presented in Section 4 also enable a partial evaluation of the extent of agreement between $CR_{wo\text{-}media}$ values for similar wildlife groups.

5.2. PHYLOGENETIC RELATIONSHIPS

Differences in $CR_{wo\text{-}media}$ values between species can be related to their evolutionary history, or phylogeny, for vascular plants and marine organisms [97, 98]. However, this approach is data intensive. Reference [97] presents an analysis for caesium, strontium, cobalt, chlorine and ruthenium transfer to plants, and describes how the approach is applied. Reference [99] demonstrates that variation in the accumulation of radiologically relevant metals (Ni, Pb, Zn, Cd, Cr and Cu) could be explained by taxonomic classification at the level of order. In aquatic systems, Ref. [98] demonstrates that the rates of uptake of nine radionuclides from water differed between chondrichthyans and species of pleuronectiform and perciform teleosts; it also describes a methodology to investigate such phylogenetic questions.

Where detailed analyses are not available, the rationale behind the approach can also be used to identify the most suitable surrogate organisms by selecting the most closely related organism for which data exist from a phylogenetic tree. Examples of phylogenetic trees are available on-line[10].

For detailed site specific assessments, the approach may also be useful to identify $CR_{wo\text{-}media}$ values for specific species which are protected and cannot be sampled.

5.3. BIOGEOCHEMICAL ANALOGUES AND IONIC POTENTIAL

Biogeochemical analogues are elements which are assumed to have the same general behaviour under similar environmental/biological conditions (simple examples include caesium and potassium ions in water systems). The similarity can be used to identify $CR_{wo\text{-}media}$ values for missing data. For instance, if a curium $CR_{wo\text{-}media}$ value for a given organism is missing, available $CR_{wo\text{-}media}$ values for plutonium and americium for that organism might provide a reasonable substitute. As for the surrogate organism approach, the feasibility of this option can be partially evaluated using the available data presented in Section 4. It may be appropriate to combine the surrogate organism and biogeochemical analogue approaches, for instance, using the $CR_{wo\text{-}soil}$ value for plutonium in mammals to predict transfer of americium to birds.

While such approaches have been used to provide surrogate values for application in both human and wildlife assessments, Refs [5, 72, 73, 76] suggest that ionic potential may better predict environmental mobility and root uptake than simple placement within the periodic table. Ionic potential is calculated as the ratio of ionic charge to ionic radius; data presented in Refs [76, 100] show an exponential decrease in plant $CR_{wo\text{-}soil}$ with decreasing ionic potential.

5.4. ALLOMETRY

The dependence of a biological variable Y on a body mass M has been typically characterized by allometric equations of the form $Y = aM^b$. Radioecological transfer parameters for terrestrial and marine animals for a limited number of radionuclides have been shown to fit such allometric relationships [15, 94, 95, 101, 102]. Application of these relationships requires suitable dietary intake values, often also derived allometrically [103].

---

[10] http://tolweb.org.
http://www.treebase.org.
http://www.mobot.org/mobot/research/apweb/welcome.html.

Combining radioecological allometric expressions with those for dietary intake, Ref. [94] proposes that for many radionuclides the concentration ratio of whole organism radionuclide activity concentration to dietary radionuclide activity concentration would be a constant for different species. This assumption can be used to estimate whole organism to dietary concentration ratios where it is not possible to derive allometric relationships. However, the assumption does not appear to be valid, based on currently available data, for the actinide elements.

Some biological traits for plants can be described by allometric functions [104, 105]. However, Ref. [76] reports that evidence to support the concept of using allometric scaling functions to estimate radionuclide activity concentrations in plants was inconclusive. This is consistent with what is observed in Ref. [96].

5.5. DATA FROM A DIFFERENT ECOSYSTEM

If data are lacking for an organism–radionuclide combination in a given ecosystem, then available $CR_{wo\text{-}media}$ values from a similar ecosystem could be applied [73]. The approach is likely to be only applicable to provide $CR_{wo\text{-}media}$ values for aquatic brackish environments by assuming values from the marine environment and vice versa.

Examination of the marine and brackish datasets (Tables 7 and 8) suggests that the approach has some validity. Taking the example of large crustaceans (to remove some of the variance that may have been introduced by considering a broader wildlife grouping), the difference between $CR_{wo\text{-}water}$ values for brackish and marine ecosystems is <5 for cadmium, cobalt, lead, manganese and strontium (where data are available for both ecosystems). The difference varies from similar values for cobalt (marine $CR_{wo\text{-}water}$ to estuarine $CR_{wo\text{-}water}$ ratio = 1.6) to greater variation for $CR_{wo\text{-}water}$ for lead (marine $CR_{wo\text{-}water}$ to estuarine $CR_{wo\text{-}water}$ ratio = 4.9). Testing for the statistical significance of the difference between the datasets is not informative because these datasets are consistently small ($n \leq 5$). Furthermore, the data for the brackish environment considered above are derived primarily from environments with relatively high salinity, characteristic of coastal marine environments. For less saline water bodies, the use of $CR_{wo\text{-}media}$ values as surrogates for the marine environment may be less appropriate.

5.6. USE OF PUBLISHED REVIEWS

There are reviews available of elemental media and wildlife concentrations [80, 106, 107] which often present data as typical concentrations in various organism tissues and in environmental media. While these have not been compiled to produce $CR_{wo\text{-}media}$ values, it is possible to use them for this purpose. However, the data for environmental media and wildlife may not be from the same geographical locations, which adds to the uncertainties associated with applying these data.

Previous compilations of wildlife radionuclide $CR_{wo\text{-}media}$ values [27, 72, 73] present complete sets of $CR_{wo\text{-}media}$ values for all of the radionuclide–organism combinations considered. However, many of these data were derived by methods such as those described here, using more limited underlying databases. This handbook, therefore, supersedes these previous reviews.

There are a large number of reviews in Russian (>400) with relevant information for the handbook. These publications were reviewed to provide $CR_{wo\text{-}water}$ values for terrestrial, freshwater and marine species [56, 58]. None of these studies were previously available in English. For freshwater and marine ecosystems, these $CR_{wo\text{-}water}$ values have been compared with those derived in international reviews [56, 58].

Appendix I

CONVERSION FACTORS FOR ASH OR DRY WEIGHT TO FRESH WEIGHT

The conversion factors for ash or dry weight to fresh weight used for the on-line database when required are listed in Tables 9 and 10. The data were derived from ERICA [108]; other useful values can be found in Ref. [6].

TABLE 9. ASSUMED ASH OR DRY WEIGHT TO FRESH WEIGHT CONVERSION FACTORS (EXPRESSED AS ASH OR DRY WEIGHT AS A FRACTION OF FRESH WEIGHT) *(adapted from Ref. [72])*

Organism	Dry weight fraction	Ash weight fraction
Lichens	0.36	0.07
Grasses and herbs	0.25	—
Shrubs (wood)	0.5	0.013
Shrubs (other parts)	0.1	0.003
Trees (wood)	0.5	0.013
Trees (other parts)	0.1	0.003
Small mammals (whole organism)	0.3	—
Mammals (bone)	0.8	0.5
Mammals (muscle)	0.25	—
Amphibians (whole organism)	0.21	—
Birds (whole organism)	0.3	—
Terrestrial arthropods	0.25	0.024
Annelids	0.17	—
Gastropods	0.2	—

TABLE 10. ASSUMED DRY WEIGHT TO FRESH WEIGHT CONVERSION FACTORS (EXPRESSED DRY WEIGHT AS A FRACTION OF FRESH WEIGHT) FOR AQUATIC ORGANISMS *(adapted from Ref. [73])*

Organism	Dry weight fraction
Marine	
All organisms[a]	0.18
Freshwater	
Phytoplankton	0.2
Vascular plants	0.25
Bivalve molluscs, crustaceans, insect larvae	0.25
Amphibians (whole organism)	0.21
Fish[b]	0.18

[a] Assumed ash weight fraction is 0.01.
[b] Value assumed for fish in this work; conversion was not required in Ref. [73].

Appendix II

CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM

Appendix II provides all of the values reported in Ref. [82] (Tables 11–16), not all of which were used in the data conversion carried out to derive the $CR_{wo\text{-}media}$ values in Section 4. Some of the values given are based on a low number of observations (see Ref. [82] for more details).

TABLE 11. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR BIRDS

Element	Tissue	Ratio
Br	Liver	1.0E+0
Ce	Liver	3.3E–1
Co	Liver	7.3E–1
Cr	Liver	2.7E–1
Cs	Liver	1.0E+0
Eu	Liver	7.4E–1
Fe	Liver	2.7E–1
Mn	Liver	1.9E–1
Rb	Liver	1.0E+0
Sc	Liver	3.8E+0
Se	Liver	1.0E+0
Zn	Liver	1.0E+0

TABLE 12. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR MARINE CRUSTACEANS (EXCLUDING EXOSKELETON)

Element	Ratio	
	Crustaceans (large)	Crustaceans (small)
Ca	2.5E+0	1.0E+1
Cd	6.3E+0	1.5E+1
Ce	4.6E+0	1.3E+1
Co	5.5E+0	8.0E+0
Cr	8.1E+0	—
Cu	3.3E+0	3.5E+0
Dy	4.5E+0	1.5E+1
Er	4.7E+0	9.7E+0
Eu	4.1E+0	1.2E+1
Fe	5.7E+0	2.6E+1
Gd	4.4E+0	1.0E+1
Ho	—	2.9E+1
La	3.5E+0	1.9E+1
Mg	1.0E+0	1.0E+0
Mn	3.2E+0	1.4E+1
Mo	3.3E+0	5.3E+0
Na	1.0E+0	1.0E+0
Nd	3.8E+0	2.4E+1
Ni	1.0E+0	1.2E+1

TABLE 12. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR MARINE CRUSTACEANS (EXCLUDING EXOSKELETON) (cont.)

Element	Ratio	
	Crustaceans (large)	Crustaceans (small)
Pb	4.4E+0	6.0E+0
Po	3.5E+0	—
Pr	4.3E+0	2.3E+1
Rb	1.0E+0	1.0E+0
Sm	3.8E+0	1.1E+1
Sr	2.5E+0	9.3E+0
Tb	—	1.5E+1
Tm	—	2.4E+1
U	—	1.7E+1
V	5.2E+0	2.1E+1
Y	4.2E+0	1.0E+1
Yb	2.9E+0	5.8E+1

TABLE 13. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR MAMMALS

Element	Tissue	Ratio
Ag	Muscle	1.2E+2
	Liver	1.3E–2
	Kidney	1.5E+1
	Bone	3.3E+3

TABLE 13. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR MAMMALS (cont.)

Element	Tissue	Ratio
Am	Muscle	1.3E+1
	Kidney	4.1E–2
	Bone	8.3E–2
Ca	Muscle	1.0E+0
	Liver	1.0E+0
	Kidney	6.2E–1
	Bone	7.3E–1
Cd	Muscle	1.0E+0
	Liver	1.6E–1
	Kidney	9.3E–2
	Bone	5.2E–1
Ce	Muscle	3.4E+1
	Liver	2.9E–1
	Kidney	1.0E+0
	Bone	7.6E–2
Cr	Muscle	1.0E+0
	Liver	2.0E+0
	Kidney	1.8E+0
	Bone	1.0E+0
Cs	Muscle	1.0E+0
	Liver	1.0E+0
	Kidney	—
	Bone	1.8E+0
Cu	Muscle	1.0E+0
	Liver	5.8E–1
	Kidney	6.8E–1
	Bone	1.7E+0
F	Liver	4.5E+0
	Kidney	3.7E+0
	Bone	1.5E–1
Mn	Liver	3.2E–1
	Kidney	5.7E–1
	Bone	1.0E+0

TABLE 13. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR MAMMALS (cont.)

Element	Tissue	Ratio
Pb	Muscle	1.0E+0
	Liver	1.0E+0
	Kidney	1.0E+0
	Bone	1.6E–1
Po	Muscle	2.0E+0
	Liver	9.6E–2
	Kidney	1.1E–1
	Bone	1.8E–1
Pu	Muscle	5.3E+0
	Liver	2.4E–1
	Kidney	1.0E+0
	Bone	2.5E–1
Ra	Muscle	3.8E+1
	Liver	1.6E+1
	Kidney	7.3E+0
Ru	Muscle	1.1E+0
	Liver	1.2E–1
	Kidney	4.1E–2
	Bone	6.4E+0
Se	Muscle	1.0E+0
	Liver	1.8E–1
	Kidney	1.4E–1
	Bone	1.0E+0
U	Muscle	4.7E+0
	Liver	4.2E+0
	Kidney	1.0E+0
	Bone	1.3E–1
Zn	Muscle	1.8E+0
	Liver	1.0E+0
	Kidney	1.0E+0
	Bone	2.8E–1

TABLE 14. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR MARINE MOLLUSCS (EXCLUDING SHELL)

Element	Ratio		Element	Ratio	
	Bivalves	Gastropods		Bivalves	Gastropods
Ca	3.9E+0	1.7E+0	Na	1.7E+0	1.0E+0
Cd	1.4E+1	4.8E+1	Nd	2.7E+0	2.6E+0
Ce	2.7E+0	3.6E+0	Ni	2.3E+0	3.9E+0
Co	3.5E+0	1.0E+1	Pb	3.3E+0	1.3E+1
Cu	—	6.5E+0	Po	2.9E+0	3.2E+0
Dy	2.7E+0	2.3E+0	Pr	2.5E+0	2.7E+0
Er	2.7E+0	8.0E+0	Pu	1.8E+0	5.2E+0
Eu	2.8E+0	1.9E+0	Rb	1.0E+0	1.0E+0
Fe	5.9E+0	1.9E+1	Sm	2.8E+0	2.6E+0
Gd	2.5E+0	2.4E+0	Sr	3.6E+0	2.2E+0
Ho	2.2E+0	2.8E+0	Tb	2.3E+0	2.1E+0
K	1.0E+0	1.0E+0	Tm	2.2E+0	1.0E+0
La	2.1E+0	2.4E+0	U	4.2E+0	3.9E+0
Lu	2.3E+0	1.0E+0	V	1.1E+1	4.0E+0
Mg	1.0E+0	1.0E+0	Y	5.2E+0	3.4E+0
Mn	2.7E+0	3.7E+0	Yb	3.2E+0	2.1E+0
Mo	5.0E+0	3.8E+0			

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Ag	Bone	5.9E–1	—	—
Ag	Kidney	1.0E+0	—	—
Ag	Liver	3.4E–1	—	—
Ag	Muscle	1.0E+0	—	—
Al	Bone	2.4E–1	—	—
Al	Kidney	2.9E–1	—	—
Al	Liver	5.6E–1	—	—
Al	Muscle	2.0E+0	—	—
As	Bone	1.0E+0	—	—
As	Kidney	1.0E+0	—	—
As	Liver	1.0E+0	—	—
As	Muscle	1.0E+0	—	—
B	Bone	5.3E–1	—	—
B	Kidney	5.3E–1	—	—
B	Liver	1.0E+0	—	—
B	Muscle	1.0E+0	—	—
Ba	Bone	1.5E–1	—	4.4E–2
Ba	Kidney	1.8E+0	—	5.0E–1
Ba	Liver	6.7E+0	—	3.9E–1
Ba	Muscle	5.6E+0	—	2.4E+0

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Be	Bone	5.6E–1	—	—
Be	Kidney	1.0E+0	—	—
Be	Liver	1.0E+0	—	—
Be	Muscle	1.0E+0	—	—
Ca	Bone	1.4E–1	—	2.1E–2
Ca	Kidney	1.9E+1	—	2.1E+1
Ca	Liver	8.3E+1	—	1.4E+1
Ca	Muscle	4.2E+1	—	1.4E+1
Cd	Bone	5.3E–1	3.1E–1	—
Cd	Kidney	2.3E–1	—	—
Cd	Liver	5.6E–1	1.0E+0	—
Cd	Muscle	1.0E+0	3.0E+0	—
Ce	Bone	2.6E–1	2.9E+0	6.9E–1
Ce	Kidney	1.5E–1	—	2.4E–1
Ce	Liver	5.3E–1	—	4.6E–2
Ce	Muscle	2.0E+0	—	3.3E+0
Co	Bone	4.2E–1	6.7E–1	7.1E–1
Co	Kidney	2.6E–1	—	—
Co	Liver	1.0E+0	1.8E–1	1.0E+0
Co	Muscle	1.0E+0	1.8E+0	1.0E+0

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Cr	Bone	2.1E–1	3.7E–1	2.7E–1
Cr	Kidney	6.3E–1	—	—
Cr	Liver	1.0E+0	3.7E–1	7.1E–1
Cr	Muscle	2.3E+0	1.0E+0	1.0E+0
Cs	Bone	5.6E–1	1.0E+0	1.0E+0
Cs	Kidney	1.7E+0	—	1.0E+0
Cs	Liver	2.6E+0	2.8E+0	2.0E+0
Cs	Muscle	1.0E+0	1.0E+0	1.0E+0
Cu	Bone	1.0E+0	5.6E–1	1.0E+0
Cu	Kidney	1.3E–1	—	5.1E–1
Cu	Liver	3.8E–2	1.0E+0	1.1E–1
Cu	Muscle	1.8E+0	1.0E+0	2.4E+0
Dy	Bone	—	—	—
Dy	Kidney	5.3E–3	—	—
Dy	Liver	—	—	—
Dy	Muscle	—	—	—
Eu	Bone	2.2E–1	—	—
Eu	Kidney	1.0E+0	—	—
Eu	Liver	1.0E+0	—	—
Eu	Muscle	2.3E+0	—	—

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Fe	Bone	1.0E+0	5.6E–1	1.0E+0
Fe	Kidney	5.3E–2	—	6.9E–2
Fe	Liver	3.2E–2	2.0E–1	5.3E–2
Fe	Muscle	2.7E+0	1.0E+0	3.2E+0
Hg	Bone	1.8E+0	—	—
Hg	Kidney	1.0E+0	—	—
Hg	Liver	1.0E+0	2.0E+1	—
Hg	Muscle	1.0E+0	6.3E–1	—
I	Bone	1.0E+0	—	—
I	Kidney	—	—	—
I	Liver	—	—	—
I	Muscle	1.0E+0	—	—
La	Bone	2.9E–1	—	—
La	Kidney	1.9E–1	—	—
La	Liver	4.3E–1	—	—
La	Muscle	1.9E+0	—	—
Mg	Bone	2.9E–1	—	2.1E–1
Mg	Kidney	2.6E+0	—	1.0E+0
Mg	Liver	2.1E+0	—	1.0E+0
Mg	Muscle	1.6E+0	—	1.0E+0

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Mn	Bone	1.4E–1	6.7E–1	2.9E–2
Mn	Kidney	1.7E+0	—	1.0E+0
Mn	Liver	1.0E+0	—	3.1E+0
Mn	Muscle	1.0E+1	—	3.5E+0
Mo	Bone	4.5E–1	—	—
Mo	Kidney	1.0E–1	1.0E+0	—
Mo	Liver	1.6E–1	1.0E+0	—
Mo	Muscle	1.0E+0	—	—
Na	Bone	3.1E–1	—	3.3E–1
Na	Kidney	5.9E–1	—	6.2E–1
Na	Liver	1.0E+0	—	6.3E–1
Na	Muscle	1.6E+0	—	1.0E+0
Nb	Bone	6.3E–1	—	—
Nb	Kidney	—	—	—
Nb	Liver	—	—	—
Nb	Muscle	1.0E+0	—	—
Ni	Bone	4.0E–1	—	2.4E–2
Ni	Kidney	2.6E–1	—	1.0E+0
Ni	Liver	7.1E–1	2.9E+1	6.2E+0
Ni	Muscle	1.3E+0	1.0E+0	2.9E+0

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
P	Bone	1.9E–1	—	6.7E–2
P	Kidney	2.5E+0	—	1.0E+0
P	Liver	2.0E+0	—	1.0E+0
P	Muscle	3.1E+0	—	1.0E+0
Pb	Bone	4.2E–1	2.0E–1	1.6E–1
Pb	Kidney	6.7E–1	—	2.3E–1
Pb	Liver	5.3E–1	1.0E+0	1.0E+0
Pb	Muscle	1.0E+0	2.4E+0	1.0E+0
Po	Bone	1.0E+0	1.0E+0	—
Po	Kidney	—	—	—
Po	Liver	—	6.7E–1	—
Po	Muscle	1.0E+0	7.0E+0	—
Pu	Bone	—	5.6E–1	—
Pu	Kidney	—	—	—
Pu	Liver	—	5.1E–1	—
Pu	Muscle	—	3.6E+1	—
Ra	Bone	2.1E–1	2.9E–1	—
Ra	Kidney	—	—	—
Ra	Liver	—	—	—
Ra	Muscle	2.4E+0	1.7E+0	—

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Rb	Bone	5.0E–1	—	1.0E+0
Rb	Kidney	1.6E+0	—	1.0E+0
Rb	Liver	1.9E+0	—	1.0E+0
Rb	Muscle	1.0E+0	—	1.0E+0
Ru	Bone	5.9E–1	3.6E–1	—
Ru	Kidney	—	1.4E–1	—
Ru	Liver	—	1.3E–1	—
Ru	Muscle	1.0E+0	1.8E+0	—
Sb	Bone	3.6E–1	—	—
Sb	Kidney	2.1E–1	—	—
Sb	Liver	2.3E–1	—	—
Sb	Muscle	1.6E+0	—	—
Sc	Bone	1.8E–1	—	—
Sc	Kidney	2.1E+0	—	—
Sc	Liver	5.9E–1	—	—
Sc	Muscle	3.8E+0	—	—
Se	Bone	1.0E+0	—	—
Se	Kidney	4.8E–1	—	—
Se	Liver	3.7E–1	—	—
Se	Muscle	1.0E+0	—	—

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Sm	Bone	—	—	—
Sm	Kidney	—	—	—
Sm	Liver	—	—	—
Sm	Muscle	—	—	—
Sr	Bone	1.4E–1	2.1E–1	2.1E–2
Sr	Kidney	1.4E+1	—	1.0E+1
Sr	Liver	2.7E+1	1.0E+0	1.3E+1
Sr	Muscle	3.8E+1	3.1E+0	1.9E+1
Te	Bone	6.3E–1	—	—
Te	Kidney	1.0E+0	—	—
Te	Liver	1.0E+0	—	—
Te	Muscle	1.0E+0	—	—
Th	Bone	2.2E–1	—	—
Th	Kidney	1.0E+0	—	—
Th	Liver	1.7E+0	—	—
Th	Muscle	2.2E+0	—	—
Ti	Bone	3.6E–1	—	—
Ti	Kidney	4.2E–1	—	—
Ti	Liver	1.0E+0	—	—
Ti	Muscle	1.0E+0	—	—

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Tl	Bone	2.2E–1	—	—
Tl	Kidney	5.6E–1	—	—
Tl	Liver	5.6E–1	—	—
Tl	Muscle	2.4E+0	—	—
U	Bone	2.1E–1	—	—
U	Kidney	2.0E+0	—	—
U	Liver	4.8E+0	—	—
U	Muscle	2.5E+0	—	—
V	Bone	5.3E–1	—	1.8E–1
V	Kidney	1.0E+0	—	5.0E–1
V	Liver	7.1E–1	2.2E+2	1.8E–1
V	Muscle	1.0E+0	8.3E+0	1.0E+0
Y	Bone	3.1E–1	—	—
Y	Kidney	3.1E–1	—	—
Y	Liver	4.2E–1	—	—
Y	Muscle	1.8E+0	—	—
Zn	Bone	2.6E–1	1.0E+0	1.7E–1
Zn	Kidney	1.6E–1	—	4.7E–1
Zn	Liver	2.7E–1	1.0E+0	4.1E–1
Zn	Muscle	2.1E+0	1.0E+0	1.3E+0

TABLE 15. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR FISH AND AMPHIBIANS (cont.)

