Effects of dynamic behaviour of Nordic marine environment to radioecological assessments (the NKS EFMARE project)

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The EFMARE project is an extension of the NKS project "Consequences of severe radioactivity releases to Nordic marine environment (COSEMA)

Statens strålevern
Norwegian Radiation Protection Authority

Scenarios:

1. Nuclear power plant accident
2. Modern Russian operative submarine accident

Marine regions:

Iceland coastal waters

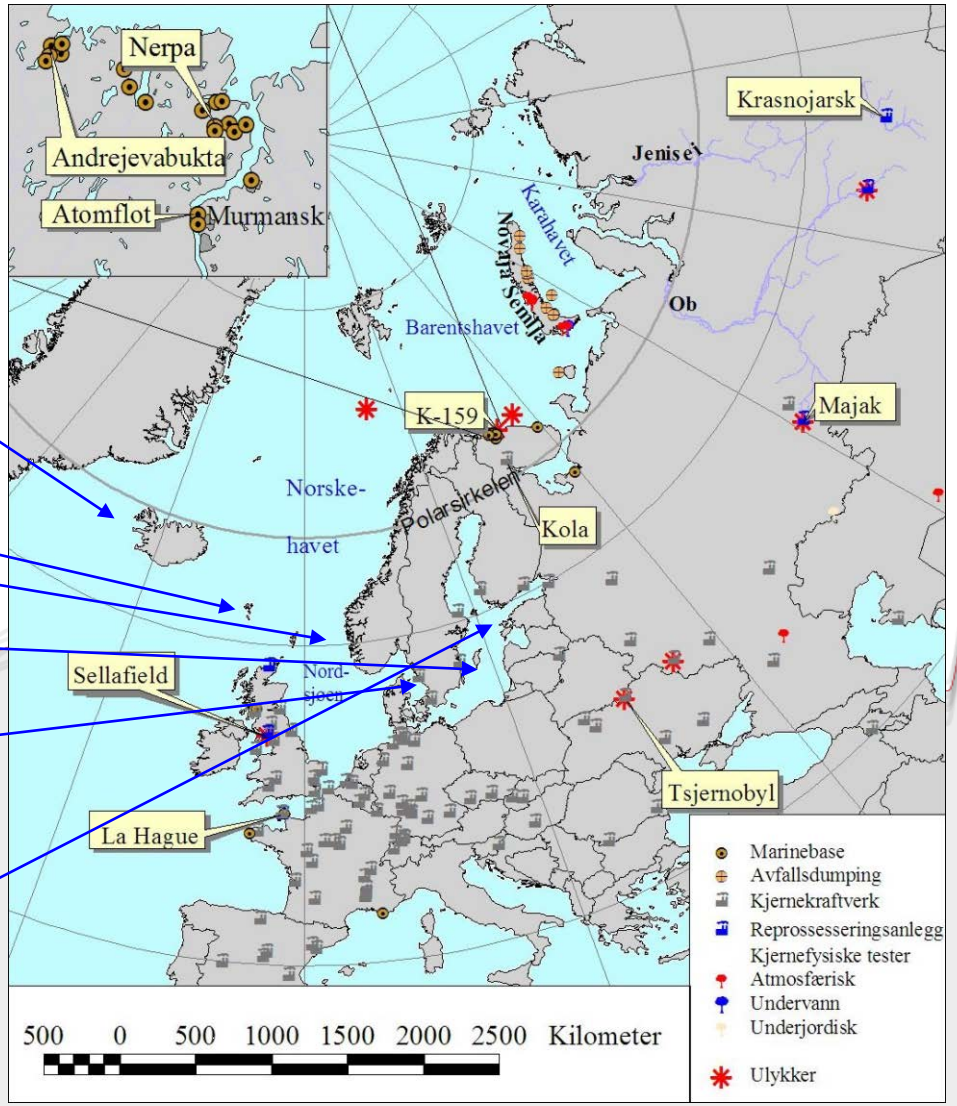
Faroe Islands

Norwegian Current

Baltic Sea

Kattegatt

