

# **EMRAS WORKING GROUP 8**

## **VIENNA, 24-28.01.2011**

### **COASTAL MARINE REGIONS PRELIMINARY RESULTS**

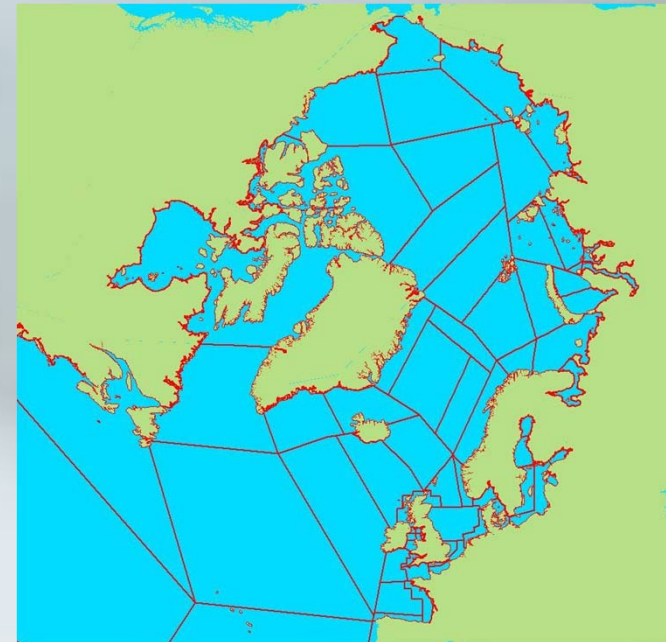
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# Piacensa Scenario

- A single deposition of 1000 Bq/m<sup>2</sup>
- Radionuclides: <sup>137</sup>Cs, <sup>90</sup>Sr, <sup>131</sup>I and <sup>239</sup>Pu;
- All marine regions (global fallout)



# Scenario

- **Age**  
adult, 10-year old and 1-year old
- **Time**  
1st year, 2nd year and 10th year after releases
- **Seafood**  
fish, molluscs, crustaceans and seaweeds

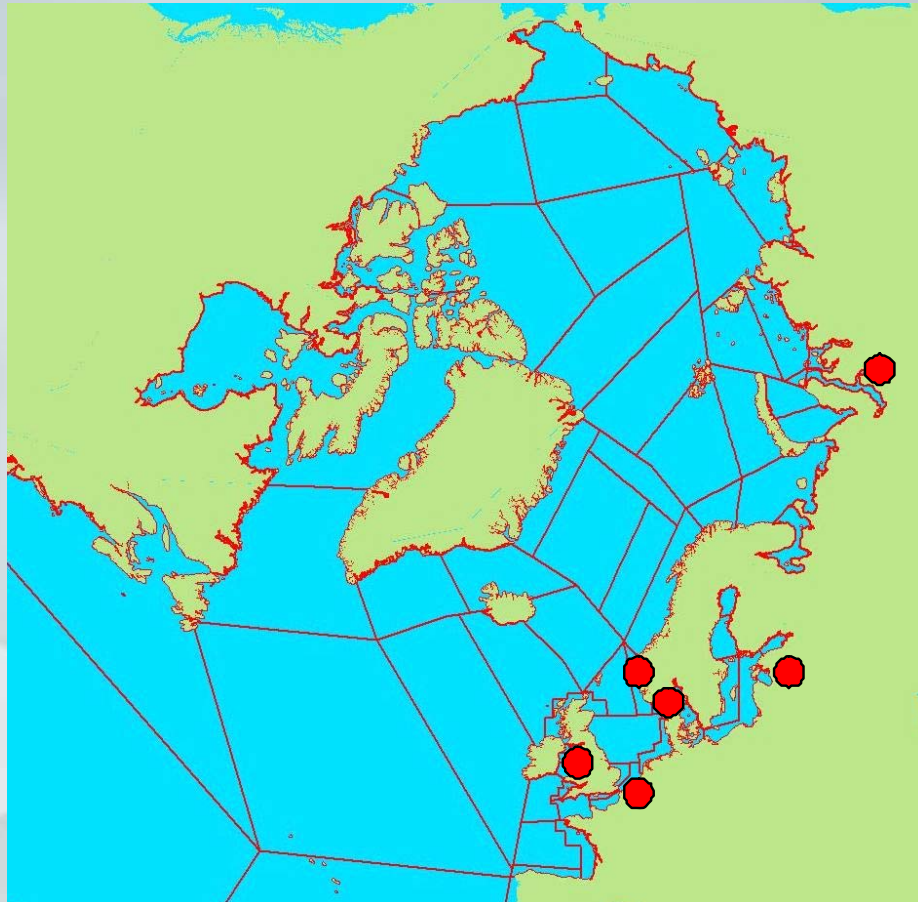


# Scenario : regions

<b>Name</b>	<b>Volume, m<sup>3</sup></b>	<b>Depth, m</b>	<b>Surface area, m<sup>2</sup></b>
Irish Sea: Cumbrian Waters	3,80E+10	2,80E+01	1,36E+09
English Channel: Lyme Bay	2,01E+11	3,95E+01	5,09E+09
North Sea: Norwegian Current Surface	9,20E+12	1,56E+02	5,90E+10
Skagerrak	6,78E+12	2,10E+02	3,23E+10
Baltic Sea: Gulf of Riga	4,05E+11	2,30E+01	1,76E+10
Kara Sea: Ob Bay	3,19E+11	1,10E+01	2,90E+10

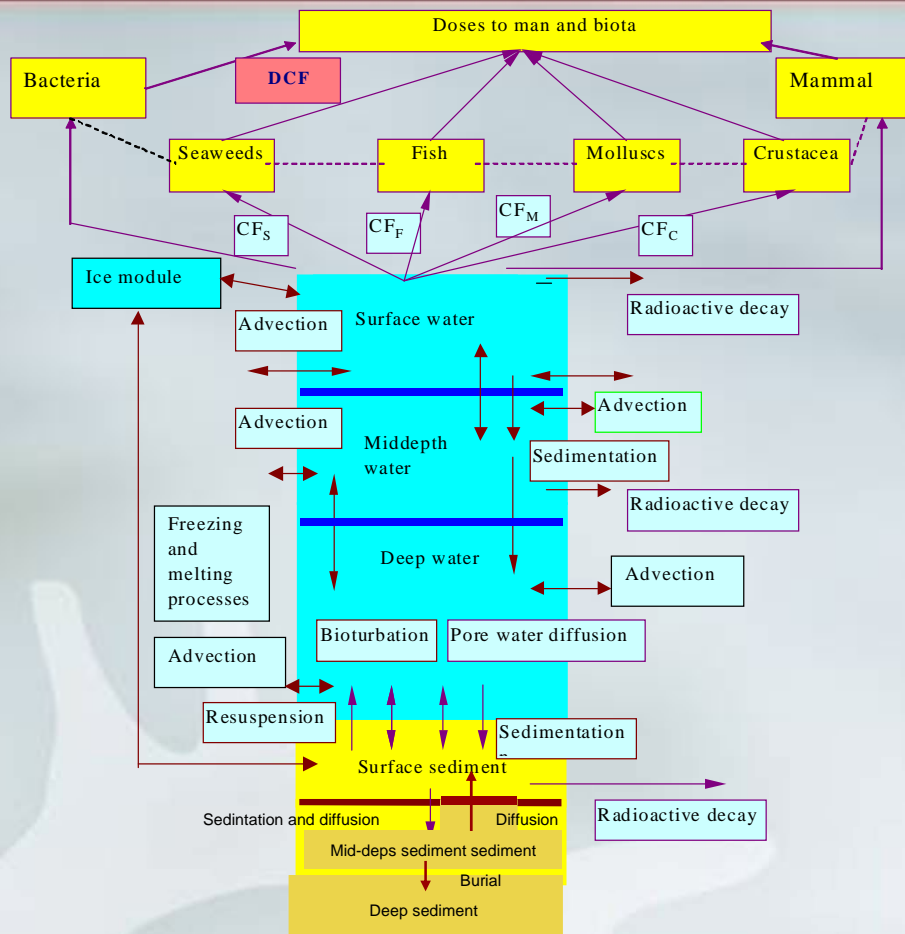


# Scenario : regions



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# Modelling approach



Radionuclides can be present in three phases: dissolved, suspended matter particles and bottom sediment

The structure of the compartments for surface, mid-depth and deep waters is developed with regards to the improved description of Polar, Atlantic and Deep waters in the Arctic Ocean and the Northern Seas (Karcher & Harms, 2000) and site-specific information for description of the compartments (the 3D NAOSIM model, AWI).



