ALLIANCE Perspectives on Integration of Humans and the Environment into the System of Radiological Protection

Hildegarde Vandenhove, Clare Bradshaw, Nick Beresford, Jordi Vives i Batlle,
Almudena Real, Jacqueling Garnier-Laplace

ICRP-RPW-2017, Paris

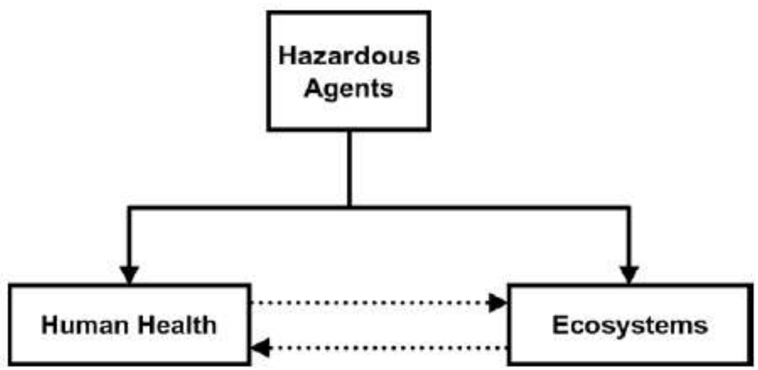
Why integrate?

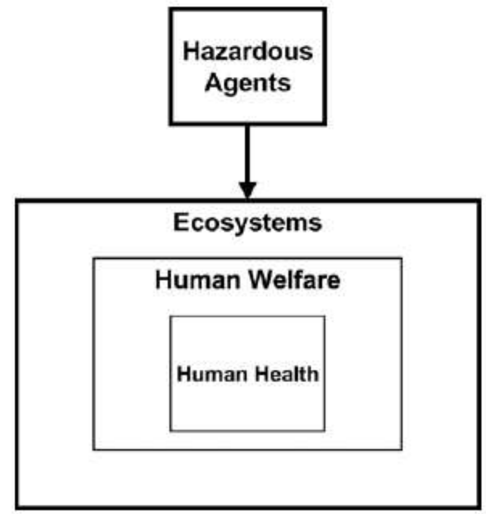
- Provides more **coherent** inputs to decision-making process (reduces likelihood of inconsistent inputs resulting in contradictory impressions of risk)
- Improves **quality** and **efficiency** of assessments through exchange of information between human and environmental risk assessors
  - Scientific **quality** of assessments is improved through sharing of information and techniques between assessment scientists in different fields
  - Considers **interdependence** (assessments that do not integrate health and ecological risks are likely to miss important modes of action that involve interactions between effects on the environment and effects on humans)

(Report Prepared for the WHO/UNEP/ILO Int. Prog. on Chemical Safety – WHO/IPCS/IRA/01/12);
Suter et al., 2005

Humans are a part of ecosystems

- Not just the end of the human food supply chain!
- Two-way interaction between humans and the environment
  - We depend on ecosystem goods and services
  - We impact ecosystems (not just through pollution)