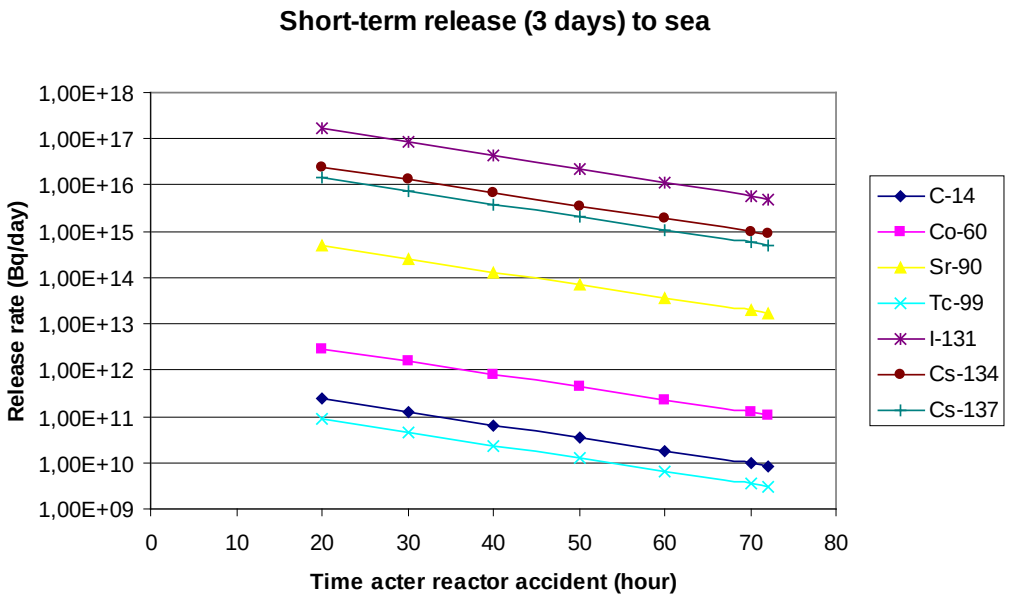
Finish and Swedish coastal waters



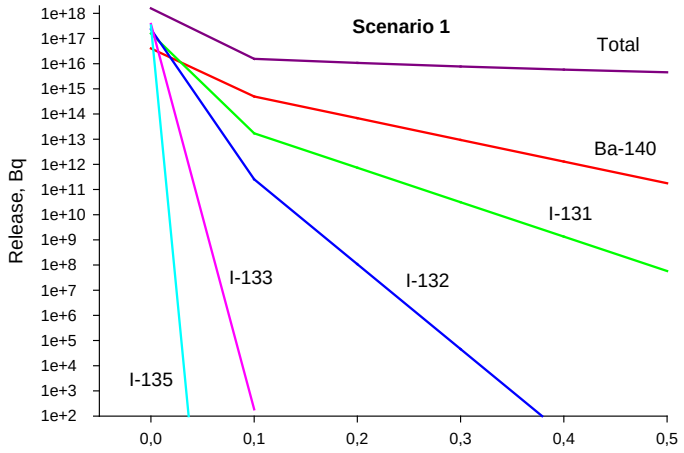
Accident release scenarios

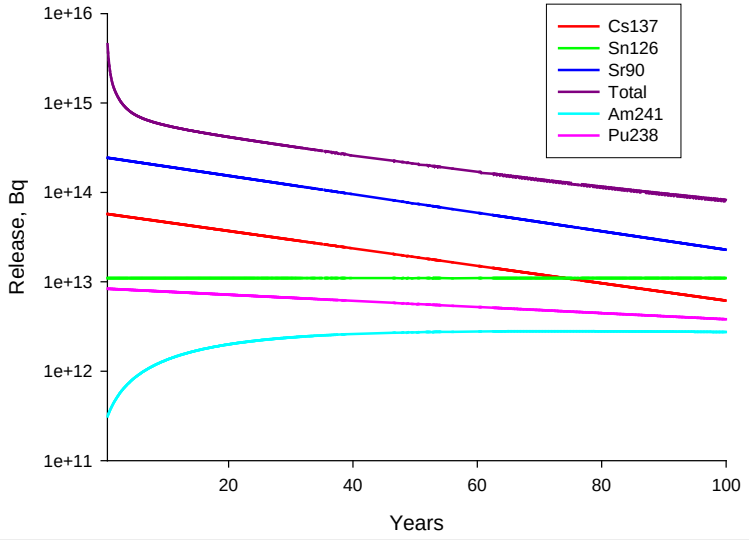
Statens strålevern
Norwegian Radiation Protection Authority

Nuclear power plant accident (COSEMA, 2013)



Submarine accident (Reisted, 2008)





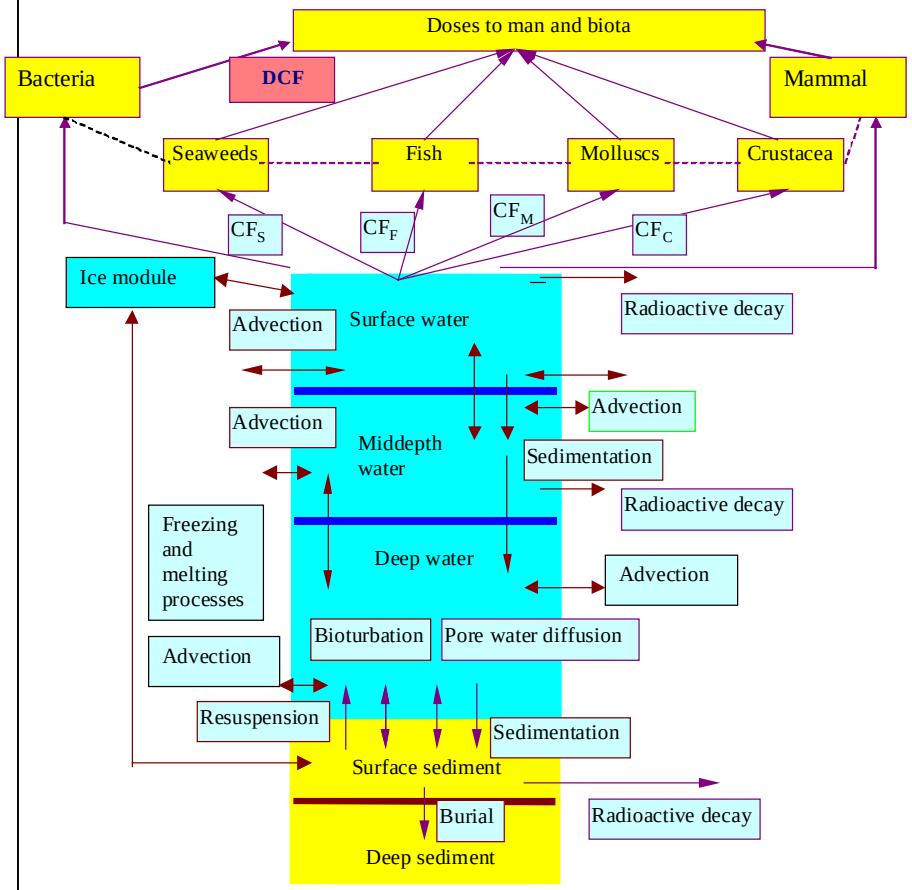
Consequences after the release of radionuclides :

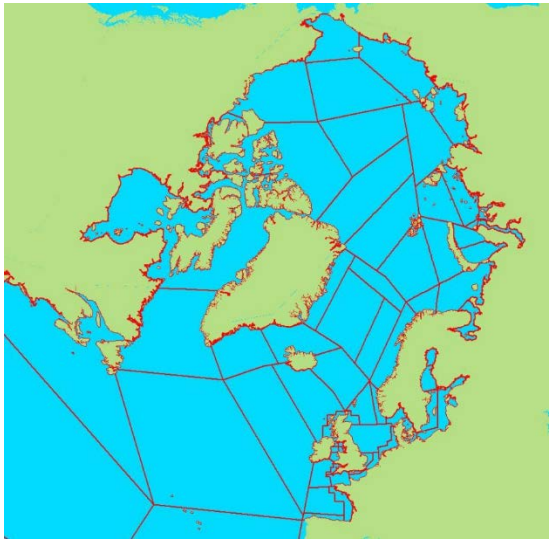
- dispersion of radionuclides in water and sediment phases
- bioaccumulation of radionuclides in biota
- doses for human and marine organisms.