# Parameters: *SSL* (suspended sediment load) and *SR* (the mass sedimentation rate)

Name	SSL t/m <sup>3</sup>	SR, t/m <sup>2</sup> /y
Irish Sea: Cumbrian Waters	1,0E-05	6,0E-03
English Channel: Lyme Bay	3,0E-06	1,0E-04
North Sea: Norwegian Current Surface	6,6E-06	1,0E-04
Skagerrak	1,0E-06	5,0E-03
Baltic Sea: Gulf of Riga	1,0E-06	5,0E-04
Kara Sea: Ob Bay	5,0E-05	1,0E-03



# Parameters: sediment concentration factor ( $k_d$ ) (IAEA, 2004).

Radionuclide	$k_d$
Cs-137	4000
Sr-90	8
I-131	70
Pu-239	10000





# Seafood consumption, kg per year (Smith & Jones, 2003)

	Group 1 (adult)	Group 2 (child)	Group 3 (infant)
<b>Fish</b>	<b>51</b>	<b>10.2</b>	<b>2.5</b>
<b>Crustacean</b>	<b>17</b>	<b>2.25</b>	<b>0</b>
<b>Molluscs</b>	<b>14</b>	<b>3.5</b>	<b>0</b>
<b>Seaweeds</b>	<b>5</b>	<b>0</b>	<b>0</b>



# Dose coefficients (Sv/Bq) (ICRP, 1996)

	<b>Cs-137</b>	<b>Sr-90</b>	<b>I-131</b>	<b>Pu-239</b>
<b>1-year</b>	1.20E-08	7.30E-08	1.80E-07	4.20E-07
<b>10-year</b>	1.00E-08	6.00E-08	5.20E-08	2.70E-07
<b>Adult</b>	1.30E-08	2.80E-08	2.20E-08	2.50E-07

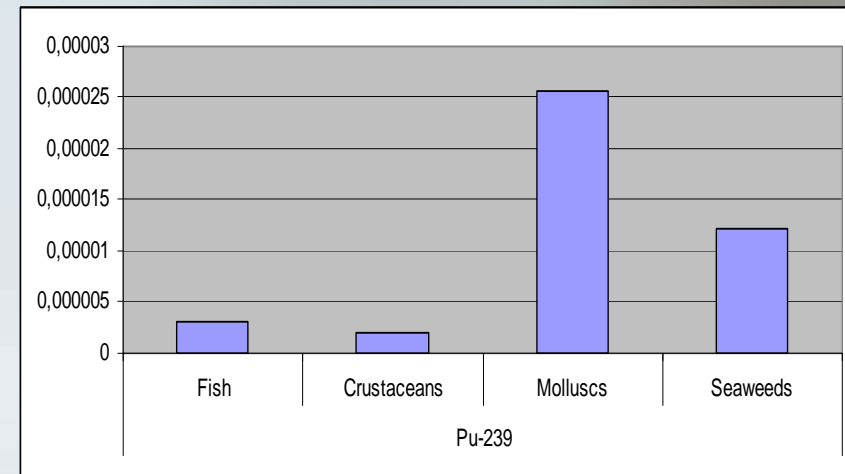
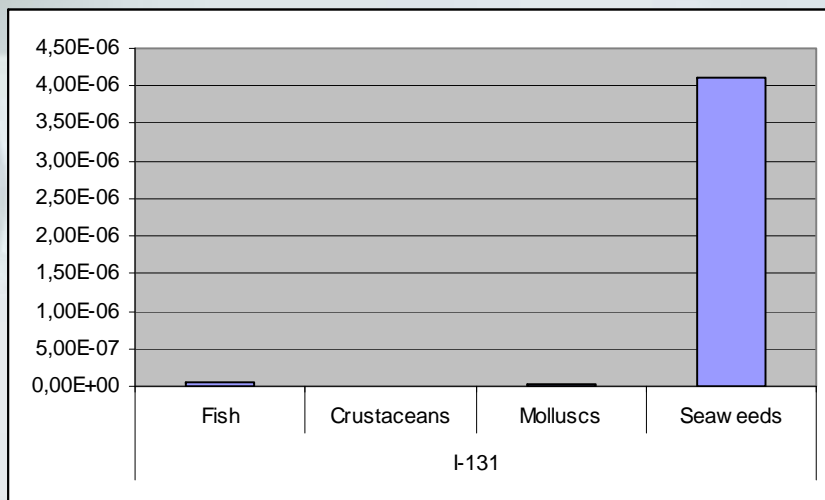
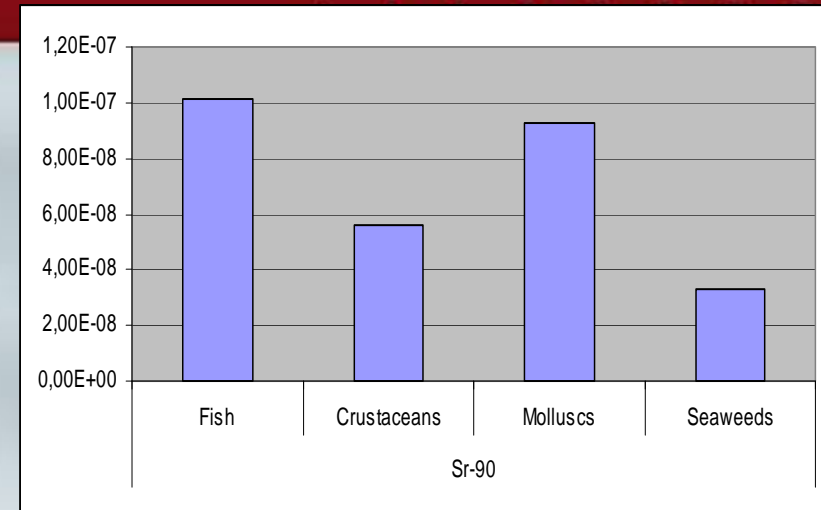
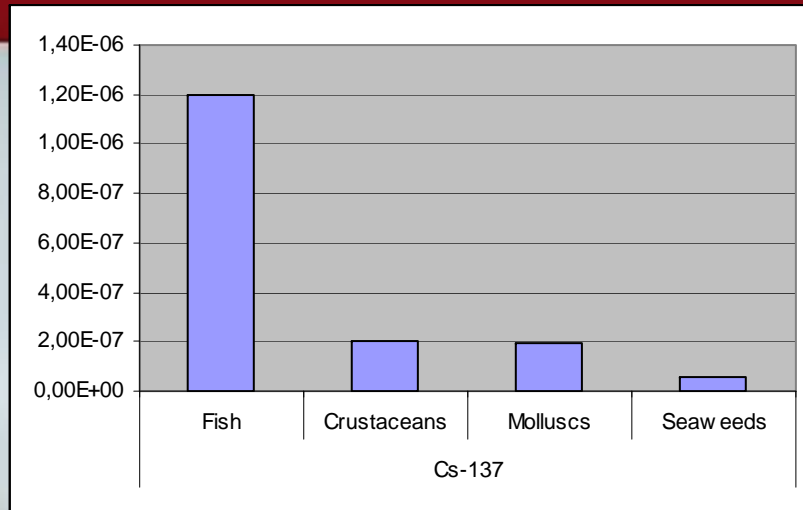


