SCK•CEN

STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Impact of hypothetical radioactive releases in the Belgian inland rivers-sea continuum

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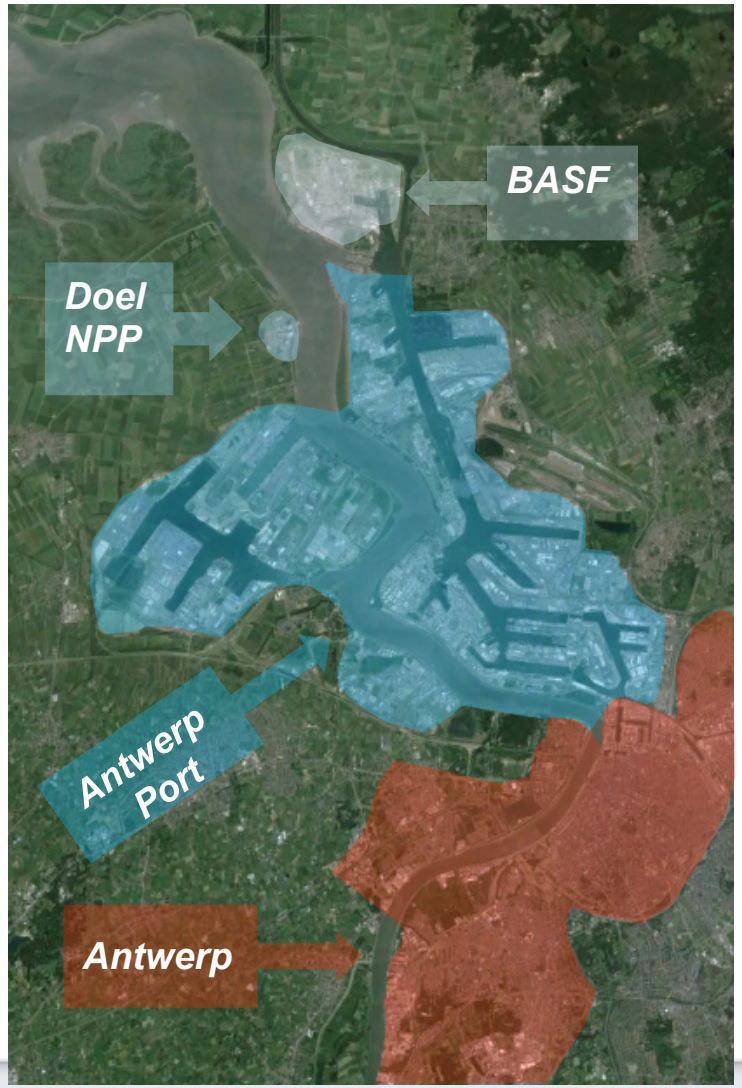
Problem description

- The Nuclear power plant in Scheldt Estuary (Belgium)

Problem description

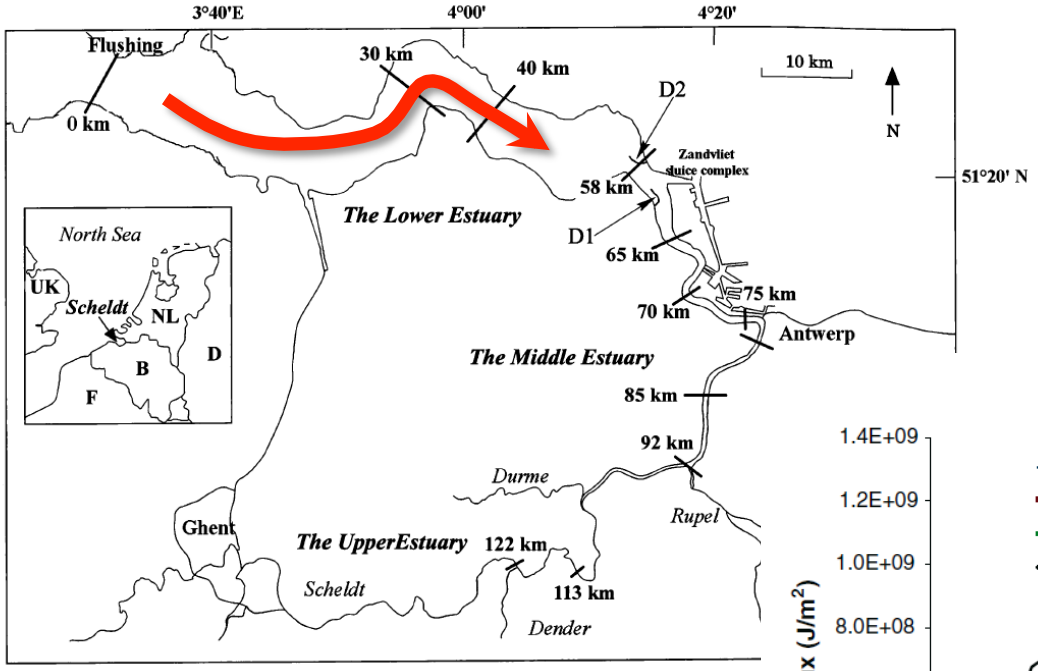
The Scheldt Estuary is one of the largest European estuaries and internationally **Important nature area. Entrance to the port of Antwerp**

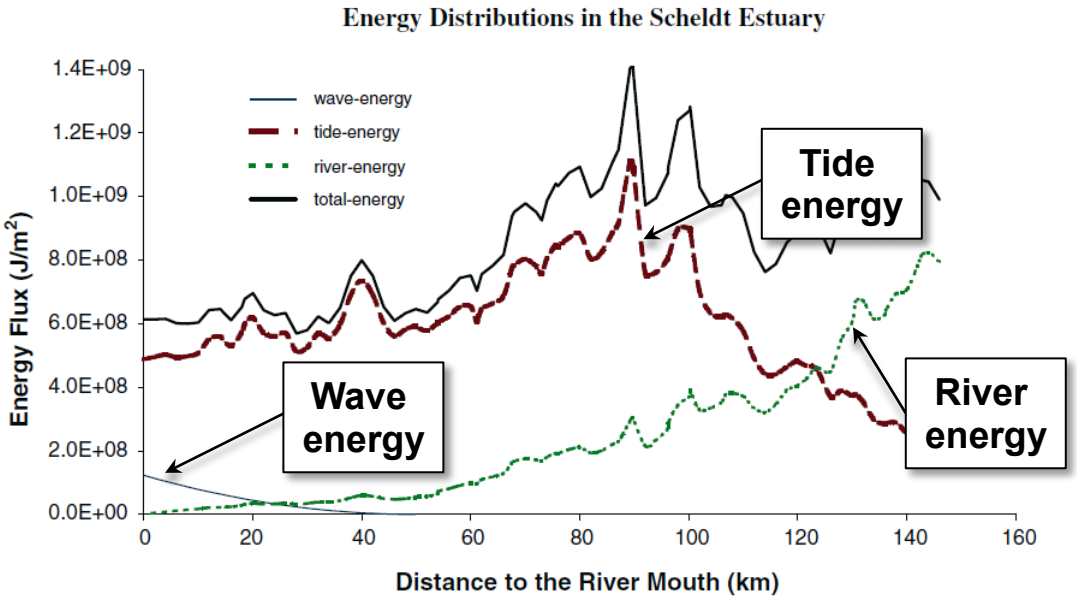


Objectives of the research

- Development of estuarine model for the simulation of the fate and transport of radioactive effluents as consequence of accidental releases
- Scenario definition based on the predictions of source term of NOODPLAN –Belgium
- Definition of possible release moments in order to include the influence of the tides in the transport
- Multiple partition coefficient scenario definition
- Estimation of the radiation dose rates to the aquatic biota

Hydrodynamic behaviour of the Scheldt Estuary

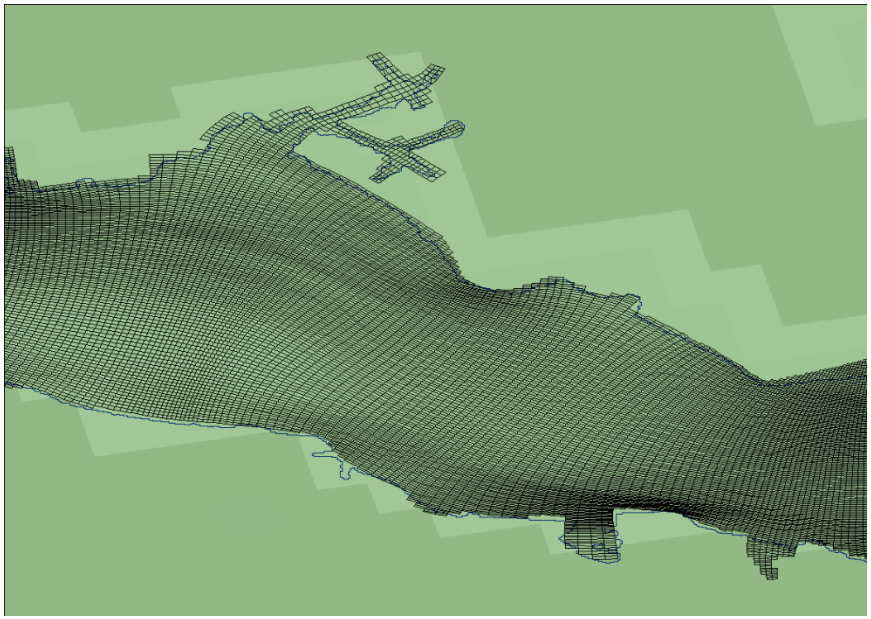




Chen, M. S., Wartel, S., van Eck, B., and van Maldegem, D. (2005b). Suspended matter in the Scheldt estuary. Hydrobiologia, 540:79 -104.