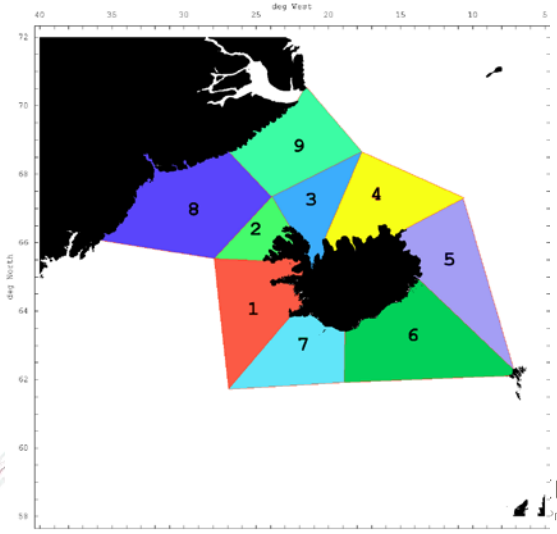
Models

- **3D Hydrodynamic numerical ocean model CODE**
- **VTT's DETRA computer code**
- **NRPA box model**
- **Regional Iceland box model for the Iceland coastal waters**

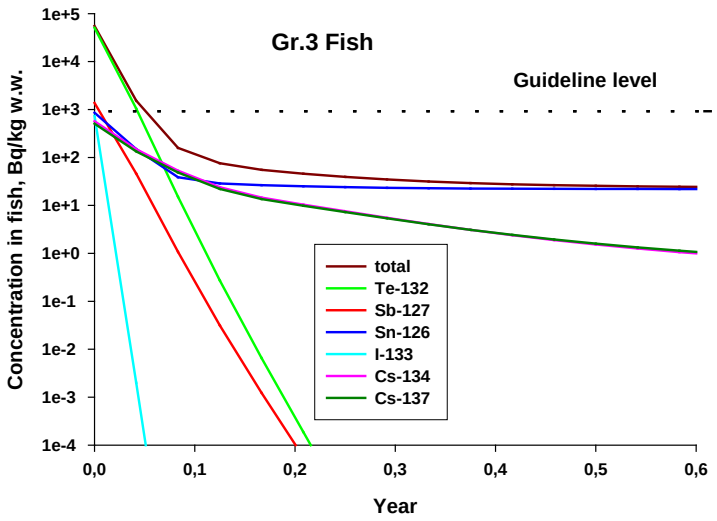
The NRPA and regional Iceland compartment models

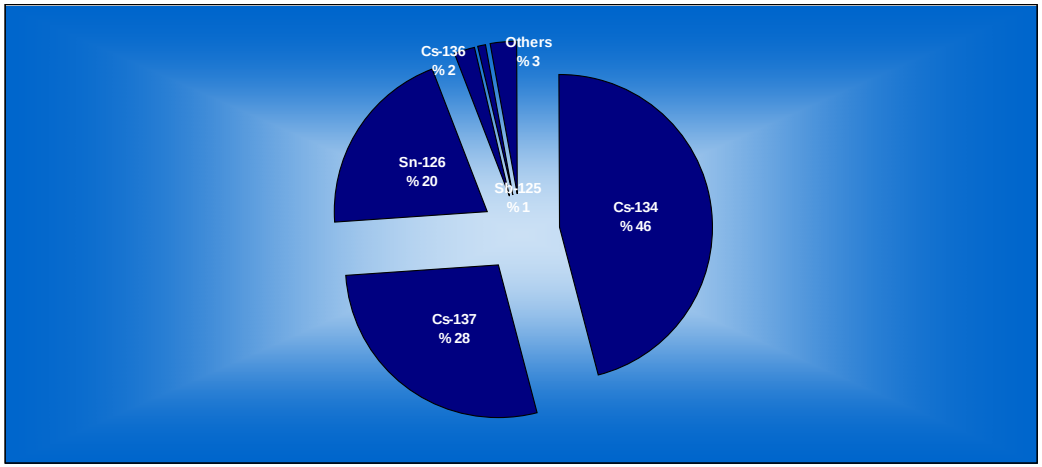






Case study: submarine accident. The end point example





Concentration in fish

Dose to the critical group (mainly from fish): 0.11 mSv

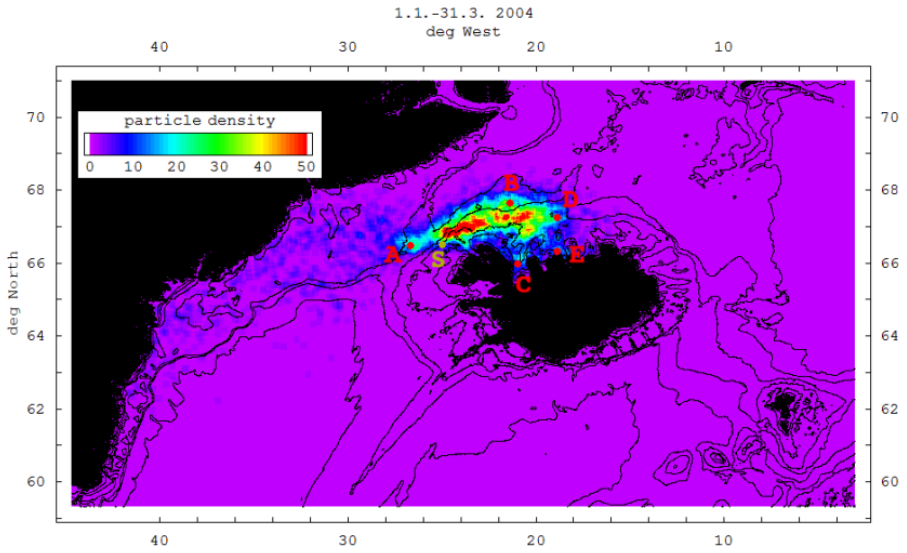
(*Dmin*= 0.009 mSv and *Dmax* = 2.4 mSv)

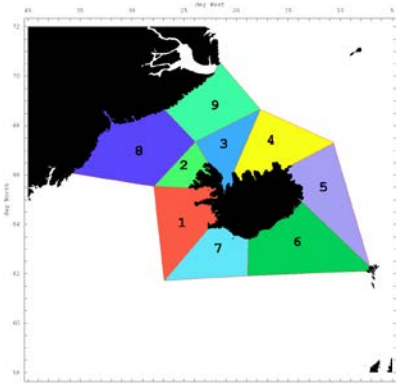
^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am, ^{241}Pu, ^{244}Cm, ^{131}I, ^{90}Sr, ^{106}Ru, ^{134}Cs, ^{137}Cs, ^{133}I, ^{126}Sn, ^{110m}Ag, ^{127}Sb, ^{132}Te, ^{136}Cs, ^{129}Te, ^{129m}Te, ^{127}Te, ^{125}Sb, ^{135}I, ^{103}Ru, ^{147}Pm, ^{242}Cm and ^{144}Ce.

