Does the use of reference organism in impact assessments provide an adequate protection of site-specific species in routine release? Clarification and reassurance

Benoit Charrasse

Does the use of reference organism in impact assessments provide an adequate protection of site-specific species in routine release? Clarification and reassurance

02 June 2022

Benoit CHARRASSE

Objectives of the ICRP / IAEA

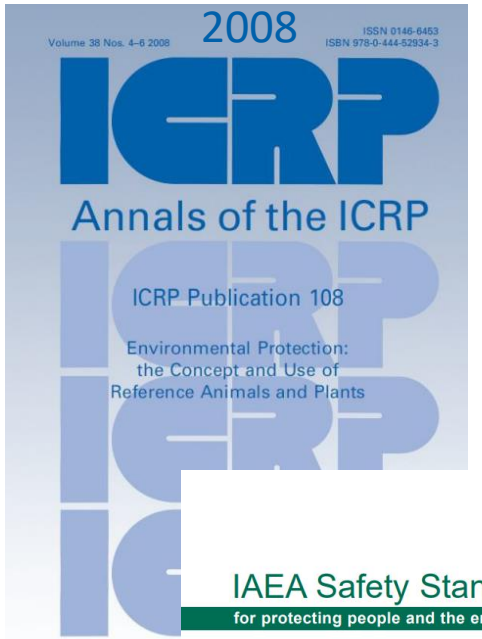
"… maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities, and ecosystems" …

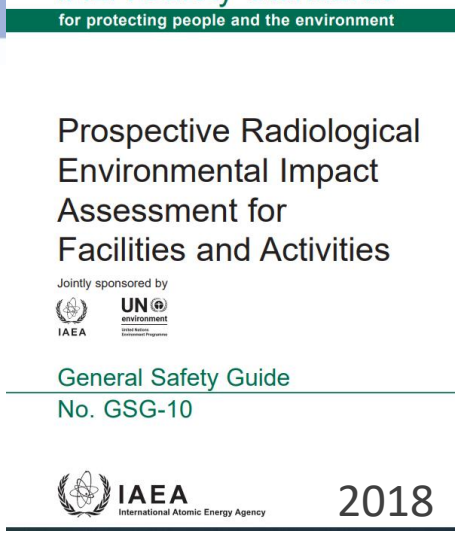
AND

"It also recognised the needs of some national authorities to demonstrate, directly and explicitly, that the environment is being protected…"

→ System developed in coherence with that for humans

The approaches are based on a set of **reference organisms**





ICRP/IAEA approach (RAP for Reference Animal and Plant)

TABLE I–1. TYPES OF ANIMALS AND PLANTS FOR THREE MAJOR ECOSYSTEMS TO BE USED IN GENERIC ASSESSMENTS OF RADIOLOGICAL IMPACT ON FLORA AND FAUNA AND RELEVANT DERIVED CONSIDERATION REFERENCE LEVELS [I–1]

Ecosystem of interest	Type of animal or plant	ICRP reference animal or plant	Derived consideration reference level (mGy/d)
Terrestrial	Large plant	Reference pine tree	0.1–1
	Small plant	Reference wild grass	1–10
	Insect	Reference bee	10–100
	Annelid	Reference earthworm	10–100
	Large mammal	Reference deer	0.1–1
	Small mammal	Reference rat	0.1–1
Freshwater	Aquatic bird	Reference duck	0.1–1
	Amphibian	Reference frog	1–10
	Fish	Reference trout	1–10
Marine	Seaweed	Reference brown seaweed	1–10
	Crustacean	Reference crab	10–100
	Fish	Reference flatfish	1–10

ICRP, 2008 (publication 108)

ERICA Approach (RO for Reference Organism)

Reference Organisms

Terrestrial Ecosystem
Amphibian (ICRP Frog)
Annelid (ICRP Earthworm)
Arthropod - detritivorous (FASSET Woodlouse)
Bird (ICRP Duck)
Flying insects (ICRP Bee)
Grasses & Herbs (ICRP Wild grass)
Lichen & Bryophytes (ICRP Bryophyte)
Mammal - large (ICRP Deer)
Mammal - small-burrowing (ICRP Rat)
Mollusc - gastropod (ICRP Snail)
Reptile (FASSET snake note this is an ellipsoid)
Tree (ICRP Pine tree)