# Concentration factors (IAEA, 2004)

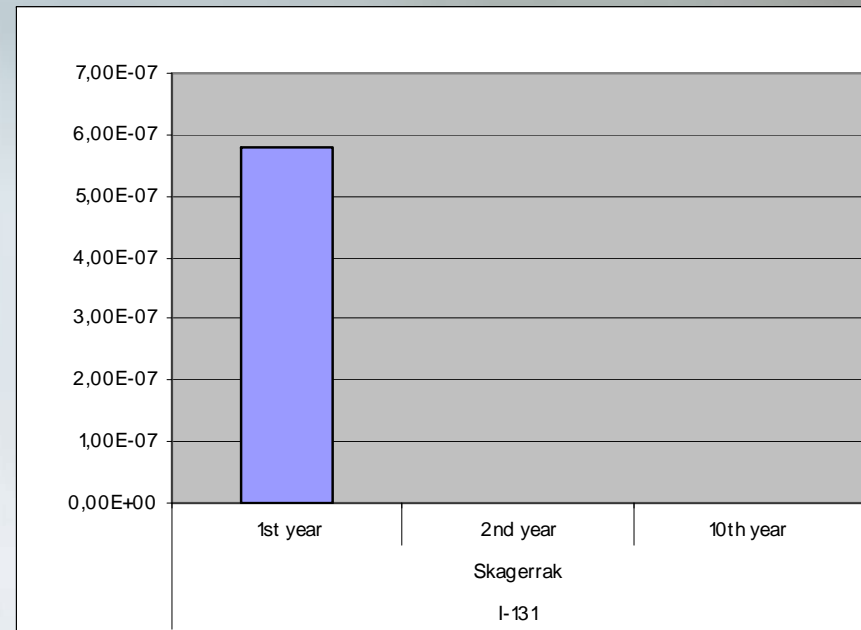
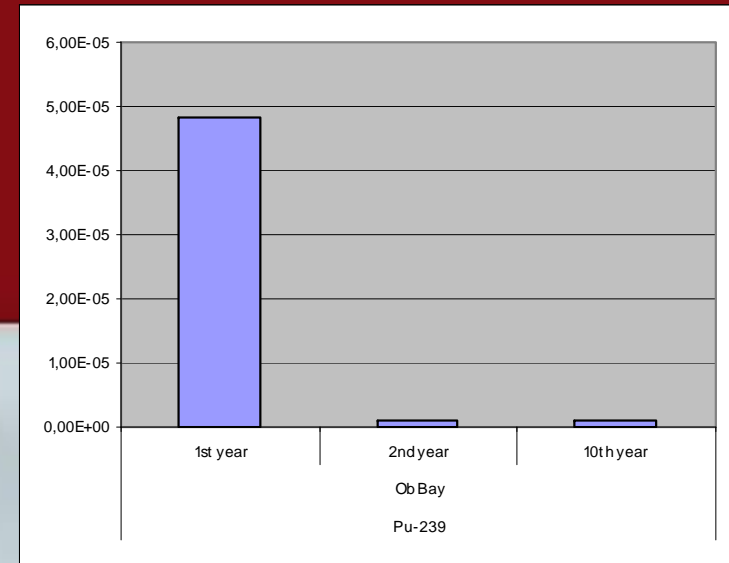
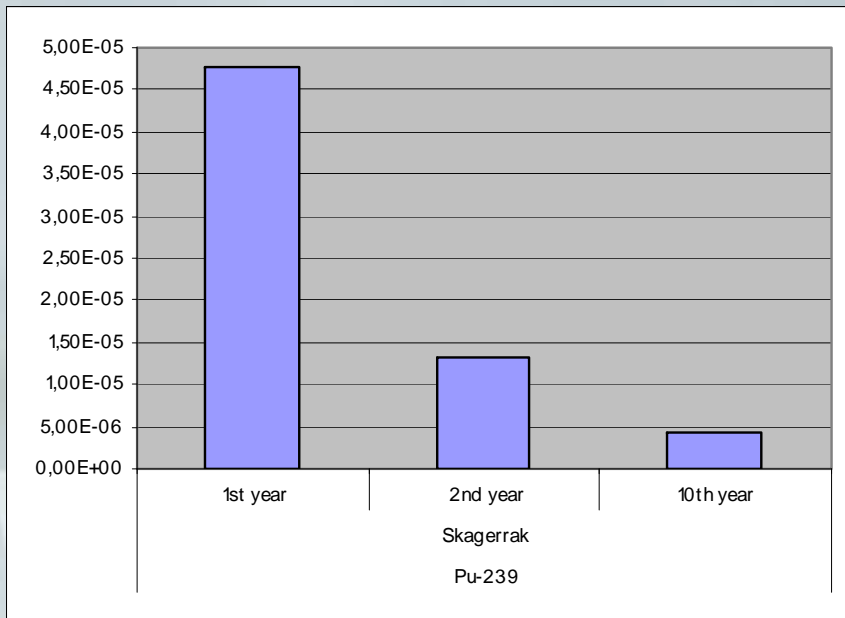
	<b>Cs-137</b>	<b>Sr-90</b>	<b>I-131</b>	<b>Pu-239</b>
<b>Fish</b>	1E+2	3E+0	9E+0	1E+2
<b>Crustacean</b>	5E+1	5E+0	3E+0	2E+2
<b>Molluscs</b>	6E+1	1E+1	1E+1	3E+3
<b>Seaweeds</b>	5E+1	1E+1	1E+4	4E+3



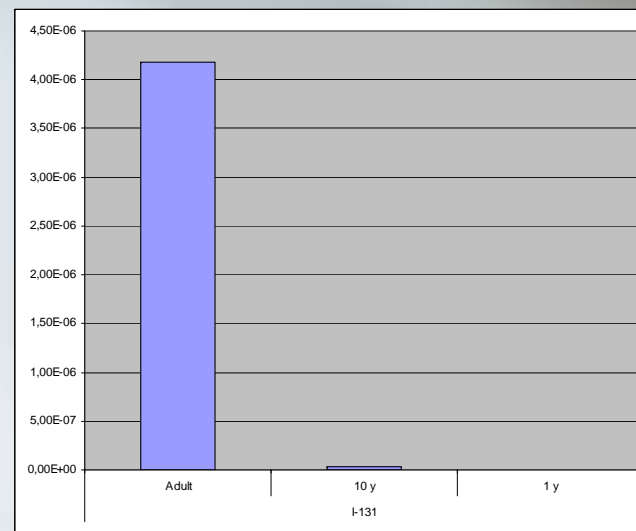
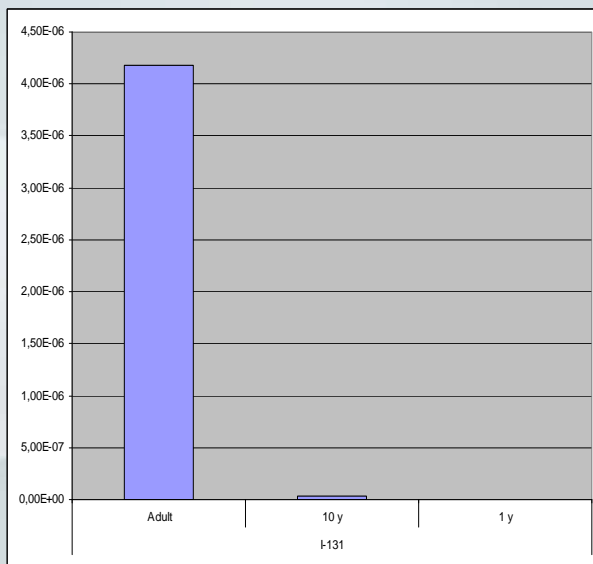
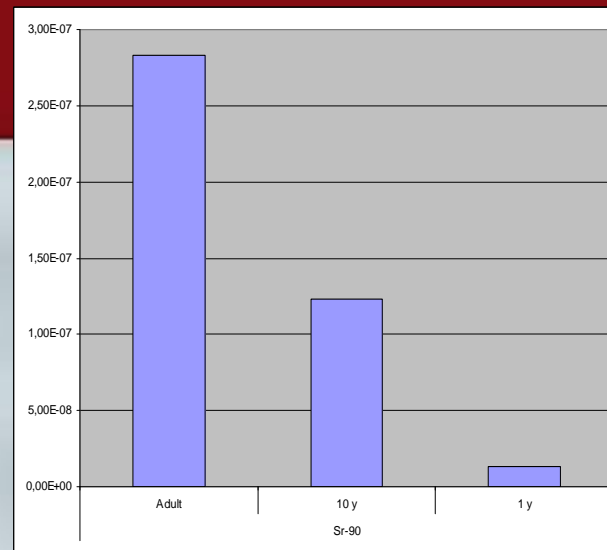
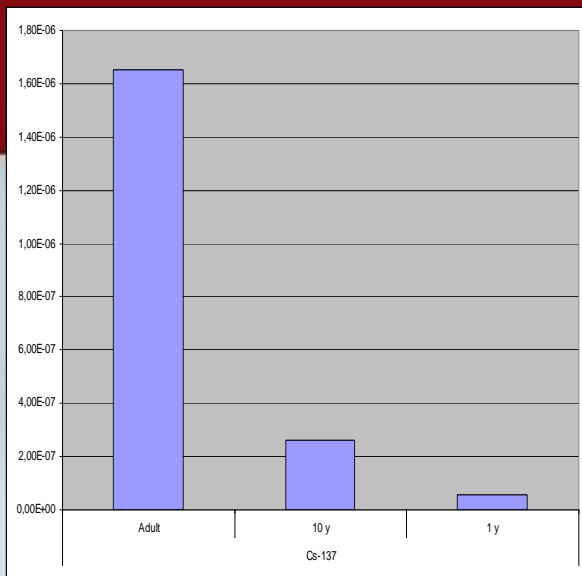
# Results: seafood dose impact to adult (Cumbrian Waters), Sv