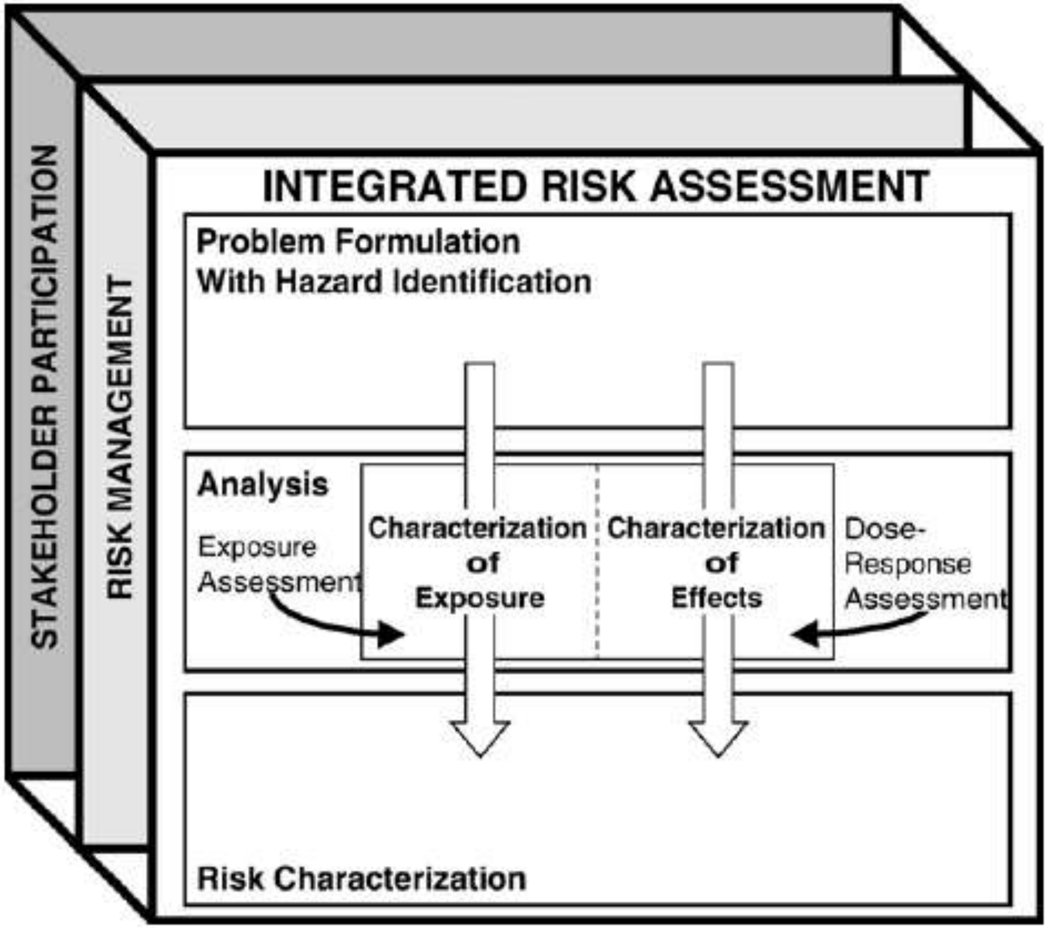


- Environmental contaminants may directly affect human health, they also indirectly affect human welfare

→ This conceptual approach links well with developments in other fields of risk assessment & environmental protection (more holistic focus)

