Terms of Reference for Radioecology WG

Title and acronym:

Marine Radioecology

Topical area

The Fukushima Dai-ichi NPP accident in 2011 has refocused the vision for marine radioecology by highlighting the importance of post-accidental consequences for the marine environment and the limited knowledge that we have in that area. It constituted the most important accidental release of artificial radionuclides to the oceans that has ever occurred. Contamination of every marine component (water, sediment and biota) has been observed. The understanding of contamination levels and radionuclide distributions in the environment, along with prediction of their future evolution requires analyses of detailed monitoring data and the use of modelling tools. In the aftermath of an accidental situation where radioisotopes in the different marine compartments have not equilibrated, time-dependent radioecological models of transfer are required. Such situations offer the opportunity to validate and improve models that are, or have the potential to be, included in decision support systems (DSS) for emergency situations. This post-accidental situation also shows the necessity to develop research on more realistic (and sophisticated) models taking into account trophic transfer process related to pelagic or benthic organisms but also to develop alternative transfer models between dynamic FC and food chain model.

Leadership

Céline Duffa (IRSN, France)

Partners with a brief description of their assigned role

Interested Organisation	Assigned role
IRSN (France)	WG coordination To improve/develop/validate relevant modelling tools liable to account for dispersion of radionuclides (via seawater and sediments) and for transfer of radionuclides to sediments and biota. It is based on: • Improvement and validation of 3D marine dispersion models in French marine areas (Atlantic and Mediterranean seas) by model/measurement comparison ; • Validation of dynamic transfer parameters between seawater and living species by model/measurement comparison over long time series (30 years) (AMORAD project); • Development and validation of sediment transport models by model/measurement comparisons in the English Channel (AMORAD project). • Improvement of transfer parameters between seawater and sediment by taking grain size into account. • Research studies with modelling and *in situ* monitoring on sediments and trophic transfer modelling in Fukushima area (AMORAD project). Part of this new-built knowledge will contribute to develop and validate an emergency modelling tool (STERNE) for marine dispersion and transfer calculations.
SCK (Belgium)	SCK has a major interest for the TWG as evidenced by the work being done currently in the Alliance Marine Group, COMET and the FRAME project and the EC project Harmone. Main focus is on improving the dynamic transfer model D-DAT but with interest also in developing better data for dynamic modelling parameterisation and improved decision support tools, with focus (but not exclusively) on Fukushima, there being other challenges for radioecology (e.g. in the Arctic, Baltic or other environments). Contributions to the challenge: • Ongoing development of the D-DAT marine model by adding new radionuclides, applying locally-derived parameters derived from the FRAME sea cruises in Fukushima and improving its radiological assessment. • Inclusion of the trophic pathway to this model by interconnecting biota compartments with ingestion rates and assimilation efficiencies, and including ingestion of sediments by benthic organisms. • Consider the interactions of pollutant metals and radionuclides • Participate and/or develop, in the international context, biokinetic model intercomparison studies for marine scenarios of interest (link to IAEA MODARIA). • Continue working on the development of allometric approaches for the extrapolation of biokinetic parameters for different biota, radionuclides and heavy metals, including the varying size of the same organisms. • Integration of dynamic transfer modelling methodologies and data into decision support methodologies (link with HARMONE). • Work towards the development of an "advanced D-DAT" modelling package migrating to a FORTRAN platform and developing a user-friendly interface for it.