Freshwater Ecosystem
Amphibian (ICRP – Frog)
Benthic fish (FASSET Benthic fish)
Bird (ICRP Duck)
Crustacean (FASSET Crustacean)
Insect larvae (FASSET Insect larvae)
Mammal (FASSET Mammal)
Mollusc - bivalve (FASSET Bivalve mollusc)
Mollusc - gastropod (FASSET Gastropod)
Pelagic fish (ICRP Salmonid/Trout)
Phytoplankton (ERICA Phytoplankton) [a]
Reptile (ERICA Freshwater reptile) [b]
Vascular plant (FASSET Vascular plant)
Zooplankton (FASSET Zooplankton)

Marine Ecosystem
Benthic fish (ICRP Flat fish)
Bird (ICRP Duck, Wading bird)
Crustacean (ICRP Crab)
Macroalgae (ICRP Brown seaweed)
Mammal (FASSET Mammal)
Mollusc - bivalve (FASSET Benthic mollusc)
Pelagic fish (FASSET Pelagic fish)
Phytoplankton (ERICA Phytoplankton) [a]
Polychaete worm (FASSET Benthic worm)
Reptile (ICRP Turtle)
Sea anemones & True coral (ICRP Polyp)
Vascular plant (FASSET Vascular plant)
Zooplankton (FASSET Zooplankton)

Endangered or protected species

VS

RO / RAP :

Generic reference points to ensure the protection of all wildlife

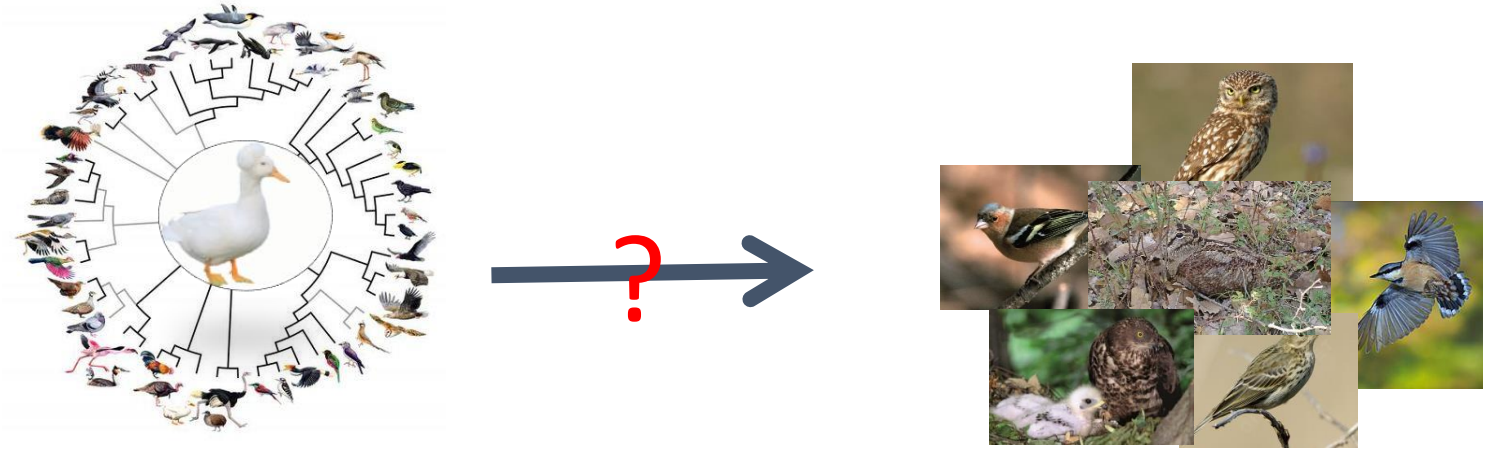
Species identified on site (Batlle et al., 2016; Charrasse et al., 2019; Jaeschke, B et al., 2013; Posiva, 2014; Torudd and Saetre, 2013, Stark et al., 2017)