EUROPEAN RADIOECOLOGY ALLIANCE

Similar risk assessment basis calls for integration

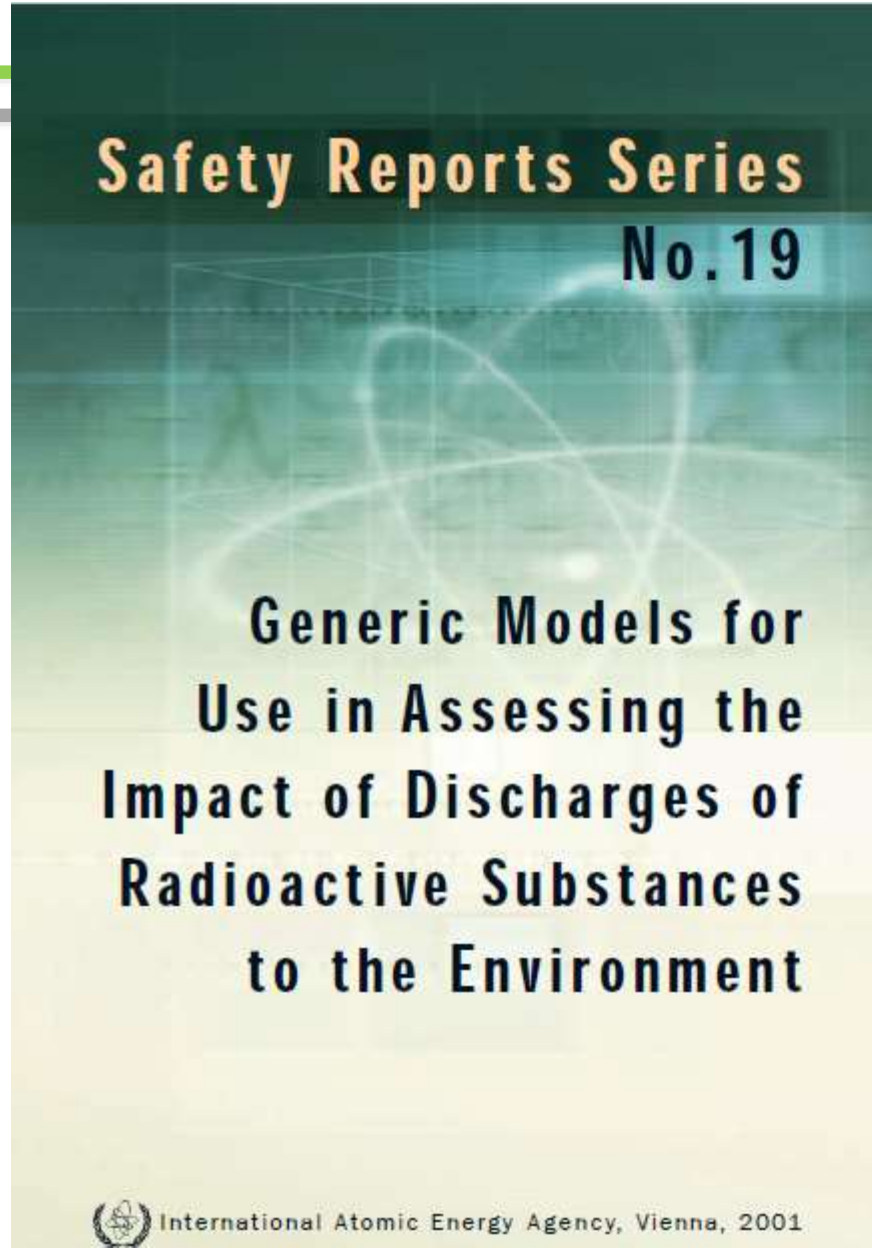


EUROPEAN RADIOECOLOGY ALLIANCE

Integrating dispersion and transfer models is justified

- Radioecological data is part of human and environmental risk assessment (HRA, ERA)
  - Underlying dispersion and transfer in environment is the same
  - Underlying physical and chemical processes are the same
- Logical to use same activity concentrations in media and/or organisms as starting point
- Logical to use same dispersion and transfer models

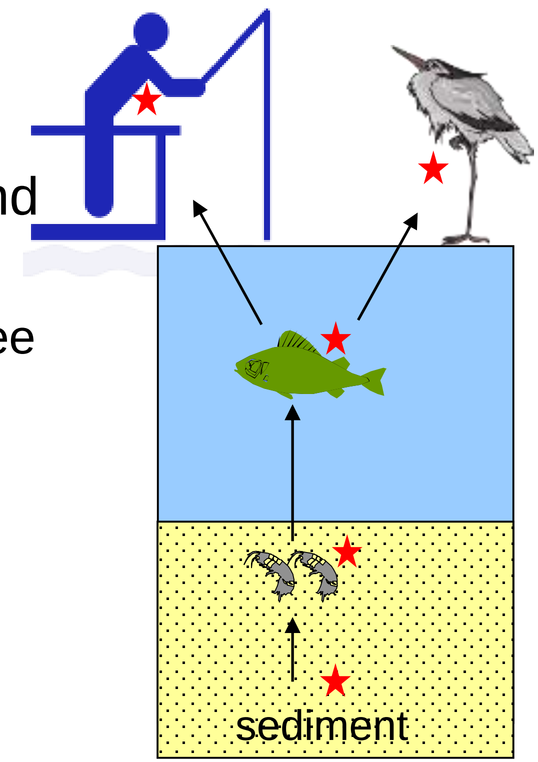
Integrating dispersion & transfer models is justified