Hypothesis for improvement

- **Development and implementation of the bioaccumulation process into the models**
- **Evaluation of the seasonality/time variability with following implementation into the models**

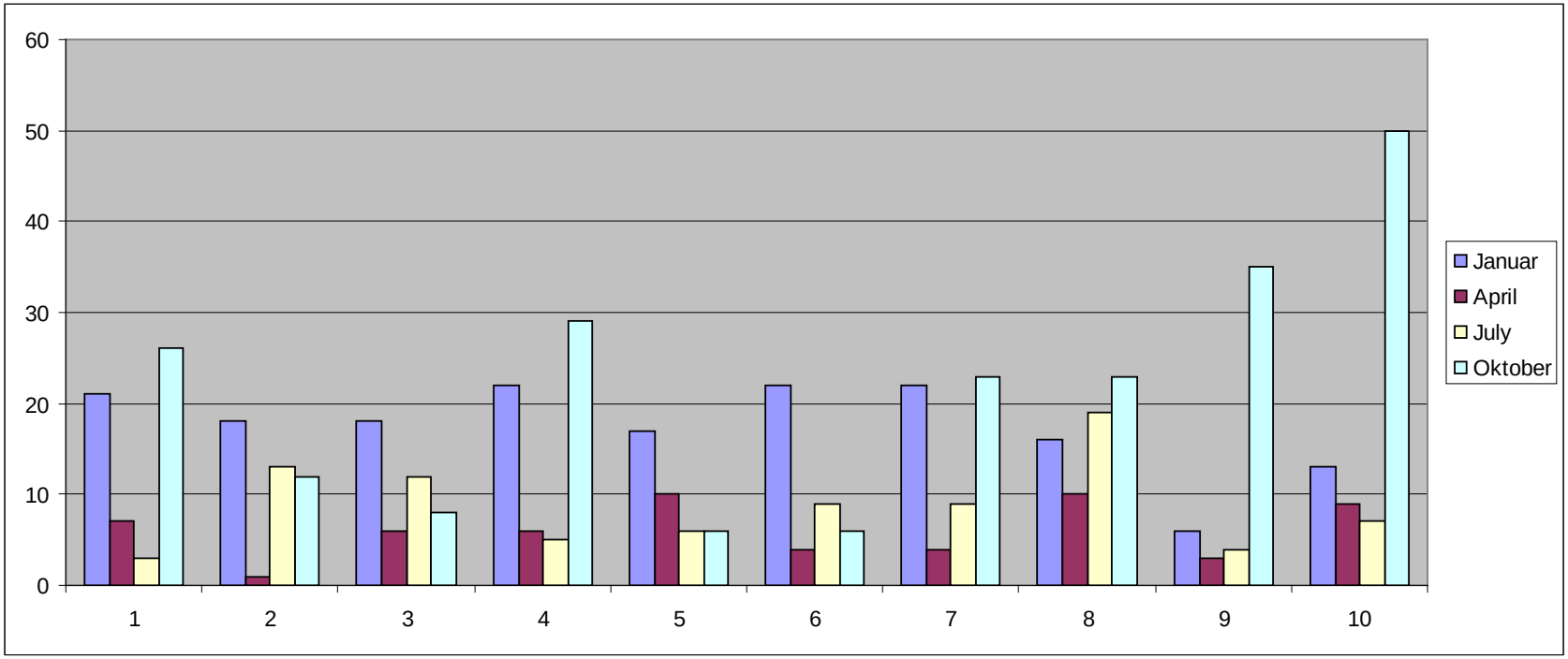
Evaluation of the seasonality / time variability with following implementation into the models (3D CODE model)