Model selection

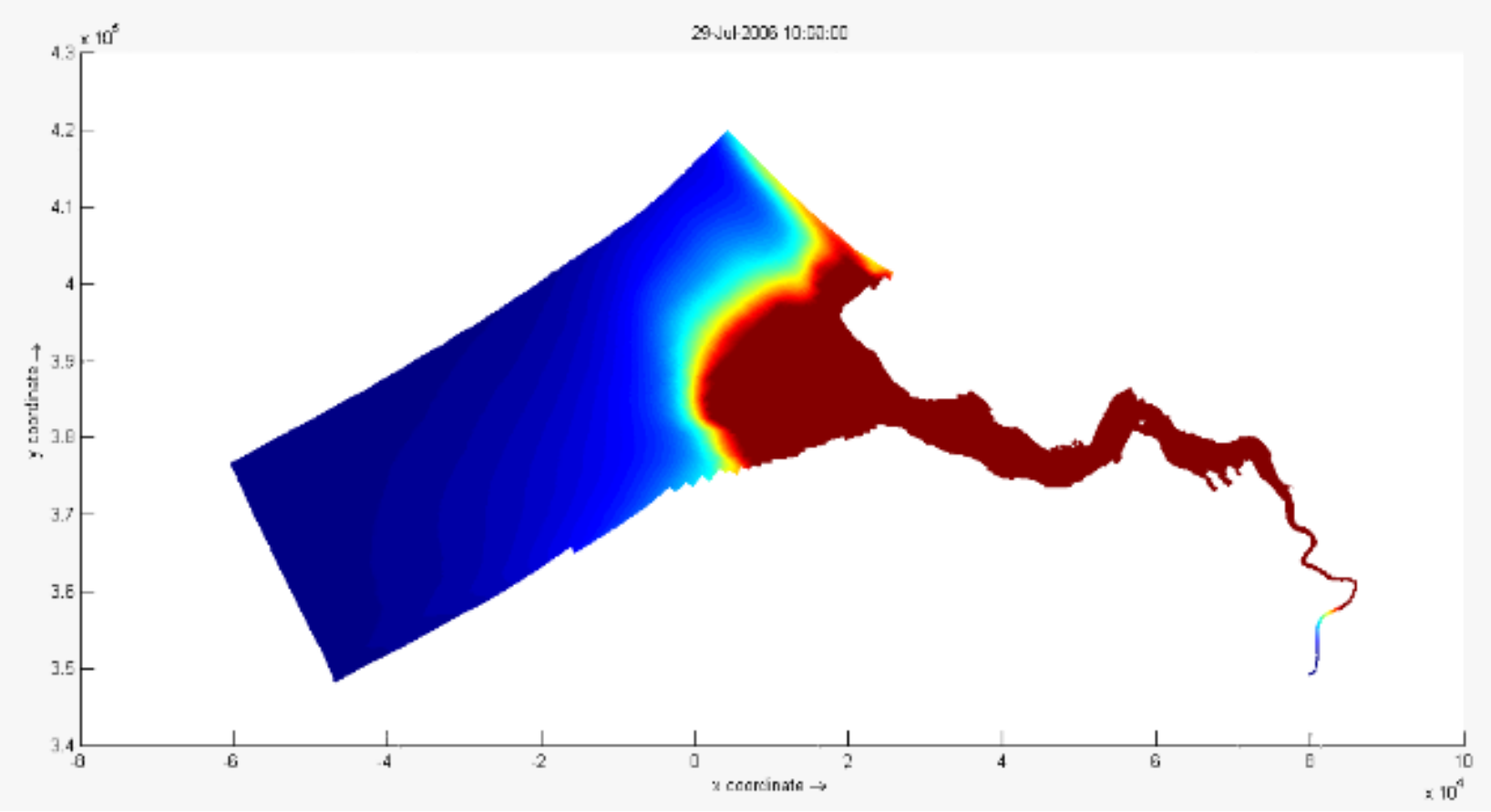
- Boundary conditions problem
- Computation time problem
- Integration of the River-Estuary-Coastal systems (1D-2D) systems



Structured grid: Limits the extension of the model due to large number of cells (around 500 000 cells)

Model selection

- Boundary conditions Problem



Model selection

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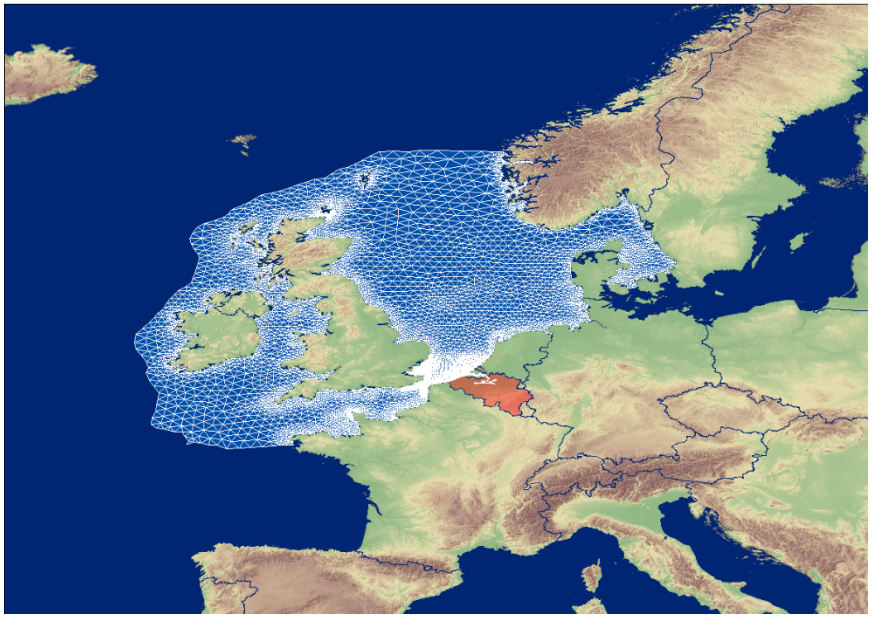
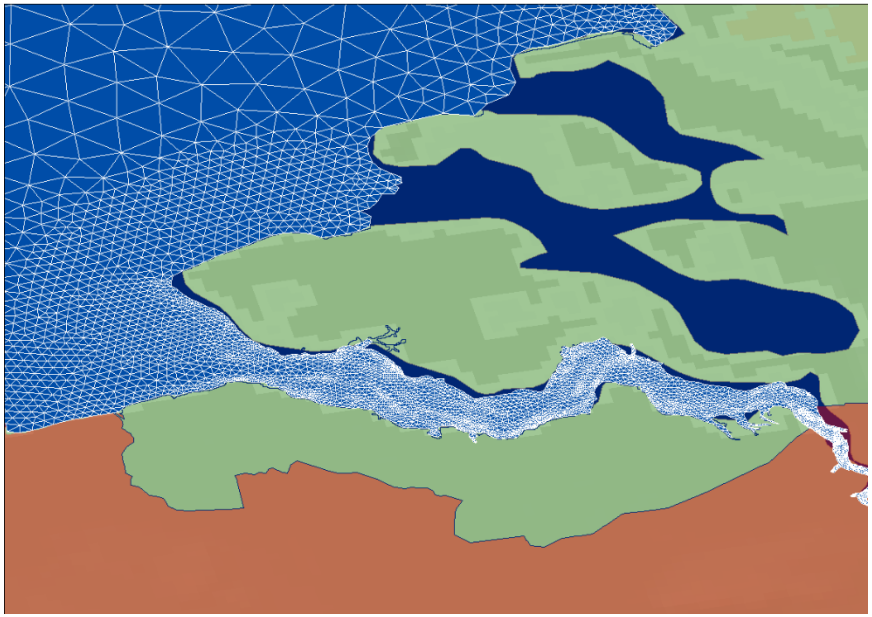
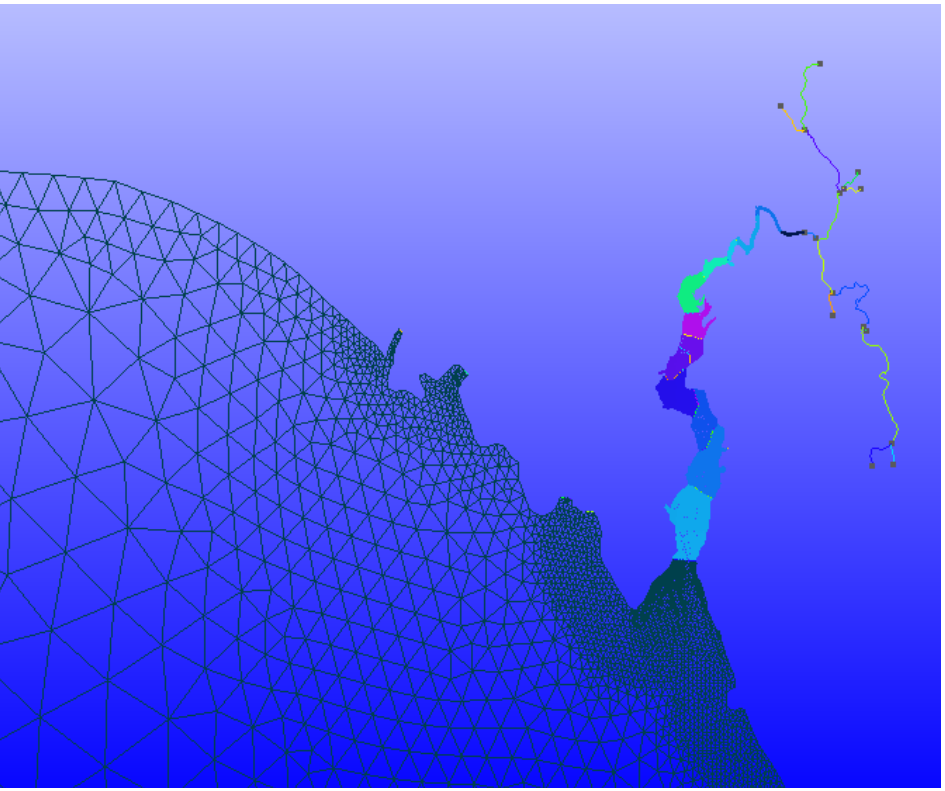