Element	Tissue	Ratio		
		Freshwater fish	Marine fish	Amphibians
Zr	Bone	4.8E–1	—	—
Zr	Kidney	1.0E+0	—	—
Zr	Liver	1.0E+0	8.3E+0	—
Zr	Muscle	1.0E+0	2.4E+0	—

TABLE 16. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR REPTILES

Element	Tissue	Ratio	
		Turtles only	Excluding turtles
Ag	Bone	—	—
	Kidney	5.5E+0	—
	Liver	6.0E–2	—
	Muscle	4.0E+1	—
Al	Bone	4.5E–1	—
	Kidney	1.9E+1	—
	Liver	6.2E+0	—
	Muscle	9.2E+0	—
As	Bone	1.0E+0	—
	Kidney	1.0E+0	7.3E–1
	Liver	1.0E+0	5.9E–1
	Muscle	1.0E+0	1.0E+0
Ca	Bone	4.4E–1	—
	Kidney	—	—
	Liver	1.7E+1	—
	Muscle	1.2E+1	—

TABLE 16. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR REPTILES (cont.)

Element	Tissue	Ratio	
		Turtles only	Excluding turtles
Cd	Bone	1.9E+0	—
	Kidney	2.3E–1	5.9E–1
	Liver	4.8E–1	3.1E–1
	Muscle	1.4E+1	1.0E+0
Co	Bone	—	—
	Kidney	3.4E–2	—
	Liver	2.4E–1	—
	Muscle	6.0E+0	—
Cr	Bone	—	—
	Kidney	1.0E+0	1.0E+0
	Liver	1.0E+0	1.0E+0
	Muscle	2.0E+0	1.0E+0
Cs	Bone	5.1E+0	—
	Kidney	2.0E+0	2.5E–1
	Liver	2.9E+0	4.3E–1
	Muscle	1.0E+0	1.0E+0
Cu	Bone	—	—
	Kidney	1.9E+0	1.6E+0
	Liver	4.6E–1	3.7E–1
	Muscle	2.0E+1	1.0E+0
Fe	Bone	5.8E+0	—
	Kidney	1.7E+0	2.2E+0
	Liver	7.4E–1	1.6E–1
	Muscle	5.6E+0	2.3E+0
Mn	Bone	—	—
	Kidney	1.8E+0	1.5E+1
	Liver	7.4E+0	9.0E+0
	Muscle	2.1E+1	2.9E+0
Ni	Bone	2.9E+0	—
	Kidney	1.0E+0	1.0E+0
	Liver	1.0E+0	1.0E+0
	Muscle	2.1E+0	1.0E+0

TABLE 16. CONVERSION FACTORS FOR TISSUE TO WHOLE ORGANISM CONCENTRATIONS FOR REPTILES (cont.)

Element	Tissue	Ratio	
		Turtles only	Excluding turtles
Pb	Bone	1.9E+0	—
	Kidney	7.5E+0	4.5E+0
	Liver	8.0E+0	7.1E+0
	Muscle	1.8E+1	4.3E+0
Ra	Bone	1.0E+0	—
	Kidney	—	—
	Liver	8.7E+0	—
	Muscle	1.0E+1	—
Rb	Bone	—	—
	Kidney	1.0E+0	—
	Liver	1.0E+0	—
	Muscle	1.0E+0	—
Se	Bone	—	—
	Kidney	1.0E+0	5.7E–1
	Liver	7.4E–1	4.8E–1
	Muscle	1.7E+0	1.0E+0
U	Bone	—	—
	Kidney	—	—
	Liver	—	2.6E–1
	Muscle	—	2.6E+0
Zn	Bone	1.0E+0	—
	Kidney	4.8E+0	1.0E+0
	Liver	3.0E+0	1.0E+0
	Muscle	5.4E+0	1.0E+0

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment, Safety Reports Series No. 19, IAEA, Vienna (2001).
[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Models and Parameters for Assessing the Environmental Transfer of Radionuclides from Routine Releases: Exposures of Critical Groups, IAEA Safety Series No. 57, IAEA, Vienna (1982).
[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments, Technical Reports Series No. 364, IAEA, Vienna (1994).
[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Sediment Kds and Concentration Factors for Radionuclides in the Marine Environment, Technical Reports Series No. 247, IAEA, Vienna (1985).
[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment, Technical Reports Series No. 422, IAEA, Vienna (2004).
[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments, Technical Reports Series No. 472, IAEA, Vienna (2010).
[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Methodology for Assessing Impacts of Radioactivity on Aquatic Ecosystems, Technical Reports Series No. 190, IAEA, Vienna (1979).
[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Assessing the Impact of Deep Sea Disposal of Low Level Radioactive Waste on Living Marine Resources, Technical Reports Series No. 288, IAEA, Vienna (1988).
[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards, Technical Reports Series No. 332, IAEA, Vienna (1992).
[10] BERESFORD, N.A., et al., Inter-comparison of models to estimate radionuclide activity concentrations in non-human biota, Radiat. Environ. Biophys. **47** (2008) 491–514.
[11] BERESFORD, N.A., et al., Findings and recommendations from an international comparison of models and approaches for the estimation of radiological exposure to non-human biota, Radioprotection **44** (2009) 565–570.
[12] BERESFORD, N.A., et al., Predicting the radiation exposure of terrestrial wildlife in the Chernobyl exclusion zone: An international comparison of approaches, J. Radiol. Prot. **30** (2010) 341–373.
[13] YANKOVICH, T.L., et al., An international model validation exercise on radionuclide transfer and doses to freshwater biota, J. Radiol. Prot. **30** (2010) 299–340.
[14] INTERNATIONAL ATOMIC ENERGY AGENCY, "Modelling radiation exposure and radionuclide transfer for non-human species, Report of the Biota Working Group of EMRAS Theme 3", Environmental Modelling for Radiation Safety (EMRAS) — A Summary Report of the Results of the EMRAS Programme (2003–2007), IAEA-TECDOC-1678, IAEA, Vienna (2012) (on the accompanying CD-ROM),

http://www-pub.iaea.org/MTCD/publications/PDF/TE_1678_CD/Reports/Theme_3_WorkingGroup1(Biota)/ModellingRadiationExposureandRadionuclideTransferforNon-humanSpecies.pdf
[15] VIVES I BATLLE, J., et al., Inter-comparison of unweighted absorbed dose rates for non-human biota, Radiat. Environ. Biophys. **46** (2007) 349–373.
[16] HOWARD, B.J., et al., Protection of the environment from ionizing radiation in a regulatory context — An overview of the PROTECT coordinated action, J. Radiol. Prot. **30** (2010) 195–214.
[17] BERESFORD, N.A., et al., Evaluation of the practicability of different approaches for protecting the environment from ionizing radiation in a regulatory context and their relative merits, Deliverable 4, PROTECT Report, Centre for Ecology and Hydrology, Lancaster, UK (2008).
[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Coordination Group on Radiation Protection of the Environment,
http://www-ns.iaea.org/tech-areas/waste-safety/coord-group-on-environment.asp?s=3
[19] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the International Commission on Radiological Protection, Publication 103, Elsevier (2008).
[20] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Environmental Protection: The Concept and Use of Reference Animals and Plants, Publication 108, Elsevier (2009).
[21] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).
[22] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, A Framework for Assessing the Impact of Ionising Radiation on Non-human Species, Publication 91, Pergamon Press, Oxford and New York (2003).
[23] EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).
[24] UNITED STATES DEPARTMENT OF ENERGY, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota, Rep. DOE-STD-1153-2002, Modules 1–3, USDOE, Washington, DC (2002).
[25] UNITED STATES DEPARTMENT OF ENERGY, Environmental Protection Program, DOE O 450.1A, USDOE, Washington, DC (2008).
[26] ENVIRONMENTAL CANADA, HEALTH CANADA, Canadian Environmental Protection Act 1999, Priority Substances List Assessment Report Releases of Radionuclides from Nuclear Facilities (Impact on Non-human Biota), Final Rep. (2003).
[27] COPPLESTONE, D., et al., Habitat Regulations for Stage 3 Assessments: Radioactive Substances Authorisations, Environment Agency R&D Technical Rep. P3-101/SP1a, Environment Agency, Bristol (2003).

[28] COPPLESTONE, D., et al., Impact Assessment of Ionizing Radiation on Wildlife, R&D Publication 128, Environment Agency and English Nature, Bristol (2001).

[29] STRÅLSÄKERHETSMYNDIGHETEN, Strålsäkerhetsmyndighetens föreskrifter och allmänna råd om skydd av människors hälsa och miljön vid slutligt omhändertagande av använt kärnbränsle och kärnavfall, SSMFS 2008:37, ISSN 2000-0987. The Swedish Radiation Protection Institute's Regulations on the Protection of Human Health and the Environment in connection with the Final Management of Spent Nuclear Fuel and Nuclear Waste, SSM, Stockholm (2009). Unofficial translation available from: http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Forfattning/Stralskydd/1998/ssifs-1998-1e.pdf

[30] RADIATION AND NUCLEAR SAFETY AUTHORITY, Long-term Safety of Disposal of Spent Nuclear Fuel, Guide YVL 8.4, Radiation and Nuclear Safety Authority, Helsinki (2001).

[31] COPPLESTONE, D., HINGSTON, J., REAL, A., The development and purpose of the FREDERICA radiation effects database, J. Environ. Radioact. **99** (2008) 1456–1463.

[32] ANDERSSON, P., et al., Protection of the environment from ionizing radiation in a regulatory context (PROTECT): Proposed numerical benchmark values, J. Environ. Radioact. **100** (2009) 1100–1108.

[33] INTERNATIONAL ATOMIC ENERGY AGENCY, Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, IAEA-TECDOC-1616, IAEA, Vienna (2009).

[34] LARSSON, C.-M., The FASSET framework for assessment of environmental impact of ionising radiation in European ecosystems: An overview, J. Radiol. Prot. **30** (2004) A1–A12.

[35] BROWN, J.E., et al., The ERICA Tool, J. Environ. Radioact. **99** (2008) 1371–1383.

[36] GARISTO, N.C., COOPER, F., FERNANDES, S.L., No-effect Concentrations for Screening Assessment of Radiological Impacts on Non-human Biota, NWMO TR2008-02, Nuclear Waste Management Organisation, Toronto (2008).

[37] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Environmental Protection: Transfer Parameters for Reference Animals and Plants, Publication 114, Elsevier (2009).

[38] PRÖHL, G., Interception of dry and wet deposited radionuclides by vegetation, J. Environ. Radioact. **100** (2009) 675–682.

[39] LECLERC, E., CHOI, Y.H., "Weathering", Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, IAEA-TECDOC-1616, IAEA, Vienna (2009) 45–48.

[40] JOURDAIN, F., "Resuspension", Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, IAEA-TECDOC-1616, IAEA, Vienna (2009) 63–68.

[41] STREBL, F., LETTNER, H., HUBMER, A.K., BOSSEW, P., "Radionuclide transfer in alpine ecosystems", Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, IAEA-TECDOC-1616, IAEA, Vienna (2009) 397–401.

[42] COMANS, R.N.J., et al., Mobilization of radiocaesium in pore water of lake sediments, Nature **339** (1989) 367–369.
[43] VIDAL, M., TENT, J., LLAURADO, M., RAURET, G., Study of the evolution of radionuclide distribution in soils using sequential extraction schemes, J. Radioecol. **1** (1993) 49–55.
[44] HIRD, A.B., RIMMER, D.L., LIVENS, F.R., Factors affecting the sorption and fixation of caesium in acid organic soils, Eur. J. Soil Sci. **47** (1996) 97–104.
[45] SMITH, J.T., et al., Temporal change in fallout ^{137}Cs in terrestrial and aquatic systems: A whole ecosystem approach, Environ. Sci. Technol. **33** (1999) 49–54.
[46] FESENKO, S., SANZHAROVA, N., TAGAMI, K., “Evolution of plant contamination with time”, Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, IAEA-TECDOC-1616, IAEA, Vienna (2009) 259–263.
[47] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Nuclear Decay Data for Dosimetric Calculations, Publication 107, Elsevier (2008).
[48] SANZHAROVA, N., FESENKO, S., REED, E., “Processes governing radionuclide transfer to plants”, Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, IAEA-TECDOC-1616, IAEA, Vienna (2009) 123–138.
[49] FESENKO, S.V., et al., Identification of processes governing long-term accumulation of ^{137}Cs by forest trees following the Chernobyl accident, Radiat. Environ. Biophys. **40** (2001) 105–113.
[50] BEYER, W.N., CONNOR, E.E., GEROULD, S., Estimates of soil ingestion by wildlife, J. Wildl. Manage. **58** (1994) 375–382.
[51] RICH, B.N., TALENT, L.G., Soil ingestion may be an important route for the uptake of contaminants by some reptiles, Environ. Toxicol. Chem. **28** (2009) 311–315.
[52] BERESFORD, N.A., HOWARD, B.J., The importance of soil adhered to vegetation as a source of radionuclides ingested by grazing animals, Sci. Total Environ. **107** (1991) 237.
[53] BERESFORD, N.A., et al., The importance of source dependent bioavailability in determining the transfer of ingested radionuclides to ruminant derived food products, Environ. Sci. Technol. **34** (2000) 4455–4462.
[54] HOWARD, B.J,. BERESFORD, N.A., BARNETT, C.L., FESENKO, S., Revision of TRS 364: Gastrointestinal fractional absorption of radionuclides in adult domestic ruminants, J. Environ. Radioact. **100** (2009) 1069–1078.
[55] HOWARD, B.J., BERESFORD, N.A., BARNETT, C.L., FESENKO, S., “Transfer to animals”, Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, IAEA-TECDOC-1616, IAEA, Vienna (2009) 267–307.
[56] FESENKO, S., FESENKO, J., SANZHAROVA, N., KARPENKO, E., TITOV, I., Radionuclide transfer to freshwater biota species: Review of Russian language studies, J. Environ. Radioact. **102** (2011) 8–25.
[57] RAMADE, F., Elements d’ecologie; ecologie appliqué, McGraw Hill, Paris (1989).
[58] FESENKO, S., et al., Radionuclide transfer to marine biota species: Review of Russian language studies, Radiat. Environ. Biophys. **49** (2010) 531–547.

[59] THOMANN, R.V., Equilibrium model of fate of microcontaminants in diverse aquatic food-chains, Can. J. Fish. Aquat. Sci. **38** (1981) 280–296.

[60] UNITED STATES DEPARTMENT OF ENERGY, RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation, User's Guide, Version 1, Rep. DOE/EH-0676, USDOE, Washington, DC (2004).

[61] HOWARD, B.J., BERESFORD, N.A., "Radiation protection of the environment: A summary of current approaches for assessment of radionuclides in terrestrial ecosystems", Nuclear Power and the Environment, Issues in Environmental Science and Technology, Vol. 32 (HESTER, R.E., HARRISON, R.M., Eds), RSC Publishing (2011) 177–198.

[62] GARNIER-LAPLACE, J., et al., A multi-criteria weight of evidence approach for deriving ecological benchmarks for radioactive substances, J. Radiol. Prot. **30** (2010) 215–233.

[63] NAPIER, B.A., Alternative Conceptual Models for Assessing Food Chain Pathways in Biosphere Models, Rep. NUREG/CR-6910, US Nuclear Regulatory Commission, Washington, DC (2006).

[64] VIVES I BATLLE, J., et al., Dynamic model for the assessment of radiological exposure to marine biota, J. Environ. Radioact. **99** (2008) 1711–1730.

[65] CIFFROY, P., DURRIEU, G., GARNIER, J.-M., Probabilistic distribution coefficients (Kds) in freshwater for radioisotopes of Ag, Am, Ba, Be, Ce, Co, Cs, I, Mn, Pu, Ra, Ru, Sb, Sr and Th — Implications for uncertainty analysis of models simulating the transport of radionuclides in rivers, J. Environ. Radioact. **100** (2009) 785–794.

[66] BROWN, J., STRAND, P., HOSSEINI, A., BØRRETZEN, P., Handbook for Assessment of the Exposure of Biota to Ionizing Radiation from Radionuclides in the Environment, Deliverable 5: Appendix 2, Underpinning Scientific Information (life history sheets, empirical data and models), FASSET project, NRPA, Østerås (2003).

[67] GALERIU, D., et al., A metabolic derivation of tritium transfer coefficients in animal products, Radiat. Environ. Biophys. **40** (2001) 325–334.

[68] GALERIU, D., BELOT, Y., A standard guide for dose assessment of routine releases of tritium for any tritium facility, Report WP3, IDRANAP 31-02/2002 (2002).

[69] BELOT, Y., ROY, M., METIVIER, H., Le tritium: de l'environment a l'homme, Les éditions de physique (1996).

[70] GALERIU, D., et al., Modelling ^{3}H and ^{14}C transfer to farm animals and their products under steady state conditions, J. Environ. Radioact. **98** (2007) 205–217.

[71] MELINTESCU, A., GALERIU, D., Dynamic model for tritium transfer in an aquatic food chain, Radiat. Environ. Biophys. **50** (2011) 459–473.

[72] BERESFORD, N.A., et al., Derivation of transfer parameters for use within the ERICA Tool and the default concentration ratios for terrestrial biota, J. Environ. Radioact. **99** (2008) 1393–1407.

[73] HOSSEINI, A., THØRRING, H., BROWN, J.E., SAXÉN, R., ILUS, E., Transfer of radionuclides in aquatic ecosystems — Default concentration ratios for aquatic biota in the Erica Tool, J. Environ. Radioact. **99** (2008) 1408–1429.

[74] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Radionuclide Transformations — Energy and Intensity of Emissions, Publication 38, Pergamon Press, Oxford and New York (1983).
[75] VANDENHOVE, H., CREMERS, A., SMOLDERS, E., Potassium bentonite addition to soil reduces availability of cesium to plants, Eur. J. Soil Sci. **54** (2003) 91–102.
[76] HIGLEY, K.A., Estimating transfer parameters in the absence of data, Radiat. Environ. Biophys. **49** (2010) 645–656.
[77] THIRY, Y., et al., Uranium distribution and cycling in Scots pine (*Pinus sylvestris* L.) growing on a revegetated U-mining heap, J. Environ. Radioact. **81** (2005) 201–219.
[78] DUQUÈNE, L., et al., Plant-induced changes in soil chemistry do not explain differences in uranium transfer, J. Environ. Radioact. **90** (2006) 1–14.
[79] STRACZEK, A., et al., Differences in U root-to-shoot translocation between plant species explained by U distribution in roots, J. Environ. Radioact. **101** (2010) 258–266.
[80] BOWEN, H.J.M., Trace Elements in Biochemistry, Academic Press, London (1966).
[81] MILLERO, F.J., Chemical Oceanography, 2nd edn, CRC Press, Boca Raton, FL (1996) 469.
[82] YANKOVICH, T.L., et al., Whole-body to tissue concentration ratios for use in biota dose assessments for animals, Radiat. Environ. Biophys. **49** (2010) 549–565.
[83] WOOD, M.D., BERESFORD, N.A., SEMENOV, D.V., YANKOVICH, T.L, COPPLESTONE, D., Radionuclide transfer to reptiles, Radiat. Environ. Biophys. **49** (2010) 509–530.
[84] BERESFORD, N.A., et al., Assessment of risk to wildlife from ionizing radiation: Can initial screening tiers be used with a high level of confidence? J. Radiol. Prot. **30** (2010) 265–284.
[85] VOSE, D., Quantitative Risk Analysis, A Guide to Monte Carlo Simulation Modelling, John Wiley and Sons (1996).
[86] TAYLOR, A.C., Using objective and subjective information to develop distributions for probabilistic exposure assessment, J. Expo. Anal. Environ. Epidemiol. **3** (1993) 285–298.
[87] SHEPPARD, S.C., Perspective: Transfer parameters: Are on-site data really better? Hum. Ecol. Risk Assess. **11** (2005) 939–949.
[88] GELMAN, A., CARLIN, J.B., STERN, H.S., RUBIN, D.B., Bayesian Data Analysis, Chapman Hall/CRC (2003).
[89] GAMERMAN, D., LOPES, H.F., Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, 2nd edn, Chapman Hall/CRC Texts in Statistical Science (2006).
[90] BUSBY, R., McCARTNEY, M., McDONALD, P., Technetium-99 concentration factors in Cumbrian seafood, Radioprotection Colloq. **32** (1997) 311–316.
[91] JOHANSEN, M.P., et al., Assessing doses to terrestrial wildlife at a radioactive waste disposal site: Inter-comparison of modelling approaches, Sci. Total Environ. **427–428** (2012) 238–246.
[92] HAKONSON, T.E., NYHAN, J.W., “Ecological relationships of plutonium in southwest ecosystems”, Transuranic Elements in the Environment (HANSON, W.C., Ed.), Rep. DOE/TIC-22800, USDOE, Washington, DC (1980) 403–419.

[93] TOAL, M.E., WALKER, L.A., SHORE, R.F., Modeling cadmium dynamics in the guts and tissues of small mammals: Dose implications for predators, Environ. Toxicol. Chem. **21** (2002) 2493–2499.

[94] BERESFORD, N.A., BROADLEY, H.R., HOWARD, B.J., BARNETT, C.L., WHITE, P.J., Estimating radionuclide transfer to wild species — Data requirements and availability for terrestrial ecosystems, J. Radiol. Prot. **24** (1994) A89–A103.

[95] HIGLEY, K.A., DOMOTOR, S.L., ANTONIO, E.J., A kinetic-allometric approach to predicting tissue radionuclide concentrations for biota, J. Environ. Radioact. **66** (2003) 61–74.

[96] TAGAMI, K., UCHIDA, S., Can elemental composition of crop leaves be used to estimate radionuclide transfer to tree leaves? Radiat. Environ. Biophys. **49** (2010) 583–590.

[97] WILLEY, N.J., Phylogeny can be used to make useful predictions of soil-to-plant transfer factors for radionuclides, Radiat. Environ. Biophys. **49** (2010) 613–623.

[98] JEFFREE, R.A., OBERHANSLI, F., TEYSSIE, J.-L., Phylogenetic consistencies among chondrichthyan and teleost fishes in their bioaccumulation of multiple trance elements from seawater, Sci. Total Environ. **408** (2010) 3200–3210.

[99] BROADLEY, M.R., et al., Phylogenetic variation in heavy metal accumulation in angiosperms, New Phytol. **152** (2001) 9–27.

[100] TYLER, G., Ionic charge, radius, and potential control root/soil concentration ratios of fifty cationic elements in the organic horizon of a beech (*Fagus sylvatica*) forest podzol, Sci. Total Environ. **329** (2004) 231–239.