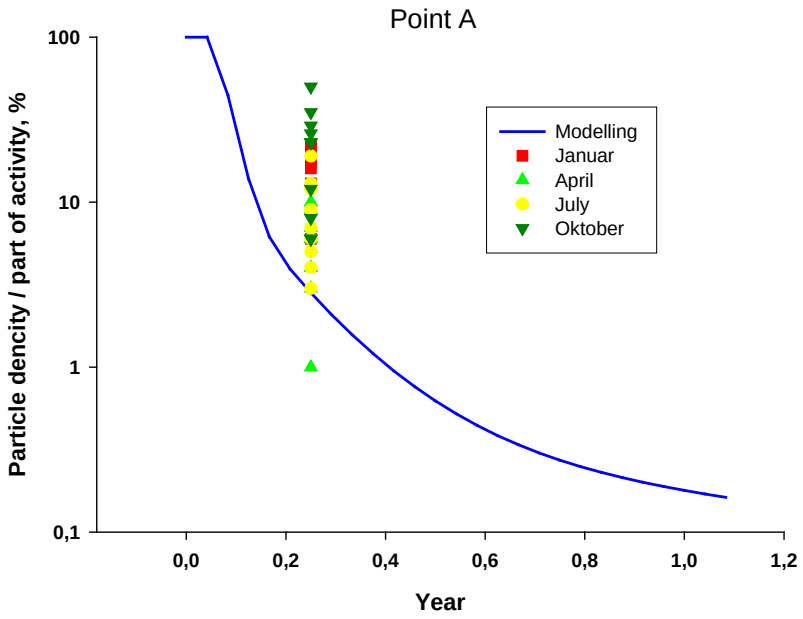


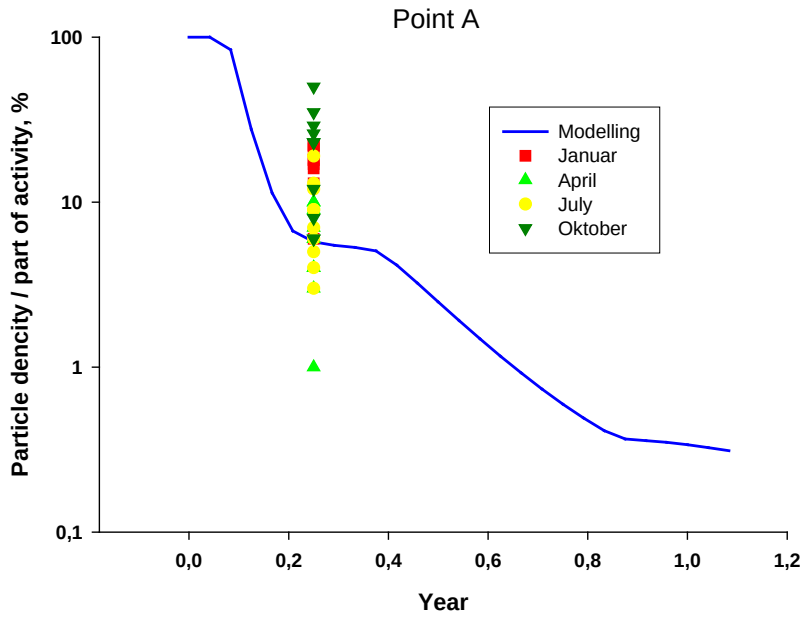
5000 particles; 40 experiments for each points

Particle density, point A (2002-2014)

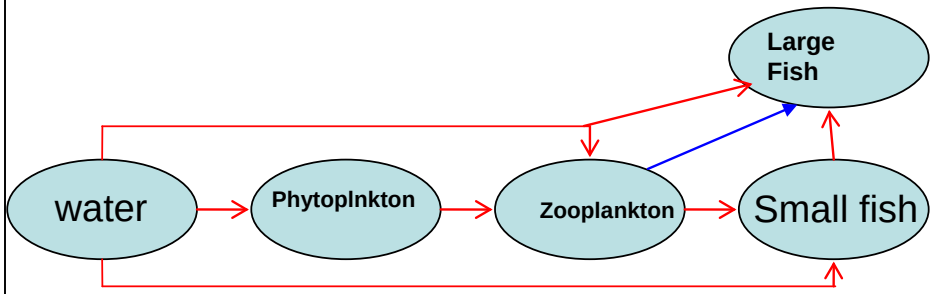


Comparison between 3D CODE and Regional Iceland models

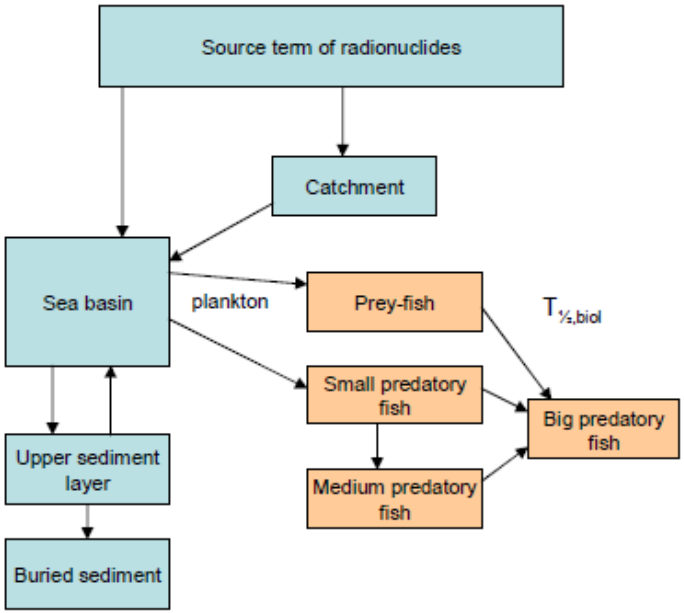




Bioaccumulation submodels

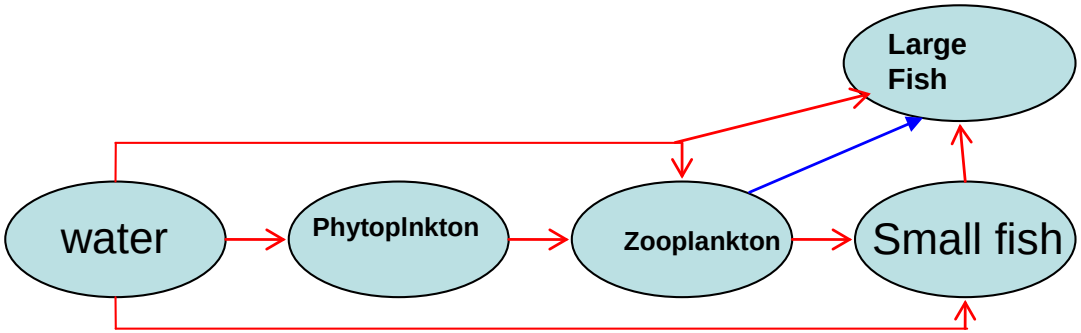


Bioaccumulation model based on Thomann (1981)



Conceptual bioaccumulation model for the DETRA computer code

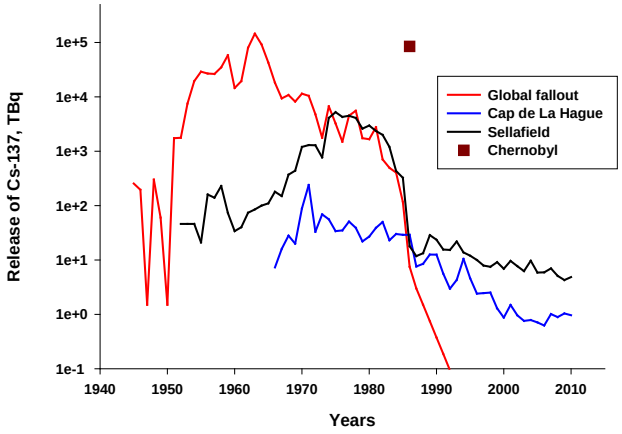
Case study: dynamic bioaccumulation submodel based on Thomann (1981)