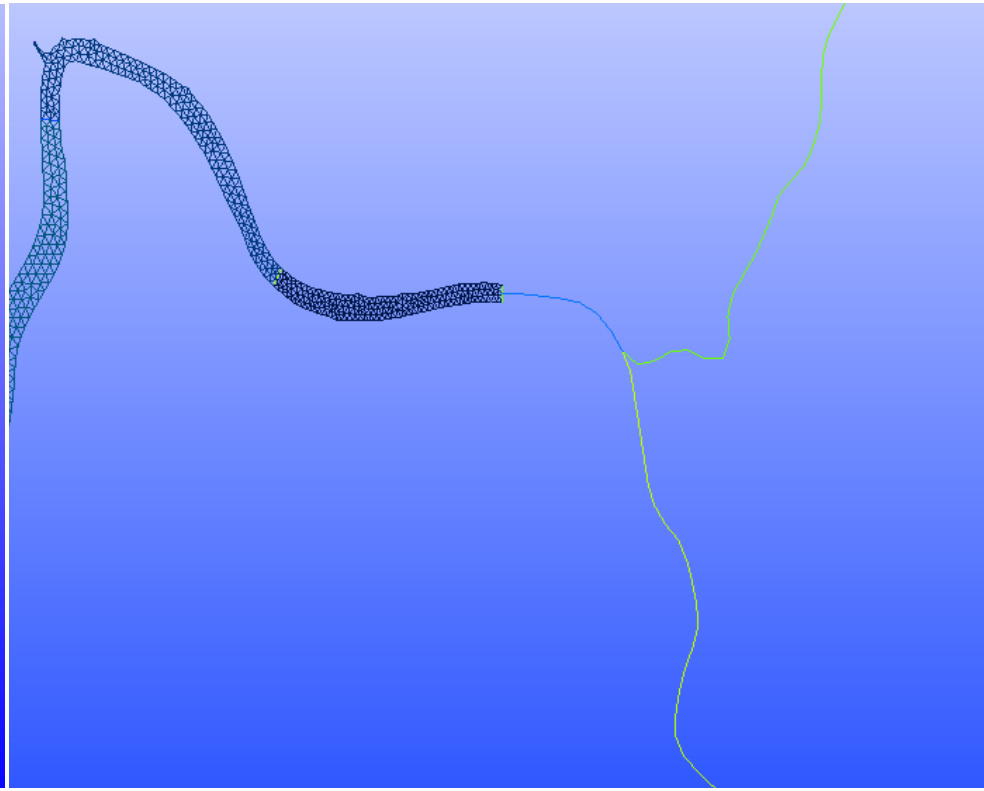


Unstructured grid: Allows to extend model without loss of detail (around 30 000 cells)

Model selection

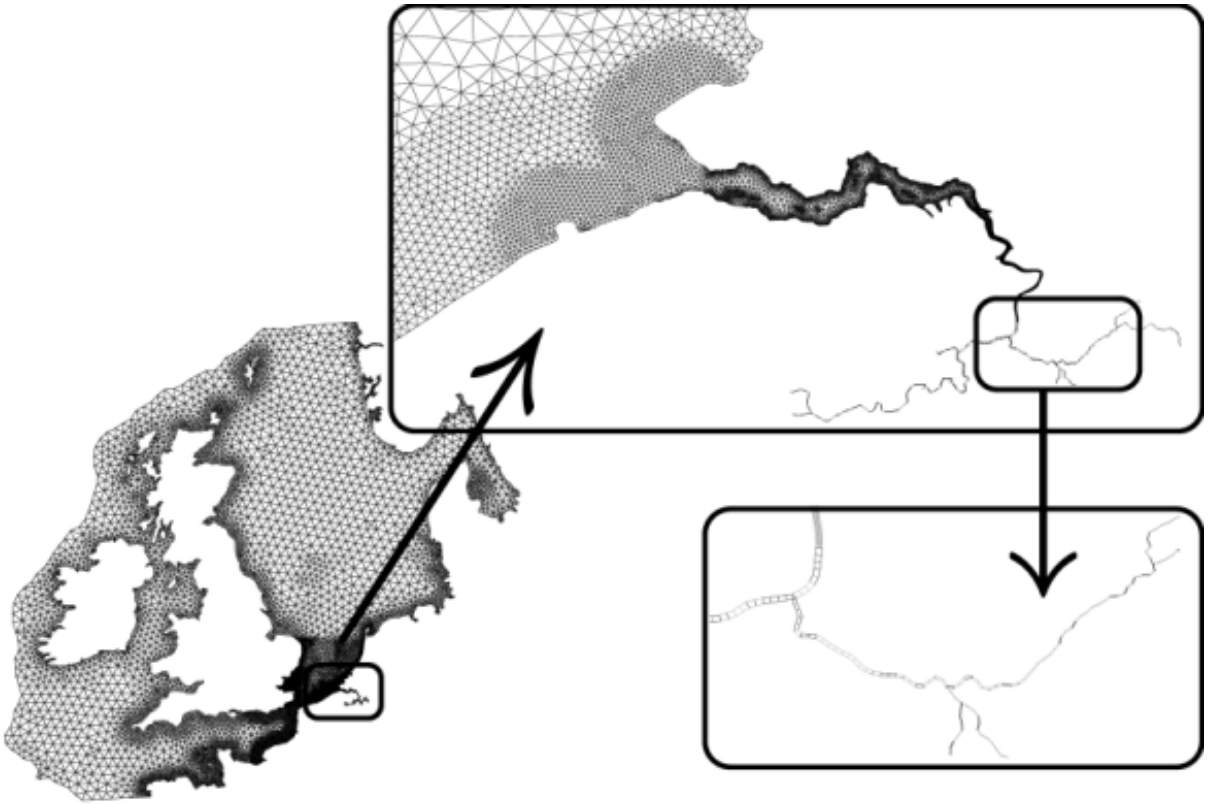
- Integration of the River-Estuary-Coastal systems (1D-2D) systems