SU (Sweden)	Detailed field investigation of the role of food web structure in Cs-137 uptake and transfer in benthic food webs, based on new data from a cruise in the Fukushima area in July-August 2015. Possibly ecosystem modelling (depending on future staffing at SU). Continuing contribution to the Alliance Marine Group Possible experimental investigation of uptake of RNs and effects on benthic fauna (in collaboration with other Institutes) – depends on new PhD position.
HMGU (Germany)	Participation in the Alliance working group "Marine radioactivity around Fukushima" Artificial and naturally occurring radionuclides in the Antarctic Ocean seawater and ice will be studied by gamma spectrometry and accelerator mass spectrometry. Valuable additional data for a study of environmental contamination in the Antarctic Ocean area can be expected.
CEA (France)	Contribution to the challenge : Understand the long-term behavior and fate of radionuclides released by Fukushima accident, e.g. sustained concentrations due to ongoing discharges and land runoff by a better and quantitative assessment of radionuclide release from continental source towards the Pacific Ocean in the area of Fukushima. This involves monitoring of radionuclide isotope composition and content in river systems and possibly in clay to silt-sized marine sediment off the estuaries of the coastal rivers draining the main part of continental Fukushima radioactive pollution plume (within AMORAD French project).
UAB (Spain)	FRAME project (also included in COMET Initial Research Activity): • Evaluation of the distribution of radioactive contamination in the various compartments of the marine environment off Fukushima (water column, sediments, biota) and the temporal evolution. • Investigation of the on-going sources from land. • Modelling of future trends.
EPA (Ireland)	Marine Dispersion Modelling • Continuous development and validation of hydrodynamic model of the Irish Sea taking into account transfer factors from seawater to biota and sediments. • Investigate transfer factors from seawater to biota through in-situ monitoring • Investigation of New Build NPP in the UK on the environment through modelling the behavior of potential discharges (both continuous and short term plumes) from the proposed sites, taking into account the various reactor types proposed. • Sensitivity analysis of current marine dispersion modelling tools • Investigate the impact climate change and rising sea levels will have on current and future NPP coastal sites
DTU (Denmark)	Studying long-term behaviour of radionuclides in the Baltic Sea and transfer of man-made radionuclides from Europe to the Faroe Islands and Greenland including dispersion, uptake and modelling
NRPA (Norway)	Dispersion and transfer modelling. Stochastic modelling for simple biokinetic submodels. Sensitivity analysis for the model parameters, especially for the parameters for water-sediment interactions.

NMBU/CERAD CoE (Norway)	Modelling development with higher spatial and temporal resolution will be tested against previous releases from Sellafield (PhD). Development of marine modelling including river and estuarine transport. Implementation of particle codes. Modelling of releases from dumped nuclear submarines in the Kara and Barents seas. Pu and U atom ratios for source characterization (Japan, Kara Sea).
CEH (UK)	Development of REML models for marine biota with NRPA.
CIEMAT (Spain)	Minor contribution (modelling)

Starting date and estimated duration of the WG to accomplish its plan

Starting date: September 1, 2015

Duration of the WG: 5 years

Intended activities

The intended activities contribute to 3 main tasks:

Task 1: Marine dispersion modelling

The task is devoted to development and validation of tools to model marine radionuclide dispersion. It includes knowledge of activity levels in marine areas.

Dissolved or particulate bound radionuclides are concerned in this task.

Approach:

Knowledge of seawater activity trends in different regions (HMGU, IRSN).

Existing hydrodynamic models are used by IRSN. Validation of modelling results is one of the major points of this task. This includes direct measurement of physical parameters (currents, salinity…) and use of existing radiotracers (already proved to be valuable tools for the improvement of radionuclide dispersion models, in the English Channel and the southern North Sea), Inputs of tritium from French nuclear power plants (via Loire and Gironde estuaries) will be used to perform similar validation in the gulf of Biscay, by using ultra-low level measurements of dissolved tritium (HTO). NMBU/CERAD will also validate model development (improved resolution) using existing data from Sellafield releases into the North Sea, as well as dispersion within Kara Sea and Barents Sea associated with sunken submarines (collaboration with NRPA).

NRPA uses box modelling approach for the Baltic Sea and Fukushima coastal waters with regards to accidental releases. This box approach uses non-instantaneous dispersion of radionuclides in seawater where sea region is “open” for dispersion after some time after accident (time of availability).