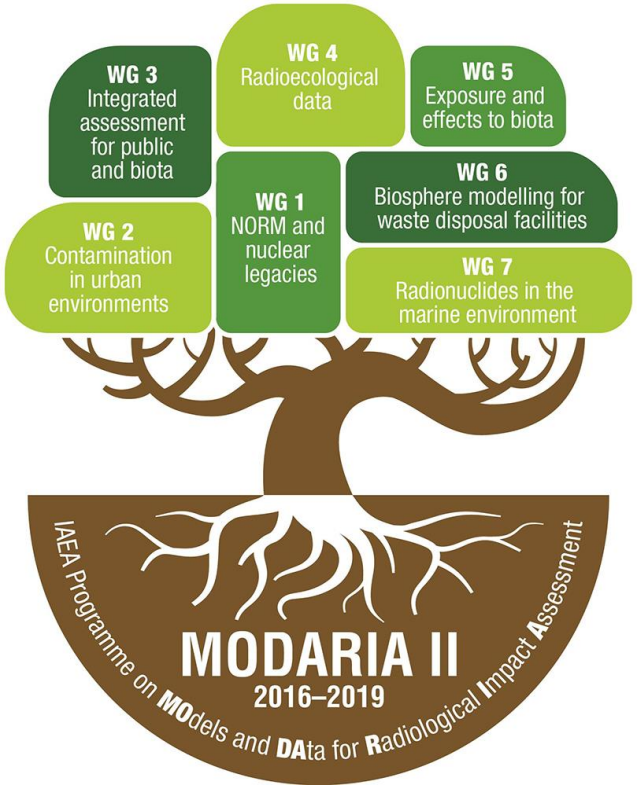
+

Default OR or **RAP**

(Ait Bout et al., 2021; Batlle et al., 2011; Brown et al., 2016; Carolan et al., 2011; Kautsky et al., 2016; Lavrentyeva et al., 2016; Robinson et al., 2010; Shishkina et al., 2016; Smith et al., 2010; Vandenhove et al., 2013, Stark et al., 2017)

Pragmatic question : "Does the use of the generic organisms defined by different approaches in a risk assessment really protect all species in the different target ecosystems in terms of dosimetry?"





- MODARIA II program from the IAEA (**Modelling and Data for Radiological Impact Assessments**)

→ Collaboration with the WG 3 (« *Assessments and control of exposures to public and biota for planned releases to the environment* »)