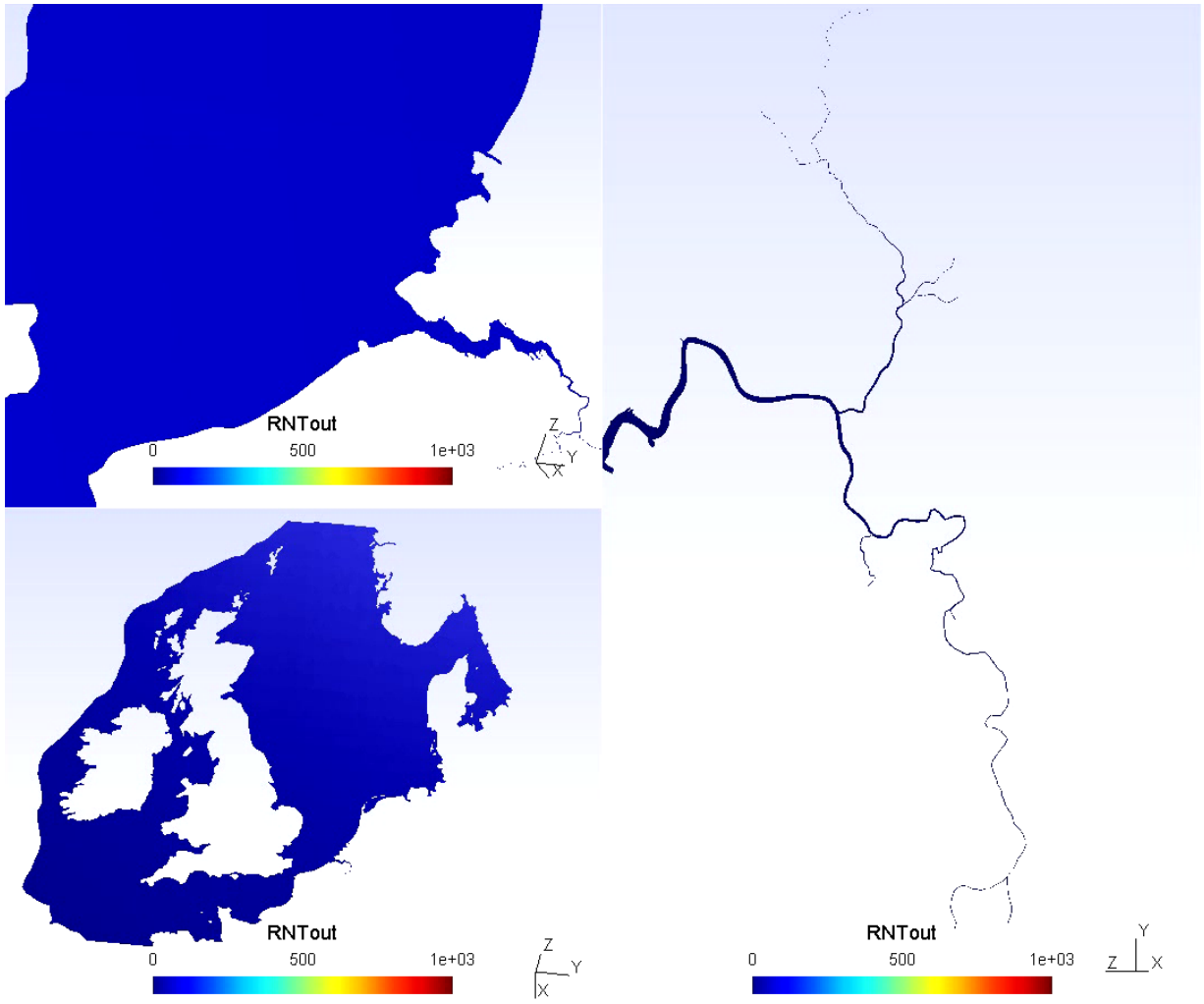
Model selection

- SLIM model



Second-generation Louvain-la-Neuve Ice-ocean Model (SLIM)
Institute of Mechanics, Materials and Civil Engineering (IMMC) & Earth and Life Institute (ELI) Université catholique de Louvain (Deleersnijders E., Lambrechts J., Gourgue O., de Brye B.)
https://sites.uclouvain.be/slim/

General overview of the radioactive plume



Scenario description

- Source term:

Based on the estimated total release inside the reactor building Doel 1 to 4

Scenario	Fraction	^{131}I MBq	^{137}Cs MBq
		≈2.00E+11	***≈2.00E+11***
Scenario 1	2.0E-08	2.0E+03	2.0E+03
Scenario 2	2.0E-07	2.0E+04	2.0E+04
Scenario 3	2.0E-06	2.0E+05	2.0E+05
Scenario 4	2.0E-05	2.0E+06	2.0E+06
Scenario 5	**2.0E-04**	**2.0E+07**	**2.0E+07**
Scenario 6	2.0E-03	2.0E+08	2.0E+08
Scenario 7	2.0E-02	2.0E+09	2.0E+09
Scenario 8	2.0E-01	2.0E+10	2.0E+10
Scenario 9	2.0E+00	2.0E+11	2.0E+11

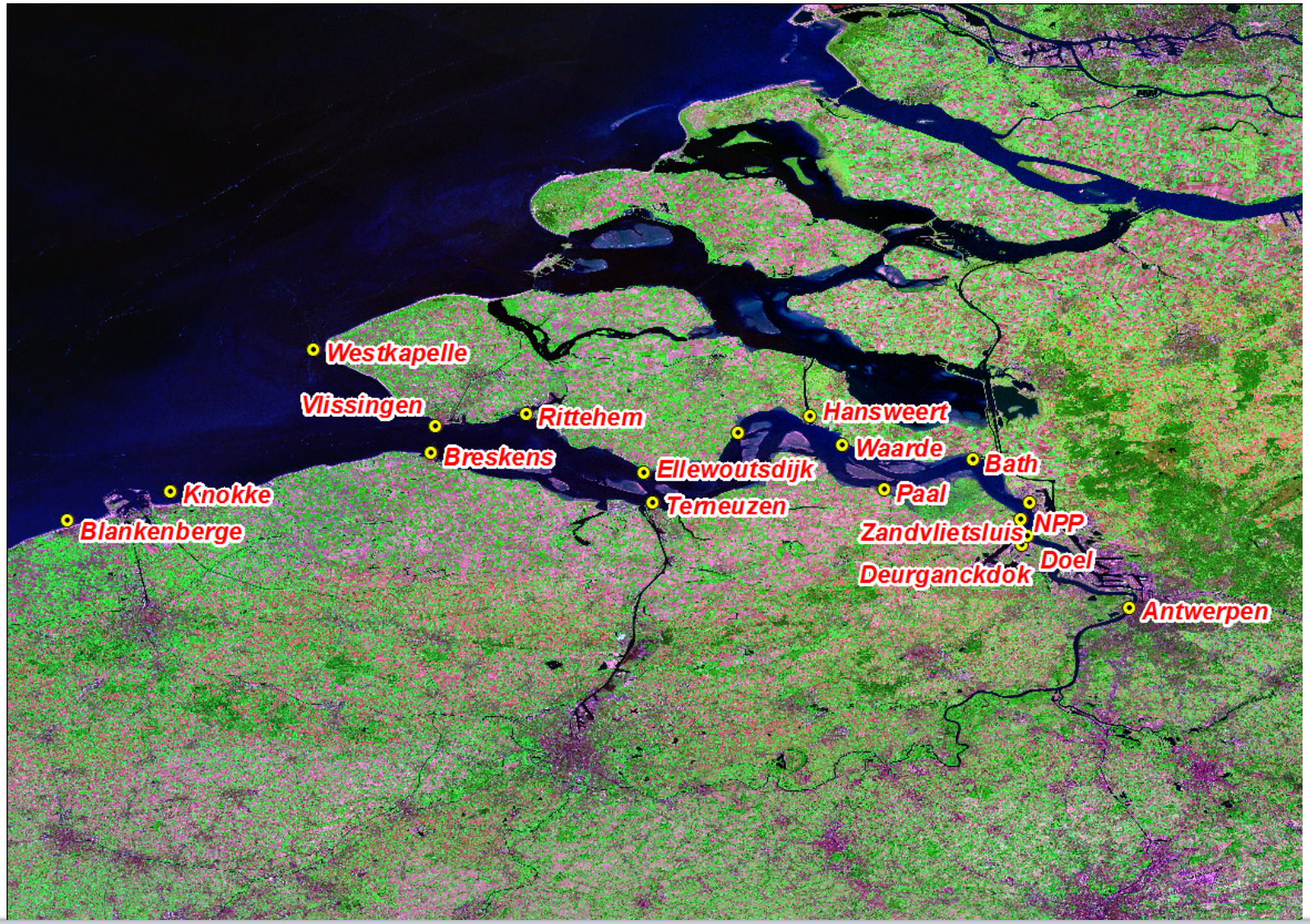
Scenario description

- Partition Coefficient: Based on values of ERICA Tool

Scenario	Fraction	^{131}I L/kg	^{137}Cs L/kg
		1.00E+02	***1.00E+04***
Low Kd	1.E-01	1.E+01	1.E+03
High Kd	1.E+01	1.E+03	1.E+05