# Results (Sv) for different times



# Results: age (Cumbrian waters)



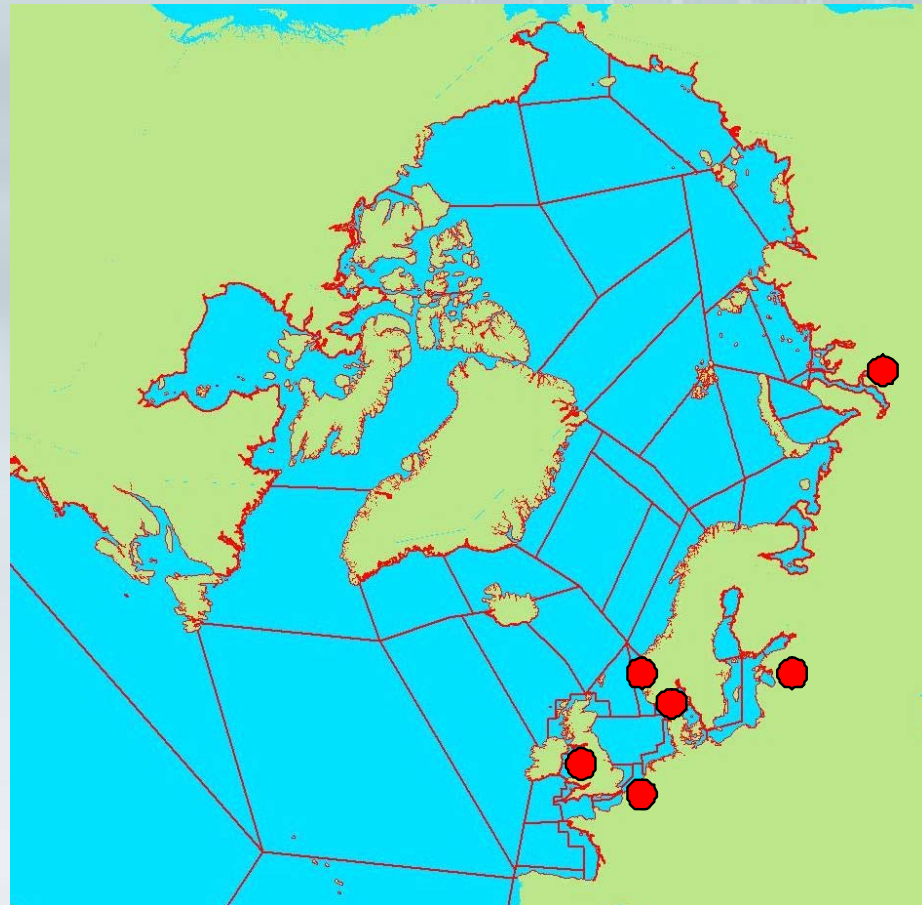
# Doses to man during the first year, Sv/y

	Cs-137			Sr-90			I-131			Pu-239		
	Adult	10 y	1 y	Adult	10 y	1 y	Adult	10 y	1 y	Adult	10 y	1 y
Irish Sea: Cumbrian Waters	1.65E-6	2.60E-7	5.52E-8	2.83E-7	1.23E-7	1.32E-8	4.2E-6	3.79E-8	1.47E-9	4.30E-5	8.1E-6	2.61e-7
English Channel: Lyme Bay	9.45E-7	1.49E-7	7.62E-9	1.32E-7	5.72E-8	6.13E-9	2.9E-6	2.40E-8	9.27E-10	6.75E-5	1.3E-5	4.10e-7
North Sea: Norwegian Current Surface	6.16E-7	9.70E-8	2.06E-8	8.72E-8	3.79E-8	4.07E-9	7.6E-7	7.20E-9	2.80E-10	1.23E-5	2.3E-6	7.49e-8
Skagerrak	8.77E-7	1.38E-7	2.93E-8	1.28E-7	5.55E-8	5.95E-9	5.8E-7	6.45E-9	2.53E-10	4.76E-5	9.0E-6	2.89e-7
Baltic Sea: Gulf of Riga	2.58E-6	4.06E-7	8.62E-8	4.22E-7	1.84E-7	1.98E-8	5.1E-6	4,54E-8	1.76E-9	9.33E-5	1.8E-5	5.67e-7
Kara Sea: Ob Bay	2.86E-6	4.51E-7	9.57E-8	5.09E-7	2.21E-7	2.37E-8	1.1E-5	9.07E-8	5.27E-8	4.83E-5	9.1E-6	2.93E-7



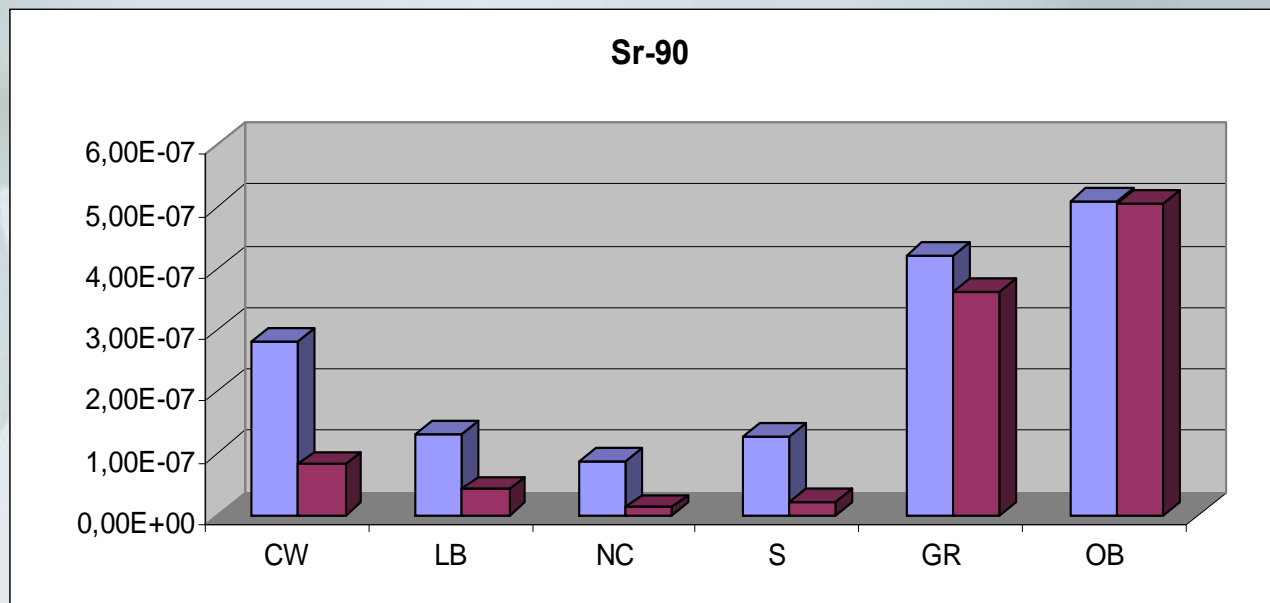
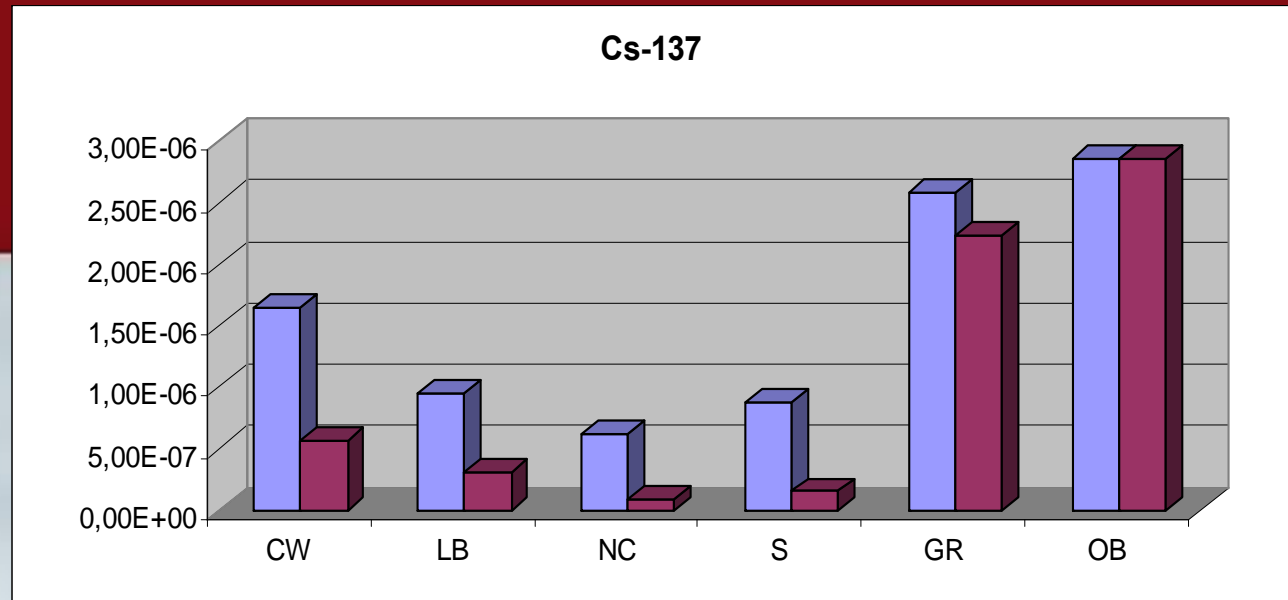
# The Additional Scenario