EUROPEAN RADIOECOLOGY ALLIANCE

Challenge: availability & use of transfer data

- Data relatively plentiful for (e.g.)
  - Uptake/depuration in human bodies/organs
  - Transfer in human food chains
- Data often scarce for the wide range of species and habitats that exist
  - Extrapolation methods used to a much larger degree
- CRs are less easy to harmonise?
  - Many based on parts (tissues) eaten by humans
  - IAEA-TRS472 – IAEA-TRS 479
    CR wildlife (e.g. deer, freshwater fish): different
  - Human: foodchain ←→wildlife: medium
- Kds should be equally valid in HRA and ERA
  - Describe partitioning between sediment or soil and water

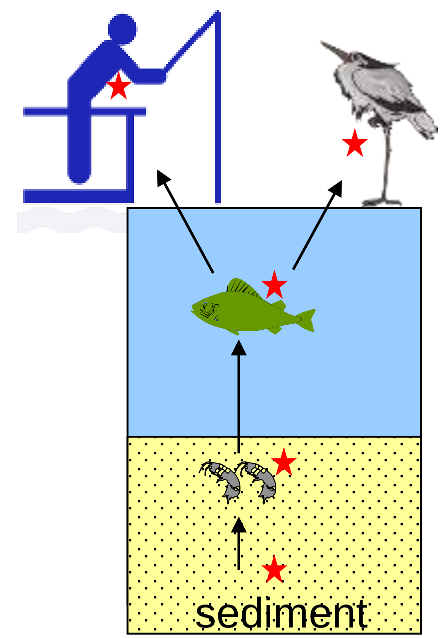


(IAEA Tecdoc 1616)

EUROPEAN RADIOECOLOGY ALLIANCE

Transport and transfer – amenable to integration

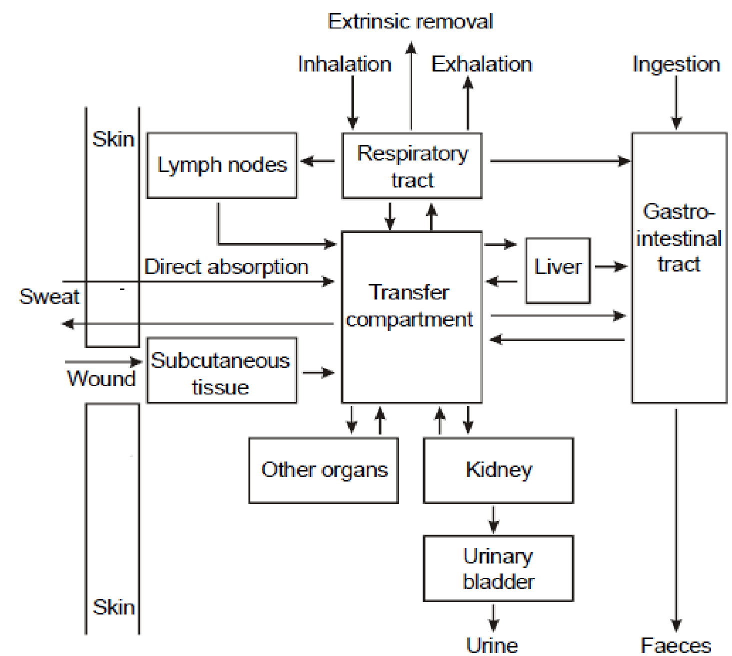
An integrated approach for human and wildlife risk assessment recognises the similarity in environmental processes and assessment context and ensures consistency in databases, parameter values and representation of data, whilst respecting the need to represent the intake (and resulting internal exposure pathway) differently for biota and for humans.