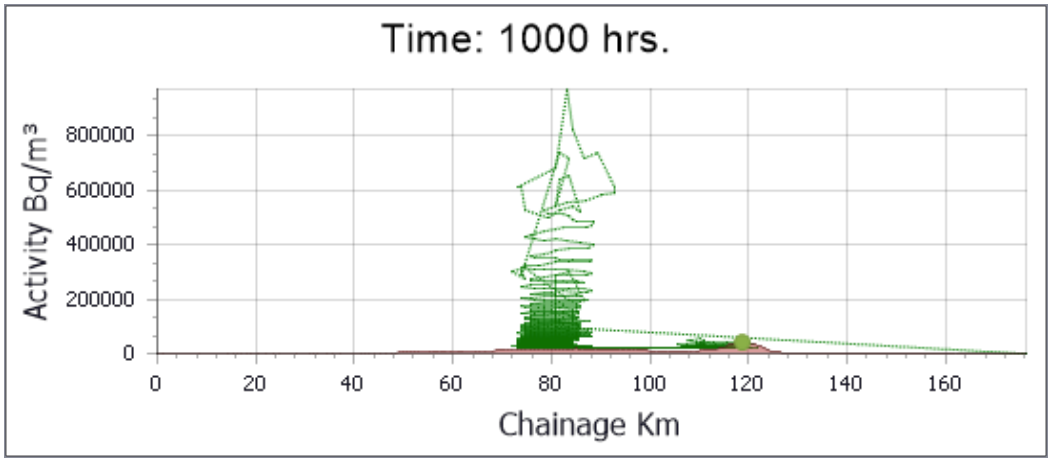
- Discharge time: **24hr**.