[101] MacDONALD, C.R., Ingestion rates and radionuclide transfer in birds and mammals on the Canadian shield, Rep. TR-722 COG-95-551, AECL, Ontario (1996).

[102] VIVES I BATLLE, J., WILSON, R.C., WATTS, S.J., McDONALD, P., CRAZE, A., Derivation of allometric relationships for radionuclides in marine phyla, Radioprotection **44** (2009) 47–52.

[103] NAGY, K.A., Food requirements of wild animals: Predictive equations for free-living mammals, reptiles, and birds, Nutr. Abstr. Rev. Ser. B Livest. Feeds Feed. **71** (2001) 1R–12R.

[104] ENQUIST, B.J., et al., A general integrative model for scaling plant growth, carbon flux, and functional trait spectra, Nature **449** (2007) 218–222.

[105] NIKLAS, K.J., Plant allometry, leaf nitrogen and phosphorus stoichiometry, and interspecific trends in annual growth rates, Ann. Bot. **97** (2006) 155–163.

[106] MERTZ, W., Trace Elements in Human and Animal Nutrition, 5th edn, Vol. 1, Academic Press, London (1987).

[107] HOFFMAN, D.J., BARNETT, A., RATTNER, G., BURTON, A., Jr., CAIRNS, J., Jr. (Eds), Handbook of Ecotoxicology, 2nd edn, CRC Press, Boca Raton, FL (2002).

[108] HOWARD, B.J., LARSSON, C.-M., The ERICA integrated approach and its contribution to protection of the environment from ionizing radiation, J. Environ. Radioact. **99** (2008) 1371–1363.

Annex

PUBLICATIONS USED TO BUILD THE CONCENTRATION RATIO TABLES

The publications given below relate to identification (ID) numbers in the tables with concentration ratios ($CR_{wo\text{-}media}$) (Tables 5–8, in Section 4 in this report). Some ID numbers are not sequential as some of the on-line database entries are not used in Tables 5–8.

Publication	ID number
AARKROG, A., et al., AMAP Greenland 1994–1996, Environmental Project No. 356, Ministry of Environment and Energy, Danish Environmental Protection Agency, Copenhagen (1997).	1
ABU-HILAL, A.H., Effect of depositional environment and sources of pollution on uranium concentration in sediment, coral, algae and seagrass species from the Gulf of Aqaba (Red Sea), Mar. Poll. Bull. **28** (1994) 81–88.	2
ALAM, M.N., et al., Radionuclide concentrations in mussels collected from the southern coast of Bangladesh, J. Environ. Radioact. **47** (1999) 201–212.	3
AL-MASRI, M.S., MAMISH, S., BUDEIR, Y., "Assessment of the potential impact of the phosphate industry along the Syrian coast by evaluating ^{210}Po and ^{210}Pb levels in sediment, seawater and selected marine organisms", Rep. AECS-PR\FRSR 232, Atomic Energy Commission of Syria, Damascus (2000) 27.	4
ARCTIC MONITORING AND ASSESSMENT PROGRAMME, Assessment Report: Arctic Pollution Issues, AMAP, Oslo (1998).	5
ARCTIC MONITORING AND ASSESSMENT PROGRAMME, Assessment Report: Radioactive Contamination in the Russian Arctic, Report by Russian Experts, AMAP, Oslo (1999).	6
AMIARD, J.C., ^{110m}Ag contamination mechanisms in a marine benthic food chain. 3. Influence of the mode of contamination upon the distribution of the radionuclide, Helgol. Wissenschaftliche Meeresunters. **31** (1978) 444–456.	7

Publication	ID number
AMIARD, J.C., "A study of the uptake and toxicity of some stable and radioactive pollutants in marine organisms: antimony, silver, cobalt and strontium in molluscs, crustaceans and teleosts", Rep. (CEA)-R4928, CEA, Saclay, France (1978).	8
AMIARD, J.C., AMIARD-TRIQUET, C., Health and ecological aspects of cobalt-60 transfer in seawater food chain typical of an intertidal mudflat, Int. J. Environ. Stud. **10** (1977) 113–118.	9
ANCELLIN, J., GUEGUENIAT, P., GERMAINE, P., Radioecologie Marine, Eyrolles, Paris (1979).	10
ANCELLIN, J., VILQUIN, A., Nouvelles etudes de contaminations experimentales d'espèces marines par le cesium-137, le ruthenium-106 et le cerium-144, Radioprotection **33** (1968) 185–213.	11
ARCTIC MAR, "Radiological assessment of consequences from radioactive contamination of arctic marine areas" (IOSJPE, M., Ed.), Annual Progress Rep. 01.09.99-31.08.00, Norwegian Radiation Protection Authority, Østerås (2000).	12
BACHURIN, A.A., KULEBYAKINA, L.G., POLIKARPOV, G.G., Concentration ratios of calcium, strontium and strontium-90 in some marine hydrobionts, Radiobiologiya **7** (1967) 481–483 (in Russian).	13
BERROW, S.D., et al., Radionuclides (Cs-137 and K-40) in harbour porpoises *Phocoena phocoena* from British and Irish coastal waters, Mar. Poll. Bull. **36** (1998) 569–576.	14
BERTINE, K.K., GOLDBERG, E.D., Trace elements in clams, mussels and shrimps, Limnol. Oceanogr. **17** (1972) 877–884.	15
BOISSON, F., HUTCHINS, D.A., FOWLER, S.W., FISHER, N.S., TEYSSIE, J.L., Influence of temperature on the accumulation and retention of 11 radionuclides by the marine alga *Fucus vesiculosus* (L.), Mar. Poll. Bull. **35** (1997) 313–321.	16
BONOTTO, S., et al., Contamination d'organismes marins par le H-3, le Cs-134 et le Co-60, Revue internationale d'oceanographie medicale **49** (1978) 127–133.	17
BONOTTO, S., et al., "Ten years of investigation on radioactive contamination of the marine environment", Impacts of Radionuclide Releases into the Marine Environment (Proc. Symp. Vienna, 1980), IAEA, Vienna (1981) 649–660.	18

Publication	ID number
BOROUGHS, H., CHIPMAN, W.A., RICE, T.R., "Laboratory experiments on the uptake, accumulation, and loss of radionuclides by marine organisms", The Effects of Atomic Radiation on Oceanography and Fisheries, Publication No. 551, National Academy of Sciences, National Research Council, Washington (1957).	19
BOURLAT, Y., MILLIES-LACROIX, J.C., CHIAPPINI, R., LE PETIT, G., BABLET, J.P., Determination of long-lived radionuclides in biological samples collected at Mururoa by a scientific delegation headed by the IAEA, J. Radioanal. Nucl. Chem. **226** (1997) 15–22.	20
BOWEN, H.J.M., Environmental Chemistry of the Elements, Academic Press, London (1979).	21
BROWN, J., IOSJPE, M., Radioactivity in the marine environment 1999, in NRPA Rep. 9, Norwegian Radiation Protection Authority, Østerås (2001) 29–30.	22
BROWN, J.E., et al., Levels of Tc-99 in seawater and biota samples from Norwegian coastal waters and adjacent seas, Mar. Poll. Bull. **38** (1999) 560–571.	23
BRUNGOT, A.L., CARROL, J.L., RUDJORD, A.L., FOYN, L., "A presentation of the Norwegian national surveillance programme of radioactivity in the marine environment in the period 1996–1998", Extended Abstracts of the 4th Int. Conf. on Environmental Radioactivity, Edinburgh, 1999 (STRAND, P., JØLLE, T., Eds), Norwegian Radiation Protection Authority, Østerås (1999) 189–192.	24
BUSBY, R., McCARTNEY, M., McDONALD, P., Technetium-99 concentration factors in Cumbrian seafood, Radioprotection Colloq. **32** (1997) 311–316.	25
BUYANOV, N.I., BOIKO, E.V., Cobalt-60 accumulation by brown algae of different age, Okeanologiya **12** (1972) 471–474 (in Russian).	26
CARPENTER, J.H., GRANT, V.F., Concentration and state of cerium in coastal waters, J. Mar. Res. **25** (1967) 228–238.	27
CARVALHO, F.P., Po-210 in marine organisms: A wide range of natural radiation dose domains, Radiat. Prot. Dosimetry **24** (1988) 113–117.	28
CHERRY, R.D., SHANNON, L.V., The alpha radioactivity of marine organisms, At. Energy Rev. **12** (1974) 3–45.	29

Publication	ID number
CHRISTENSEN, G.C., STEINNES, E., “Radionuclides in minke whale from the Arctic Ocean”, Extended Abstracts of the 4th Int. Conf. on Environmental Radioactivity in the Arctic (STRAND, P., JØLLE, T., Eds), Norwegian Radiation Protection Authority, Østerås (1999) 197–199.	30
COHEN, B.L., Bioaccumulation factors in marine organisms, Health Phys. **49** (1985) 1290–1294.	31
CONTI, M.E., CECCHETTI, G., A biomonitoring study: Trace metals in algae and molluscs from Tyrrhenian coastal areas, Environ. Res. **93** (2003) 99–112.	32
COOPER, L.W., et al., Radionuclide contamination burdens in Arctic marine mammals harvested during subsistence hunting, Arctic **53** (2000) 174–182.	33
CORCORAN, E.F., KIMBALL, J.F., “The uptake, accumulation and exchange of strontium-90 by open sea phytoplankton”, Radioecology (SCHULTZ, V., KLEMENT, A.W., Jr., Eds), (Proc. 1st Int. Symp on Radioecology, Colorado, Fort Collins, 1961), Reinhold Publishing, NY, and American Institute of Biological Sciences, Washington, DC (1963) 187–191.	34
COUGHTREY, P.J., JACKSON, D., JONES, C.H., THORNE, M.C., Radionuclide Distribution and Transport in Terrestrial and Aquatic Ecosystems — A Critical Review of Data, Vol. 5, A.A. Balkema, Rotterdam (1984).	35
COUGHTREY, P.J., THORNE, M.C., Radionuclide Distribution and Transport in Terrestrial and Aquatic Ecosystems — A Critical Review of Data, Vol. 2, A.A. Balkema, Rotterdam (1983).	36
COUGHTREY, P.J., THORNE, M.C., Radionuclide Distribution and Transport in Terrestrial and Aquatic Ecosystems — A Critical Review of Data, Vol. 1, A.A. Balkema, Rotterdam (1983).	37
DAHLGAARD, H., BERGAN, T.D.S., CHRISTENSEN, G.C., Technetium-99 and caesium-137 time series at the Norwegian coast monitored by the brown alga *Fucus vesiculosus*, Radioprotection Colloq. **32** (1997) 353–358.	38
DIETZ, R., PACYNA, J., THOMAS, D.J., “Heavy metals”, AMAP Assessment Report: Arctic Pollution Issues, AMAP, Oslo (1998) 373–524.	39
EL-MOSELHY, K.M., GABAL, M.N., Trace metals in water, sediments and marine organisms from the northern part of the Gulf of Suez, Red Sea, J. Mar. Syst. **46** (2004) 39–46.	40

Publication	ID number
FISHER, N.S., BJERREGAARD, P., FOWLER, S.W., Interactions of marine plankton with transuranic elements. 1. Biokinetics of neptunium, plutonium, americium, and californium in phytoplankton, Limnol. Oceanogr. **28** (1983) 432–447.	41
FISHER, N.S., BURNS, K.A., CHERRY, R.D., HEYRAUD, M., Accumulation and cellular distribution of ^{241}Am, ^{210}Po and ^{210}Pb in two marine algae, Mar. Ecol. Prog. Ser. **11** (1983) 233–237.	42
FISHER, N.S., et al., Radionuclide bioconcentration factors and sediment partition coefficients in Arctic Seas subject to contamination from dumped nuclear wastes, Environ. Sci. Technol. **33** (1999) 1979–1982.	43
FISHER, N.S., REINFELDER, J.R., "The trophic transfer of metals in marine systems", Metal Speciation and Bioavailability in Aquatic Systems (TESSIER, A., TURNER, D.R., Eds), John Wiley & Sons, Chichester (1995) 363–406.	44
FISHER, N.S., TEYSSIE, J.L., KRISHNASWAMI, S., BASKARAN, M., Accumulation of Th, Pb, U, and Ra in marine phytoplankton and its geochemical significance, Limnol. Oceanogr. **32** (1987) 131–142.	45
FOLSOM, T.R., WONG, K.M., HODGE, V.F., "Some extreme accumulations of natural polonium radioactivity observed in certain oceanic organisms" (Proc. Symp. on the Natural Radiation Environment, Houston, TX, 1972), Vol. 2, USERDA, Rep. CONF-720805 (1973) 863–882.	46
FOSTER, P., Concentrations and concentration factors of heavy metals in brown algae, Environ. Poll. **10** (1976) 45–53.	47
FOWLER, S.W., TEYSSIE, J.L., ACOSTA, A., GATTUSO, J.P., JAUBERT, J., "Radiotracer studies on radionuclide and trace element cycling in corals", Marine Pollution (Proc. Symp. Monaco, 1998), IAEA-TECDOC-1094, IAEA, Vienna (1999) 587–588.	48
FRANIĆ, Z., LOKOBAUER, N., Sr-90 and Cs-137 in pilchards from the Adriatic Sea, Arhiv za Higijenu Rada i Toksikologiju (Archives of Industrial Hygiene and Toxicology) **44** (1993) 293–301.	49
GERMAIN, P., LECLERC, G., LE CAVELIER, S., SOLIER, L., BARON, Y., Évolution spatio-temporelle des concentrations, des rapports isotopiques et des facteurs de concentration du plutonium dans une espèce d'algue et deux espèces de mollusques en Manche, Radioprotection **35** (2000) 175–200.	50

Publication	ID number
GOMEZ, L.S., MARIETTA, M.G., JACKSON, D.W., Compilation of Selected Marine Radioecological Data for the Formerly Utilized Sites Remedial Action Program: Summaries of Available Radioecological Concentration Factors and Biological Half-lives, Sandia National Laboratories, Rep. SAND89-1585 RS-8232-2/, Sandia National Laboratories, Albuquerque, NM (1991).	51
GUARY, J.C., HIGGO, J.J.W., CHERRY, R.D., HEYRAUD, M., High concentrations of transuranics and natural radioactive elements in the branchial hearts of the cephalopod, *Octopus vulgaris*, Mar. Ecol. Prog. Ser. **4** (1981) 123–126.	52
GUTHRIE, R.K., DAVIS, E.M., CHERRY, D.S., MURRAY, H.E., Biomagnification of heavy metals by organisms in the marine microcosm, Bull. Environ. Contam. Toxicol. **31** (1979) 53–61.	53
GWYNN, J.P., ANDERSEN, M., DOWDALL, M., LYDERSEN, C., KOVACS, K., "Cesium-137 in marine mammals from Svalbard and the Barents and Greenland Seas", Proc. 6th Int. Conf. on Environmental Radioactivity in the Arctic and Antarctic, Nice, 2005, Norwegian Radiation Protection Authority, Østerås (2005).	54
HAYASHI, N., KATAGIRI, H., NARITA, O., KINOSHITA, M., Concentration factors of plutonium and americium for marine products, J. Radioanal. Nuclear Chem. **138** (1990) 331–336.	55
HEFT, R.E., HARRISON, F.L., PHILLIPS, W.A., "Radioecological study of the Humbolt Bay marine environment", Nuclear Methods in Environmental Research (VOGT, J.R., PARKINSON, T.F., CLARK R.L., Eds), University of Missouri, Columbia (1971) 158–168.	56
HELCOM, HELCOM MORS Database on Environmental Radioactivity in the Baltic Sea, Baltic Marine Environment Protection Commission, Helsinki (2010).	57
HELDAL, H.E., STUPAKOFF, I., FISHER, N.S., Bioaccumulation of Cs-137 and Co-57 by five marine phytoplankton species, J. Environ. Radioact. **57** (2001) 231–236.	58
HEYRAUD, M., CHERRY, R.D., Polonium-210 and lead-210 in marine food chains, Mar. Biol. **52** (1979) 227–236.	59
HOLM, E., et al., Transuranium elements in macroalgae at Monaco following the Chernobyl accident, Eur. J. Solid State Inorg. Chem. **28** (1991) 375–378.	60

Publication	ID number
WILLIAMS, A.R., "Background radiological data for the proposed Beverly Uranium Development", South Australia, Australian Atomic Energy Commission, Lucas Heights (1981).	61
HOLM, E., et al., Radionuclides in macro algae at Monaco following the Chernobyl accident, J. Radioanal. Nuclear Chem. **177** (1994) 51–72.	62
HOLM, E., PERSSON, B.R.R., HALLSTADIUS, L., AARKROG, A., DAHLGAARD, H., Radiocesium and transuranium elements in the Greenland and Barents Seas, Oceanol. Acta **6** (1983) 457–462.	63
HOLM, E., PERSSON, R.B.R., "Behaviour of natural (Th, U) and artificial (Pu, Am) actinides in coastal waters", Marine Radioecology (Proc. 3rd NEA Sem. Tokyo, 1979), OECD, Paris (1980) 237–244.	64
HOU, X., YAN, X., Study on the concentration and seasonal variation of inorganic elements in 35 species of marine algae, Sci. Total Environ. **222** (1998) 141–156.	65
HURTGEN, C., KOCH, G., VAN DER BEN, D., BONOTTO, S., The determination of technetium-99 in the brown marine alga *Fucus spiralis* collected along the Belgian Coast, Sci. Total Environ. **70** (1988) 131–149.	66
ICHIKAWA, R., OHNO, S., Levels of cobalt, caesium and zinc in some marine organisms in Japan, Bull. Jap. Soc. Sci. Fish. **40** (1974) 501–508.	67
IKAHEIMONEN, T.K., RISSANEN, K., MATISHOV, D.G., MATISHOV, G.G., "Plutonium in fish, algae, and sediments in the Barents, Petshora, and Kara Sea" (Proc. Int. Conf. on Environmental Radioactivity in the Arctic, Oslo), Norwegian Radiation Protection Authority, Østerås (1995) 227–232.	68
ILUS, E., Summary Report of the NKS-B/INDOFERN Project (New Indicator Organisms for Environmental Radioactivity), (Proc. of Summary Seminar NKS-B Programme 2002–2005, Tartu, 2005), NKS-143, STUK, Finland (2005) 1–13.	69
ILUS, E., KLEMOLA, S., IKAHEIMONEN, T.K., VARTTI, V.-P., MATTILA, J., "Indicator value of certain aquatic organisms for radioactive substances in the sea areas off the Loviisa and Olkiluoto nuclear power plants (Finland)" (Proc. of Summary Seminar NKS-B Programme 2002–2005, Tartu, 2005), Nordic Nuclear Safety Research, Roskilde, Denmark (2005) 67–73.	70

Publication	ID number
ILUS, E., KLEMOLA, S., IKAHEIMONEN, K., “Radiocaesium in seals and terns off the Finnish coast after the Chernobyl accident”, Proc. 6th Int. Conf. on Environmental Radioactivity in the Arctic and Antarctic, Nice, 2005, Norwegian Radiation Protection Authority, Østerås (2005).	71
ISHII, T., SUZUKI, H., IIMURA, M., KOYANAGI, T., “Concentration of trace elements in marine organisms”, NIRS-R-5, National Institute of Radiological Sciences, Chiba, Japan (1976) 28–29.	72
JEFFREE, R.A., SZYMCZAK, R., PECK, G.A., “Po-210 and Pb-210 concentration factors for zooplankton and pellets in the oligotrophic South-West pacific” (Proc. Int. Conf. on Isotopes in Environmental Studies — Aquatic Forum, Monaco, 2004) (2004).	73
JENKINS, C.E., Radionuclide distribution in Pacific Salmon, Health Phys. **17** (1969) 507–512.	74
KAHN, B., TURGEON, K.S., “The bioaccumulation factor for phosphorus-32 in edible fish tissue”, US Nuclear Regulatory Commission, Rep. NUREG/CR-1336, University of Michigan Library (1980) 1–116.	75
KANISCH, G., NAGEL, G., Radioactivity in fish from the North Sea, Information for the Fishing Industry in Fisheries Research **39** (1992) 32–39 (in German).	76
KASAMATSU, F., KAWABE, K., INATOMI, N., MURAYAMA, T., A note on radionuclide ^{137}Cs and ^{40}K concentrations in Dall’s porpoises *Phocoenoides dalli* in coastal waters of Japan, J. Cetacean Res. Manage. **1** (1999) 275–278.	77
KERSHAW, P.J., McMAHON, C.A., RUDJORD, A.L., SMEDLEY, C., LEONARD, K.S., Spatial and temporal variations in concentration factors in NW European Seas secondary use of monitoring data, Radioprotection **40** (2005) S93–S99.	78
KILIZHENKO, V.P., “Some data on Barents Sea contamination”, Atomic Energy on Sea Safety and Ecology, International Scientific Seminar of the USSR Nuclear Society, Moscow, 1990, Nuclear Society (1992) 250–252.	79
KIMURA, Y., OGAWA, Y., HONDA, Y., KATSURAYAMA, K., Studies on the concentration of radioactive substances by plankton, *Chlorella pyrenoidosa*, Igaku **25** (1990) 361–368.	80

Publication	ID number
KOLSTAD, A.K., RUDJORD, A.L., "Organ distribution of technetium-99 in lobster (*Homarus gammarus*) from Norwegian coastal areas", Proc. 6th Int. Conf. on Environmental Radioactivity in the Arctic and Antarctic, Nice, 2005, Norwegian Radiation Protection Authority, Østerås (2005).	81
KULEBAKINA, L.G., POLIKARPOV, G.G., On algal radioecology of the Black sea shelf, Okeanologiya **7** (1967) 278–286 (in Russian).	82
KURABAYASHI, M., FUKUDA, S., KUROKAWA, Y., "Concentration factors of marine organisms used for the environmental dose assessment", Marine Radioecology (Proc. 3rd OECD/NEA Sem. Tokyo, 1979), OECD Paris (1980) 355.	83
LEAL, M.C.F., VASCONCELOS, M.T., SOUSA-PINTO, I., CABRAL, J.P.S., Biomonitoring with benthic macroalgae and direct assay of heavy metals in seawater of the Oporto coast (Northwest Portugal), Mar. Poll. Bull. **34** (1997) 1006–1015.	84
LENTSCH, J.W., KNEIP, T.J., WREN McDONALD, E., HOWELLS, G.P., EISENBUD, M., "Stable Mn and Mn-54 distributions in the physical and biological components of the Hudson River Estuary", Radionuclides in Ecosystems (NELSON, D.J., Ed.), CONF-710501, NTIS Springfield, VA (1971) 752–768.	85
LINDAHL, P., ROOS, P., HOLM, E., DAHLGAARD, H., Studies of Np and Pu in the marine environment of Swedish–Danish waters and the North Atlantic Ocean, J. Environ. Radioact. **82** (2005) 285–301.	86
LOCATELLI, C., TORSI, G., Determination of Se, As, Cu, Pb, Cd, Zn and Mn by anodic and cathodic stripping voltammetry in marine environmental matrices in the presence of reciprocal interference. Proposal of a new analytical procedure, Microchemical J. **65** (2000) 293–303.	87
MARUMO, K., ISHII, T., ISHIKAWA, Y., UEDA, T., Concentration of elements in marine zooplankton from coastal waters of Boso Peninsula, Jap. Fish. Sci. **64** (1998) 185–190.	88
MASSON, M., et al., Time series for sea water and seaweed of Tc-99 and Sb-125 originating from releases at La Hague, J. Mar. Syst. **6** (1995) 397–413.	89