- A single deposition of 1000 Bq/m<sup>2</sup> for selected areas (not for all regions)
- Radionuclides: Cs-137, Sr-90, I-131 and Pu-239;
- One simulation for each region

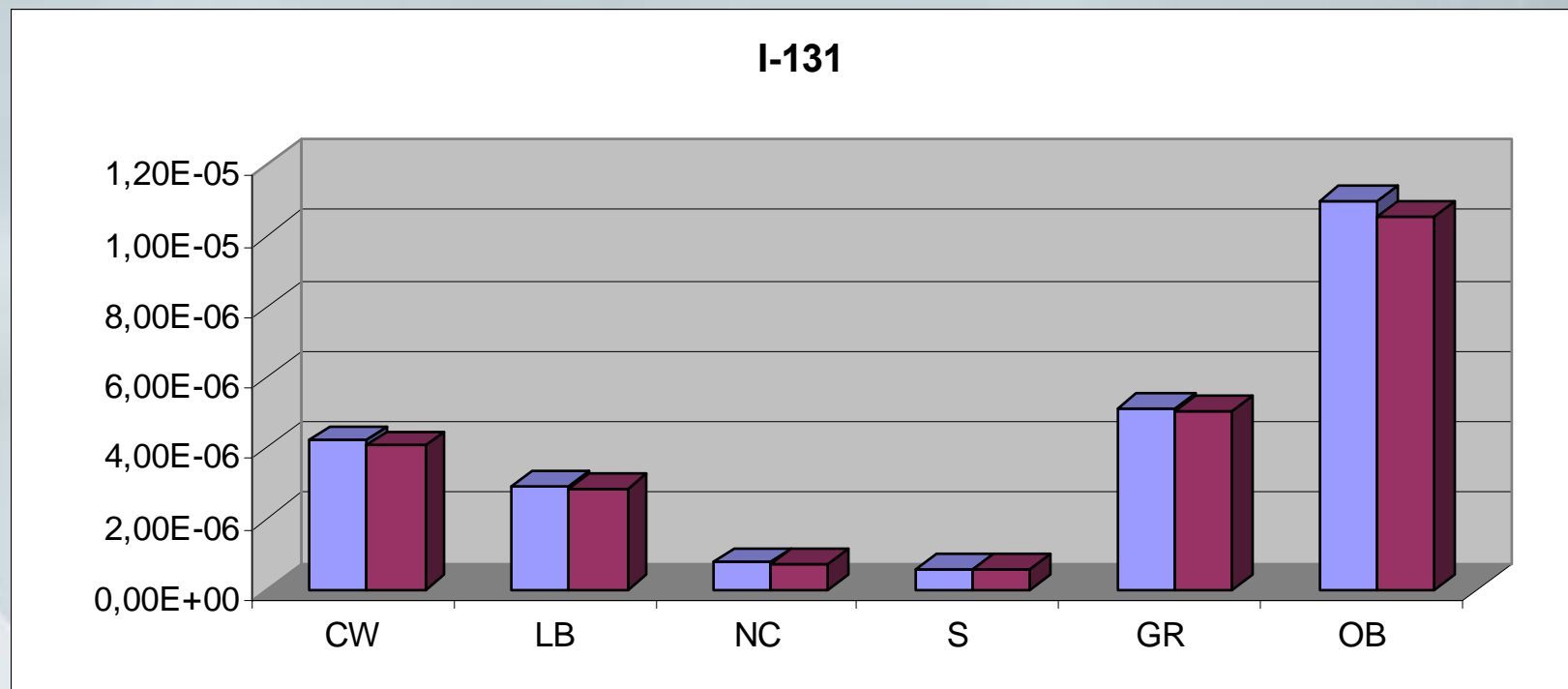




# Comparison of scenarios

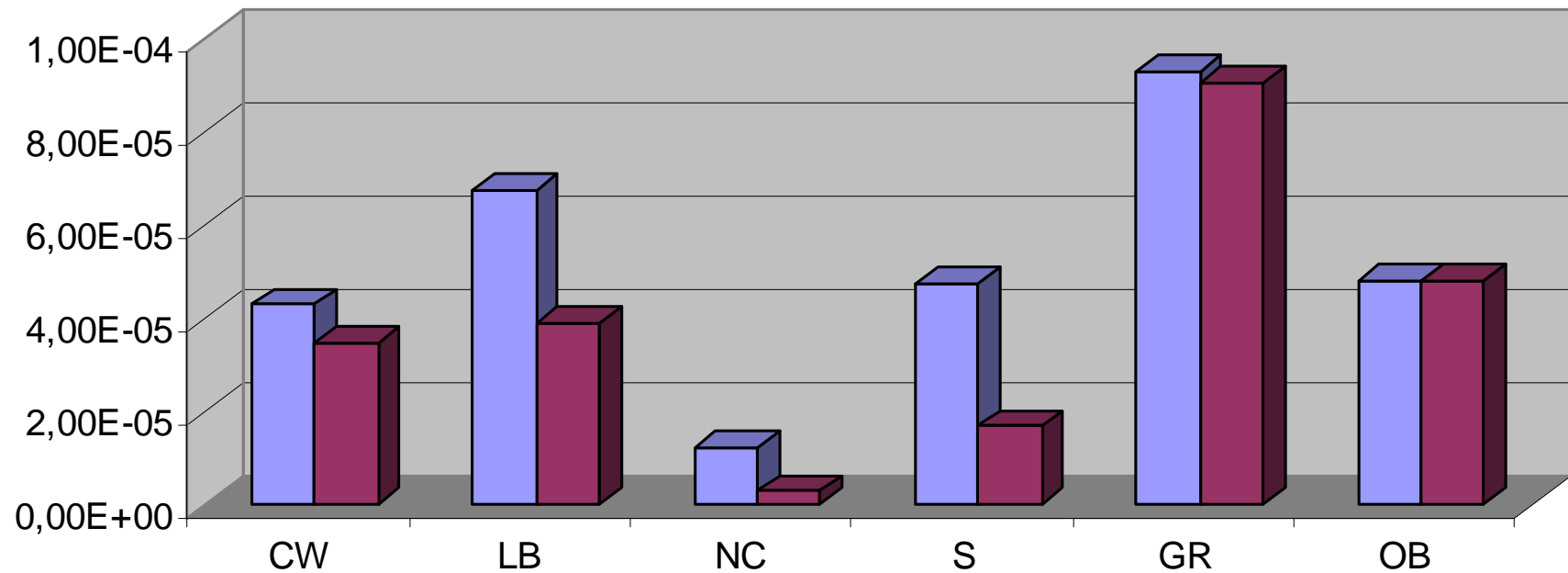


# Comparison of scenarios



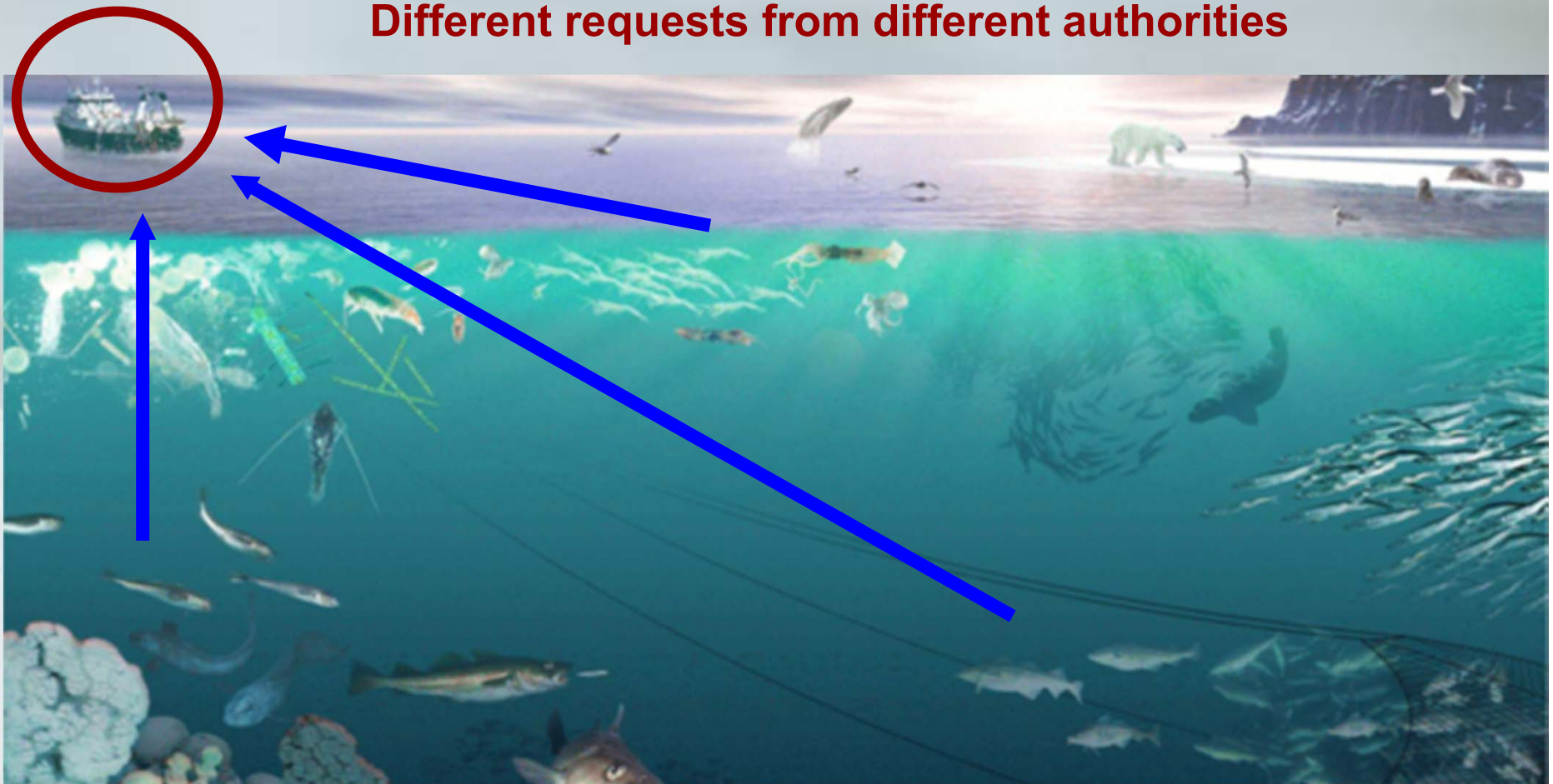
# Comparison of scenarios

Pu-239



# Environmental sensitivity: evaluation of the potential endpoints (the case study)

The ecosystems in the Barents sea:  
Different requests from different authorities



# Case study scenario: potential Russian submarine accident involving a third-generation vessel

## Core-melt release:

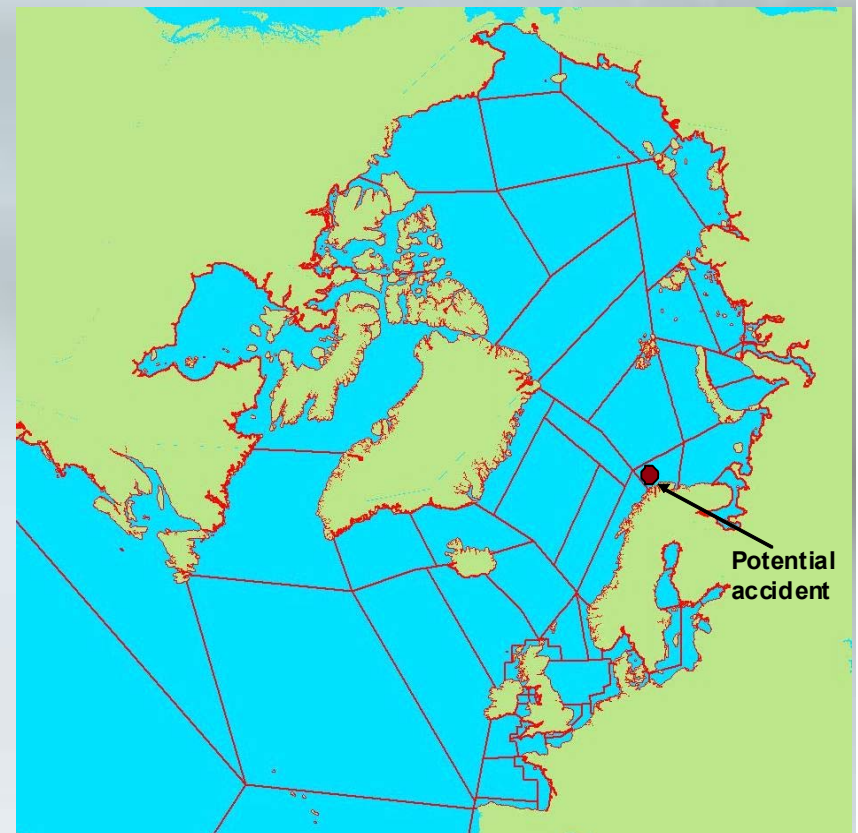
Immediate discharge of release fractions (High Flux reactor)

## Examples of fractions:

Actinides - 0.01; Sr - 0.1; Cs & Te - 0.8

## Fuel corrosion:

Constant release of fuel corrosion products: corrosion rate: 0.01 % of fuel material annually