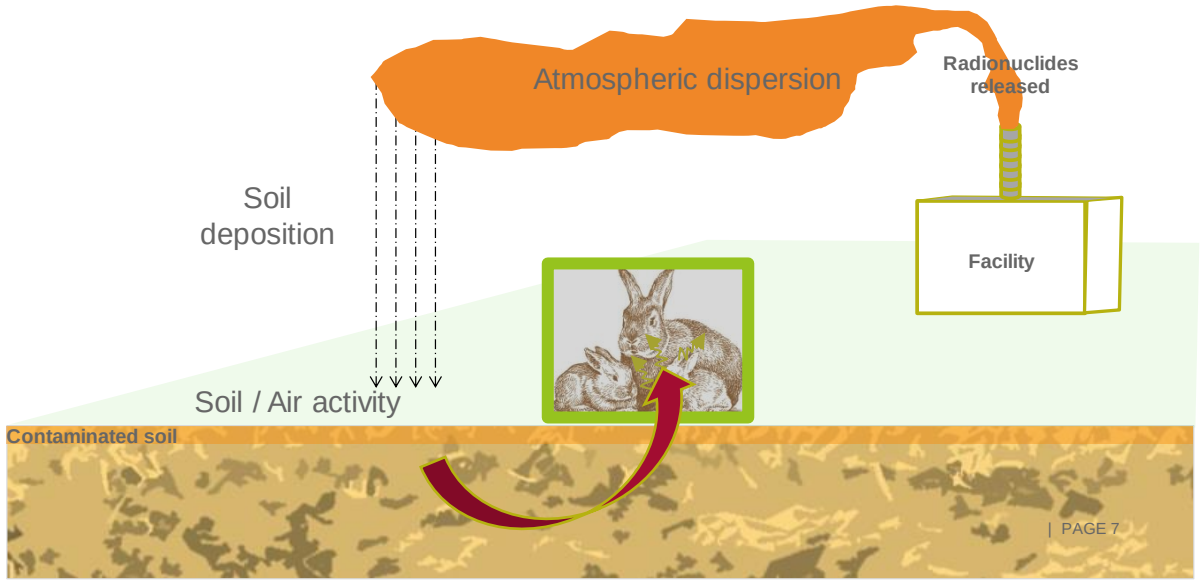
Activity concentration in the media

↑

Concentration ratio* (CR)

↓

Concentration in organism



Assumptions for endangered/protected species or not well characterized species :

Identical CR

*ICRP, 2008; 2009; WTD; www. wildlifetransferdatabase.org/, Copplestone et al., 2013, Beresford et al, 2016

Activity concentration in the media

↑

Concentration ratio* (CR)

↓

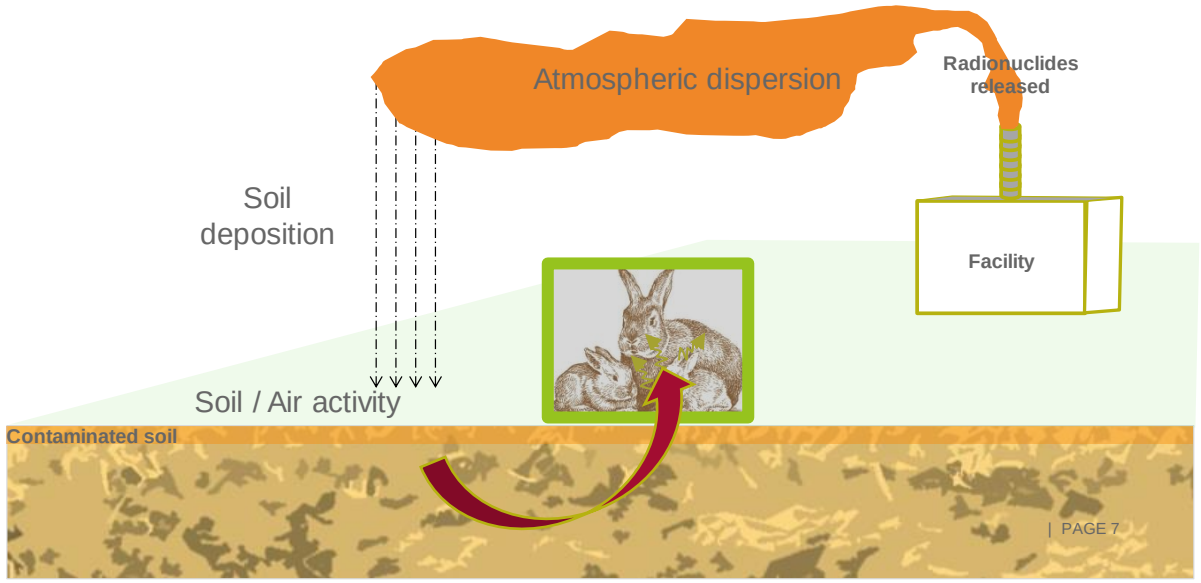
Concentration in organism

↑

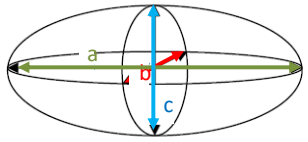
Dose coefficient (int/ext)

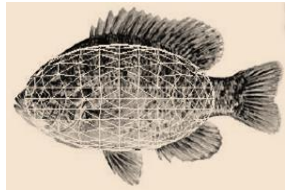
↓

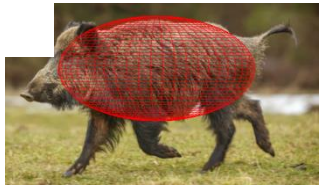
Dose rate



- **Geometric shape**
- **Mass**
- **Habitat**







**ICRP, 2008; 2009; WTD; www. wildlifetransferdatabase.org/, Copplestone et al., 2013, Beresford et al, 2016*

Activity concentration in the media

↑

Concentration ratio* (CR)