Publication	ID number
MATISHOV, G.G., MATISHOV, D.G., NAMJATOV, A.A., “Modern level of the content of ^{137}Cs in fish and seaweed of the Barents Sea”, Extended Abstracts of the 4th Int. Conf. on Environmental Radioactivity, Edinburgh, 1999 (STRAND, P., JØLLE, T., Eds), Norwegian Radiation Protection Authority, Østerås (1999) 242–243.	90
MATISHOV, G.G., MATISHOV, D.G., SZCZYPA, J., RISSANEN, K., “Radionuclides in the Ecosystem of the Barents and Kara Seas Region”, Proc. Kola Science Center, Apatity (1994) (in Russian).	91
MATISHOV, G.G., RODIN, A.V., (Eds), Atlantic Cod. Biology, Ecology, Fishery, Nauka, St. Petersburg (1996) (in Russian).	92
MAUCHLINE, J., TEMPLETON, W.L., Dispersion in the Irish Sea of the radioactive liquid effluent from Windscale Works of the UK Atomic Energy Authority, Nature **198** (1963) 623–626.	93
McDONALD, P., BAXTER, M.S., FOWLER, S.W., Distribution of radionuclides in mussels, winkles and prawns. Part 1. Study of organisms under environmental conditions using conventional radio-analytical techniques, J. Environ. Radioact. **18** (1993) 181–202.	94
McDONALD, P., COOK, G.T., BAXTER, M.S., Natural and anthropogenic radioactivity in coastal regions of the UK, Radiat. Prot. Dosimet. **45** (1992) 707–710.	95
MEINHOLD, A.F., HAMILTON, L.D., “Radium concentration factors and their use in health and environmental risk assessment”, Proc. Int. Conf. Produced Water: Technological/environmental Issues and Solutions (RAY, J.P., ENGELHARDT, F.R., Eds), Plenum Press, New York (1992) 293–302.	96
MELHUUS, A., SEIP, K.L., SEIP, H.M., MYKLESTAD, S., A preliminary study of the use of benthic algae as biological indicators of heavy metal pollution in Sørfjorde Norway, Environ. Poll. **15** (1978) 101–107.	97
NAKAHARA, M., KOYANAGI, T., SAIKI, M., “Concentrations of radioactive cobalt by seaweeds in the food chains”, Impacts of Nuclear Releases into the Aquatic Environment (Proc. Symp. Otaniemi, 1975), IAEA, Vienna (1975) 301–312.	98

Publication	ID number
NAUSTVOLL, S., OVREVOLL, B., HELLSTROM, T., EIKELMANN, J.M.H., “Radiocaesium in marine fish in the coastal waters of Northern Norway and in the Barents Sea”, Extended Abstracts of the 3rd Int. Conf. on Environmental Radioactivity in the Arctic, Tromsø, Norway, 1997 (STRAND, P., Ed.), Norwegian Radiation Protection Authority, Østerås (1997) 215–216.	99
NILSSON, M., et al., “Radionuclides in *Fucus* from inter-Scandinavian waters”, Impacts of Radionuclide Releases into the Marine Environment (Proc. Symp. Vienna, 1980), IAEA, Vienna (1981) 501–513.	100
TAKATA, H., AONO, T., TAGAMI, K., UCHIDA, S., Concentration ratios of stable elements for selected biota in Japanese estuarine areas, Radiat. Environ. Biophys. **49** (2010) 591–601.	101
NOLAN, C., WHITEHEAD, N., TEYSSIE, J.-L., Tellurium — speciation in seawater and accumulation by marine phytoplankton and crustaceans, J. Environ. Radioact. **13** (1991) 153–169.	102
NONNIS-MARZANO, F., TRIULZI, C., Radioecological research on the marine environment facing the Italian base in Antarctica (1989–91), Int. J. Environ. Anal. Chem. **55** (1994) 243–252.	103
NOSHKIN, V.E., BOWEN, V.T., WONG, K.M., BURKE, J.C., “Plutonium in North Atlantic Ocean organisms: Ecological relationships” (Proc. 3rd Nat. Symp. on Radioecology, Oak Ridge, TN), (NELSON, D.J., Ed.), CONF.710501-P2 (1971) 688–691.	104
NOSHKIN, V.E., WONG, K.M., EAGLE, R.J., GATROUSIS, C., Transuranics and other radionuclides in Bikini Lagoon: Concentration data retrieved from aged coral sections, Limnol. Oceanogr. **20** (1975) 729–742.	105
NORWEGIAN RADIATION PROTECTION AUTHORITY, Radioactive Contamination at Dumping Sites for Nuclear Waste in the Kara Sea, Results from Norwegian–Russian 1992–1994 Expeditions to the Kara Sea, NRPA, Østerås (1996).	106
NORWEGIAN RADIATION PROTECTION AUTHORITY, Radioactive Contamination at Dumping Sites for Nuclear Waste in the Kara Sea, Results from Norwegian–Russian 1993 Expedition to the Kara Sea, NRPA, Østerås (1994).	107
NORWEGIAN RADIATION PROTECTION AUTHORITY, Radioactive Contamination in the Marine Environment (BRUNGOT, A.L., et al., Eds), NRPA, Østerås (1997).	108

Publication	ID number
NORWEGIAN RADIATION PROTECTION AUTHORITY, Radioactive Contamination in the Marine Environment, StrålevernRapport 1999:6 (BRUNGOT, A.L., et al., Eds), NRPA, Østerås (1999).	109
NORWEGIAN RADIATION PROTECTION AUTHORITY, Radionuclide Uptake and Transfer in Pelagic Food Chains of the Barents Sea and Resulting Doses to Man and Biota, Final Rep., Norwegian Transport and Effects Programme, NRPA, Østerås (2000).	110
NORWEGIAN RADIATION PROTECTION AUTHORITY, Radioactivity in the Marine Environment, NRPA Rep. 1995:1 (SICKEL, M.A.K., et al., Eds), NRPA, Østerås (1995).	111
NORWEGIAN RADIATION PROTECTION AUTHORITY, Technetium-99 Contamination in the North Sea and in Norwegian Coastal Areas 1996 and 1997 (BROWN, J., KOLSTAD, A.K., LIND, B., RUDJORD, A.L., STRAND, P., Eds), NRPA, Østerås (1998).	112
OSVATH, I., BOLOGA, A., DOVLETE, C., Environmental Cs-137 concentration factors for Black Sea biota. Preliminary data, Rapport du Commission Internationale Mer Méditerranée **32** (1990) 320.	113
PENTREATH, R.J., Monitoring of Radionuclides, FAO Fisheries Technical Paper 150, FAO, Rome (1976) 8–23.	114
PENTREATH, R.J., Radionuclides in marine fish, Oceanogr. Mar. Biol. Ann. Rev. **15** (1977) 365–460.	115
PENTREATH, R.J., LOVETT, M.B., Transuranic nuclides in plaice (*Pleuronectes platessa)* from the north-eastern Irish Sea, Mar. Biol. **48** (1978) 19–26.	116
PERTSOV, L.A., Biological aspects of radioactive contamination of sea, Atomizdat, Moscow (1978) (in Russian).	117
POLIKARPOV, G.G., Radioecology of marine organisms, Atomizdat, Moscow (1964) 85–90 (in Russian).	118
POLIKARPOV, G.G., Ability of some Black Sea organisms to accumulate fission products, Science **133** (1961) 1127–1128.	119
POLIKARPOV, G.G., “Radioecology of aquatic organisms: The accumulation and biological effects of radioactive substances”, Reinhold, New York (1966).	120

Publication	ID number
PORNTEPKASEMSAN, B., NEVISSI, A.E., Mechanism of radium-226 transfer from sediments and water to marine fishes, Geochem. J. **24** (1990) 223–228.	121
POSTON, T.M., KLOPFER, D.C., “A literature review of the concentration ratios of selected radionuclides in freshwater and marine fish”, PNL-5484, Pacific Northwest Laboratory, Richland, WA (1986).	122
POSTON, T.M., KLOPFER, D.C., Concentration factors used in the assessment of radiation dose to consumers of fish: A review of 27 radionuclides, Health Phys. **55** (1988) 751–766.	123
RICE, T.R., The accumulation and exchange of strontium by marine planktonic algae, Limnol. Oceanogr. **1** (1956) 123–138.	124
RISSANEN, K., IKAHEIMONEN, T.K., MATISHOV, D., MATISHOV, G.G., Radioactivity levels in fish, benthic fauna, seals, and sea birds collected in the northwest arctic of Russia, Radioprotection Colloq. **32** (1997) 323–331.	125
RISSANEN, K., IKAHEIMONEN, T.K., VLIPIETI, J., MATISHOV, D.G., MATISHOV, G.G., “Plutonium in algae, sediments and biota in the Barents, Pechora and Kara Seas” (Proc. Int. Workshop on Distribution and Speciation of Radionuclides in the Environment), (INABA, J., HISAMATSU, S., OHTSUKA, Y., Eds), Rokkasho, Aomori, Japan (2000) 107–114.	126
RISSANEN, K., MATISHOV, D.G., MATISHOV, G.G., “Radioactivity levels in Barents, Petshora, Kara Sea, Laptev and White Sea” (Proc. Int. Conf. on Environmental Radioactivity in the Arctic, Oslo), Norwegian Radiation Protection Authority, Østerås (1995) 208–214.	127
RISSANEN, K., PEMPKOWIAK, K.J., IKAHEIMONEN, T.K., MATISHOV, D.G., MATISHOV, G.G., “^{137}Cs, ^{239,240}Pu, ^{90}Sr and selected metal concentrations in organs of Greenland seal pups in the White Sea area”, Extended Abstracts of the 4th Int. Conf. on Environmental Radioactivity, Edinburgh, 1999 (STRAND, P., JØLLE, T., Eds), Norwegian Radiation Protection Authority, Østerås (1999) 186–188.	128
RUDJORD, A.L., KOLSTAD, A.K., HELDAL, H.E., “Concentration factors for Tc-99 in lobster (*Homarus gammarus*) from Norwegian coastal areas”, Isotopes in Environmental Studies — Aquatic Forum 2004 (Proc. Int. Conf. Monaco, 2004) (2006) 318–320.	129

Publication	ID number
RYAN, T.P., DOWDALL, A.M., McGARRY, A.T., POLLARD, D., CUNNINGHAM, J.D., Po-210 in *Mytilus edulis* in the Irish marine environment, J. Environ. Radioact. **43** (1999) 325–342.	130
SAZYKINA, T.G., Long-distance radionuclide transfer in the Arctic Seas related to fish migrations, Radiat. Prot. Dosimetry **75** (1998) 219–222.	131
SHUTOV, V.N., et al., “The current radioactive contamination of the environment and foodstuffs in the Kola Region of Russia”, Extended Abstracts of the 4th Int. Conf. on Environmental Radioactivity, Edinburgh, 1999 (STRAND, P., JØLLE, T., Eds), Norwegian Radiation Protection Authority, Østerås (1999) 307–309.	132
SIVINTSEV, Yu.V., et al., Anthropogenic radionuclides in seas bounding Russia. Radioecological Impact of Radioactive Waste Disposal to Arctic and Far East Seas (“WHITE BOOK — 2000”), Moscow, IzdaT (2005) 248 (in Russian).	133
SKWARZEC, B., BOJANOWSKI, R., Po-210 content in sea water and its accumulation in southern Baltic plankton, Mar. Biol. **97** (1988) 301–307.	134
SKWARZEC, B., FALKOWSKI, L., Accumulation of Po-210 in Baltic invertebrates, J. Environ. Radioact. **8** (1988) 99–109.	135
SMITH, V., et al., Technetium-99 in the Irish marine environment, J. Environ. Radioact. **56** (2001) 269–284.	136
STEELE, A.K., Derived concentration factors for Cs-137 in edible species of North Sea fish, Mar. Poll. Bull. **21** (1990) 591–594.	137
STEPNOWSKI, P., SKWARZEC, B., A comparison of Po-210 accumulation in molluscs from the southern Baltic, the coast of Spitsbergen and Sasek Wielki lake in Poland, J. Environ. Radioact. **49** (2000) 201–208.	138
STRAND, P., et al., “Survey of artificial radionuclides in the Kara Sea”, Environmental Radioactivity in the Arctic and Antarctic (STRAND, P., HOLM, E., Eds), Norwegian Radiation Protection Authority, Østerås (1993) 53–65.	139
SUZUKI, H., ISHII, T., IIMURA, M., KOYANAGI, T., “Studies on concentration of minor stable elements in marine environmental samples”, NIRS-R-8, National Institute of Radiological Sciences, Chiba, Japan (1978) 17–21.	140

Publication	ID number
SUZUKI, H., KOYANAGI, T., SAIKI, M., "Studies on rare earth elements in seawater and uptake by marine organisms", Impacts of Nuclear Releases into the Aquatic Environment (Proc. Symp. Otaniemi, 1975), IAEA, Vienna (1975) 77–91.	141
SWIFT, D.J., PENTREATH, R.J., The accumulation of plutonium by the edible winkle (*Littorina littorea* L.), J. Environ. Radioact. **7** (1988) 29–48.	142
TATEDA, Y., KOYANAGI, T., Concentration factors for Cs-137 in Japanese coastal fish (1984–1990), J. Radiat. Res. **37** (1996) 71–79.	143
TATEDA, Y., KOYANAGI, T., Concentration factors for Cs-137 in marine algae from Japanese coastal waters, J. Radiat. Res. **35** (1994) 213–221.	144
TEMPLETON, W.L., "Fission products and aquatic organisms", The Effects of Pollution on Living Material, Institute for Biology, London (1959) 125–140.	145
VAKULOVSKY, S.M., (Ed.), The Radiation Situation within Russia and Adjacent States in 2007, RosHydromet-SPA Typhoon, Obninsk (2008) (in Russian).	146
VAN AS, D., FOURIE, H.O., VLEGGAAR, C.M., Trace element concentrations in marine organisms from the Cape West Coast South African, J. Sci. **71** (1975) 151–154.	147
VAN WEERS, A.W., "Uptake and loss of ^{65}Zn and ^{60}Co by the mussel *Mytilus edulis* L.", Radioactive Contamination of the Marine Environment (Proc. Symp. Seattle, 1972), IAEA, Vienna (1973) 385–401.	148
VAN WEERS, Q.W., VAN RAAPHORST, J.G., "Accumulation of trace metals in coastal marine organisms", Marine Radioecology (Proc. 3rd OECD/NEA Sem. Tokyo, 1979), OECD, Paris (1980) 303.	149
WANG, W.-X., DEI, R.C.H., Effects of major nutrient additions on metal uptake in phytoplankton, Environ. Pollut. **111** (2001) 233–240.	150
WANG, W.-X., DEI, R.C.H., Influences of phosphate and silicate on Cr(VI) and Se(IV) accumulation in marine phytoplankton, Aquat. Toxicol. **5** (2001) 39–47.	151
WANG, W.-X., DEI, R.C.H., Metal uptake in a coastal diatom influenced by major nutrients (N, P, and Si), Water Res. **35** (2001) 315–321.	152
VINTSUKEVICH, N.V., TOMILIN, Yu.A., Radionuclide distribution in aquatic system (NPP cooling pond-river-sea estuary), Ekologiya **6** (1987) 72–74.	153

Publication	ID number
YEATS, P., STENSON, G., HELLOU, J., Essential elements and priority contaminants in liver, kidney, muscle and blubber of harp seal beaters, Sci. Total Environ. **243/244** (1999) 157–167.	154
YEN, J., Sorption of plutonium-237 by two species of marine phytoplankton, J. Phycol. **17** (1981) 346–352.	155
YOSHITOME, R., et al., Global distribution of radionuclides (^{137}Cs and ^{40}K) in marine mammals, Environ. Sci. Technol. **37** (2003) 4597–4602.	156
ZHANG, G.H., HU, M.H., HUANG, Y.P., HARRISON, P.J., Se uptake and accumulation in marine phytoplankton and transfer of Se to the calm *Puditapes phillippnarum*, Mar. Environ. Res. **30** (1990) 179–190.	157
ANDREWS, S.M., COOKE, J.A., "Cadmium within a contaminated grassland ecosystem established on metalliferous mine waste", Metals in Animals (OSBORN, D., Ed.), CEH Monkswood, Huntingdon (1982).	158
ANDREWS, S.M., JOHNSON, M.S., COOKE, J.A., Distribution of trace-element pollutants in a contaminated grassland ecosystem established on metalliferous fluorspar tailings, 1. Lead, Environ. Poll. **58** (1989) 73–85.	159
BAKUNOV, N.A., PANASENKOVA, O.I., DRICHKO, V.F., ^{90}Sr, ^{137}Cs and natural radionuclides in the ecosystem of a deep lake, Russian J. Ecol. **30** (1998) 361–363 (in Russian).	160
BASTIAN, R.K., JACKSON, W.B., "Cs-137 and Co-60 in a terrestrial community at Enewatak Atoll" (Proc. Symp. 4th Natl Symp. on Radioecology and Energy Resources, Corvallis, OR, 1975), (CUSHING, C.E.J., Ed.), The Ecological Society of American, Special Publication **1** (1975) 314–320.	161
BERESFORD, N.A., Estimating the transfer of ^{110m}Ag originating from the Chernobyl accident in west Cumbrian soil and vegetation samples, J. Radiol. Prot. **9** (1989) 281–283.	162
BERESFORD, N.A., et al., Approaches to estimating the transfer of radionuclides to Arctic biota, Radioprotection **40** (2005) S285–S290.	163
BERESFORD, N.A., WRIGHT, S.M., BROWN, J.E., SAZYKINA, T., "Review of approaches for the estimation of radionuclide transfer to reference Arctic biota", EPIC Deliverable 2, Centre for Ecology and Hydrology, Merlewood (2002).	164

Publication	ID number
BEYER, W.N., CHANEY, R.L., MULHERN, B.M., Heavy metal concentrations in earthworms from soil amended with sewage sludge, J. Environ. Qual. **11** (1982) 381–385.	165
BUNZL, K., et al., Examination of a relationship between Cs-137 concentrations in soils and plants from alpine pastures, J. Environ. Radioact. **48** (2000) 145–148.	166
BUNZL, K., KRACKE, W., Distribution of ^{210}Pb, ^{210}Po, stable lead and fallout ^{137}Cs in soil, plants and moorland sheep of a heath, Sci. Total Environ. **39** (1984) 143–159.	167
CHRISTALDI, M., IERADI, L.A., MASCANZONI, D., MATTEI, T., Environmental impact of the Chernobyl accident: Mutagenesis in bank voles from Sweden, Int. J. Radiat. Biol. **59** (1991) 31–40.	168
COOPER, K., The Effect of Chronic Radiation on Invertebrate Diversity and Abundance within the Chernobyl Exclusion Zone, MSc Thesis, Liverpool Univ. (2002).	169
COPPLESTONE, D., Coniferous Woodland Ecosystem — Lady Wood. The Food Chain Transfer of Radionuclides through Semi Natural Habitats, Section 3, PhD Thesis, Liverpool Univ. (1996) 77–164.	170
COPPLESTONE, D., The Food Chain Transfer of Radionuclides through Semi Natural Habitats, PhD Thesis, Liverpool Univ. (1996).	171
COPPLESTONE, D., JOHNSON, M.S., JONES, S.R., TOAL, M.E., JACKSON, D., Radionuclide behaviour and transport in a coniferous woodland ecosystem: Vegetation, invertebrates and wood mice, *Apodemus sylvaticus*, Sci. Total Environ. **239** (1999) 96–109.	172
COUGHTREY, P.J., JACKSON, D., JONES, C.H., THORNE, M.C., Radionuclide Distribution and Transport in Terrestrial and Aquatic Ecosystems — A Critical Review of Data, Vol. 5, A.A. Balkema, Rotterdam (1984).	173
COUGHTREY, P.J., JACKSON, D., THORNE, M.C., Radionuclide Distribution and Transport in Terrestrial and Aquatic Ecosystems — A Critical Review of Data, Vol. 3, A.A. Balkema, Rotterdam (1983).	174
CROSSLEY, D.A.J., “Comparative movement of ^{106}Ru, ^{60}Co and ^{137}Cs in arthropod food chains”, Proc. Symp. 2nd Natl Symp. on Radioecology, Washington (NELSON, D.J., EVANS, F.C., Eds), United States Atomic Energy Commission Rep. CONF-670503, Washington, DC (1973) 687–695.	175

Publication	ID number
CROSSLEY, D.A.J., "Movement and accumulation of radiostrontium and radiocesium in insects", Radioecology, Fort Collins, CO, Reinhold Publishing Corporation, The American Institute of Biological Sciences (1961).	176
DAVIDSON, M.F., GOW, C., WATSON, I.N., WELHAM, D., Grass and Soil Sampling around Nuclear Sites: 1996 Report, Rep. NRPB M798, National Radiological Protection Board, Didcot, United Kingdom (1997).	177
VETIKKO, V., SAXEN, R., Application of the ERICA Assessment Tool to freshwater biota in Finland, J. Environ. Radioact. **101** (2010) 82–87.	178
DEITERMANN, W.I., HAUSCHILD, J., ROBENSPALAVINSKAS, E., AUMANN, D.C., Soil-to-vegetation transfer of natural I-127, and of I-129 from global fallout, as revealed by field-measurements on permanent pastures, J. Environ. Radioact. **10** (1989) 79–88.	179
EFROYMSON, R.A., SAMPLE, B.E., SUTER, G.W., Uptake of inorganic chemicals from soil by plant leaves: Regressions of field data, Environ. Toxicol. Chem. **20** (2001) 2561–2571.	180
ENVIRONMENT AGENCY, ENVIRONMENT AND HERITAGE SERVICE, FOOD STANDARDS AGENCY, SCOTTISH ENVIRONMENT PROTECTION AGENCY, Radioactivity in Food and the Environment, 2002, RIFE 8, CEFAS (2003) 1–220.	181
ENVIRONMENT AGENCY, ENVIRONMENT AND HERITAGE SERVICE, FOOD STANDARDS AGENCY, SCOTTISH ENVIRONMENT PROTECTION AGENCY, Radioactivity in Food and the Environment, 2003, RIFE 9, CEFAS (2004) 1–234.	182
ERTEL, J., ZIEGLER, H., Cs-134/137 contamination and root uptake of different forest trees before and after the Chernobyl accident, Radiat. Environ. Biophys. **30** (1991) 147–157.	183
FERENBAUGH, J.K., FRESQUEZ, P.R., EBINGER, M.H., GONZALES, G.J., JORDAN, P.A., Radionuclides in soil and water near a low level disposal site and potential ecological and human health impacts, Environ. Monit. Assess. **74** (2002) 243–254.	184
FOOD STANDARDS AGENCY, SCOTTISH ENVIRONMENT PROTECTION AGENCY, Radioactivity in Food and the Environment, 1999, RIFE 5, CEFAS (2000) 1–180.	185