# Radioological consequences: parameters/endpoints and sensitivity indexes

- Concentration of radionuclides in seafood
- Collective dose-rate to man
- Doses to the critical group
- Doses to marine organisms

$$SI_{P_i} = \left\{ \frac{P_i}{R_{P_i}} \right\}$$

parameter used for consequence analysis

maximum value for parameter  $P_i$  according to the existing recommendations and criterions



# Example of the parameter $R_{P_i}$ (maximum value for parameter $P_i$ according to the existing recommendations)

## Group 1: Pu-239, Am-241....:

Infant food: 1 Bq/kg; Other food: 10 Bq/kg

## Group 2: Sr-90, Ru-106,....:

Infant food: 100 Bq/kg; Other food: 100 Bq/kg

## Group 3: Cs-134, Cs-137, ....:

Infant food: 1000 Bq/kg; Other food: 1000 Bq/kg

## Group 4: H-3, Tc-99,....:

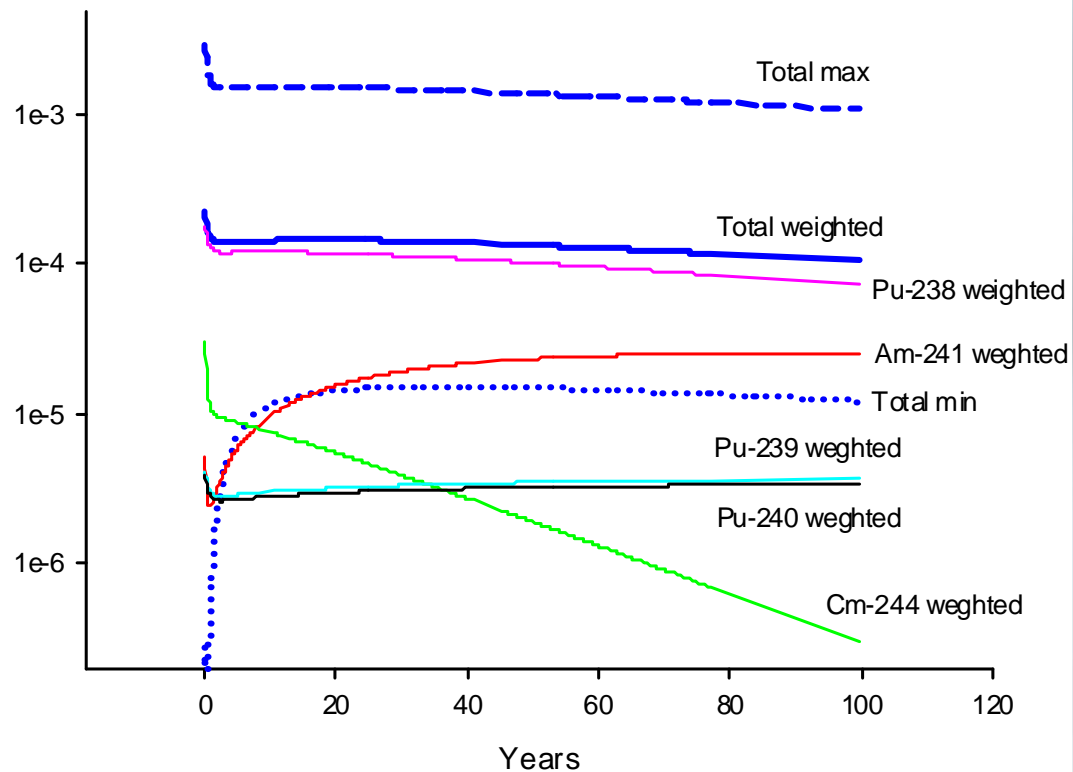
Infant food: 1000 Bq/kg; Other food: 10000 Bq/kg