↓

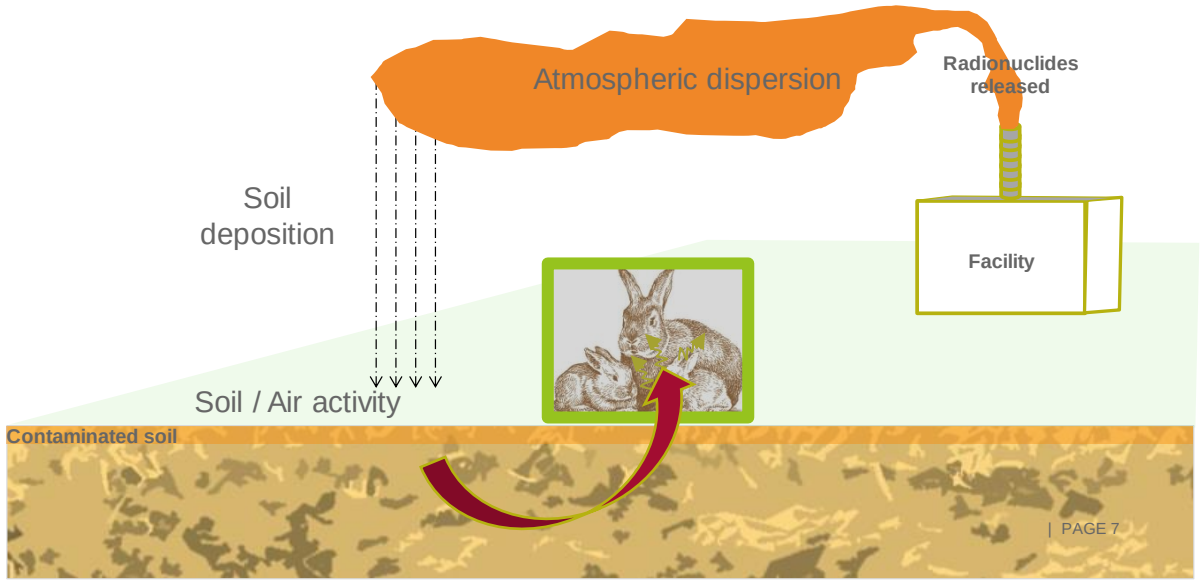
Concentration in organism

↑

Dose coefficient (int/ext)

↓

Dose rate



The question comes down to

What is the influence of the diversity of sizes and shapes of the ellipsoid + Habitat diversity ?

**ICRP, 2008; 2009; WTD; www. wildlifetransferdatabase.org/, Copplestone et al., 2013, Beresford et al, 2016*

Objective : To bound uncertainties around the conceptual representation of species in assessments in case of routine atmospheric releases

Maximal predicted Dose rate (DR) differences between hypothetical organisms and its corresponding Generic Organism (GO) were estimated.

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Journal of Radiological Protection

PAPER

Bounding uncertainties around the conceptual representation of species in radiological assessment in the context of routine atmospheric release

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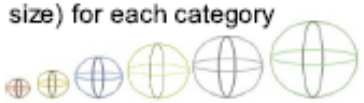
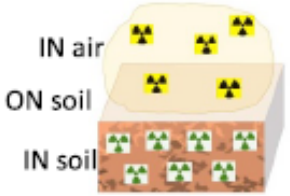
METHODOLOGY

Step 1- a

Hypothetical organisms
Extreme shape (min and max size) for each category



Different habitats (in soil, on soil, in air)

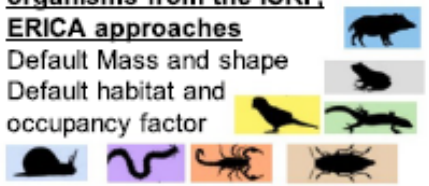


Step 1- b

Compilation of source term pattern for different facilities – Chronic atmospheric release

Exposure scenario
Release time
Soil bulk density
Deposition coefficient

Terrestrial surrogate organisms from the ICRP, ERICA approaches
Default Mass and shape
Default habitat and occupancy factor