Publication	ID number
FOOD STANDARDS AGENCY, SCOTTISH ENVIRONMENT PROTECTION AGENCY, Radioactivity in Food and the Environment, 2000, RIFE 6, CEFAS (2001) 1–186.	186
FOOD STANDARDS AGENCY, SCOTTISH ENVIRONMENT PROTECTION AGENCY, Radioactivity in Food and the Environment, 2001, RIFE 7 (2002) 1–194.	187
GASCHAK, S., International Radioecology Laboratory, Slavutych, Ukraine, personal communication, 2007.	188
GASCHAK, S., et al., “Radioecology of small birds in the Chernobyl zone”, Proc. Int. Conf. on Radioactivity in the Environment, Nice, 2005 (STRAND, P., BORRETZEN, P., JØLLE, T., Eds), Norwegian Radiation Protection Authority, Østerås (2005) 494–497.	189
GASCHAK, S., CHIZHEVSKY, I., ARKHIPOV, A., BERESFORD, N.A., BARNETT, C.L., “The transfer of ^{137}Cs and ^{90}Sr to wild animals within the Chernobyl exclusion zone”, Protection of the Environment from the Effects of Ionizing Radiation (Proc. Int. Conf. Stockholm, 2003), IAEA, Vienna (2005) (on accompanying CD-ROM).	190
GASO, I., SEGOVIA, N., MORTON, O., *In situ* biological monitoring of radioactivity and metal pollution in terrestrial snails *Helix aspersa* from a semiarid ecosystem, Radioprotection **37** (2002) 865–871.	191
GASO, M.I., SEGOVIA, N., MORTON, O., Environmental impact assessment of uranium ore mining and radioactive waste around a storage centre from Mexico, Radioprotection **40** (2005) S739–S745.	192
GASTBERGER, M., STEINHAUSLER, F., GERZABEK, M.H., LETTNER, H., HUBMER, A., Soil-to-plant transfer of fallout caesium and strontium in Austrian lowland and Alpine pastures, J. Environ. Radioact. **49** (2000) 217–233.	193
GILHEN, M., Current radionuclide activity concentrations in the Chernobyl Exclusion Zone and an assessment of the ecological impact, MSc Thesis, Liverpool Univ. (2001).	195
GREEN, N., HAMMOND, D.J., DAVIDSON, M.F., WILKINS, B.T., WILLIAMS, B., The radiological impact of naturally occurring radionuclides in foods from the wild, Rep. NRPB-W30, National Radiological Protection Board, Didcot, United Kingdom (2002).	196

Publication	ID number
HANSON, W.C., "Transuranic elements in arctic tundra ecosystems", Transuranic Elements in the Environment, Rep. DOE/TIC-22800 (HANSON, W.C., Ed.), USDOE, Washington, DC (1980) 441–458.	197
HASCHEK, W.M., LISK, D.J., STEHN, R.A, "Accumulation of lead in rodents from two old orchard sites in New York", Animals as Monitors of Environmental Pollutants (NIELSEN, S.W., MIGAKI, G., SCARPELLI., D.G., Eds), National Academy of Sciences, Washington, DC (1979) 192–199.	198
HENDRIKS, A.J., MA, W.C., BROUNS, J.J., DE RUITER-DIJKMAN, E.M., GAST, R., Modelling and monitoring organochlorine and heavy metal accumulation in soils, earthworms, and shrews in Rhine-delta floodplains, Arch. Environ. Contam. Toxicol. **29** (1995) 115–127.	199
HINTON, T.G., KNOX, A.S., KAPLAN, D.I., SARITZ, R., Phytoextraction of uranium and thorium by native trees in a contaminated wetland, J. Radioanal. Nucl. Chem. **264** (2005) 417–422.	200
HOLTZMAN, R.B., "Radium-226 and the natural airborne of ^{210}Pb and ^{210}Po in Arctic biota", Proc. First Int. Congr. on Radiation Protection, Italy, 1966, Part 2 (SNYDER, W.S., et al., Eds), Pergamon Press, New York (1968) 1087–1096.	201
HUNTER, B.A., JOHNSON, M.S., "Food chain relationship of copper and cadmium in herbivorous and insectivorous small mammals", Metals in Animals (OSBORN, D., Ed.), CEH Monkswood, Huntingdon (1984) 5–10.	202
HUSSEIN, M.A., OBUID-ALLAH, A.H., MOHAMMAD, A.H., SCOTT-FORDSMAND, J.J., EL-WAKEIL, K.F.A., Seasonal variation in heavy metal accumulation in subtropical population of the terrestrial isopod, *Porcellio laevis*, Ecotoxicol. Environ. Saf. **63** (2006) 168–174.	204
JAGOE, C.H., MAJESKE, A.J., OLEKSYK, T.K., GLENN, T.C., SMITH, M.H., Radiocesium concentrations and DNA strand breakage in two species of amphibians from the Chernobyl exclusion zone, Radioprotection Colloq. **37** (2002) C1 873–878.	205
JAMES, S.M., LITTLE, E.E., SEMLITSCH, R.D., The effect of soil composition and hydration on the bioavailability and toxicity of cadmium to hibernating juvenile American toads (*Bufo americanus*), Environ. Poll. **132** (2004) 523–532.	206
JANSSEN, M.P.M., GLASTRA, P., LEMBRECHTS, J.F.M.M., Uptake of Cs-134 from a sandy soil by two earthworm species: The effects of temperature, Arch. Environ. Contam. Toxicol. **31** (1996) 184–191.	207

Publication	ID number
JOHANSON, K.J., “Radiocaesium in game animals in Nordic countries”, Nordic Radioecology — The Transfer of Radionuclides through Nordic Ecosystems to Man (DAHLGARRD, H., Ed.), Elsevier, Amsterdam (1994) 287–301.	208
JOHANSON, K.J., BERGSTROM, R., Radiocesium transfer to man from moose and roe deer in Sweden, Sci. Total Environ. **157** (1994) 309–316.	209
JOHANSON, K.J., BERGSTROM, R., ERIKSSON, O., ERIXON, A., Activity concentrations of Cs-137 in moose and their forage plants in mid-Sweden, J. Environ. Radioact. **22** (1994) 251–267.	210
JOHNSON, M.S., ROBERTS, R.D., Distribution of lead, zinc and cadmium in small mammals from polluted environments, Oikos **30** (1978) 153–159.	211
JONES, K.C., PETERSON, P.J., DAVIES, B.E., MINSKI, M.J., Determination of silver in plants by flameless atomic-absorption spectrometry and neutron-activation analysis, Int. J. Environ. Anal. Chem. **21** (1985) 23–32.	212
KARASOV, W.H., JUNG, R.E., VAN DEN LANGENBERG, S., BERGESON, T.L.E., Field exposure of frog embryos and tadpoles along a pollution gradient in the Fox River and Green River ecosystem in Wisconsin, USA, Environ. Toxicol. Chem. **24** (2005) 942–953.	213
KAURANEN, P., MIETTINEN, J.K., Po-210 and Pb-210 in the Arctic food chain and the natural radiation exposure of Lapps, Health Phys. **16** (1969) 287–295.	214
LAPHAM, S.C., MILLARD, J.B., SAMET, J.M., Health implications of radionuclide levels in cattle raised near U mining and milling facilities in Ambrosia Lake, New Mexico, Health Phys. **56** (1989) 327–340.	215
LITTLE, C.A., “Plutonium in a grassland ecosystem“, Transuranic Elements in the Environment, Rep. DOE/TIC-22800 (HANSON, W.C., Ed.), USDOE, Washington, DC (1980) 420–440.	216
LITVER, B.Ya., NIZHNIKOV, A.I., RAMZAEV, P.V., TEPLYKH, L.A., TROITSKAYA, M.N., Pb-210, Po-210, Ra-226, Th-228 in the biosphere of Far North of USSR, Atomizdat, Moscow (1976) (in Russian).	217
LUBASHEVSKY, N., et al., Radioactive contamination of the Yamal Peninsula and assessment of radiation protection of its population, Ecology **4** (1993) 39–45 (in Russian).	218

Publication	ID number
MA, W.C., The influence of soil properties and worm-related factors on the concentration of heavy metals in earthworms, Pedobiologia **24** (1982) 109–119.	219
MAHON, D.C., MATHEWS, R.W., Uptake of naturally-occurring radioisotopes by vegetation in a region of high radioactivity, Can. J. Soil Sci. **63** (1983) 281–290.	220
MARKHAM, O.D., PUPHAL, K.W., FILER, T.D., Radionuclides in soil and water near a low level disposal site and potential ecological and human health impacts, Environ. Monit. Assess. **7** (1978) 422–428.	221
MIETELSKI, J.W., "Plutonium in the environment of Poland (a review)", Plutonium in the Environment (Proc. Second Int. Symp. Osaka, 1999), (KUDO, A., Ed.), Elsevier, Amsterdam (2001) 401–412.	222
MIETELSKI, J.W., et al., Cs-137, K-40, Sr-90, Pu-238, Pu-239+240, Am-241 and Cm243+244 in forest litter and their transfer to some species of insects and plants in boreal forests: Three case studies, J. Radioanal. Nucl. Chem. **262** (2004) 645–660.	223
MINISTRY OF AGRICULTURE, FISHERIES FOOD, Radioactivity in Food and the Environment, 1995, RIFE 1 (1996) 1–141.	224
MINISTRY OF AGRICULTURE, FISHERIES FOOD, SCOTTISH ENVIRONMENT PROTECTION AGENCY, Radioactivity in Food and the Environment, 1996, RIFE 2 (1997) 1–151.	225
MINISTRY OF AGRICULTURE, FISHERIES FOOD, SCOTTISH ENVIRONMENT PROTECTION AGENCY, Radioactivity in Food and the Environment, 1997, RIFE 3 (1998) 1–166.	226
MINISTRY OF AGRICULTURE, FISHERIES FOOD, SCOTTISH ENVIRONMENT PROTECTION AGENCY, Radioactivity in Food and the Environment, 1998, RIFE 4 (1999) 1–178.	227
MIRETSKY, G., ALEKSEEV, P.V., RAMZAEV, O.A., TEODOROVICH, I.E., SHUVALOV, I.E., "New radioecological data for the Russian Federation (from Alaska to Norway)", Environmental Radioactivity in the Arctic and Antarctic (STRAND, P., HOLM, E., Eds), Norwegian Radiation Protection Authority, Østerås (1993) 69–272.	228

Publication	ID number
MORGAN, J.E., MORGAN, A.J., The distribution of cadmium, copper, lead, zinc and calcium in the tissues of the earthworm *Lumbricus rubellus* sampled from one uncontaminated and four polluted soils, Oecologia **84** (1990) 559–566.	229
NELIN, P., Radiocesium uptake in moose in relation to home-range and habitat composition, J. Environ. Radioact. **26** (1995) 189–203.	230
NIELSEN, M.G., GISSEL-NIELSEN, G., Selenium in soil-animal relationships, Pedobiologia **15** (1975) 65–67.	231
NOTTEN, M.J.M., OOSTHOEK, A.J.P., ROZEMA, J., AERTS, R., Heavy metal concentrations in a soil-plant-snail food chain along a terrestrial soil pollution gradient, Environ. Pollut. **138** (2005) 178–190.	232
OPYDO, J., UFNALSKI, K., OPYDO, W., Heavy metals in Polish forest stands of *Quercus robur* and *Q. petraea*, Water Air Soil Pollut. **161** (2005) 175–192.	233
PETERSON, L.R., TRIVETT, V., BAKER, A.J.M., AGUIAR, C., POLLARD, A.J., Spread of metals through an invertebrate food chain as influenced by a plant that hyperaccumulates nickel, Chemoecology **13** (2003) 103–108.	234
PIETRZAKFLIS, Z., SKOWRONSKASMOLAK, M., Transfer of Pb-210 and Po-210 to plants via root-system and aboveground interception, Sci. Total Environ. **162** (1995) 139–147.	235
PIETRZAKFLIS, Z., RADWAN, I., ROSIAK, L., WIRTH, E., Migration of ^{137}Cs in soils and its transfer to mushrooms and vascular plants in mixed forest, Sci. Total Environ. **186** (1996) 243–250.	236
PIETZ, R.I., PETERSON, J.R., PRATER, J.E., ZENZ, D.R., Metal concentrations in earthworms from sewage sludge amended soils at a strip mine reclamation site, J. Environ. Qual. **13** (1984) 651–654.	237
POKARZHEVSKII, A., ZHULIDOV, A., “Halogens in soil animal bodies: a background level”, Contaminated Soil (VAN DEN BRINK, W.J., BOSMAN, R., ARENDT, F., Eds), Academic Publishers, Dordrecht (1995) 403–404.	238
POKARZHEVSKII, A.D., KRIVOLUTZKII, D.A., Background concentrations of Ra-226 in terrestrial animals, Biogeochem. **39** (1997) 1–13.	239

Publication	ID number
PRINCE, S.P.M., SENTHILKUMAR, P., SUBBURAM, V., Mulberry-Silkworm food chain — A template to assess heavy metal mobility in terrestrial ecosystems, Environ. Monit. Assess. **69** (2001) 231–238.	240
RAMZAEV, P.V., Hygienic Investigation of Radiation Situation in the Far North of the USSR Attributed to Global Fallout, PhD Thesis, Institute for Radiation Hygiene, Leningrad (1967) (in Russian).	241
RANTAVAARA, A.H., "Transfer of radiocesium through natural ecosystems to foodstuffs of terrestrial origin in Finland", Transfer of Radionuclides in Natural and Semi-natural Environments (DESMET, G., NASSIMBENI, P., BELLI, M., Eds), Elsevier Applied Science, New York (1990) 202–209.	242
READ, H.J., MARTIN, M.H., The effect of heavy metals on populations of small mammals from woodlands in Avon (England); with particular emphasis on metal concentrations in *Sorex araneus* L. and *Sorex minitus* L., Chemosphere **27** (1993) 2197–2211.	243
ROBERTS, R.D., JOHNSON, M.S., HUTTON, M., Lead contamination of small mammals from abandoned metalliferous mines, Environ. Pollut. **15** (1978) 61–69.	244
RYABOKON, N.I., SMOLICH, I.I., KUDRYASHOV, V.P., GONCHAROVA, R.I., Long-term development of the radionuclide exposure of murine rodent populations in Belarus after the Chernobyl accident, Radiat. Environ. Biophys. **44** (2005) 169–181.	245
SAMPLE, B.E., SUTER, G.W., Screening evaluation of the ecological risks to terrestrial wildlife associated with a coal ash disposal site, Hum. Ecol. Risk Assess. **8** (2002) 637–656.	246
SCHEUHAMMER, A.M., BOND, D.E., BURGESS, N.M., RODRIGUE, J., Lead and stable lead isotope ratios in soil, earthworms, and bones of American woodcock (*Scolopax minor*) from eastern Canada, Environ. Toxicol. Chem. **22** (2003) 2585–2591.	247
SHARMA, R.P., SHUPE, J.L., "Trace metals in ecosystems: Relationships of residues of copper, molybdenum, selenium, and zinc in animal tissues to those in vegetation and soil in the surrounding environment", Biological Implications of Metals in the Environment, Rep. CONF 750929 (DRUCKER, H., WILDUNG, R.E., Eds), National Technical Information Service, Springfield, VA (1977) 595–608.	248

Publication	ID number
SHEPPARD, S.C., EVENDEN, W.G., Critical compilation and review of plant-soil concentration ratios for uranium, thorium and lead, J. Environ. Radioact. **8** (1988) 255–285.	249
SHEPPARD, S.C., Application of IUR soil plant database to Canadian settings, AECL-11474, Atomic Energy of Canada Limited, Pinawa (1995).	250
SHEPPARD, S.C., EVENDEN, W.G., MacDONALD, C.R., Variation among chlorine concentration ratios for native and agronomic plants, J. Environ. Radioact. **43** (1999) 65–76.	251
SHEPPARD, S.C., EVENDEN, W.G., Characteristics of plant concentration ratios assessed in a 64-site field survey of 23 elements, J. Environ. Radioact. **11** (1990) 15–36.	252
TSVETNOVA, O.V., SHEGLOV, A.I., ^{137}Cs in components of natural ecosystems in the 30-km zone affected by Smolenskaya nuclear power plant, Vestnik Moskovskogo Universiteta, Pochvovedenie **17** (2009) 3–8 (in Russian).	253
SKUBALA, P., KAFEL, A., Oribatid mite communities and metal bioaccumulation in oribatid species (*Acari*, *Oribatida*) along the heavy metal gradient in forest ecosystems, Environ. Pollut. **132** (2004) 51–60.	254
STANICA, F., “Accumulation of different metals in apple tree organs from an unfertilised orchard”, IUR Soil to Plant Transfer Working Group (GERZABEK, M.H., Ed.), International Union of Radioecology, Cadarache, France (1999) 96–100.	255
STARK, K., AVILA, R., WALLBERG, P., Estimation of radiation doses from ^{137}Cs to frogs in a wetland ecosystem, J. Environ. Radioact. **75** (2004) 1–14.	256
TOAL, M.E., COPPLESTONE, D., JOHNSON, M.S., JACKSON, D., JONES, S.R., Quantifying ^{137}Cs aggregated transfer coefficients in a semi-natural woodland ecosystem adjacent to a nuclear reprocessing facility, J. Environ. Radioact. **63** (2002) 85–103.	257
TROITSKAYA, M.N., Hygienic Assessment of Increased Levels of Exposure of Population of the Far North, PhD Thesis, Institute for Radiation Hygiene, Leningrad (1981) (in Russian).	258
VARSKOG, P., NAEUMANN, R., STEINNES, E., Mobility and plant availability of radioactive Cs in natural soil in relation to stable Cs, other alkali elements and soil fertility, J. Environ. Radioact. **22** (1994) 43–53.	259

Publication	ID number
VERHOVSKAYA, I.N., Radioecological Investigations in Natural Biogeocenoses, Nauka, Moscow (1972) (in Russian).	260
WHICKER, F.W., LITTLE, C.A., WINSOR, T.F., “Plutonium behaviour in the terrestrial environs of the Rocky Flats installation”, Environmental Surveillance around Nuclear Installations (Proc. Symp. Warsaw, 1973), Vol. II, IAEA, Vienna (1974) 89–103.	261
WILLIAMSON, P., EVANS, P.R., Lead: Levels in roadside invertebrates and small mammals, Bull. Environ. Cont. Toxicol. **8** (1972) 280–288.	262
WOOD, M.D., et al., Application of the ERICA Integrated Approach at the Drigg coastal sand dunes, J. Environ. Radioact. **99** (2008) 1484–1495.	263
YOSHIDA, S., MURAMATSU, Y., PEIJNENBURG, W.J.G.M., Multi-element analyses of earthworms for radioecology and ecotoxicology, Radioprotection **40** (2005) S491–S495.	264
ANJOS, R.M., MOSQUERA, B., SANCHES, N., CAMBUI, C.A., MERCIER, H., Caesium, potassium and ammonium distribution in different organs of tropical plants, Environ. Exper. Bot. **65** (2009) 111–118.	265
APPS, M.J., DUKE, M.J.M., STEPHENS NEWSHAM, L.G., A study of radionuclides in vegetation on abandoned uranium tailings, J. Radioanal. Nucl. Chem. Art. **123** (1988) 133–147.	266
BARNETT, C.L., GASCHAK, S., BERESFORD, N.A., HOWARD, B.J., MAKSIMENKO, A., Radionuclide activity concentrations in two species of reptiles from the Chernobyl exclusion zone, Radioprotection **44** (2009) 537–542.	267
BERESFORD, N.A., et al., Estimating the exposure of small mammals at three sites within the Chernobyl exclusion zone — A test application of the ERICA Tool, J. Environ. Radioact. **99** (2008) 1496–1502.	268
BOUDA, S., Uranium in Dartmoor plants of southwest England, J. Geochemical Exploration **26** (1986) 145–150.	269
BRAHIM, S.A., WHICKER, F.W., Plant-soil concentration ratios of Ra-226 for contrasting sites around an active U mine-Mill, Health Phys. **55** (1988) 903–910.	270
DAVY, D.R., O’BRIEN, B.G., The fate of discharged heavy metal in Rum Jungle Environmental Studies, Rep. AAEC/E365, Australian Atomic Energy Commission (1975).	271

Publication	ID number
DOWDALL, M., et al., Uptake of radionuclides by vegetation at a High Arctic location, Environ. Pollut. **133** (2005) 327–332.	272
GERZABEK, M.H., STREBL, F., TEMMEL, B., Plant uptake of radionuclides in lysimeter experiments, Environ. Pollut. **99** (1998) 93–103.	273
GREEMAN, D.J., ROSE, A.W., WASHINGTON, J.W., DOBOS, R.R., CIOLKOSZ, E.J., Geochemistry of radium in soils of the Eastern United States, Appl. Geochem. **14** (1999) 365–385.	274
GWYNN, J.P., FUGLEI, E., DOWDAL, M., Cs-137 in arctic foxes (*Alopex lagopus*) on Svalbard, J. Environ. Radioact. **92** (2007) 30–40.	275
HARIDASAN, P.P., PAUL, A.C., DESAI, M.V.M., Natural radionuclides in the aquatic environment of a phosphogypsum disposal area, J. Environ. Radioact. **53** (2001) 155–165.	276
IBRAHIM, S.A., WHICKER, F.W., Plant accumulation and plant-soil concentration ratios of Pb-210 and Po-210 at various sites within a uranium mining and milling operation, Environ. Experim. Bot. **27** (1987) 203–213.	277
IBRAHIM, S.A., WHICKER, F.W., Comparative plant uptake and environmental behavior of U-series radionuclides at a uranium mine-mill, J. Radioanal. Nucl. Chem-Art. **156** (1992) 253–267.	278
IDIZ, E.F., CARLISLE, D., KAPLAN, I.R., Interaction between organic matter and trace metals in a uranium rich bog, Kern County, California, USA, Appl. Geochem. **1** (1986) 573–590.	279
LINSALATA, P., et al., An assessment of soil-to-plant concentration ratios for some natural analogs of the transuranic elements, Health Phys. **56** (1989) 33–46.	280
LINSALATA, P., et al., Transport pathways of Th, U, Ra and La from soil to cattle tissues, J. Environ. Radioact. **10** (1989) 115–140.	281
MASCANZONI, D., Long-term transfer from soil to plant of radioactive corrosion products, Environ. Pollut. **57** (1989) 49–62.	285
MASCANZONI, D., Plant uptake of activation and fission-products in a long-term field-study, J. Environ. Radioact. **10** (1989) 233–249.	286
MISLEVY, P., BLUE, W.G., ROESSLER, C.E., Productivity of clay tailings from phosphate mining 1, Biomass Crops, J. Environ. Qual. **18** (1989) 95–100.	287