EUROPEAN RADIOECOLOGY ALLIANCE

Challenge: integrating dosimetry

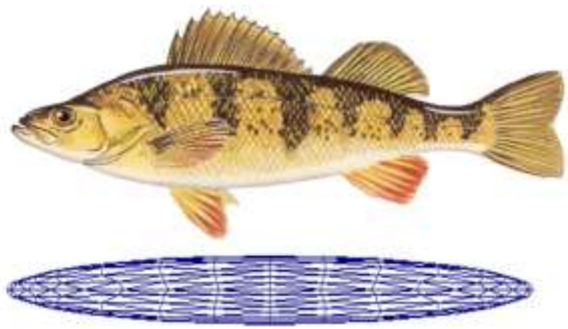
- Human dosimetry is very sophisticat
  - Based on biokinetic model
  - Organ and RBE weighing factors → effective dose (Sv)
  - Organ/tissue-specific
  - Age-specific
  - Voxel phantoms,...



EUROPEAN RADIOECOLOGY ALLIANCE

Reference organisms: a “shaped” environment

- Organism shapes approximated by ellipsoids, spheres or cylinders of stated dimensions.

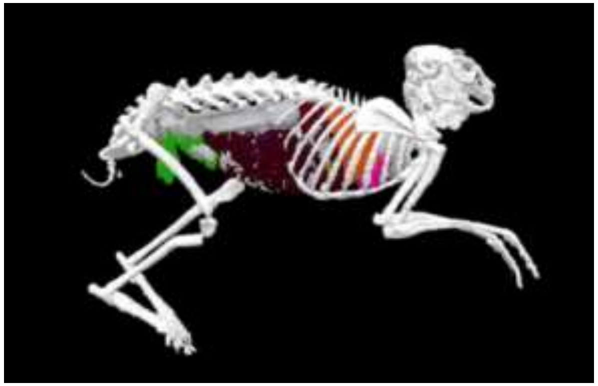


- Homogeneous distribution of radionuclides within the organism: organs are not considered.
- Organism immersed in uniformly contaminated medium.
- Dose rate averaged over organism volume
- Dosimetry method for wildlife: simplification of more complex dosimetry approach employed for humans. Simplification necessary, given large range of shapes, sizes and masses of organisms from microscopic bacteria to the largest plants and animals.

EUROPEAN RADIOECOLOGY ALLIANCE

Advanced human dosimetry methods have been applied to other species

- Physics of interaction of radiation with matter same for all organisms, Monte Carlo codes are the same
- But probably not justified (resource demanding)?
- Not so relevant in ERA (focus on individuals)?
- Voxel models
  - allow for calculating accurate organ dose rates
  - aid in validating the use of ellipsoidal models for regulatory purposes
  - unlikely integrated within tools like the ERICA for their high data demand and lack of underpinning data, plus the simplified ellipsoidal representation provides reasonable conservative estimation of dose