List of radionuclides (75)

Step 2

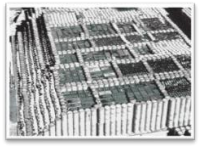
Dose rate calculation considering individual radionuclide and external ground shine, external cloud shine and internal exposure
DC estimated with BiotaDC v.1.5.1 (http://biotadc.icrp.org/; ICRP publication 136)

Step 3

DR comparison between the DR obtained for hypothetical organisms and its corresponding surrogate organism

Nuclear Power Plant (NPP)

^{110m}Ag ^{242,243,244}Cm ^{85,85m,87,88}Kr ^{122,124,125}Sb ^{241}Am ^{51}Cr ^{141,144}Ce ^{131m,133,135,135m,138}Xe ^{41}Ar ^{14}C ^{140}Ba ^{57,58,60}Co ^{55,59}Fe ^{103,106}Ru ^{35}S ^{65}Zn ^{95}Zr ^{129,131,132,133,135}I ^{134,137}Cs ^{3}H ^{140}La ^{54}Mn ^{95}Nb ^{63}Ni ^{238,239,240}Pu ^{89,90}Sr



Waste disposal

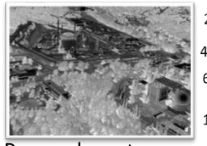
^{241}Am ^{238,239,240}Pu ^{3}H ^{125,129,131}I ^{14}C ^{137}Cs ^{85,85m,87,88}Kr ^{60}Co ^{90}Sr

Fuel fabrication, reprocessing plants

^{241}Am ^{60}Co ^{129,131}I ^{210,214}Pb ^{125}Sb ^{14}C ^{242,243,244}Cm ^{210,218}Po ^{90}Sr ^{144}Ce ^{134,137}Cs ^{85}Kr ^{228,230,232}Th ^{3}H ^{232,234,235,236,238}U ^{238,239,240,241}Pu ^{237}Np ^{106}Ru ^{99}Tc

Radiopharmaceutical facilities and hospitals

^{198}Au ^{22}Na ^{32}P ^{89}Sr ^{99m}Tc ^{14}C ^{67}Ga ^{111}In ^{201}Tl ^{223}Ra ^{47}Ca ^{3}H ^{123,129,131}I ^{133}Xe ^{90}Y ^{169}Er ^{177}Lu ^{99}Mo ^{153}Sm ^{186}Re