Implementation of sediment transport model to hydrodynamic modelling is included in this task. IRSN will perform this model connection for some case studies.

Steps to accomplish:

IRSN will perform measurements of tritium concentrations French coastal areas, together with other tracers (salinity) and physical parameters and model/measurements comparisons. In situ

measurements of particulate matter and of different parameters to calibrate and validate locally sediment transport models.

NRPA will make sensitivity analysis for the model parameters, especially for the parameters for water-sediment interactions.

NMBU/CERAD will improve the model resolution, and implement particle codes.

Expected outcomes

Validated dispersion model relevant for normal or accidental discharges from nuclear plants or ship wreckage, usable in DSS or for post accidental studies.

Task 2: Radioecological transfer in marine environment

This task includes modelling and experimental studies (to quantify transfer parameters or to study specific processes).

2.1 Transfer to biota

Approach:

Estimation of dynamic transfer parameters between seawater or sediments and biota.

Use of available time-series of radionuclide concentration obtained in-situ (IRSN will use data from the Channel, in the vicinity of the release point of the reprocessing plant of La Hague), or specific experimental study.

Use of dedicated experimental studies for pelagic or benthic species (SU).

Implementation or validation of existing models (including results already obtained during Initial Research Activity) (SCK, IRSN, NRPA).

Test models based on taxonomic groupings (CEH).

Steps to accomplish:

Existing FC and Tb data compilation (direct link with IRA).

Define experimental studies to perform and the experimental procedures.

Use of allometric approach for extrapolation of biokinetic paramaters (SCK, CEH, NRPA).

Improvement or extension of existing dynamic transfer models (SCK, IRSN, NRPA).

Sensitivity analysis.

Expected outcomes:

Documented database of dynamic transfer parameters for an extended list of radionuclides and marine biota.

Radionuclide dynamic transfer modelling to marine biota with implementation of the trophic pathway in parallel with the seawater pathway.

2.2 Transfer to sediments

Approach:

Development and validation of dynamic models instead of simple Kd use by Implementing or improving radionuclide transfer to the sediments modelling.

Steps to accomplish:

Deriving operational relationship between radionuclide concentration (and Kd) in sediments and particle grain-size (IRSN).

Improving of kinetic transfer parameters using model/measurements comparison (IRSN, SCK).

Sensitivity analysis (NRPA).

Implement estuarine processes, and Improving Pu atom ratio database (NMBU/CERAD)

Expected outcomes:

Use of more realistic transfer parameters for modelling the dispersion of sediment-bound radionuclides.

Task 3: Fukushima case study

This task aims to have a better understanding and estimation of the long-term behavior and fate of radionuclides released from Fukushima station.

Approach:

Examination of available activities time series for every compartment (seawater, sediments, biota).

Dedicated studies and projects including *in situ* measurements and samplings in rivers, estuaries and sea (oceanographic cruises). These studies' results will improve our knowledge and understanding of the contamination state and evolution. FRAME and AMORAD projects are directly linked to this task.

Investigation of the inputs from land (from rivers or from underground water).

The transfer to biota will be one of the main research challenges, especially for the benthic species.

Steps to accomplish:

Evaluation of the distribution of radioactive contamination in the various compartments of the marine environment (water column, sediments, biota) and the temporal evolution (UAB, SCK, IRSN, CEA).

Design and validation of erosion models to estimate impacts of land use change / rainfall scenarios on radionuclide export from Fukushima coastal catchments to the ocean (CEA).

Estimation of the land ^{137}Cs inputs contribution to the ongoing contamination of the coastal area (IRSN).

Measurements of $^{240}Pu/^{239}Pu$ ratios for source identification (NMBU/CERAD).

Design of sediment un-mixing models based on plutonium isotopic ratios (e.g. $^{241}Pu/^{239}Pu$ ratio) to calculate spatial and temporal variations of this radionuclide redistribution (CEA).