Guideline levels  
for concentrations  
of radionuclides in  
seafood, Food and  
Agriculture  
Organisation of  
the United Nations  
& World Health  
Organisation  
(CAC, 2006)



# Concentrations of radionuclides in seafood (fish, crustaceans, molluscs): Group 1 - fish

Group 1: concentration of radionuclides in fish

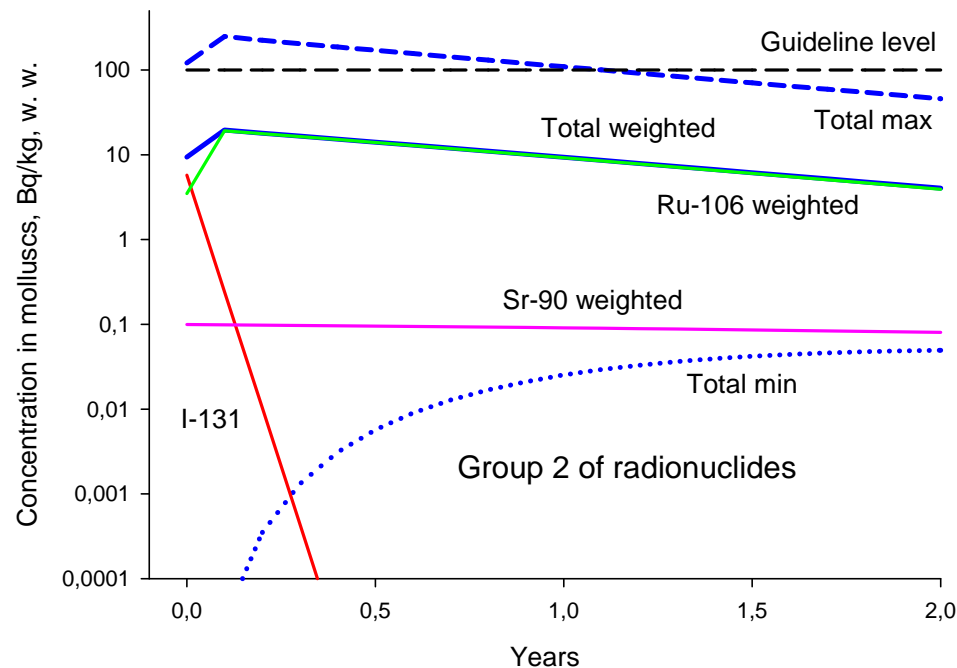


$$SI_{C_{fish}^{(Gr1)}} = \left\{ \frac{C_{fish}^{(Gr1)}}{R_{C_{fish}^{(Gr1)}}} \right\} = 0.003$$

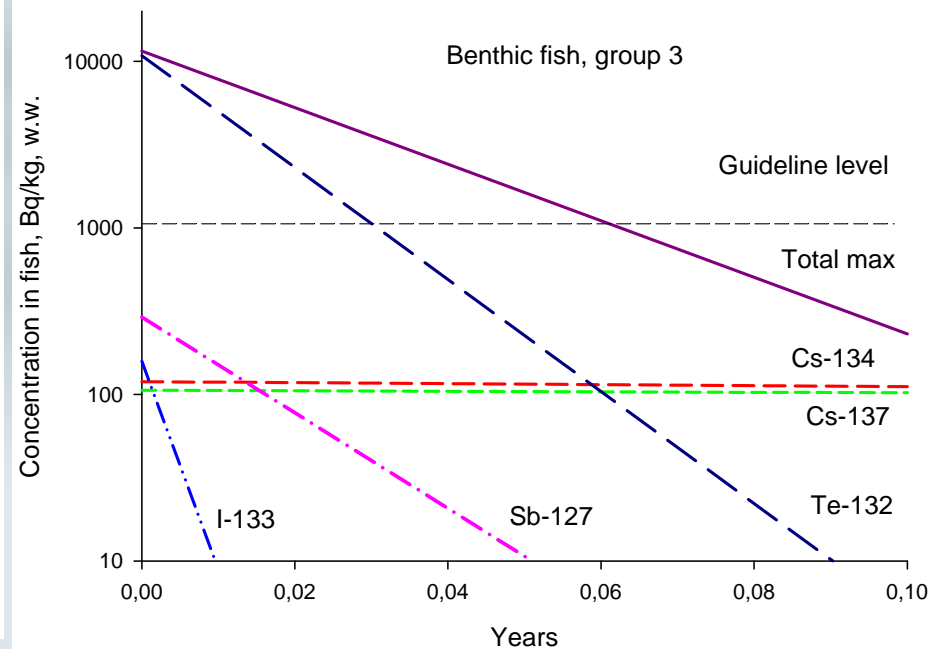




# Concentrations of radionuclides in seafood: Group 2 – molluscs & Group 3 – fish (bottom waters)



**SI= 2.5**

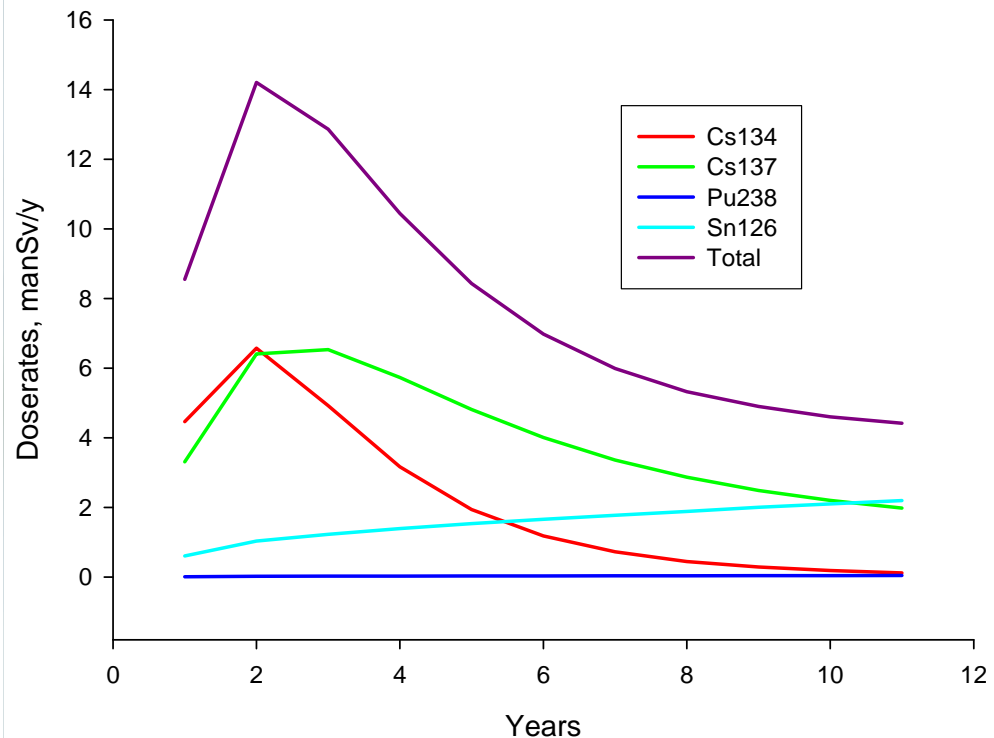


**SI= 11.5**



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# Collective dose-rate to man



Rough approximation based on information about consumption and catches of seafood: actual population to be in the range of  $1.4 \cdot 10^7$  -  $2.9 \cdot 10^7$ . Annual dose from natural sources  $1.4 \cdot 10^4$  -  $2.9 \cdot 10^5$  manSv (UN SCEAR, 2000),

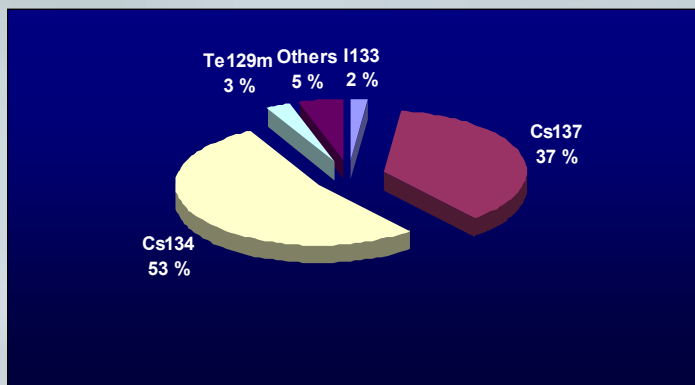
1-10  $\mu$ Sv per year constitutes, according to (UN SCEAR, 2000), a negligible component of the annual effective dose from natural sources.