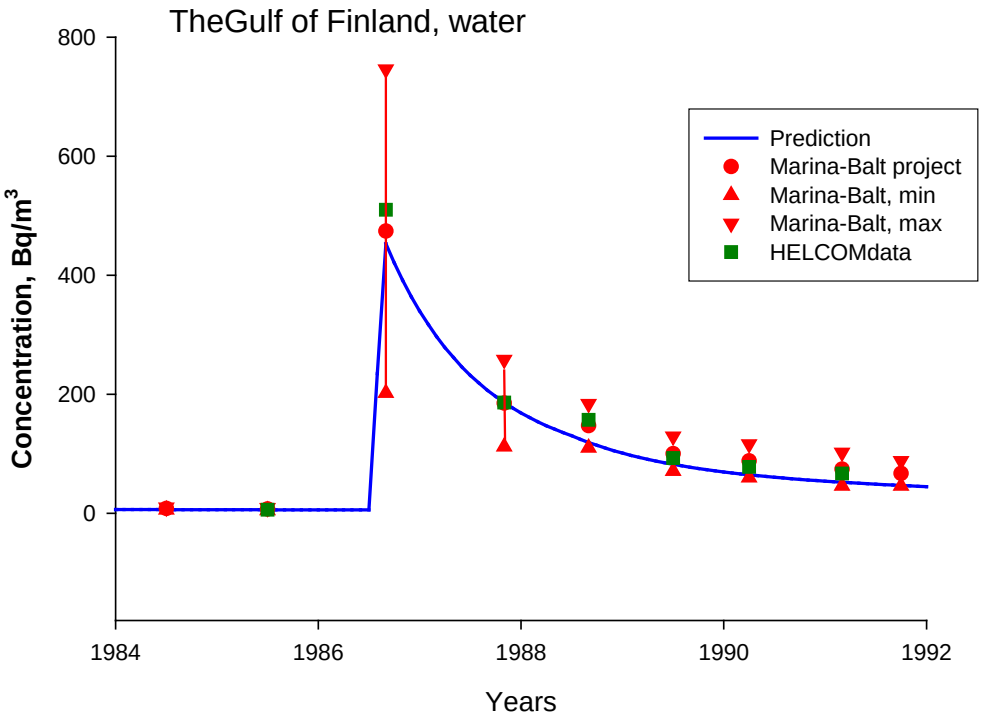
$$\frac{dC_i^{(tl)}}{t} = AE_i \cdot IR_i \cdot C_{i-1}^{(tl)} + k_{u,i} \cdot C_w - C_i^{(tl)} \cdot k_{e,i}$$

Here $C^{(tl)}_i$ and $C^{(tl)}_{i-1}$ – concentrations of radinuclide in trophic levels ”i” and ”i-1”,
C_W – concentration of radionuclide in water column,
AE_i – the assimilation efficiency for trophic level "i",
IR_i – ingestion per unit mass for trophic level "i",
$k_{u,i}$ – rate of the direct uptake of activity from water column for trophic level "i",
$k_{e,i}$ – the excretion rate for trophic level "i".