Scenario description

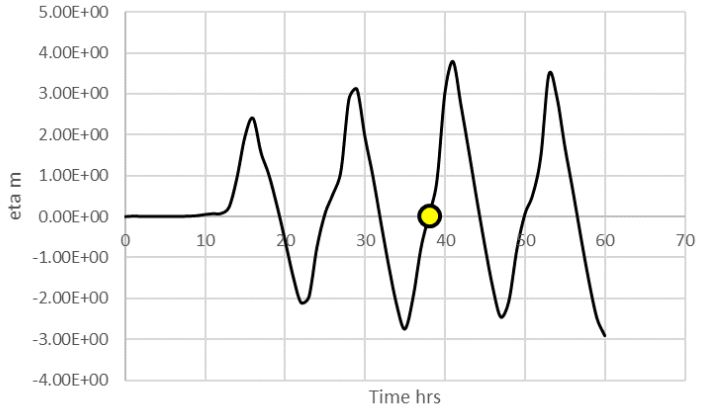


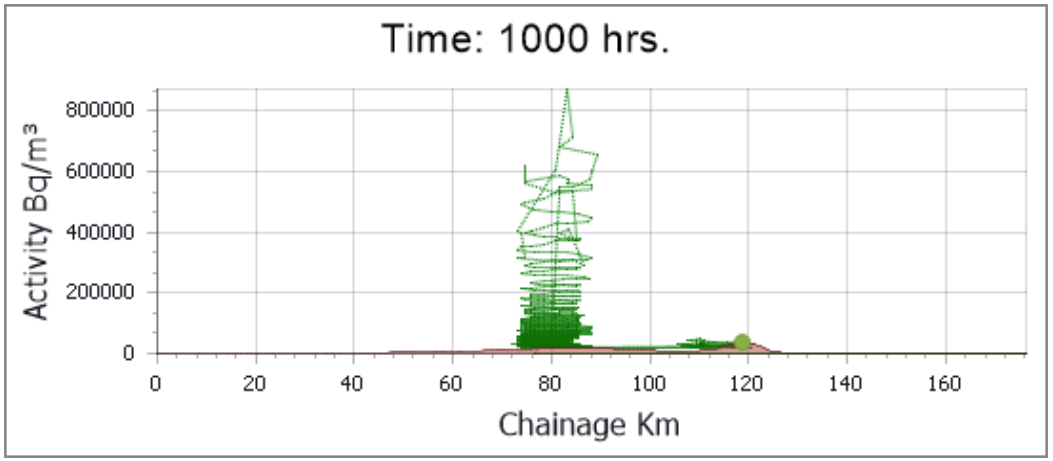
Scenario ^{137}Cs

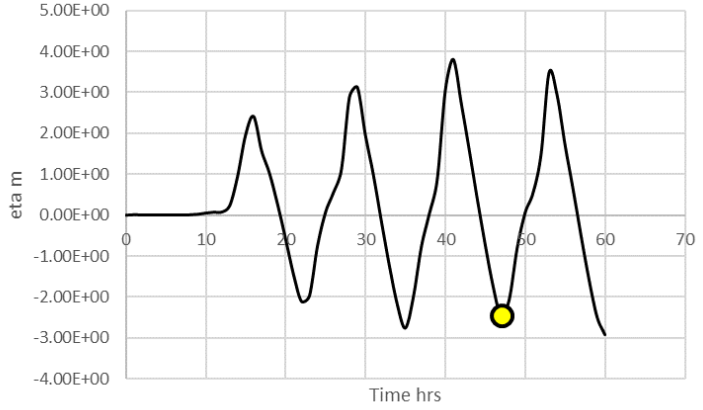
- Longitudinal profile



Release time

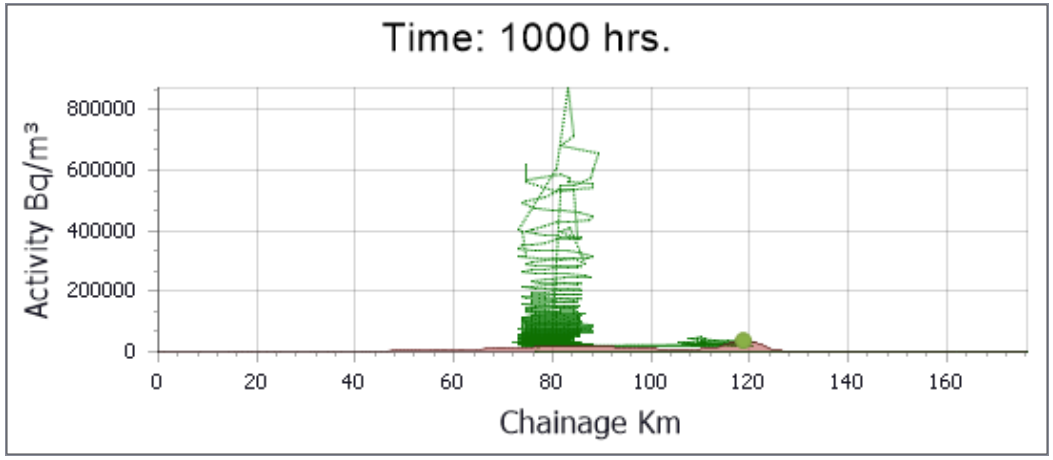


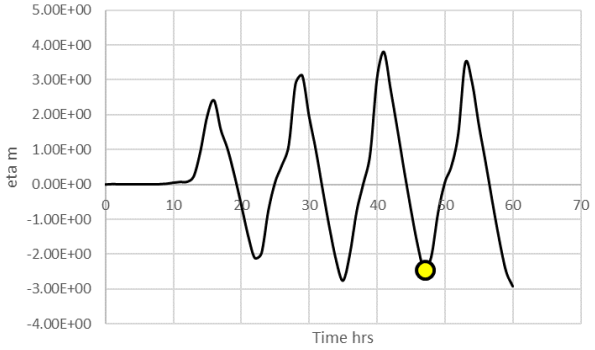




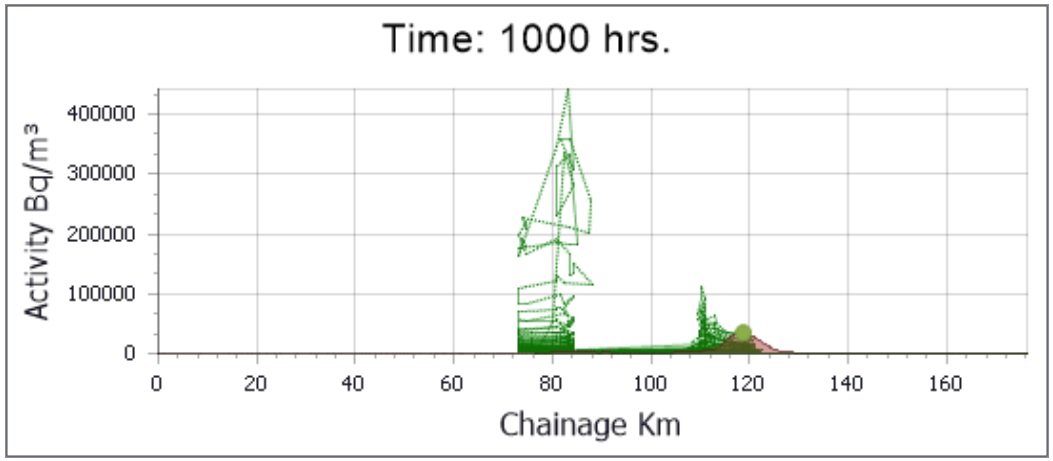
Scenario ^{137}Cs

- Longitudinal profile





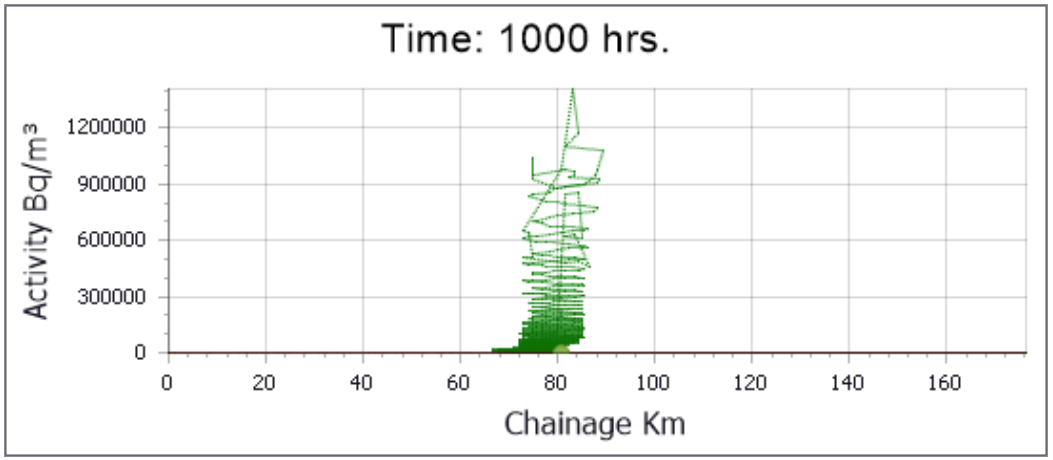
Low Kd scenario

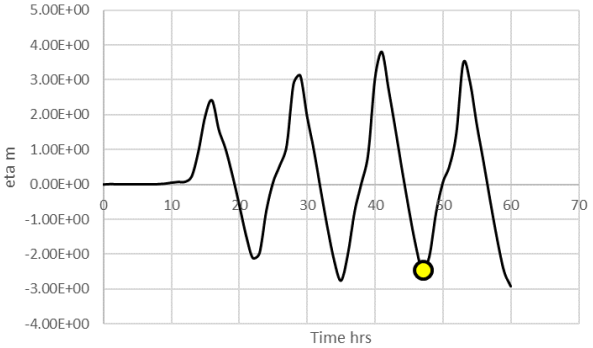


High Kd scenario

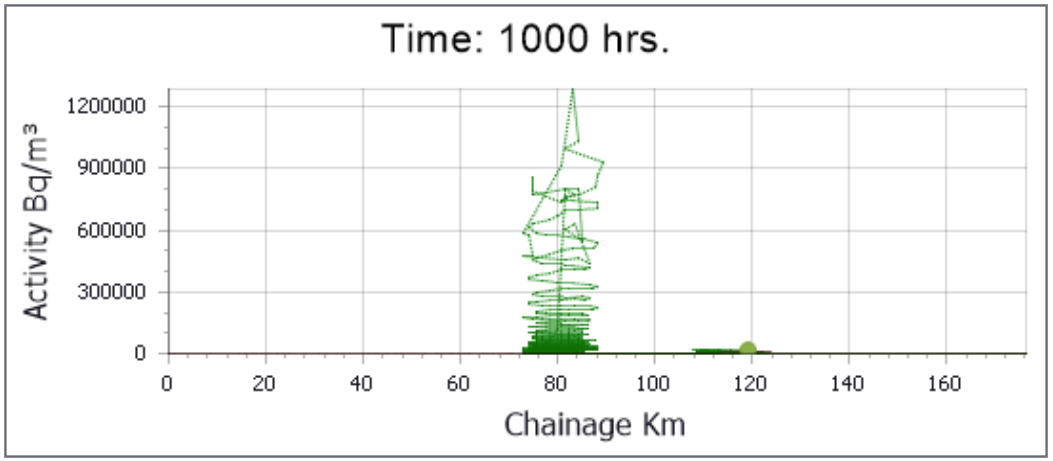