Publication	ID number
MORTVEDT, J.J., Plant and soil relationships of uranium and thorium decay series radionuclides — A review, J. Environ. Qual. **23** (1994) 643–650.	288
PALLER, M.H., JANNICK, T.G., WIKE, L.D., Concentration ratios for small mammals collected from the exposed sediments of a ^{137}Cs contaminated reservoir, J. Environ. Radioact. **90** (2006) 224–235.	289
PAUL, A.C., PILLAI, K.C., Transfer and uptake of radium in a natural and in a technologically modified radiation environment, J. Environ. Radioact. **3** (1986) 55–73.	290
RUMBLE, M.A., BJUGSTAD, A.J., Uranium and radium concentrations in plants growing on uranium mill tailings in South-Dakota, Reclam. Reveg. Res. **4** (1986) 271–277.	292
SIMON, S.L., FRALEY, L., Uptake by sagebrush of uranium progeny injected in situ, J. Environ. Qual. **15** (1986) 345–350.	293
STEINNES, E., GAARE, E., ENGEN, S., Influence of soil acidification in southern Norway on the ^{137}Cs exposure to moose? Sci. Total Environ. **407** (2009) 3905–3908.	294
TOME, F.V., RODRIGUEZ, P.B., LOZANO, J.C., Distribution and mobilization of U, Th and Ra-226 in the plant-soil compartments of a mineralized uranium area in south-west Spain, J. Environ. Radioact. **59** (2002) 41–60.	295
TOME, F.V., RODRIGUEZ, P.B., LOZANO, J.C., Soil-to-plant transfer factors for natural radionuclides and stable elements in a Mediterranean area, J. Environ. Radioact. **65** (2003) 161–175.	296
VANDENHOVE, H., et al., Assessment of radiation exposure in the uranium mining and milling area of Mailuu Suu, Kyrgyzstan, J. Environ. Radioact. **88** (2006) 118–139.	298
BEAK CONSULTANTS, Survey of data on the radionuclide content of fish in Canada, Report prepared for the Atomic Energy Control Board, Ottawa, Canada (1987).	299
BIRD, G., Fate of Co-60 and Cs-134 added to the hypolimnion of a Canadian Shield Lake: Accumulation in biota, Can. J. Fish. Aquat. Sci. **55** (1998) 987–998.	300
BLAYLOCK, B.G., Radionuclide data bases available for bioaccumulation factors for freshwater biota, Nucl. Saf. **23** (1982) 427–438.	301

Publication	ID number
CARLSSON, S., LIDÉN, K., ^{137}Cs and potassium in fish and littoral plants from a humus-rich oligotrophic lake 1961–1976, Oikos **30** (1978) 126–132.	302
CARVALHO, F.P., OLIVEIRA, J.M., LOPES, I., BATISTA, A., Radionuclides from past uranium mining in rivers of Portugal, J. Environ. Radioact. **98** (2007) 298–314.	303
CHAPMAN, W.H., FISHER, H.L., PRATT, M.W., “Concentration factors of chemical elements in edible aquatic organisms”, Rep. UCRL-50564, National Technical Information Service, Springfield, VA (1968).	304
CLULOW, F.V., DAVE, N.K., LIM, T.P., AVADHANULA, R., Radium-226 in water, sediments, and fish from lakes near the city of Elliot Lake, Ontario, Canada, Environ. Pollut. **99** (1998) 13–28.	305
EDGINGTON, D.N., WAHLGREN, M.A., MARSHALL, J.S., “The behaviour of plutonium in aquatic ecosystems: A summary of studies on the Great Lakes”, Environmental Toxicity of Aquatic Radionuclides: Models and Mechanisms (MILLER, M.W., STANNARD, J.N., Eds), Ann Arbor Science Publishers, Ann Arbor, MI (1976) 45–79.	306
EMERY, R.M., KLOPFER, D.C., GARLAND, T.R., WEIMER, W.C., “The ecological behaviour of plutonium and americium in a freshwater ecosystem”, PNL Annual Report for 1975, Part 2, Ecological Sciences, Rep. BNWL2000, Battelle Pacific Northwest Laboratories, Richland, WA (1976).	307
EYMAN, L.D., TRABALKA, J.R., “Patterns of transuranic uptake by aquatic organisms: Consequences and implications”, Transuranic Elements in the Environment (HANSON, W.C., Ed.), Technical Information Center, USDOE, Oak Ridge, TN (1980) 612–624.	308
GARTEN, C.T., TRABALKA, J.R., BOGLE, M.A., “Comparative food chain behaviour and distribution of actinide elements in and around a contaminated fresh-water pond”, Int. Symp. on Migration in the Terrestrial Environment of Long-lived Radionuclides from the Nuclear Fuel Cycle, Knoxville, TN, 1981 (1981) 12–24.	309
GRAHAM, R.V., BLAYLOCK, B.G., HOFFMAN, F.O., FRANK, M.L., Comparison of selenomethionine and selenite cycling in freshwater experimental ponds, Water Air Soil Pollut. **62** (1992) 25–42.	310

Publication	ID number
HAMEED, P.S., ASOKAN, R., IYENGAR, M.A.R., KANNAN, V., The freshwater mussel *Parreysia favidens* (Benson) as a biological indicator of Polonium-210 in a riverine system, Chem. Ecol. **8** (1993) 11–18.	311
HAMEED, P.S., SHAHEED, K., SOMASUNDARAM, S.S.N., A study on distribution of natural radionuclide polonium-210 in a pond ecosystem, J. Biosci. **22** (1997) 627–634.	312
HEWETT, C.J., JEFFERIES, D.F., The accumulation of radioactive caesium from food by the plaice (*Pleuronectes platessa*) and the brown trout (*Salmo trutta*), J. Fish Biol. **13** (1978) 143–153.	313
JINKS, S.M., EISENBUD, M., Concentration factors in the aquatic environment, Radiat. Data Rep. **13** (1972) 243–247.	314
KEVERN, N.R., SPIGARELLI, S.A., "Effects of selected limnological factors on the accumulation of cesium-137 fallout by largemouth bass (*Micropterus salmoides*)", Proc. 3rd Natl Symp. on Radioecology, Oak Ridge, TN (1971) 354–360.	315
KRUMHOLZ, L.A., Observations on the food population of a lake contaminated by radioactive wastes, Bull. Am. Mus. Nat. Hist. **110** (1956) 277–368.	317
LAMBRECHTS, A., FOULQUIER, L., GARNIER LAPLACE, J., Natural radioactivity in the aquatic components of the main French rivers, Radiat. Prot. Dosimetry **45** (1992) 253–256.	318
LINDNER, G., et al., "Biological transfer and sedimentation of Chernobyl radionuclides in Lake Constance", Large Lakes: Ecological Structure and Function, Lake Constance (TILZERAND, M.M., SENUYA, C., Eds), Springer-Verlag, Berlin (1990) 265–287.	319
MARCHYULENENE, E.-D.P., Exchange of certain radionuclides between the environment and fresh-water algae, Ecologiya **9** (1978) 163–165 (in Russian).	320
MARSHALL, J.S., WAILERAND, B.J., YAGUCHI, E.M., Plutonium in the Laurentian Great Lakes: Food-chain relationship, Verh. Internat. Verein Limnol. **19** (1975) 323–329.	321
NELSON, D.J., "Cesium-137, and potassium concentrations in white crappie and other Clinch River fish", Proc. 2nd Natl Symp. on Radioecology, Ann Arbor, MI, 1967, Rep. CONF-670503 (NELSON, D.J., EVANS, F.C., Eds), US Atomic Energy Commission, Washington, DC (1969) 240–248.	322

Publication	ID number
NEWMAN, M.C., BRISBIN, I.L., Jr., Variation of ^{137}Cs levels between sexes, body sizes, and collection localities of mosquitofish, *Gambusia holbrooki* (Girard, 1859), inhabiting a reactor cooling reservoir, J. Environ. Radioact. **12** (1990) 131–141.	323
OPHEL, I.L., FRASER, J.M., JUDD, J.M., "Concentration factors and bottom sediments of a freshwater lake", Radioecology Applied to the Protection of Man and His Environment, Commission of the European Communities, Luxembourg (1972) 509–530.	324
PRESTON, D.F., DUTTON, J.W.R., The concentrations of caesium-137 and strontium-90 in the flesh of brown trout taken from rivers and lakes in the British isles between 1961 and 1966: The variables determining the concentrations and their use in radiological assessments, Water Res. **1** (1967) 475–496.	326
ROWAN, D.J., RASMUSSEN, J.B., Bioaccumulation of radiocesium by fish — The influence of physicochemical factors and trophic structure, Can. J. Fish. Aqua. Sci. **51** (1994) 2388–2410.	327
SHAHEED, K., SOMASUNDARAM, S.S.N., HAMEED, P.S., IYENGAR, M.A.R., A study of polonium-210 distribution aspects in the riverine ecosystem of Kaveri, Tiruchirappalli, India, Environ. Pollut. **95** (1997) 371–377.	328
SHORTI, Z.F., PALUMBO, R.F., OLDON, P.B., DONALDSON, J.R., Uptake of I-131 by biota of Fern Lake, Washington, in a laboratory and field experiment, Ecology **50** (1969) 979–989.	329
TRAPEZNIKOV, A.V., et al., Contamination of the Techa River, the Urals, Health Phys. **65** (1993) 481–488.	331
VANDERPLOEG, H.A., PARZCYK, D.C., WILCOX, W.H., KERCHNER, J.R., JAYE, S.V., Bioaccumulation Factors for Radionuclides in Freshwater Biota, Rep. ORNL-5002, Oak Ridge Natl Lab., Oak Ridge, TN (1975).	332
YANKOVICH, T.L., Compilation of Concentration Ratios for Aquatic Non-human Biota Collected by the Canadian Power Reactors Sector, CANDU Owners Group, Toronto, Ontario (2010) 7.	333
COGEMA — CONOR PACIFIC ENVIRONMENTAL TECHNOLOGIES, Cluff Lake Decommissioning Comprehensive Study, Sections on: Existing Environment and Assessment of Potential Impacts, Saskatoon, Saskatchewan (2000).	334

Publication	ID number
AREVA, Shea Creek Project Area, Environmental Baseline Investigation 2007–2009, Draft Report, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2010).	336
COGEMA, Cluff Lake Uranium Mine 2004, Environmental Effects Monitoring and Environmental Monitoring Programs, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2005).	339
AREVA, Pore-water Study Using In Situ Dialysis for the Link Lakes at the Rabbit Lake Operation, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2007).	340
COGEMA, McClean Lake Project 1998/99 Environmental Monitoring Program, Prepared by Conor Pacific Environmental Technologies, Saskatoon, Saskatchewan (2000).	342
COGEMA, Cluff Lake Project, Suspension of Operations and Eventual Decommissioning of the TMA, Biological Environment, Prepared by Conor Pacific Environmental Technologies, Saskatoon, Saskatchewan (1998).	343
VERMEULEN, F., et al., Habitat type-based bioaccumulation and risk assessment of metal and As contamination in earthworms, beetles and woodlice, Environ. Pollut. **157** (2009) 3098–3105.	344
AREVA, 2003 Status of the Environment Report, McClean Lake Operation, Prepared by Jacques Whitford Environmental Ltd, Saskatoon, Saskatchewan (2003).	345
COGEMA, McClean Lake Project, Baseline Investigation 1993–1995, Prepared by Terrestrial Aquatic Environmental Managers Ltd, Saskatoon, Saskatchewan (1996).	346
COGEMA RESOURCES CANADA (AREVA), McClean Lake Operation Status of the Environment Report, Assessment Period 2003–2005, Saskatoon, Saskatchewan (2006).	347
AREVA RESOURCES CANADA (AREVA), McClean Lake Operation Status of the Environment Report, Assessment Period 2006–2008, Saskatoon, Saskatchewan (2009).	348
CAMECO, 2008 Lichen and Soil Monitoring Program at the Key Lake Operation, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2009).	349

Publication	ID number
CAMECO, Beaverlodge Decommissioning, Results of the 2002 Aquatic Biological Investigations at the Dubyna Mine Site Area, Northern Saskatchewan, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2003).	350
CAMECO, Aquatic, Terrestrial, and Heritage Studies for the Rabbit Lake Optimism Tailings Disposal Site, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2009).	354
CAMECO, Biophysical Baseline Program for the Millennium Project Area, Draft Report, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2008).	355
CAMECO, Cigar Lake Project, 2007 Comprehensive Aquatic Environment Monitoring Report, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2008).	356
CAMECO, Pore-water Study Using In Situ Dialysis for the Link Lakes at the Rabbit Lake Operation, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2007).	357
CAMECO, Rabbit Lake Operation, 2008 Comprehensive Aquatic Environment Monitoring Report, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2009).	358
CAMECO, Results of the 2009 Key Lake Northern Pike Chemistry Monitoring Program, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2009).	359
CAMECO, Technical Memorandum — Water Quality Results from Eagle Drill Hole and Dubyna Drill Hole, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2001).	361
CAMECO, The Cigar Lake Uranium Project, Environmental Effects Monitoring and Biological Monitoring Studies 2004 Interpretive Report, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2005).	363
CAMECO, McArthur River Operation, 2007, Comprehensive Aquatic Environment Monitoring Report, Prepared by Canada North Environmental Services, Saskatoon, Saskatchewan (2008).	364

Publication	ID number
CAMECO, Current Period Environmental Monitoring Program for the Beaverlodge Mine Site — Revision 2, Prepared by Conor Pacific Environmental Technologies, Saskatoon, Saskatchewan (2000).	371
CAMECO, Key Lake State of the Environment Report, Assessment Period 1993–1998, Prepared by Conor Pacific Environmental Technologies and SENES Consultants Ltd, Saskatoon, Saskatchewan (2000).	373
CAMECO, Key Lake Operation Comprehensive Environmental Effects Monitoring Program Interpretive Report, Prepared by Golder Associates, Saskatoon, Saskatchewan (2005).	374
CAMECO, McArthur River Operation Comprehensive Environmental Effects Monitoring Program, Interpretative Report, Prepared by Golder Associates, Saskatoon, Saskatchewan (2005).	376
CAMECO, Rabbit Lake Environmental Effect Monitoring/Environmental Monitoring Program, 2002, Prepared by Golder Associates, Saskatoon, Saskatchewan (2003).	377
CAMECO, Rabbit Lake Uranium Operation Comprehensive Environmental Effect Monitoring Program Interpretive Report, Prepared by Golder Associates, Saskatoon, Saskatchewan (2005).	378
BRITISH NUCLEAR FUELS, ROBERT Database, BNFL Statutory Environmental Database 1971–2004.	381
DRAGOVIC, S., HOWARD, B.J., CABORN, J.A., BARNETT, C.L., MIHAILOVIC, N., Transfer of natural and anthropogenic radionuclides to ants, bryophytes and lichen in a semi-natural ecosystem, Environ. Monit. Assess. **166** (2010) 667–686.	382
SAXEN, R., OUTOLA, I., “Polonium-210 in freshwater and brackish environment”, Deliverable Report for NKS-B, October 2008, GAPRAD — Filling Knowledge Gaps in Radiation Protection Methodologies for Non-human Biota (GJELSVIK, R., BROWN, J.E., Eds), Nordic Nuclear Safety Research, Roskilde, Denmark (2009) 13–21.	383
BROWN, J., et al., Filling Knowledge Gaps in Radiation Protection Methodologies for Non-human Biota, Final Summary Report, Nordic Nuclear Safety Research Report, NKS, Roskilde, Denmark **17** (2009).	384

Publication	ID number
YUN, J.Y., et al., Marine Environmental Radioactivity Survey Data, Rep. KINS/ER-092, Vol. 3, Korea Institute of Nuclear Safety (2007).	385
LEE, D.M., et al., Marine Environmental Radioactivity Survey Data, Rep. KINS/ER-092, Vol. 2, Korea Institute of Nuclear Safety (2006).	386
WILSON, R.C., WATTS, S.J., VIVES I BATLLE, J., McDONALD, P., Laboratory and field studies of polonium and plutonium in marine plankton, J. Environ. Radioact. **100** (2009) 665–669.	387
DRAGOVIC, S., JANKOVIC MANDIC, L.J., Transfer of radionuclides to ants, mosses and lichens in seminatural ecosystems, Radiat. Environ. Biophys. **49** (2010) 625–634.	388
OUTOLA, I., SAXEN, R., HEINÄVAARA, S., Transfer of Sr-90 into fish in Finnish lakes, J. Environ. Radioact. **100** (2009) 657–664.	389
ADAMOVA, L.I., KIRUSHEVA, E.I., MUSAKKA, T.N., "Radioecology of ecosystem with high level of natural radioactivity, Uranium concentration and chemical forms in alluvial-soddy soils", Proc. of Institute of Biology, Komi Scientific Center, Ural Division of USSR Academy of Sciences **81** (1987) 105–112 (in Russian).	390
AHMAD, M.K., ISLAM, S., RAHMAN, S. HAQUE, M.R., ISLAM, M.M., Heavy metals in water, sediment and some fishes of Buriganga River, Bangladesh, Int. J. Environ. Res. **4** (2010) 321–332.	391
AL-KAHTANI, M.A., Accumulation of heavy metals in talapia fish (*Oreochromis niloticus*) from Al-Khadoud spring, Al-Hassa, Saudia Arabia, Amer. J. Appl. Sci. **6** (2009) 2024–2029.	392
ANTONENKO, T.M., Radioecological Study of ^{137}Cs Accumulation, Distribution and Migration in the Water Bodies of the Steppe Zone of the Ukraine, PhD Thesis, INBUM Sevastopol (1978) (in Russian).	393
APOSTOAER, A.I., et al., Radionuclide Releases from X-10 to the Clinch River — Measurements in the Flesh of Edible Species of Fish, Task 4 Report, Radionuclide Release to the Clinch River from White Oak Creek on the Oak Ridge Reservation — An Assessment of Historical Quantities, Chemrisk/SENES Oak Ridge Inc., Oak Ridge, TN (1999).	394

Publication	ID number
BEKYASHEVA, T.A., SHUTOV, V.N., BASALAYEVA, L.N., “Effects of soil properties on radiocesium accumulation by natural grasses”, Radioecology of Soil and Plants, Vol. 1, 3rd All-Union Conf. on Agricultural Radiology, Obninsk, 1990, Russian Institute for Agricultural Radiology and Agroecology, Obninsk (1990) 49–50.	395
BOLSUNOVSKY, A.I.A., ERMAKOV, A.I., BURGER, M., DEGERMENDZY, A.G., SOBOLEV, A.I., Accumulation of artificial radionuclides by the Yenisei river aquatic plants in the area affected by the activity of the mining-and-chemical combine, Radiatsionnaya Biologiya Radioekologiya **42** (2002) 194–199 (in Russian).	396
BRENNER, M., SMOAK, J.M., LEEPER, D.A., STREUBERT, M., BAKER, S.M., Radium-226 accumulation in Florida freshwater mussels, Limnol. Oceanogr. **52** (2007) 1614–1623.	397
BURTON, D.T., TURLEY, S.D., FISHER, D.J., GREEN, D.J., SHEDD, T.R., Bioaccumulation of total mercury and monomethylmercury in earthworms *Eisenia fetida*, Water Air Soil Pollut. **170** (2006) 37–54.	398
CULIOLI, J.-L., FOUQUOIRE, A., CALENDINI, S., MORI, C., ORSINI, A., Trophic transfer of arsenic and antinomy in a freshwater ecosystem: A field study, Aquat. Toxicol. **94** (2009) 286–293.	399
DRITCHKO, V.F., PONIKAROVA, T.M., EFREMOVA, M.A., Uptake ^{137}Cs in *Bromopsis inermis* L. from peat soil on surface-applied K-fertilizer, Int. Conf. on Radiology of Peatlands, St. Petersburg (1994) 75–79.	400
DUBYNIN, O.D., Migration of ^{129}I in a freshwater ecosystem, Ekologiya **5** (1987) 91–92 (in Russian).	401
DUSHAUSKENE-DUZH, N.-R.F., A Comparative Study into Accumulation of Strontium-90 and Lead-210 in Fresh Water Hydrobionts of the Lithuanian Republic, Candidate Thesis, PhD Thesis, INBUM Sebastopol (1969) (in Russian).	402
FESENKO, S.V., SPIRIDONOV, S.I., SANZHAROVA, N.I., ANISIMOV, V.S., ALEXAKHIN, R.M., Modelling of ^{137}Cs migration in soil-plant system on peaty soils, which was contaminated after the accident at the Chernobyl NPP, Ekologiya **3** (2002) 185–182 (in Russian).	403
FIRSAKOVA, S.K., GREBENSCHIKOVA, N.V., Assimilation of ^{90}Sr and ^{137}Cs by Meadow Vegetation from Sod Layer, Reports of USSR Academy of Agricultural Sciences, Moscow **9** (1980) 19–22 (in Russian).	404

Publication	ID number
GASHCHAK, S., BERESFORD, N.A., International Radioecology Laboratory, Slavutych, Ukraine; Centre for Ecology and Hydrology, United Kingdom, Personal communication, 2009.	405
GASHCHAK, S., BERESFORD, N.A., MAKSIMENKO, A., VLASCHENKO, A.S., Strontium-90 and caesium-137 activity concentrations in bats in the Chernobyl exclusion zone, Radiat. Environ. Biophys. **49** (2010) 635–644.	406
GILES, M.S., TWINING, J.R., WILLIAMS, A.R., JEFFREE, R.A., DOMEL, R.U., "Rehabilitation of former nuclear test sites in Australia", Final Report of the Technical Assessment Group for the Maralinga Rehabilitation Project — Study No. 2, Radioecology, Technical Assessment Group, AGPS, Canberra (1990).	407
GOLUBEV, A.P., SIKORSKI, V.G., KALININ, V.N., AFONIN, V.Yu., CHEKAN, G.S., The radioactive contamination dynamics of water body ecosystems of different types in the Chernobyl atomic station alienation zone, Radiobiologiya **47** (2007) 326–329 (in Russian).	408
GREBENSHCHIKOVA, N.V., et al., Investigations of radiocaesium behavior in soil-vegetation cover of Belorussia Polesje after the accident at the Chernobyl NPP, Agrochimiya **1** (1992) 91–99 (in Russian).	409
GUDKOV, D.I., et al., Radionuclides Sr-90, Cs-137, Pu-239+240 and Am-241 in macrophytes of Krasnenskaya holm: Species specificity of concentration and distribution in phytocenoses components, Radiatsionnaya Biologiya Radioekologiya (2001) 206–217 (in Russian).	410
GUDKOV, D.I., et al., The distribution of the radionuclides in the main components of lake ecosystems within the Chernobyl NPP exclusion zone, Radiatsionnaya Biologiya Radioekologiya **45** (2005) 271–280 (in Russian).	411
ILIENKO, A.I., RYABTSEV, I.A., "Strontium-90 and cesium-137 in food chains of freshwater biogeocenosis", Radioecological Problems of NPP Cooling Ponds, Proc. of Institute of Ecology of Plants and Animals, Ekaterinburg (1978) 81–85 (in Russian).	412
ILYIN, M.I., PEREPELYATNIKOV, G.P., PRISTER, B.S., Effects of radical improvement of natural meadows in the Ukrainian Polessie on radiocaesium transfer from soil into sward, Agrochimiya **1** (1991) 101–105 (in Russian).	413