Validation I: The Gulf of Finland

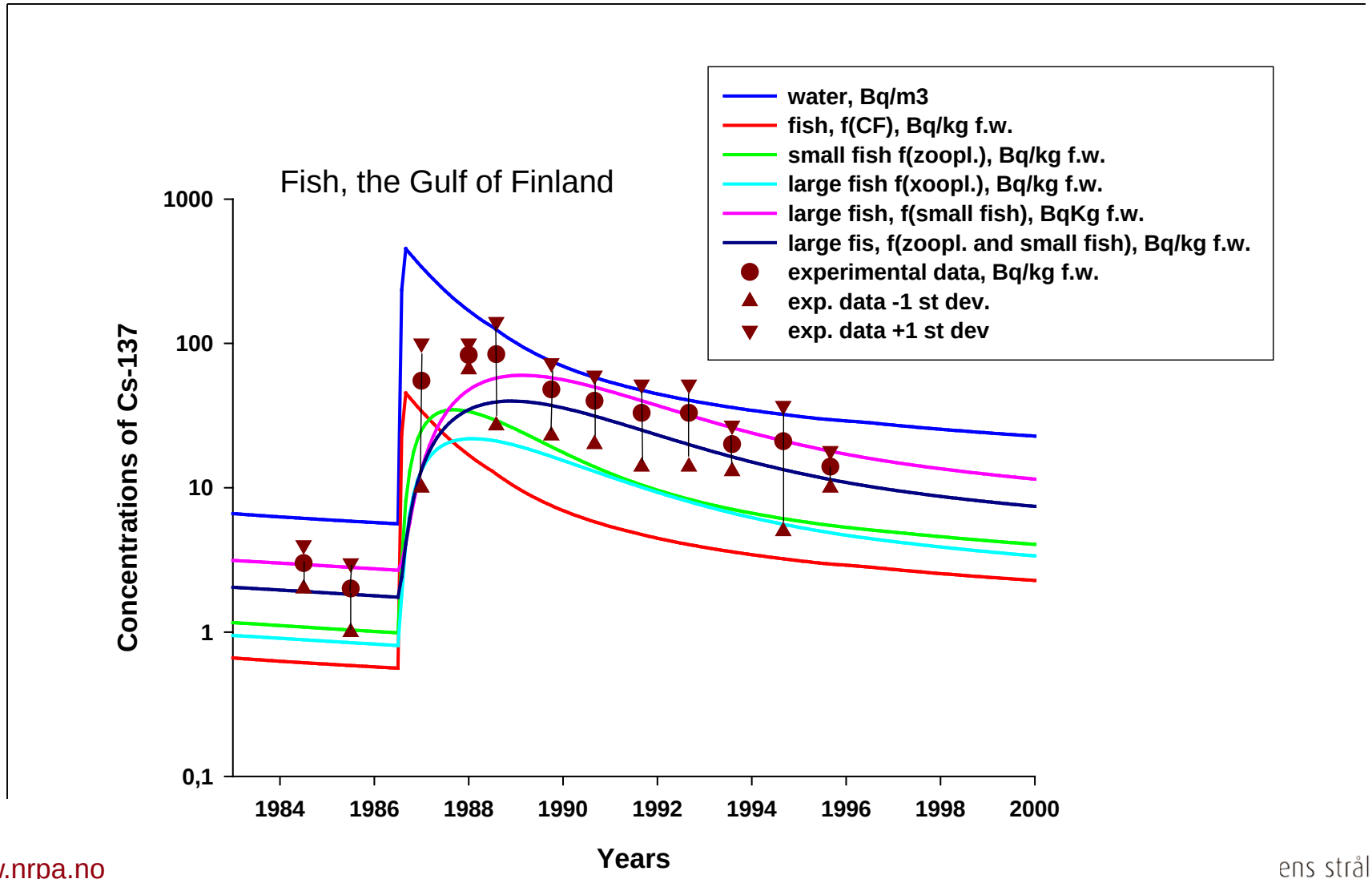


Sources

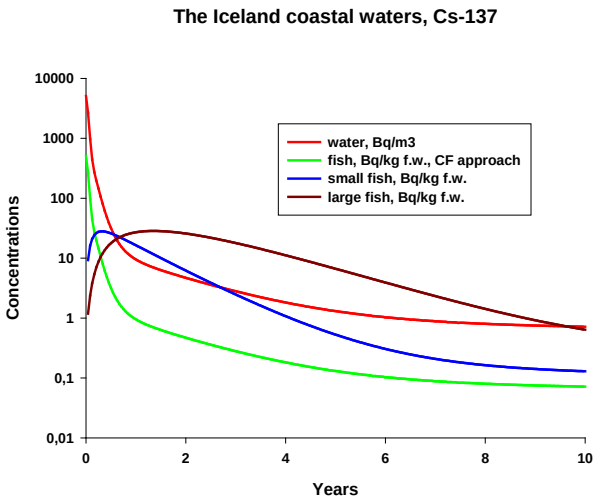


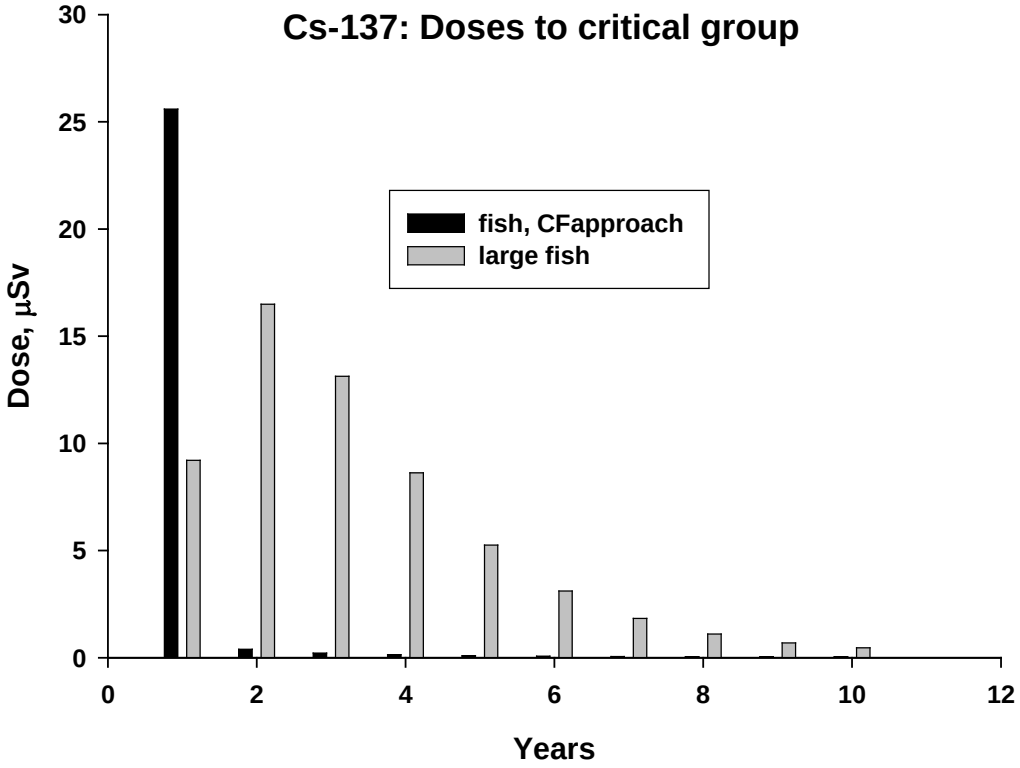
Concentration in seawater

Validation II: The Gulf of Finland

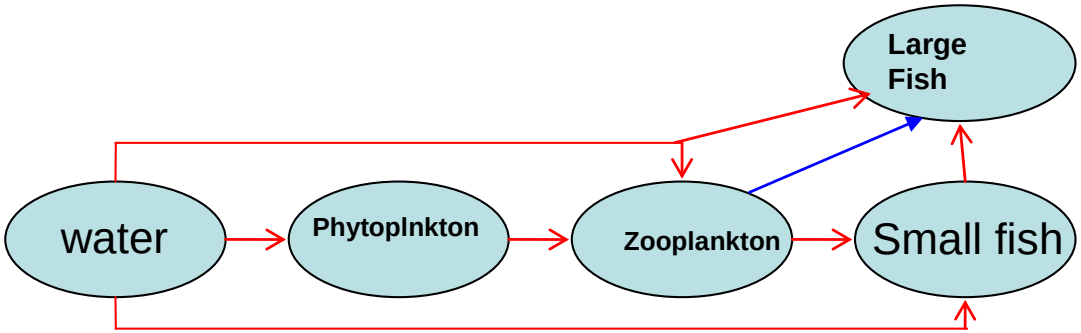


Case study: the Iceland coastal waters





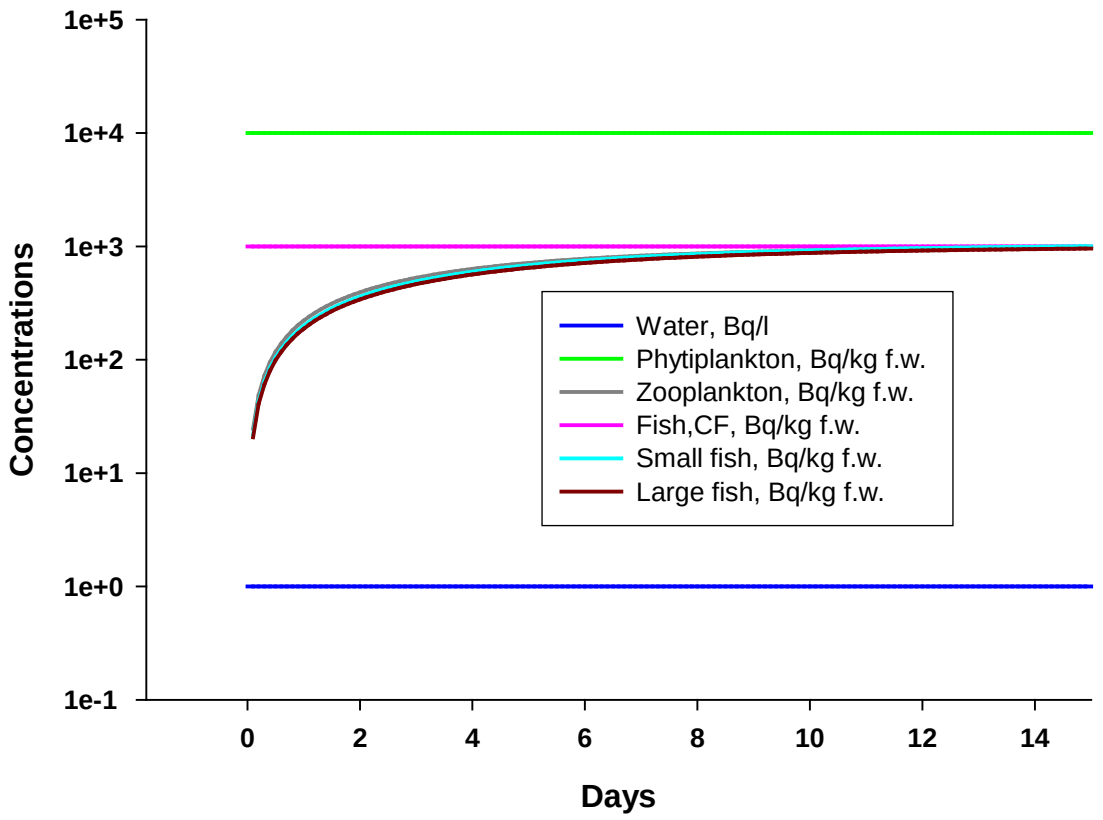
Te-132



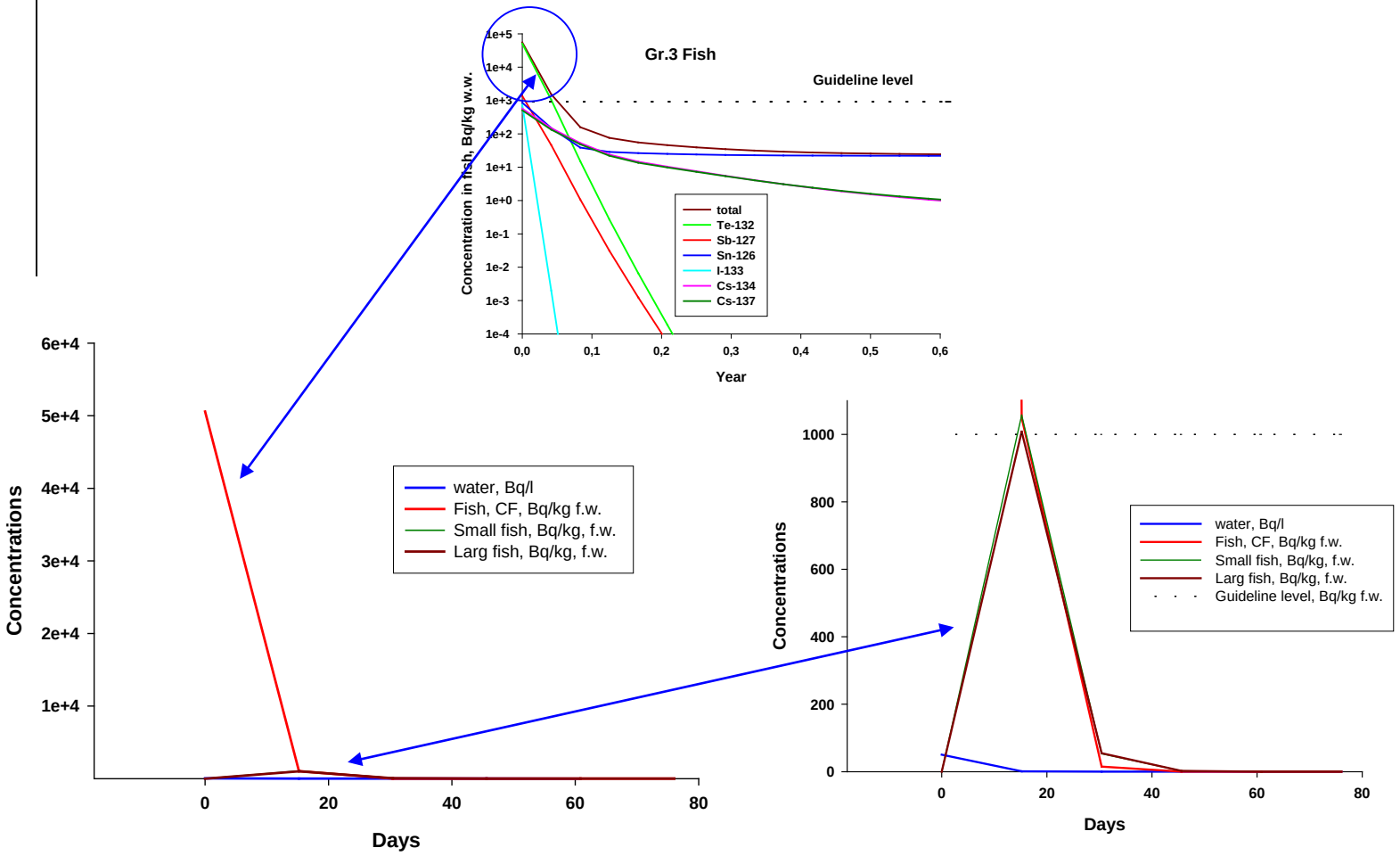
$$\frac{dC_i^{(tl)}}{t} = AE_i \cdot IR_i \cdot C_{i-1}^{(tl)} + k_{u,i} \cdot C_w - C_i^{(tl)} \cdot k_{e,i}$$

Te-132 - ??????????

Te-132: ”equilibrium way”



Te-132: ”Equilibrium Way” for Submarine Accident Scenario



Conclusions

- **Results of implementation of the kinetic model for bioaccumulation processes into models clearly demonstrated that there is a significant quantitative difference between the kinetic modelling approach and the approach based on the constant concentration rates.**
- **It is clearly demonstrated that dynamic modelling of the bioaccumulation processes can provide a more correct description of the concentration of radionuclides in biota and, therefore, these results support the main goal of the EFMARE project.**
- **The results emphasize the necessity to use operational hydrodynamic ocean models in order to forecast pollutant dispersal in Icelandic waters with regards to evaluate the temporal variability . The use of particle density can be used for comparison and improvement of the modelling tools.**