Scenario ^{131}I

- Longitudinal profile



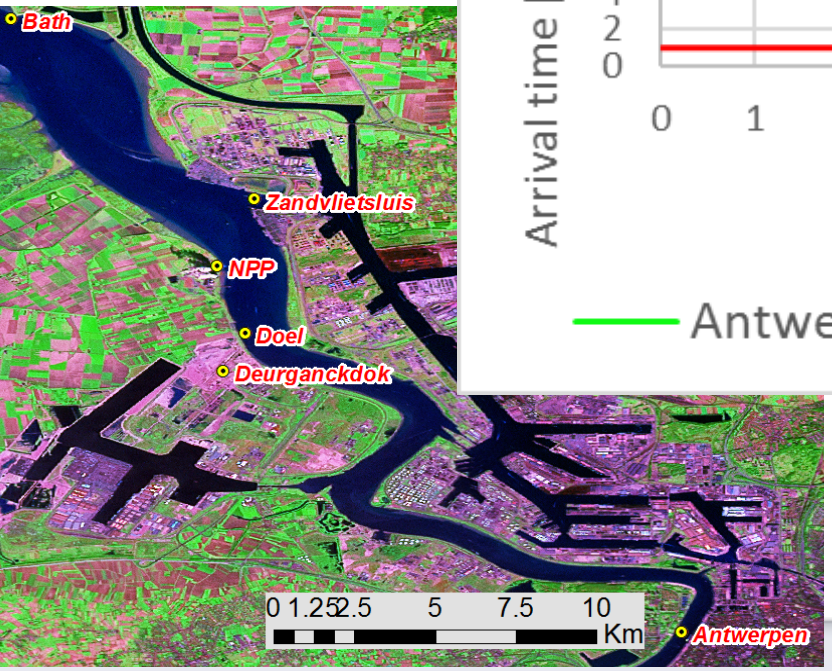


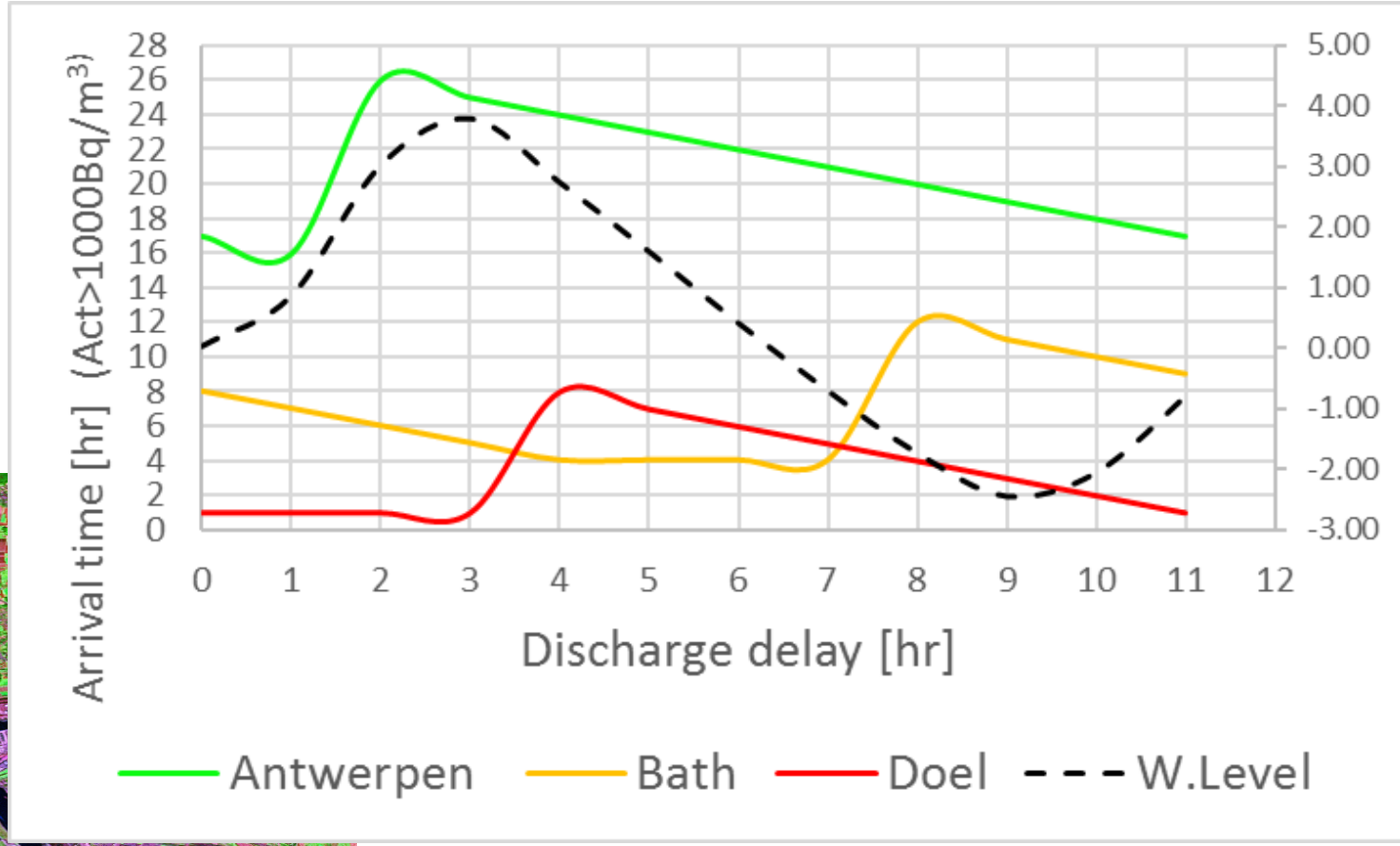
Low Kd scenario



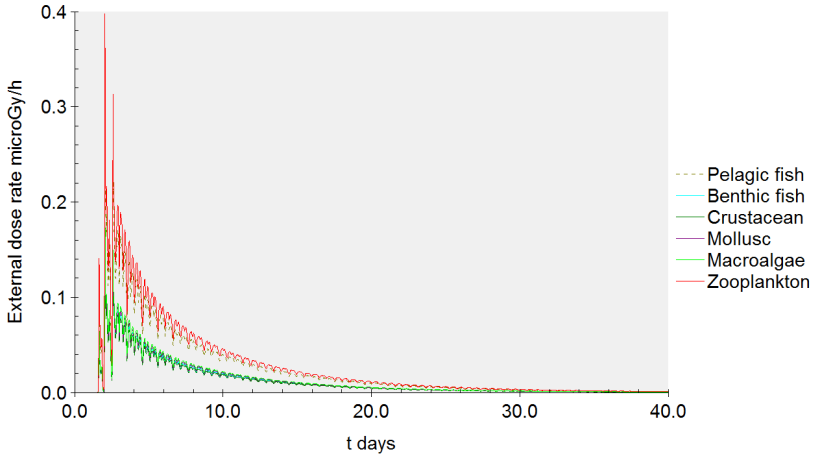
High Kd scenario

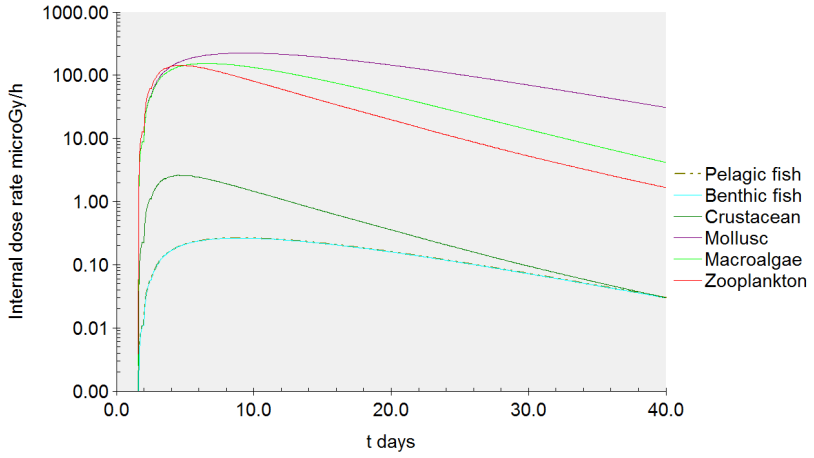
Time of arrival



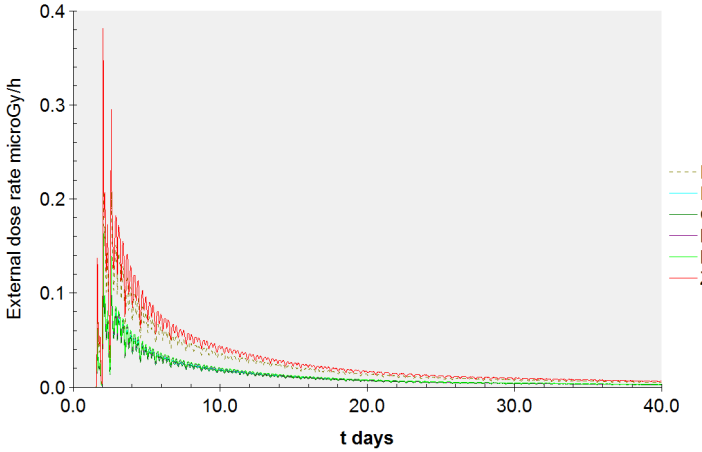


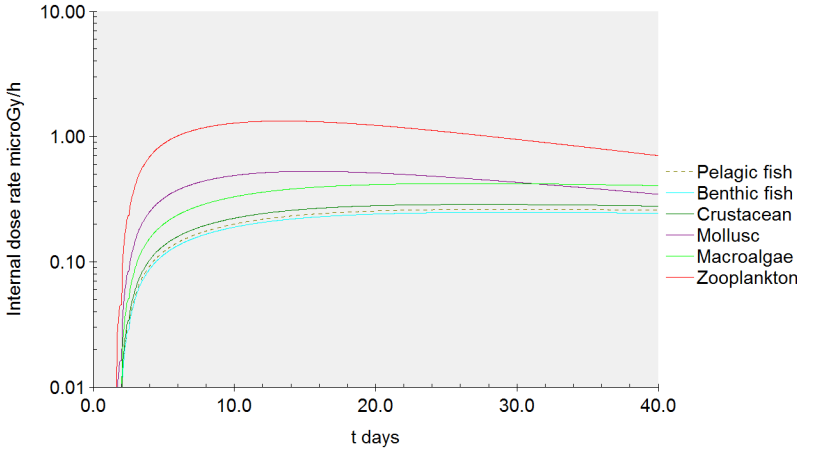
Dose to biota-Doel Low Kd





^{131}I



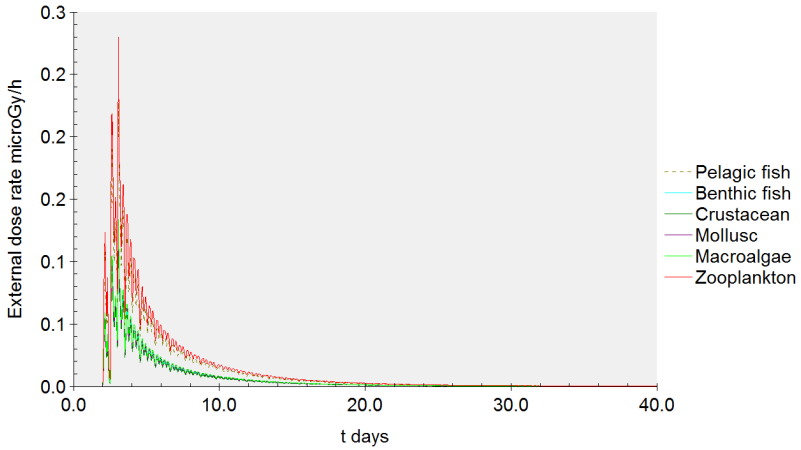


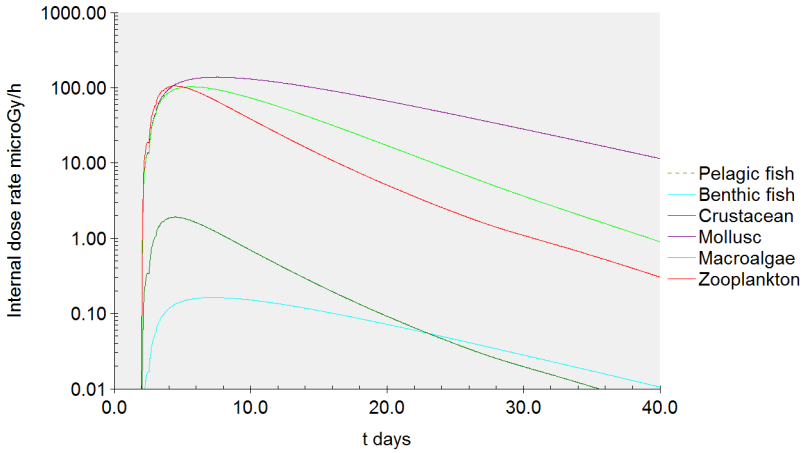
^{137}Cs

Computed with D-DAT model

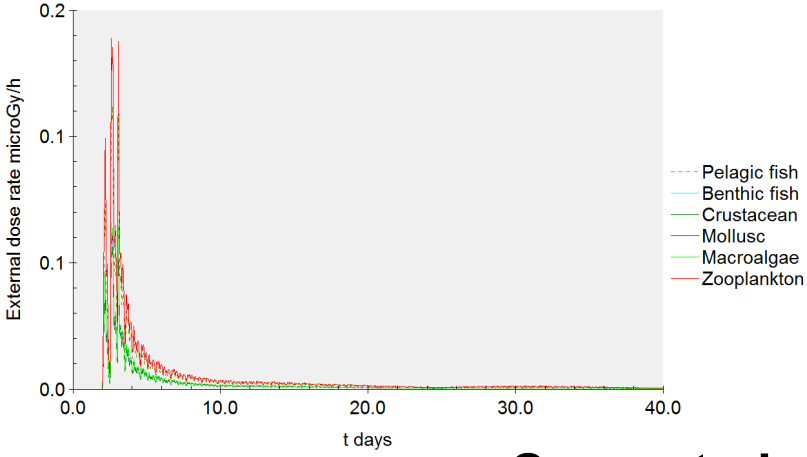