Research center

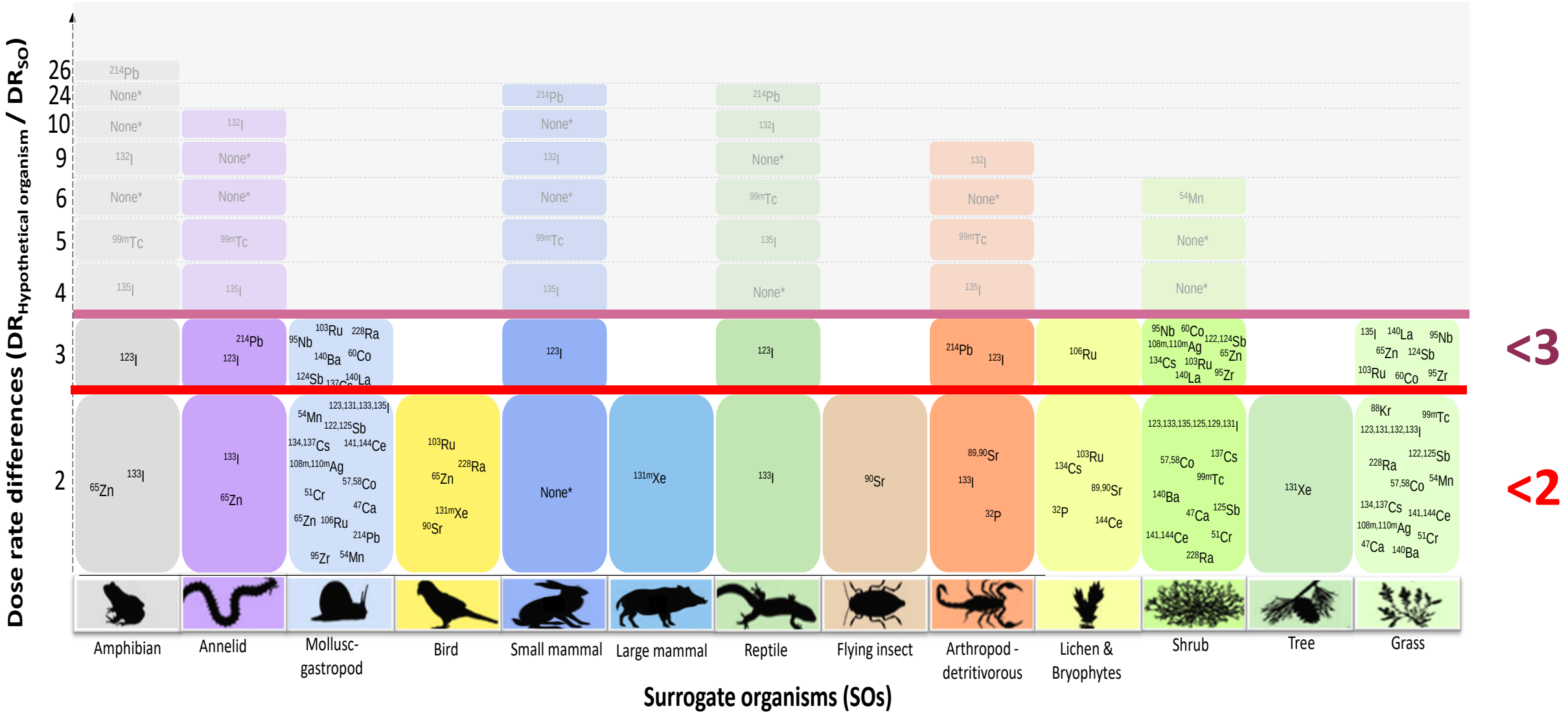
^{241}Am ^{131m,133,135,135m,138}Xe ^{41}Ar ^{238,241}Pu ^{232}Th ^{60}Co ^{90}Sr ^{137}Cs ^{125}Sb ^{234,235,238}U ^{14}C ^{242}Cm ^{3}H ^{106}Ru ^{129,131}I

Norm activity

^{214}Bi ^{220,222}Rn ^{40}K ^{232}Th ^{234,235,238}U ^{226,228}Ra

Decommissioning

^{108m}Ag ^{110m}Ag ^{137}Cs ^{14}C ^{60}Co ^{239}Pu ^{3}H



*None for no radionuclide in this range of dose rate difference

CONCLUSION

*"**Pragmatic question :** Does the use of the generic organisms defined by different approaches in a risk assessment really protect all species in the different target ecosystems in terms of dosimetry?"*

YES, in the vast majority of cases, by a factor of 2/3

Particular attention to short-lived RNs if they contribute mostly to the dose rate

On the condition that the CRs/transfer factors used are identical between "real" and "reference" organism

The greatest uncertainty relies on the CR ratio (Johansen et al, 2012; Stark et al, 2015)

Adding site specific species to the set of reference organism can respond to various interests, such as demonstrating to the stakeholders more specifically the actual protection of the environment

CONCLUSION

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Does the use of reference organisms in radiological impact assessments provide adequate protection of all the species within an environment?

Benoit Charrasse [a,*], Amanda Anderson [b], Juan C. Mora [c], Justin Smith [d], Emilie Cohenny [a], Ari T.K. Ikonen [e], Ville Kangasniemi [e], Benjamin Zorko [f], Yuri Bonchuk [g], Léa Beaumelle [h], Nipun Gunawardena [i], Valeria Amado [j], Lodovit Liptak [k], Elisabeth Leclerc [l], Diego Telleria [m]