Publication	ID number
KHOMICH, V.K., "On biological peculiarities of plants and absorption coefficients — Kn and Kd — for various agricultural crops after the Chernobyl accident", Radioecology of Soil and Plants, Vol. 1, 3rd All-Union Conf. on Agricultural Radiology, Obninsk, 1990, Russian Institute for Agricultural Radiology, Obninsk (1990) (in Russian).	414
KRYSHEV, A.I., RYABOV, I.N., Model for calculation of fish contamination by ^{137}Cs and its application for lake Kozhanovskoe (Bryansk region), Radiatsionnaya Biologiya Radioekologiya **45** (2005) 338–345 (in Russian).	415
KULIKOV, N.V., CHEBOTINA, M.Ya., "Radioecology of fresh water biosystems", Proc. Institute of Ecology of Plants and Animals, Nauka, Sverdlovsk (1988) (in Russian).	416
KULIKOV, N.V., CHEBOTINA, M.Ya., BOCHENIN, E.F., Sr-90 and ^{137}Cs accumulation by some components of charophytes biocenosis, Ekologiya **8** (1977) 46–53 (in Russian).	417
KULIKOV, N.V., KULIKOVA, V.G., On ^{90}Sr and ^{137}Cs accumulation by some representatives of freshwater fish in natural conditions, Ekologiya **5** (1977) 45–49 (in Russian).	418
KULIKOV, N.V., MOLCHANOVA, I.V., "Continental radioecology", Soil and Freshwater Ecosystems, Nauka, Moscow (1975) (in Russian).	419
LEVINA, S.G., SHIBKOVA, D.Z., DERYAGIN, V.V., ZAKHAROV, S.G., POPOVA, I.Ya., Current radioecological conditions of Lake Maly Igish located on the axial part of the East-Urals Radioactive Trace, Radiatsionnaya Biologiya Radioekologiya **46** (2006) 111–116 (in Russian).	420
LEVINA, S.G., ZEMEROVA, Z.P., SHIBKOVA, D.Z., DERYAGIN, V.V., POPOVA, I.Ya., ^{90}Sr and ^{137}Cs in higher aquatic plants of some water basins on the East-Urals radioactive trace: Species features of radionuclide concentration, Radiatsionnaya Biologiya Radioekologiya **46** (2006) 575–583 (in Russian).	421
LEVINA, S.G., POPOVA, I.Ya., ZAKHAROV, S.G., UDACHIN, V.N., DERYAGIN, V.V., "Radioecological and hydrochemical aspects of the man-made radionuclide behaviour in aquatic ecosystems illustrated by the East Urals Radioactive Trail lakes", Problems of Radioecology and Adjacent Disciplines (URUSKUL, B., IGISH, B., SUNGUL, Eds), Institute of Ecology of Plants and Animals, Ekaterinburg (2005) 375–392 (in Russian).	422

Publication	ID number
LOWSON, R.T., WILLIAMS, A.R., "A baseline radioecological survey, Manyingee Uranium Prospect, Western Australia", Australian Atomic Energy Commission, Research Establishment, Lucas Heights Research Laboratories, Lucas Heights, New South Wales (1985).	423
LUBIMOVA, S.A., "EDTA effects on radioactive isotopes uptake by plants from the soil", Radioactive Isotopes in System Soil-plants (LUBIMOVA, S.A., KULIKOV, N.V., Eds), Proc. Institute of Ecology of Plants and Animals, Sverdlovsk (1972) 59–63 (in Russian).	424
LUBIMOVA, S.A., "Accumulation of radionuclides by some species of pondweed", Accumulation of Radioisotopes by Aquatic Plants (LUBIMOVA, S.A., KULIKOV, N.V., Eds), Proc. Institute of Ecology of Plants and Animals, Sverdlovsk (1978) 8–9 (in Russian).	425
MAKEEV, A.P., PYTNOV, Yu.N., POVOLYEV, A.P., "Uranium accumulation by wild and sown grasses in Kazakhstan", Radioecology of Soil and Agricultural Plants, Vol. 1, 2nd All-Union Conf. on Agricultural Radiology, Russian Institute for Agricultural Radiology, Obninsk (1984) 87.	426
MALIK, N., BISWAS, A.K., QURESHI, T.A., BORANA, K., VIRHA, R., Bioaccumulation of heavy metals in fish tissues of a freshwater lake of Bhopal, Environ. Monit. Assess. **160** (2010) 267–276.	427
MARCHULENENE, D.P., LEGIN, V.K., KUZNETSOV, Yu.V., SIMONYAK, Z.N., POSPELOV, Yu.V., Comparative study of plutonium and thorium accumulation by hydrophytes, Ekologiya **3** (1988) 69–70 (in Russian).	428
MARTIN, P., HANCOCK, G.J., JOHNSTON, A., MURRAY, A.S., Natural-series radionuclides in traditional north Australian Aboriginal foods, J. Environ. Radioact. **40** (1998) 37–58.	429
MIROSHICHENKO, T.A., DAVYDOV, A.I., US'AROV, A.G., "Effects of genesis and physico-chemical properties of soils on ^{238}U and ^{232}Th accumulation by natural vegetation on uplands of the Central Caucasus", Radioecology of Soil and Plants, Vol. 1, 3rd All-Union Conf. on Agricultural Radiology, Obninsk, 1990, Russian Institute for Agricultural Radiology, Obninsk (1990) 80 (in Russian).	430
MOHAMED, F.A.S., Bioaccumulation of selected metals and histopathological alterations in tissues of *Oreochromis niloticus* and *Lates niloticus* from Lake Nasser, Egypt, Global Veterinaria **2** (2008) 205–218.	431

Publication	ID number
MOLCHANOVA, I.V., KARAVAEVA, E.N., “Accumulation of radionuclides by herbs in Beloyarskaya NPP area”, Eco-geochemical Aspects of Radionuclides Migration in Soil-plant System, Vol. 3.2.3 (BOLSHAKOV, V.N., Ed.), Proc. of Institute of Ecology of Plants and Animals, Ekaterinburg (2001) 88–90 (in Russian).	432
MOLCHANOVA, I.V., KARAVAEVA, E.N., “Behaviour of ^{90}Sr and ^{137}Cs in floodplain of River Techa, which was contaminated by liquid sludge of Mayak”, Eco-geochemical Aspects of Radionuclides Migration in Soil-plant System, Vol. 3.3 (BOISHAKOV, V.N., Ed.), Proc. of Institute of Ecology of Plants and Animals, Ekaterinburg (2001) 91–100 (in Russian).	433
MOLCHANOVA, I.V., KARAVAEVA, E.N., “Behaviour of radionuclides in natural ecosystem of Beloyarskaya NPP area”, Eco-geochemical Aspects of Radionuclides Migration in Soil-plant System, Vol. 3.2 (BOLSHAKOV, V.N., Ed.), Proc. of Institute of Ecology of Plants and Animals, Ekaterinburg (2001) 50–62 (in Russian).	434
MOLCHANOVA, I.V., KARAVAEVA, E.N., “Radionuclides behaviour in ecosystem of Chernobyl NPP 30 km area”, Eco-geochemical Aspects of Radionuclides Migration in Soil-plant System, Vol. 4.2 (BOLSHAKOV, V.N., Ed.), Proc. of Institute of Ecology of Plants and Animals, Ekaterinburg (2001) 118–129 (in Russian).	435
MOLCHANOVA, I.V., KARAVAEVA, E.N., “Radionuclides behaviour in natural ecosystems contaminated by liquid radioactive waste of Beloyarskaya NPP”, Eco-geochemical Aspects of Radionuclides Migration in Soil-plant System, Vol. 3.2.2 (BOLSHAKOV, V.N., Ed.), Proc. of Institute of Ecology of Plants and Animals, Ekaterinburg (2001) 72–87 (in Russian).	437
MUSCATELLO, J.R., JANZ, D.M., Selenium accumulation in aquatic biota downstream of a uranium mining and milling operation, Sci. Total Environ. **407** (2009) 1318–1325.	438
NATIONAL INSTITUTE OF RADIOLOGICAL SCIENCE, Studies on the Environmental Transfer Parameters of Radionuclides in the Japanese Biosphere, NIRS Annual, Ministry of Economy, Trade and Industry (METI), Chiba City, Japan (2009).	439
NIFONTOVA, M.G., KULIKOV, N.V., TARSHIS, G.I., DJACHENKO, A.P., Radioecological investigation of natural ecosystems around nuclear power plants, Ekologiya **407** (1988) 40–45.	440

Publication	ID number
OZTURK, M., OZOZEN, G., MINARECI, O., MINARECI, E., Determination of heavy metals in fish, water and sediments of Avsar dam lake in Turkey, Iran. J. Environ. Health Sci. Eng. **6** (2009) 73–80.	441
PODOLYAK, A.G., The Influence of Agrochemical and Agrotechnics Practices Improvement of the Main Types of Meadows in Belarussian Polesye on ^{137}Cs and ^{90}Sr Transfer into the Herbage, Belarussian Republic Institute of Radiology, Minsk (2002) (in Russian).	442
PODOLYAK, A.G., TIMOFEEV, S.F., PERSIKOVA, T.F., Cesium-137 and strontium-90 transfer to grass stands on peat-bog soils of lowland meadow, Agrochimiya **11** (2004) 63–70 (in Russian).	443
PODOLYAK, A.G., TIMOFEEV, S.F., PERSIKOVA, T.F., Prognosis of accumulation of ^{137}Cs and ^{90}Sr in the herbage of the main types of the Belarus polessje meadows using agrochemical soil properties, Radiatsionnaya Biologiya Radioekologiya **6** (2005) 100–111 (in Russian).	444
TRAPEZNIKOV, A.V., Radioecology of Freshwater Ecosystems (Exemplified by the Urals Region), PhD Thesis, Institute of Ecology of Plants and Animals, Ekaterinburg (2001) (in Russian).	445
ZESENKO, A.Ya., KULEBYAKINA, L.G., ^{90}Sr content in the Danube mouth and adjacent north-western part of the Black Sea, Ekologiya **5** (1982) 39–43 (in Russian).	446
PRISTER, B.S., LOSHILOV, N.A., NEMETS, O.F., POYARKOV, V.A., “Principles of agricultural radiology”, Radionuclide Behaviour in the Soil-plant System (KLIMENKO, R.F., Ed.), Urozhay Press, Kiev (1988) 163 (in Russian).	448
RASHED, M.N., Monitoring of environmental heavy metals in fish from Nasser Lake, Environment International **27** (2001) 27–33.	449
READ, J., PICKERING, R., Ecological and toxicological effects of exposure to an acid, radioactive tailings storage, Environ. Monit. Assess. **54** (1999) 69–85.	450
SANZHAROVA, N.I., ABRAMOVA, T.N., SHUKHOVTSEV, B.I., “^{90}Sr content in soils and agricultural products”, Problems of Agricultural Radiology, Vol. 4, 3rd All-Union Conf. on Agricultural Radiology, Obninsk, 1990, Russian Institute for Agricultural Radiology, Obninsk (1990) 13–14 (in Russian).	451

Publication	ID number
SAPEGIN, L.M., TIMOFEEV, S.F., DAYNEKO, N.M., AVSEENKO, S.V., "On reduction in the radionuclide accumulation by the grass stand of floodplain meadow communities of the Dnieper basin", Radiobiological Congr., Vol. 3, Puschino, Kiev (1993) 888–889 (in Russian).	452
SHUTOV, V.N., BEKYASHEVA, T.A., BASALAYEVA, L.N., BRUK, G.Ya., PAVLOV, I.Yu., Influence of soil properties on ^{137}Cs and ^{90}Sr radionuclides uptake by natural grasses, Pochvovedenie **8** (1993) 67–71 (in Russian).	453
SMAGIN, A.I., The study of the multifactor anthropogenic influence on the ecosystems of the industrial reservoirs of "Mayak" PA, Radiatsionnaya Biologiya Radioekologiya **46** (2006) 94–110 (in Russian).	454
TASKAEV, A.I., Radioecology as an ecological factor of anthropogenic contamination, type of distribution and migration of the U and Th isotopes group in ecosystems with a naturally high level of radioactivity, Proc. of Institute of Biology, Komi Scientific Center, Syktuvkar (1984) 9–27 (in Russian).	455
TIMOFEEVA-RESOVSKAY, E.A., Distribution of radionuclides among the main compartments of freshwater water bodies, Proc. of Institute of Ecology of Plants and Animals, Sverdlovsk (1963) 49–204 (in Russian).	456
TITAEVA, N.A., "Uranium and thorium distribution in plants", Nuclear Geochemistry (SHCHEHURA, I.I., BARINOVA, N.V., Eds), MSU Press, Moscow (1992) 78–80 (in Russian).	457
WILLIAMS, A.R., The Distribution of Some Naturally Occurring Elements in the Environment of the Yeelirrie Uranium Deposit, Western Australia, Three Baseline Studies in the Environment of the Uranium Deposit at Yeelirrie, AAEC/E447, Australian Atomic Energy Commission, Lucas Heights (1978).	458
TITAEVA, N.A., TOSKAEV, A.I., "Uranium and thorium distribution in plants", Nuclear Geochemistry (SHCHEHURA, I.I., BARINOVA, N.V., Eds), MSU Press, Moscow (1983) 54–58 (in Russian).	459
TKATCHEVA, V., HOLOPAINEN, I.J., HYVARINEN, H., Heavy metals in perch (*Perca fluviatilis*) from the Kostomuksha region (North-western Karelia, Russia), Boreal Environ. Res. **5** (2000) 209–220 (in Russian).	460
TRAPEZNIKOV, A.V., MOLCHANOVA, I.V., KARAVAEVA, E.N., TRAPEZNIKOVA, V.N., "Freshwater ecosystems", Radionuclide Migration in Freshwater and Terrestrial Ecosystems, Urals Branch of the Russian Academy of Sciences, Ekaterinburg (2007) 356–357 (in Russian).	461

Publication	ID number
TRAPEZNIKOV, A.V., et al., Radioactive contamination of the river Techa in the Urals, Ekologiya **6** (1993) 72–77 (in Russian).	462
TRAPEZNIKOV, A.V., TRAPEZNIKOVA, V.N., On ^{60}Co accumulation by freshwater plants in natural conditions, Ekologiya **2** (1979) 104–106 (in Russian).	463
TRAPEZNIKOV, A.V., et al., Radioecological characteristic of the Techa-Iset river system, Ekologiya **9** (2000) 248–256 (in Russian).	464
TRAPEZNIKOVA, V.N., TRAPEZNIKOV, A.V., KULIKOV, N.V., ^{137}Cs accumulation in food fish of the cooling pond of the Beloyarsk NPP, Ekologiya **6** (1984) 36–39 (in Russian).	465
HIGLEY, K.A., Estimating transfer parameters in the absence of data, Radiat. Environ. Biophys. **49** (2010) 645–656.	467
PANCHENKO, S.V., PANFILOVA, A.A., “Regarding the role of the forest ecosystems in exposure of the population”, Problems of Forest Radioecology (PANCHENKO, S.V., Ed.), MOGUL, Moscow (2000) 228–293 (in Russian).	468
TITAEVA, N.A., TOSKAEV, A.I., “Uranium and thorium distribution in plants”, Nuclear Geochemistry (SHCHEHURA, I.I., BARINOVA, N.V., Eds), MSU Press, Moscow (1992) 78–80 (in Russian).	469
ALEXAKHIN, R.M., NARYSHKIN, M.A., Radionuclide Migration in Forest Biogeocenoses (PREVOLOTSKY, A.N., Ed.), Nauka, Moscow (1977) 148 (in Russian).	470
BOGACHEV, A.V., Ca and ^{90}Sr migration in the soil-plant system, Problems of Forest Radioecology (PANCHENKO, S.V., Ed.), Gidrometeoizdat, Moscow **302** (2000) 89–101 (in Russian).	471
DVORNIK, A.V., IPATYEV, V.A., “Modelling and predictive estimates of the radionuclide accumulation by woody plants and forest-derived foodstuffs”, Forest. Human. Chernobyl. Forest Ecosystems after the Accident at the Chernobyl NPP: Condition, Prediction, Response of the Population, Ways of Rehabilitation (IPATYEV, V.A., Ed.), Institute of Forest of National Academy of Science, Gomel Retchinsk **454** (2005) 178–213 (in Russian).	472

Publication	ID number
BULKO, N.I., “The dynamics of radioactive contamination levels of the soil and tree layer”, Forest. Human. Chernobyl. Forest Ecosystems after the Accident at the Chernobyl NPP: Condition, Prediction, Response of the Population, Ways of Rehabilitation (IPATYEV, V.A., Ed.), Gomel Retchinsk **454** (1999) 94–137 (in Russian).	473
IPATYEV, M.A., BULKO, N.I., MITIN, N.V., SHABALEVA, M.A., DIDENKO, L.G., “The hydromeliorative method for decreasing radionuclide concentrations in forest ecosystems”, Radioecological Phenomena of Forest Ecosystems, The Institute of Forest of the National Academy of Science of Belarus, Gomel, Belarus (2004) 137–166 (in Russian).	474
IPATYEV, M.A., BULKO, N.I., MITIN, N.V., SHABALEVA, M.A., DIDENKO, L.G., “The silvicultural (phytologic) method for decreasing radioactivity levels in forest ecosystems”, Radioecological Phenomena of Forest Ecosystems, The Institute of Forest of the National Academy of Science of Belarus, Gomel, Belarus (2004) 67–104 (in Russian).	475
BULKO, N.I., IPATYEV, V.A., Forest. Human. Chernobyl. Forest Ecosystems after the Accident at the Chernobyl NPP: Condition, Prediction, Response of the Population, Ways of Rehabilitation (IPATYEV, V.A., Ed.), The Institute of Forest of the National Academy of Science of Belarus, Gomel, Belarus **454** (2005) 7–303 (in Russian).	476
MARTINOVICH, B.S., GOLUSHKO, R.M., VLASOV, V.K., AFINOGENOV, A.M., Interspecific differences in radionuclide accumulation by woody plants in the Chernobyl zone emissions and their causality, Radioactivity after Nuclear Detonations and Accidents **8** (2000) 187–194 (in Russian).	477
MOLCHANOV, A.A., et al., Some regularities of distribution of fission products deposited in composition of global fallout in forest vegetation, Lesovedenie (1968) 18–23 (in Russian).	478
MUKHAMEDSHIN, K.D., CHILIMOV, A.I., BEZUGLOV, V.K., SNYTKIN, G.V., “Certification of forest resources by the radiation characteristic as the basis to obtain safe forest products in areas affected by radionuclides”, Problems of Forest Radioecology (PANCHENKO, S.V., Ed.), MOGUL, Moscow **302** (2000) 7–46 (in Russian).	479
PEREVOLOTSKY, A.N., ^{137}Cs and ^{90}Sr Distribution in Forest Biogeocenoses (PREVOLOTSKY, A.N., Ed.), Institute for Radiology, Gomel (2006) 124–127 (in Russian).	480

Publication	ID number
PEREVOLOTSKY, A.N., Effects of Cultivation Conditions on ^{137}Cs and ^{90}Sr Accumulation Levels in Wood and Bark of the Major Stand-forming Species (PREVOLOTSKY, A.N., Ed.), Gomel (2006) 267–273 (in Russian).	482
SHCHEGLOV, A.I., Biogeochemistry of Technogenic Radionuclides in Forest Ecosystems of the Central Regions of the East European Plain, PhD Thesis, Moscow State Univ. (1997) (in Russian).	484
YUSHKOV, P.I., ^{90}Sr and ^{137}Cs accumulation and distribution in birch near the liquid wastes disposal site of the Beloyarskaya NPP, Ekologiya **7** (2000) 106–112 (in Russian).	485
WOOD, M.D., Assessing the Impact of Ionizing Radiation in Temperate Coastal Sand Dunes: Measurement and Modelling, PhD Thesis, Liverpool Univ. (2010).	486
WOOD, M.D., BERESFORD, N.A., SEMENOV, D.V., YANKOVICH, T.L., COPPLESTONE, D., Radionuclide transfer to reptiles, Radiat. Environ. Biophys. **49** (2010) 509–530.	487
WOOD, M.D., LEAH, R.T., JONES, S.R., COPPLESTONE, D., Radionuclide transfer to invertebrates and small mammals in a coastal sand dune ecosystem, Sci. Total Environ. **407** (2009) 4062–4074.	488
VANDENHOVE, H., VAN HEES, M., WANNIJN, J., WOUTERS, K., WANG, L., Can we predict uranium bioavailability based on soil parameters? Part 2: Soil solution uranium concentration not a good bioavailability index, Environ. Pollut. **145** (2006) 577–586.	489
SAXEN, R., et al., Cs-137 in small forest lakes of Finland after the Chernobyl accident, STUK-A236, Helsinki (2009).	490
BOONE, F.W., NG, C., PALMS, J.M., Terrestrial pathways of radionuclide particulates, Health Phys. **41** (1981) 735–747.	491
GALEAS, M.L., ZHANG, L.H., FREEMAN, J.L., WEGNER, M., PILON-SMITS, E.A., Seasonal fluctuations of selenium and sulfur accumulation in selenium hyperaccumulators and related nonaccumulators, New Phytol. **173** (2007) 517–525.	492
GARTEN, C.T., Jr., HOFFMAN, F.O., BONDIETTI, E.A., Field and greenhouse experiments on the fate of technetium in plants and soil, Health Phys. **46** (1984) 647–656.	493

Publication	ID number
KASHPAROV, V., COLLE, C., LEVCHUK, S., YOSCHENKO, V., ZVARICH, S., Radiochlorine concentration ratios for agricultural plants in various soil conditions, J. Environ. Radioact. **95** (2007) 10–22.	494
WYTTENBACH, A., FURRER, V., TOBLER, L., The concentration ratios plant to soil for the stable elements Cs, Rb and K, Sci. Total Environ. **173/174** (1995) 361–367.	495
SHARMASARKAR, S., VANCE, G.F., Soil and plant selenium at a reclaimed uranium mine, J. Environ. Radioact. **31** (2002) 1516–1521.	497
TSUKADA, H., NAKAMURA, L., Transfer factors of 31 elements in several agricultural plants collected from 150 farm fields in Aomori, Japan, J. Radioanal. Nucl. Chem. **236** (1998) 123–131.	498
TYLER, G., OLSSON, T., Rare earth elements in forest-floor herbs as related to soil conditions and mineral nutrition, Biol. Trace Elem. Res. **106** (2005) 177–192.	499
UCHIDA, S., TAGAMI, K., RUHM, W., STEINER, M., WIRTH, E., Separation of Tc-99 in soil and plant samples collected around the Chernobyl reactor using a Tc-selective chromatographic resin and determination of the nuclide by ICP-MS, Appl. Radiat. Isot. **53** (2000) 69–73.	500
VIDAL, M., et al., Soil- and plant-based countermeasures to reduce Cs-137 and Sr-90 uptake by grasses in natural meadows: The REDUP project, J. Environ. Radioact. **56** (2001) 139–156.	501
BOLLHÖFER, A., BRAZIER, J., HUMPHREY, C., RYAN, B., ESPARON, A., A study of radium bioaccumulation in freshwater mussels, *Velesunio angasi*, in the Magela Creek catchment, Northern Territory, Australia, J. Environ. Radioact. **102** (2010) 964–974.	502
JOHNSTON, A., Radiation Exposure of Members of the Public Resulting from Operation of the Ranger Uranium Mine, Technical Memorandum 20, Supervising Scientist for the Alligator Rivers Region, Australian Government Publishing Services, Canberra (1987).	504
JOHNSTON, A., MURRAY, A., MARTEN, R., MARTIN, P., PETTERSON, H., Uranium Series Radionuclide Concentrations in Significant Aboriginal Foods, Alligator Rivers Region Research Institute, Research Report 1983–84, Supervising Scientist for the Alligator Rivers Region, Australian Government Publishing Services, Canberra (1984) 43–44.	505