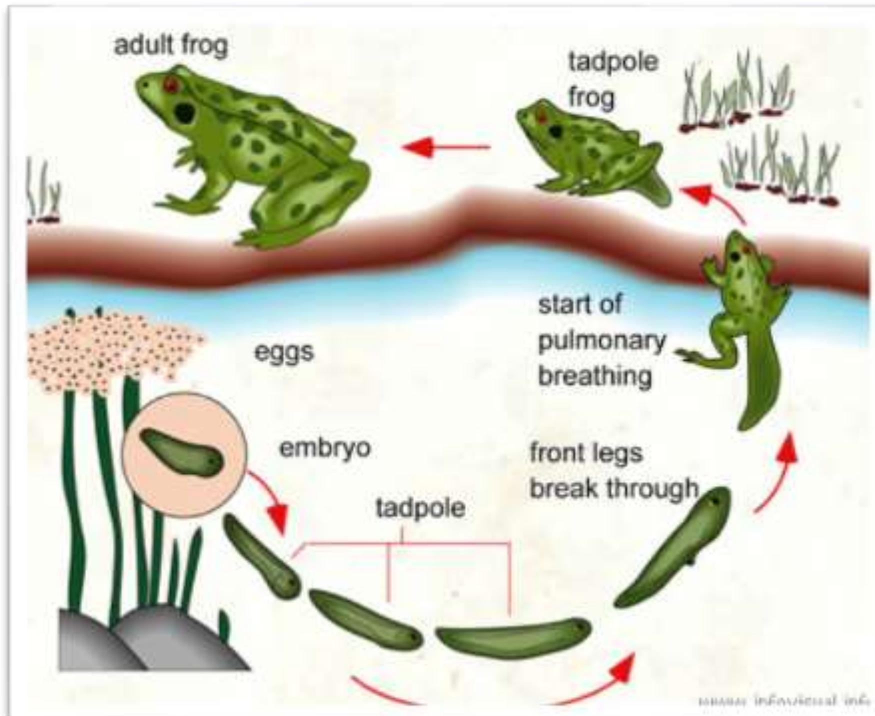


←Caffrey et al. 2016
Stabin et al. 2016 →

EUROPEAN RADIOECOLOGY ALLIANCE

Challenge: Spatial and temporal variability influence transfer and exposure

- Same applies to humans and non-humans
- Well-characterised for humans
- Lack of data for other species, especially variation within a mobile population
- We do not know how this affects exposure estimates for biota



Semi-terrestrial
Respire through lungs. Carnivorous - eat worms, insects.

Aquatic
Respire through external gills, then internal gills.
Eat periphyton, leaves, detritus.

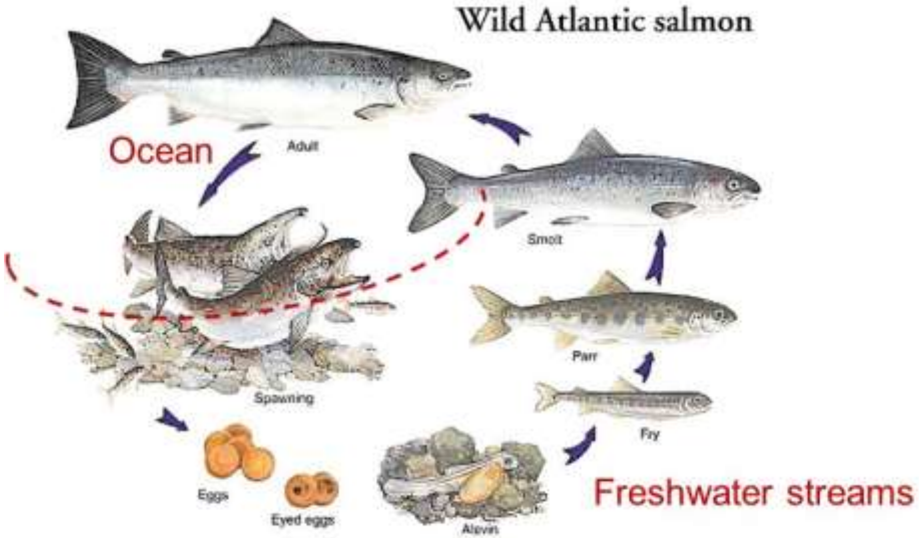
Adapted from www.infovisual.info and Duellman & Trueb, 1994

EUROPEAN RADIOECOLOGY ALLIANCE

Integrating human and environmental dosimetry = unlikely

- Additional difficulty: different life stages and hence different exposure rates. Feeding habits, physiology and sensitivity vary with life stage but associated parameter values and underpinning data are generally not available.
- Most commonly used data are those for the adult stage.
- Human risk assessment: standard tables for human habits ifo age class
- Approach to calculate biota committed effective dose not available for wildlife

→ Unlikely effective to integrate human and wildlife dose assessment: effort will likely exceed the benefit



EUROPEAN RADIOECOLOGY ALLIANCE

Challenge: protection endpoints
Different frameworks, different goals

Environment:

"a negligible impact on the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities, and ecosystems"

Focus: populations

Human health:

"the management and control of exposures to ionising radiation such that deterministic effects are prevented, and the risks of stochastic effects are reduced to a reasonably achievable level "

(ICRP, 2007)

Focus: individuals

> Endpoints unlikely to be integrated, but frameworks could be?