Evaluation of pathways of trophic transfer in benthic food webs, through collection of new field data from Fukushima benthic coastal ecosystems (SU).

Expected outcomes:

Better understanding of the post-accidental situation and possibly evaluate future trends. Improvement of knowledge concerning radioecological transfer processes.

Test and validation of existing or developing radioecological models (this task constitutes one case study for task 1 and 2).

Work plan

Partner	Concerned tasks	Means, fundings	Resources
IRSN	Coordination Task 1 Task 2 Task 3	T1: IRSN, Marine IRA T2: AMORAD T3: Marine IRA, IRSN PhD 2016-2019	T1: 36 man.months (PhD) T2: 72 man.months T3: 72 man.months
SCK	Task 2	FRAME project, Marine IRA	3.75 man.months
SU	Task 2 Task 3	SU PhD funding SU own funds	12 man.months 3 man months
HMGU	Task 2 Task 3		4 man.months
CEA	Task 3	AMORAD CEA PhD funding (36 months)	20 man.months
UAB	Task 3		
EPA	Task 1		
DTU	Task 1		
NMBU	Task 1 Task2 Task 3	CERAD (PhD), Bilateral Norwegian – Russian projects	18 man.months 6 man.months 2 man.months
NRPA	Task1 Task2	EFMARE (NKS project); CERAD (Norwegian program) PREPARE	14 man.months
CEH	Task 2	TREE	1 man.months

Cited projects:

AMORAD (Improvement of radionuclides dispersion and impact assessment. modelling in the environment), 2013-2019 – supported by ANR (French National Research Agency),

CERAD is a Norwegian center of excellence for environmental radioactivity, established at NMBU

EFMARE (Effects of dynamic behaviour of Nordic marine environment to radioecological assessments) supported by the Nordic nuclear safety research (NKS).

PREPARE (Innovative integrated tools and platforms for radiological emergency preparedness and post-accident response in Europe, http://www.prepare-eu.org/), supported by EU commission.

TREE (Transport, Exposure, Effects, http://www.ceh.ac.uk/tree)

FRAME (The impact of the recent releases from the Fukushima nucleaR Accident on the Marine Environment), COMET supported project (2014 call).

HARMONE (Harmonising Modelling Strategies of European Decision Support Systems for Nuclear Emergencies – an OPERRA project).

Major elements of the communication plan (workshops, publications, guidance documents…)

IRSN	COMET meetings, workshops, conferences, publication in international journals
SCK	COMET meetings and workshops, conferences, publication in international journals
SU	International conferences, publication in international journals, teaching
HMGU	publication in international journals, workshops
CEA	International workshops (EGU Vienna, AGU San Francisco,…) Publications in international journals
UAB	Publications under FRAME project
EPA	
DTU	
NMBU	Refereed publications, International conferences
NRPA	International conferences, publication in international journals, PhD
CEH	Refereed publications, conferences and workshops

Links with other activities identified at the national and the international levels

IRSN	AMORAD (French National Agency Project 2014-2019)
SCK	FRAME
SU	Collaborations with TUMSAT, Hokkaido University and Fukushima University (Japan), CERAD (Norway)
HMGU	
CEA	AMORAD (French National Agency Project 2014-2019)
UAB	FRAME
EPA	
DTU	
NMBU	CERAD, Bilateral Norwegian – Russian collaboration, Prepare
NRPA	EFMARE, PREPARE, CERAD
CEH	TREE

Expected problems, gaps/lack of knowledge, etc. that might prevent the accomplishment of the research

- Organization and funding of cruises to collect marine samples.
- Access to environmental description data concerning Fukushima marine area.
- Accessibility to marine ecosystem trophic chain description, especially benthic ecosystem.
- Difficulty to sample clay- to silt-sized sediment in marine environments (dominance of coarse material off the estuaries in Fukushima).
- Difficulties to match models and data when data is not of the type or in the form needed by the models.