Publication	ID number
KUMBLAD, L., BRADSHAW, C., Element composition of biota, water and sediment in the Forsmark area, Baltic Sea. Concentrations, bioconcentration factors and partitioning coefficients (Kd) of 48 elements, Technical Rep. SKB TR-08-09, Swedish Nuclear Fuel and Waste Management Co, Stockholm (2008) 1–109, http://www.skb.se/upload/publications/pdf/TR-08-09.pdf	506
MARTIN, P., HANCOCK, G.J., JOHNSTON, A., MURRAY, A.S., Bioaccumulation of Radionuclides in Traditional Aboriginal Foods from the Magela and Cooper Creek Systems, Research Rep. 11, Supervising Scientist for the Alligator Rivers Region, Australian Government Publishing Services, Canberra (1995).	507
RYAN, B., BOLLHÖFER, A., MARTIN, P., Radionuclides and metals in freshwater mussels of the upper South Alligator River, Australia, J. Environ. Radioact. **99** (2008) 509–526.	508
RYAN, B., BOLLHÖFER, A., MEDLEY, P., Bioaccumulation in Terrestrial Plants on Rehabilitated Landforms, ERISS Research Summary 2007–2008, Supervising Science Rep. 200, Supervising Scientist (JONES, D.R., WEBB, A., Eds), Darwin, NT (2009) 152–159.	509
PONIKAROVA, T.M., DRICHKO, V.F., KOMAROV, A.A., SHIDLOVSKAY, T.P., LUNINA, N.F., “Effects of hydrolysis lignin and surface-active substances on radiocaesium accumulation by plants”, Radioecology of Soil and Plants, Vol. 1, 3rd All-Union Conf. on Agricultural Radiology, Obninsk, 1990, Russian Institute for Agricultural Radiology, Obninsk (1990) 87–88 (in Russian).	510
CAMECO, Distribution of Metals in the Aquatic Environment at the Key Lake and McArthur River Operations, Prepared by Golder Associates, Saskatoon, Saskatchewan (2005).	511
TAGAMI, K., UCHIDA, S., Soil-to-plant transfer factors of technetium-99 for various plants collected in the Chernobyl area, J. Nucl. Radiochem. Sci. **6** (2005) 261–264.	512
CLULOW, F.V., MIRKA, M.A., DAVÉ, N.K., LIM, T.P., ^{226}Ra and other radionuclides in water, vegetation, and tissues of Beavers (*Castor canadensis*) from a watershed containing U tailings near Elliot Lake, Canada, Environ. Pollut. **69** (1991) 277–310.	513
BARRENTO, S., et al., Accumulation of elements (S, As, Br, Sr, Cd, Hg, Pb) in two populations of *Cancer pagurus*: Ecological implications to human consumption, Food Chem. Toxicol. **47** (2009) 150–156.	514

Publication	ID number
PENTREATH, R.J., The presence of ^{237}Np in the Irish sea, Mar. Ecol. Prog. Ser. **6** (1981) 243–247.	515
BERESFORD, N.A., HOWARD, B.J., BARNETT, C.L., The uptake by vegetation of Chernobyl and aged radiocaesium in upland west Cumbria, J. Environ. Radioact. **16** (1992) 181–195.	516
ENGDAHL, A., TERNSELL, A., HANNU, S., “Oskarshamn site investigation — Chemical characterisation of deposits and biota”, SKB Rep. P-06-320, Swedish Nuclear Fuel and Waste Management Co, Stockholm (2006).	517
HOPE, B., LOY, C., MILLER, P., Uptake and trophic transfer of barium in a terrestrial ecosystem, Bull. Environ. Cont. Toxicol. **56** (1996) 683–689.	518
LIVENS, F.R., HORRILL, A.D., SINGLETON, D.L., Distribution of radiocesium in the soil-plant systems of upland areas of Europe, Health Phys. **60** (1991) 539–544.	519

DEFINITIONS

Where available, definitions are taken from the IAEA Safety Glossary[11], in which further information can be found on some of the definitions.

absorbed dose, *D*. The fundamental dosimetric quantity *D*, defined as:

$$D = \frac{d\bar{\varepsilon}}{dm}$$

where $d\bar{\varepsilon}$ is the mean energy imparted by ionizing radiation to matter in a volume element and d*m* is the mass of matter in the volume element.

The energy can be averaged over any defined volume, the average dose being equal to the total energy imparted in the volume divided by the mass in the volume.

Absorbed dose is defined at a point; for the average dose in a tissue or organ.

Unit: gray (Gy), equal to 1 J/kg (formerly, the rad was used).

activity concentration. See specific activity.

allometry. Mathematical relationships between body mass of organisms and various parameters (including radionuclide biological half-life and dietary dry matter intake).

bioaccumulation. The process whereby an organism accumulates substances in living tissues to concentrations higher than those existing in the surrounding media.

bioavailability. Defined as the fraction of the contaminant that can be taken up by living organisms, dependent both on the chemical speciation of the exposure source(s) and on the physiological status of the organism.

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Glossary, Terminology Used in Nuclear Safety and Radiation Protection, 2007 Edition, IAEA, Vienna (2007).

biogeochemical analogues. Elements which are assumed to have the same general behaviour under similar environmental/biological conditions.

biological half-life. The time taken for the quantity of a material in a specified tissue, organ or region of the body (or any other specified biota) to halve as a result of biological processes.

conversion factor. Factor used here to enable tissue specific data to be used in the estimation of whole organism concentration ratios.

concentration ratio, $CR_{wo\text{-}media}$. Whole organism concentration ratio: used to quantify the equilibrium activity concentration between an environmental medium and the whole living organism. Previously referred to as concentration factor or bioaccumulation factor. Generally does not include parts of the organism which might be contaminated by environmental media (soil, silt) such as gut, pelt.

dietary component. Components of an animal's diet, for instance, the different species ingested.

distribution coefficient, K_d. Distribution coefficient used to quantify the equilibrium between solid and liquid phases (soil or sediment–interstitial water), usually expressed in litres per kilogram. It is the ratio of the mass of the solute species adsorbed (or precipitated) on the solid particles per unit of dry mass of the soil or sediment to the solute concentration in the liquid phase. It represents the partition of the solute in the soil or sediment matrix and soil or sediment water, assuming that equilibrium conditions exist between the solid and liquid phases. The K_d values are dependent on the soil or sediment and water physical and chemical characteristics.

dosimetry. The measurement and calculation of radiation dose in matter and tissue resulting from exposure to ionizing radiation.

dynamic model. A model used to express and model the behaviour of the system over time.

environmental medium. The environmental compartment from which the contaminant (radionuclide) is derived. Can be soil, sediment, water or air.

equilibrium. In the context of this handbook, the steady state condition in which there is a constant ratio between the activity concentration in an organism and an environmental medium.

exposure pathway. A route by which radiation or radionuclides can reach humans and cause exposure.

ⓘ An exposure pathway may be very simple, e.g. external exposure from airborne radionuclides, or a more complex chain, e.g. internal exposure from drinking milk from cows that ate grass contaminated with deposited radionuclides.

ⓘ The term 'exposure pathway' can be applied to other organisms, e.g. wildlife, with similar caveats. In that case, internal exposure may be from ingestion of meat from a herbivorous prey species that ate grass contaminated with deposited radionuclides.

food chain. Food chains are components of the webs of predator–prey relationships between species within an ecosystem or habitat.

ionic potential. Measure of the strength of attraction of ions, expressed as the ratio of ionic charge Z to ionic radius r, Z:r.

Monte Carlo analysis. Analysis that uses Monte Carlo methods, a class of computational algorithms that rely on repeated random sampling to compute their results. Monte Carlo methods are often used in simulating physical and mathematical systems.

non-human biota. Commonly used term referring to all species other than humans.

phylogenetic relationship. The phylogenetic relationship refers to the relative times in the past that species shared common ancestors.

radionuclide. An unstable nuclide that undergoes spontaneous transformation, emitting ionizing radiation.

reference animals and plants. Group of idealized organisms representative of different environments used to assess radiation effects in the International Commission on Radiological Protection approach, to relate exposure to dose and dose to effect.

reference organisms. A series of entities that provide a basis for the estimation of radiation dose rate to a range of organisms that are typical, or representative, of a contaminated environment.

screening. A type of analysis aimed at eliminating from further consideration factors that are less significant for protection or safety in order to concentrate on the more significant factors. This is typically achieved by consideration of very pessimistic hypothetical scenarios.

ⓘ Screening is usually conducted at an early stage to narrow the range of factors needing detailed consideration in an analysis or assessment.

source. Anything that may cause radiation exposure — such as by emitting ionizing radiation or by releasing radioactive substances or materials — and can be treated as a single entity for protection and safety purposes.

specific activity. Of a radionuclide, the activity per unit mass of that nuclide. Of a material, the activity per unit mass or volume of the material in which the radionuclides are essentially uniformly distributed.

ⓘ The distinction in usage between ‘specific activity’ and ‘activity concentration’ is controversial. Some regard the terms as synonymous, and may favour one or the other. ISO 921[12] distinguishes between specific activity as the activity per unit mass and activity concentration as the activity per unit volume. Another common distinction is that specific activity is used (usually as activity per unit mass) with reference to a pure sample of a radionuclide or, less strictly, to cases where a radionuclide is intrinsically present in the material (e.g. ^{14}C in organic materials, ^{235}U in natural uranium), even if the abundance of the radionuclide is artificially changed. It is in this context, for ^{3}H and ^{14}C, that specific activity is used in this handbook consistent with Technical Reports Series No. 472 published by the IAEA in 2010[13]. In this usage, activity concentration (which may be activity per unit mass or per unit volume) is used for any other situation (e.g. when the activity is in the form of contamination in or on a material).

ⓘ In general, the term ‘activity concentration’ is more widely applicable, is more self-evident in meaning, and is less likely than ‘specific activity’ to be confused with unrelated terms (such as ‘specified activities’). ‘Activity concentration’ is therefore preferred to ‘specific activity’ for general use in safety related IAEA publications.

---

[12] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, Nuclear Energy — Vocabulary, ISO 921:1997, ISO, Geneva (1997).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments, Technical Reports Series No. 472, IAEA, Vienna (2010).

uncertainty. Arises from imprecision due to lack of information, expert judgement and/or measurement errors, and could be reduced with increased knowledge and/or experimentation.

***uncertainty analysis*.** An analysis to estimate the uncertainties and error bounds of the quantities involved in, and the results from, the solution of a problem.

wildlife. All non-domesticated plants, animals and other organisms.

CONTRIBUTORS TO DRAFTING AND REVIEW

Andersson, P.	Swedish Radiation Safety Authority, Sweden
Barnett, C.L.	Centre for Ecology and Hydrology, United Kingdom
Beresford, N.A.	Centre for Ecology and Hydrology, United Kingdom
Bollhöfer, A.	Department of Sustainability, Environment, Water, Population and Communities, Australia
Bradshaw, C.	University of Stockholm, Sweden
Brittain, J.	University of Oslo, Norway
Brown, J.E.	Norwegian Radiation Protection Authority, Norway
Choi, Y.-H.	Korea Atomic Energy Research Institute, Republic of Korea
Copplestone, D.	University of Stirling, United Kingdom
Dagher, E.	Canadian Nuclear Safety Commission, Canada
Dale, P.	Scottish Environment Protection Agency, United Kingdom
Doering, C.	Department of Sustainability, Environment, Water, Population and Communities, Australia
Dragović, S.	Institute for the Application of Nuclear Energy, Serbia
Ernst, P.	CANDU Owners Group, Canada
Fesenko, E.	Russian Institute of Agricultural Radiology Agroecology, Russian Federation
Fesenko, S.	International Atomic Energy Agency
Gaschak, S.	International Radioecology Laboratory, Ukraine
Higley, K.	Oregon State University, United States of America
Hosseini, A.	Norwegian Radiation Protection Authority, Norway
Howard, B.J.	Centre for Ecology and Hydrology, United Kingdom

Jeffree, R.	International Atomic Energy Agency
Johansen, M.	Australian Nuclear Science and Technology Organisation, Australia
Keum, D.-K.	Korea Atomic Energy Research Institute, Republic of Korea
Macdonald, P.	AMEC, United Kingdom
Maksimenko, A.	International Radioecology Laboratory, Ukraine
Melintescu, A.-M.	Horia Hulubei National Institute of Physics and Nuclear Engineering, Romania
Mihok, S.	Canadian Nuclear Safety Commission, Canada
Mulye, H.	Canadian Nuclear Safety Commission, Canada
Muzalevskaya, A.	Russian Institute of Agricultural Radiology Agroecology, Russian Federation
Newsome, L.	Environment Agency, United Kingdom
Olyslaegers, G.	Belgian Nuclear Research Centre, Belgium
Outola, I.	Radiation Nuclear Safety Authority, Finland
Phaneuf, M.	International Atomic Energy Agency
Pröhl, G.	International Atomic Energy Agency
Ryan, J.	CANDU Owners Group, Canada
Shishulina, M.	Russian Institute of Agricultural Radiology Agroecology, Russian Federation
Sweeck, L.	Belgian Nuclear Research Centre, Belgium
Tagami, K.	National Institute of Radiological Sciences, Japan
Telleria, D.	International Atomic Energy Agency
Thiessen, K.	Oak Ridge Center for Risk Analysis, United States of America
Twining, J.	Australian Nuclear Science and Technology Organisation, Australia

Uchida, S	National Institute of Radiological Sciences, Japan
Vandenhove, H.	Belgian Nuclear Research Centre, Belgium
Vlaschenko, A.	Interdepartmental Research Laboratory for the Study of Biodiversity and Nature Reserve Development, Ukraine
Wannijn, J.	Belgian Nuclear Research Centre, Belgium
Wells, C.	Centre for Ecology and Hydrology, United Kingdom
Willey, N.	University of the West of England, United Kingdom
Wilson, R.	Westlakes Scientific Consulting Limited, United Kingdom
Wood, M.D.	University of Salford, United Kingdom
Yankovich, T.	Saskatchewan Research Council, Canada

IAEA
International Atomic Energy Agency

No. 23

ORDERING LOCALLY

In the following countries, IAEA priced publications may be purchased from the sources listed below or from major local booksellers.

Orders for unpriced publications should be made directly to the IAEA. The contact details are given at the end of this list.

AUSTRALIA
DA Information Services
648 Whitehorse Road, Mitcham, VIC 3132, AUSTRALIA
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: books@dadirect.com.au • Web site: http://www.dadirect.com.au

BELGIUM
Jean de Lannoy
Avenue du Roi 202, 1190 Brussels, BELGIUM
Telephone: +32 2 5384 308 • Fax: +32 2 5380 841
Email: jean.de.lannoy@euronet.be • Web site: http://www.jean-de-lannoy.be

CANADA
Renouf Publishing Co. Ltd.
5369 Canotek Road, Ottawa, ON K1J 9J3, CANADA
Telephone: +1 613 745 2665 • Fax: +1 643 745 7660
Email: order@renoufbooks.com • Web site: http://www.renoufbooks.com

Bernan Associates
4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4391, USA
Telephone: +1 800 865 3457 • Fax: +1 800 865 3450
Email: orders@bernan.com • Web site: http://www.bernan.com

CZECH REPUBLIC
Suweco CZ, spol. S.r.o.
Klecakova 347, 180 21 Prague 9, CZECH REPUBLIC
Telephone: +420 242 459 202 • Fax: +420 242 459 203
Email: nakup@suweco.cz • Web site: http://www.suweco.cz

FINLAND
Akateeminen Kirjakauppa
PO Box 128 (Keskuskatu 1), 00101 Helsinki, FINLAND
Telephone: +358 9 121 41 • Fax: +358 9 121 4450
Email: akatilaus@akateeminen.com • Web site: http://www.akateeminen.com

FRANCE
Form-Edit
5 rue Janssen, PO Box 25, 75921 Paris CEDEX, FRANCE
Telephone: +33 1 42 01 49 49 • Fax: +33 1 42 01 90 90
Email: fabien.boucard@formedit.fr • Web site: http://www.formedit.fr

Lavoisier SAS
14 rue de Provigny, 94236 Cachan CEDEX, FRANCE
Telephone: +33 1 47 40 67 00 • Fax: +33 1 47 40 67 02
Email: livres@lavoisier.fr • Web site: http://www.lavoisier.fr

L'Appel du livre
99 rue de Charonne, 75011 Paris, FRANCE
Telephone: +33 1 43 07 50 80 • Fax: +33 1 43 07 50 80
Email: livres@appeldulivre.fr • Web site: http://www.appeldulivre.fr

GERMANY
Goethe Buchhandlung Teubig GmbH
Schweitzer Fachinformationen
Willstätterstrasse 15, 40549 Düsseldorf, GERMANY
Telephone: +49 (0) 211 49 8740 • Fax: +49 (0) 211 49 87428
Email: s.dehaan@schweitzer-online.de • Web site: http://www.goethebuch.de

HUNGARY
Librotade Ltd., Book Import
PF 126, 1656 Budapest, HUNGARY
Telephone: +36 1 257 7777 • Fax: +36 1 257 7472
Email: books@librotade.hu • Web site: http://www.librotade.hu

INDIA

Allied Publishers
1st Floor, Dubash House, 15, J.N. Heredi Marg, Ballard Estate, Mumbai 400001, INDIA
Telephone: +91 22 2261 7926/27 • Fax: +91 22 2261 7928
Email: alliedpl@vsnl.com • Web site: http://www.alliedpublishers.com

Bookwell
3/79 Nirankari, Delhi 110009, INDIA
Telephone: +91 11 2760 1283/4536
Email: bkwell@nde.vsnl.net.in • Web site: http://www.bookwellindia.com

ITALY

Libreria Scientifica "AEIOU"
Via Vincenzo Maria Coronelli 6, 20146 Milan, ITALY
Telephone: +39 02 48 95 45 52 • Fax: +39 02 48 95 45 48
Email: info@libreriaaeiou.eu • Web site: http://www.libreriaaeiou.eu

JAPAN

Maruzen Co., Ltd.
1-9-18 Kaigan, Minato-ku, Tokyo 105-0022, JAPAN
Telephone: +81 3 6367 6047 • Fax: +81 3 6367 6160
Email: journal@maruzen.co.jp • Web site: http://maruzen.co.jp

NETHERLANDS

Martinus Nijhoff International
Koraalrood 50, Postbus 1853, 2700 CZ Zoetermeer, NETHERLANDS
Telephone: +31 793 684 400 • Fax: +31 793 615 698
Email: info@nijhoff.nl • Web site: http://www.nijhoff.nl

Swets Information Services Ltd.
PO Box 26, 2300 AA Leiden
Dellaertweg 9b, 2316 WZ Leiden, NETHERLANDS
Telephone: +31 88 4679 387 • Fax: +31 88 4679 388
Email: tbeysens@nl.swets.com • Web site: http://www.swets.com

SLOVENIA

Cankarjeva Zalozba dd
Kopitarjeva 2, 1515 Ljubljana, SLOVENIA
Telephone: +386 1 432 31 44 • Fax: +386 1 230 14 35
Email: import.books@cankarjeva-z.si • Web site: http://www.mladinska.com/cankarjeva_zalozba

SPAIN

Diaz de Santos, S.A.
Librerias Bookshop • Departamento de pedidos
Calle Albasanz 2, esquina Hermanos Garcia Noblejas 21, 28037 Madrid, SPAIN
Telephone: +34 917 43 48 90 • Fax: +34 917 43 4023
Email: compras@diazdesantos.es • Web site: http://www.diazdesantos.es

UNITED KINGDOM

The Stationery Office Ltd. (TSO)
PO Box 29, Norwich, Norfolk, NR3 1PD, UNITED KINGDOM
Telephone: +44 870 600 5552
Email (orders): books.orders@tso.co.uk • (enquiries): book.enquiries@tso.co.uk • Web site: http://www.tso.co.uk

UNITED STATES OF AMERICA

Bernan Associates
4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4391, USA
Telephone: +1 800 865 3457 • Fax: +1 800 865 3450
Email: orders@bernan.com • Web site: http://www.bernan.com

Renouf Publishing Co. Ltd.
812 Proctor Avenue, Ogdensburg, NY 13669, USA
Telephone: +1 888 551 7470 • Fax: +1 888 551 7471
Email: orders@renoufbooks.com • Web site: http://www.renoufbooks.com

United Nations
300 East 42nd Street, IN-919J, New York, NY 1001, USA
Telephone: +1 212 963 8302 • Fax: 1 212 963 3489
Email: publications@un.org • Web site: http://www.unp.un.org

Orders for both priced and unpriced publications may be addressed directly to:

IAEA Publishing Section, Marketing and Sales Unit, International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Telephone: +43 1 2600 22529 or 22488 • Fax: +43 1 2600 29302
Email: sales.publications@iaea.org • Web site: http://www.iaea.org/books

14-02111

GENERIC MODELS FOR USE IN ASSESSING THE IMPACT OF DISCHARGES OF RADIOACTIVE SUBSTANCES TO THE ENVIRONMENT
Safety Reports Series No. 19
STI/PUB/1103 (216 pp.; 2001)
ISBN 92–0–100501–6 Price: €51.00

SEDIMENT DISTRIBUTION COEFFICIENTS AND CONCENTRATION FACTORS FOR BIOTA IN THE MARINE ENVIRONMENT
Technical Reports Series No. 422
STI/DOC/010/422 (95 pp.; 2004)
ISBN 92–0–114403–2 Price: €19.00

HANDBOOK OF PARAMETER VALUES FOR THE PREDICTION OF RADIONUCLIDE TRANSFER IN TERRESTRIAL AND FRESHWATER ENVIRONMENTS
Technical Reports Series No. 472
STI/DOC/010/472 (194 pp.; 2010)
ISBN 978–92–0–113009–9 Price: €45.00

There is a well developed system of radiological protection of humans which has been implicitly providing protection to the environment for most exposure scenarios. A complementary systematic framework for radiological protection of the environment, specifically considering exposure of wildlife, only began to evolve over the past decade and is now incorporated in the recommendations of the International Commission on Radiological Protection and is taken into account in IAEA safety standards. For many years, the IAEA has supported efforts to develop models for radiological assessments for members of the public, and for flora and fauna. The most common approach to estimate radionuclide transfer to wildlife is to use a 'concentration ratio' to predict the activity concentration of a radionuclide in the whole organism from the activity concentration in the soil, sediment, water or air. This handbook provides generic transfer parameters in the form of concentration ratio values for use in assessment of ionizing radiation exposure to wildlife as a consequence of the presence of radionuclides in the environment.

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA
ISBN 978–92–0–100714–8
ISSN 0074–1914