EUROPEAN RADIOECOLOGY ALLIANCE

Regulatory limits and consideration levels

- HRA
  - Established dose limits, dose constraints, reference levels,...
  - For different types of situations (planned, existing, emergency)
  - Aim to restrict individual doses
  - Benchmarks have a biological basis
- ERA
  - Less well-defined – screening values rather than limits
  - Not internationally agreed
    - ERICA - PNEDR, ICRP – DCRL, US DoE,...
  - Values are not so well-grounded in science
- **Not feasible (or desirable?) to integrate?**
  - **Protection goals are different**
  - **Lack of data for effects to non-human species, ecosystems**

20 mSv / y

1 mSv / y

1 mGy / d

10 mGy / d

0.1 - 1 mGy / d

10 µGy / h

EUROPEAN RADIOECOLOGY ALLIANCE

Challenge: Extrapolation and uncertainties

- Many factors that contribute to uncertainty are the same in HRA and ERA – e.g.
  - Transferring/extrapolating risk from one population to another
  - Extrapolating from acute to chronic exposures
  - Extrapolating from high dose to low dose effects
  - Extrapolating between different types of radiation
- For ERA – also a large number of different species and ecosystems
- HRA and ERA can learn from each other re. extrapolation methods
- Range of values often available for model parameters
  - Consistency and/or transparency between HRA and ERA needed (e.g. use of geometric means and s.d., PDFs, etc.)

EUROPEAN RADIOECOLOGY ALLIANCE

Challenge: looking broader and multicriteria analysis

- Environmental contaminants may directly affect human health, but indirectly affect human welfare. Nature provides variety of products & services which can be jeopardized by contamination yet not considered in routine risk assessment.
- Multiple contaminant context: Consistency between frameworks for chemicals and radiation facilitates mutual understanding.
  Taking further: cumulative risk assessments (CRAs) address combined risks from exposures to multiple chemical and nonchemical stressors
- Multi-Criteria Decision Analysis
  - employed for analysis of complex problems involving non-commensurable, conflicting criteria
  - overcomes shortcomings of traditional decision support tools (eg CBA) when dealing with values not easy to quantifiy or translated in monetary terms since of intangible nature (*e.g.,* socio-cultural or psychological issues).
- Decisions concerning management of contamination (radioactive and other) in environment only adequately informed if assessments are sufficiently integrated to address all relevant factors & targets (man/environm. in their complex setting)

EUROPEAN RADIOECOLOGY ALLIANCE

Integration feasible and/or needed?

Underlying transfer data	yes	Some data in common
Transfer and dispersion models	yes	Underlying processes are the same
Dealing with spatio-temporal variation in exposure	?	Unlikely feasible/justified in ERA
Detailed dosimetric approaches	no?	Not justified or relevant for ERA
Regulatory limits / consideration levels / benchmarks /screening levels	no	Protection aims are different

EUROPEAN RADIOECOLOGY ALLIANCE

Advances in integrated modelling tools

- **CROM8**
  - CROM originally developed for HRA
  - In CROM8, HRA and ERA can be performed in the same tool
    - Calculates activity concentrations in the environment
    - Then estimates effective doses to humans and absorbed doses to biota via different modules in the same code

- **CROMERICA**
  - Will include updated IAEA models, updated ERICA Tool parameters and screening model for humans and wildlife

EUROPEAN RADIOECOLOGY ALLIANCE

Acknowledgements

European STAR Network of Excellence in Radioecology (www.star-radioecology.org; contract number: Fission-2010-3.5.1-269672).

Karine Beaugelin
Justin Brown
Juan Carlos Mora Cañadas
Mark Dowdall
Elisabeth Hansen
Thomas Hinton

Ali Hosseini
Astrid Liland
Deborah Oughton
Beatriz Robles
Karolina Stark
Lieve Sweeck

EUROPEAN RADIOECOLOGY ALLIANCE