SI = 1.1

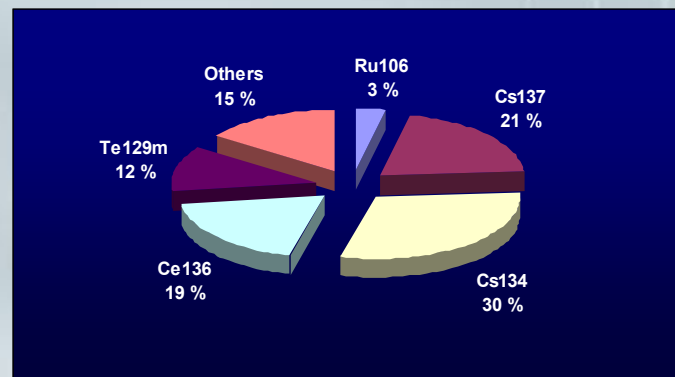


# Dose impact to the critical group

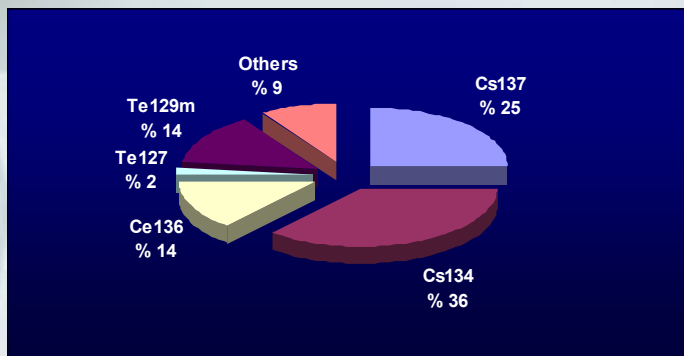
Consumption: 200g/d –fish; 40g/d –crustaceans;  
4 g/d – molluscs



Fish: 0,07 mSv/y



Molluscs: 0,002 mSv/y



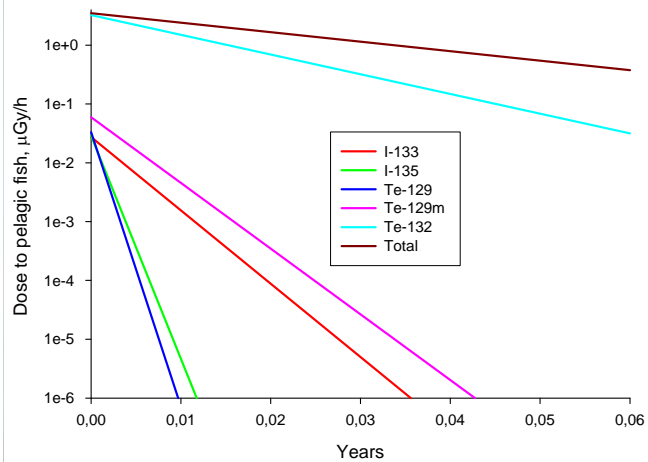
Crustacean: 0,01 mSv/y

Total: 82  $\mu$ Sv yr<sup>-1</sup>

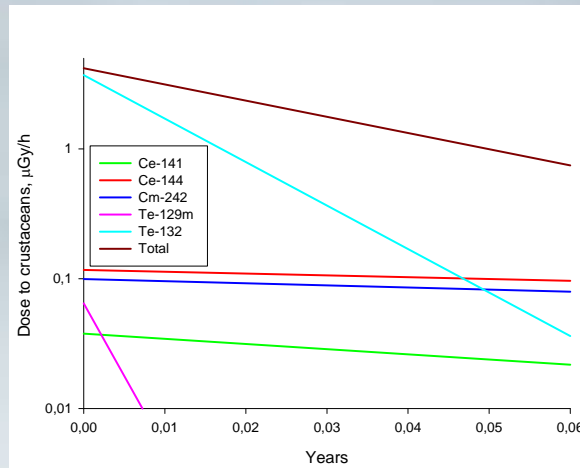
SI = 82



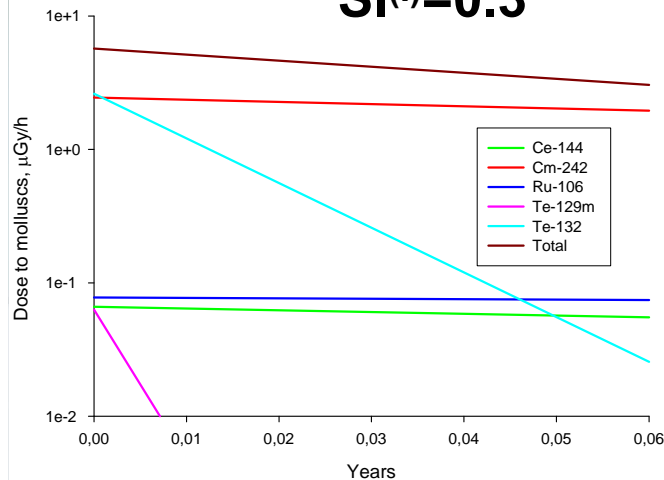
# Doses to biota



$SI^{(I)}=0.3$



$SI^{(I)}=0.4$



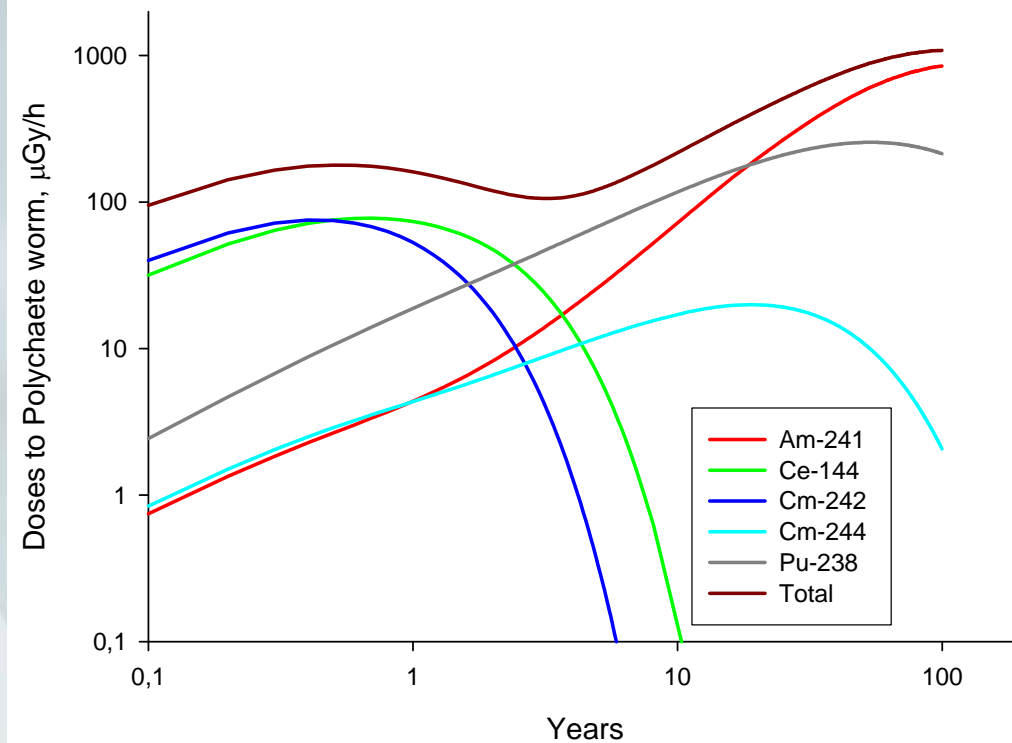
$SI^{(I)}=0.6$

•The screening dose rate of  $10 \mu\text{Gy h}^{-1}$  is not harmful to individual organisms (Brown et al., 2006).

•The dose rate limit of  $400 \mu\text{Gy h}^{-1}$  is not harmful to the population (US DoE, 2002).



# Doses to Polychaete Worm (the sediment phase)



$SI^{(I)}=108$ ;  $SI^{(P)}=2.7$



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# Preliminary conclusions

- **The doses to marine organisms living in the sea sediment near the accident location, and dose rates to the critical group are the most sensitive state parameters (endpoints) for describing the consequences to the marine environment in the present evaluation.**
- **Results of calculations confirm that "human" endpoint "dose to man" can be used widely for the evaluation of the environmental sensitivity**
- **Simultaneously, for some scenarios other endpoints could be considered**