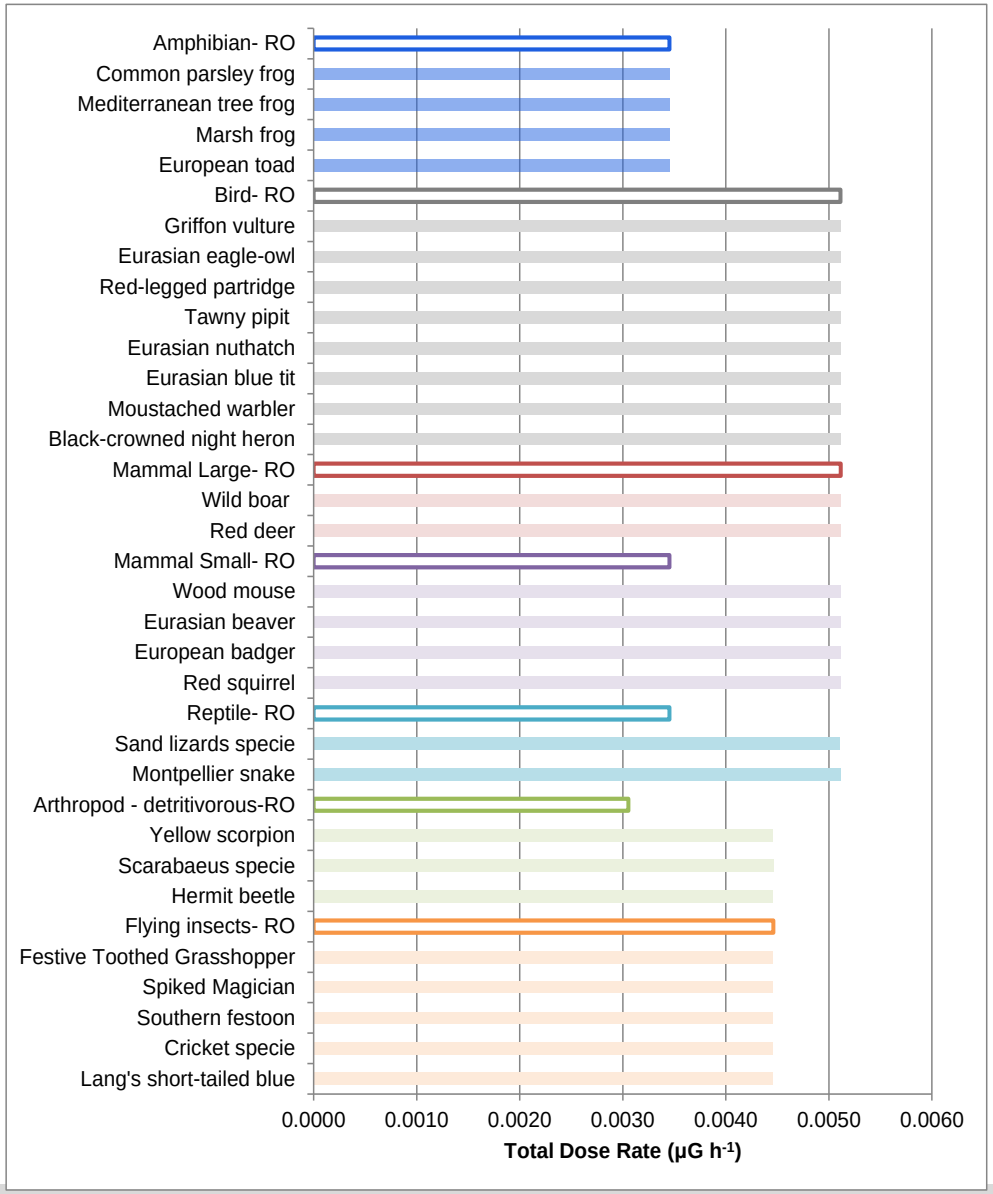
- Species selection based on ecological stakes
- Species selection based on non-human biota representation for dosimetric calculation

❑ Application of two filters

❑ Consideration of 400 species (terrestrial) (initial step)

28 species

CONCLUSION



28 species selected

Intra- species DR_{tot} difference less than a factor of 2

Despite the range of geometric characteristics, habits and habitats numerical risk assessment **is not improved** for any selected biota in this release scenario

THANKS FOR YOUR ATTENTION ☺

AND

A special thanks to all the participants from the WG3 and the scientific secretaries