J. Vives i Batlle, R.C. Wilson, S.J. Watts, S.R. Jones, P. McDonald, S. Vives-Lynch, Dynamic model for the assessment of radiological exposure to marine biota, Journal of Environmental Radioactivity

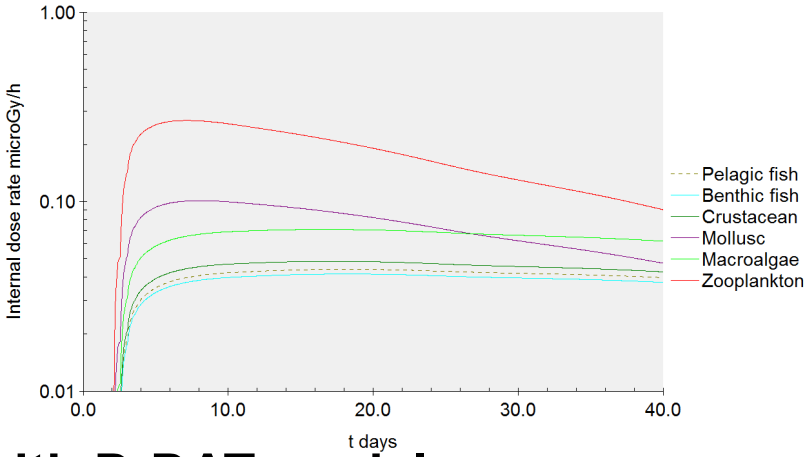
Dose to biota-Doel High Kd





^{131}I





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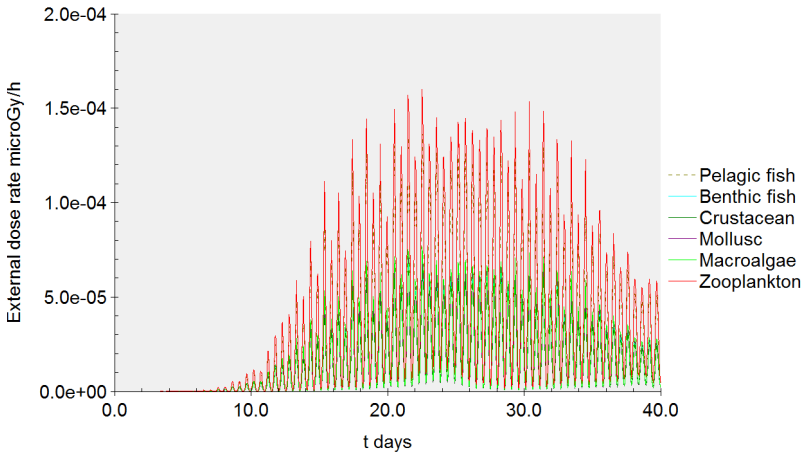
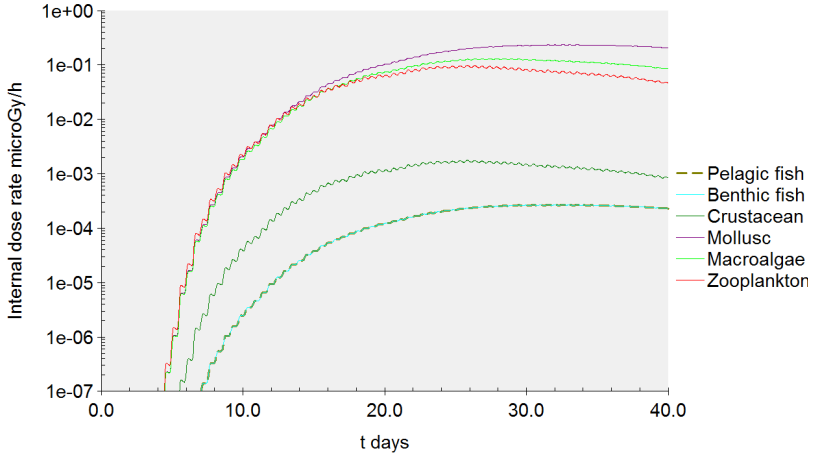
Dose to biota-Vlissingen Low Kd





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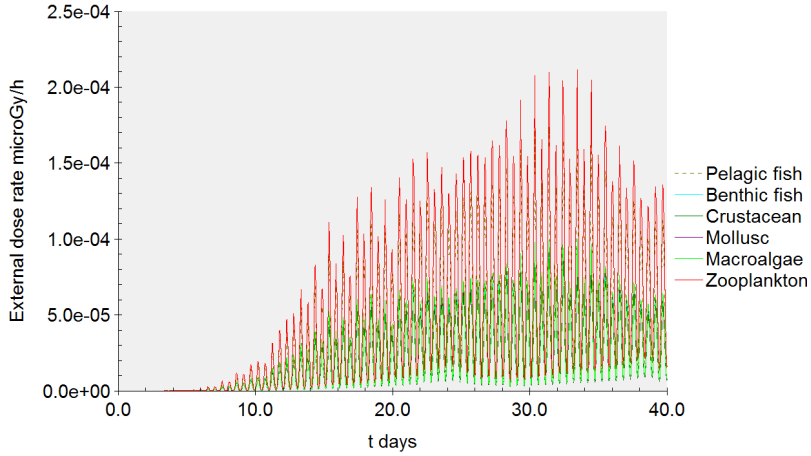
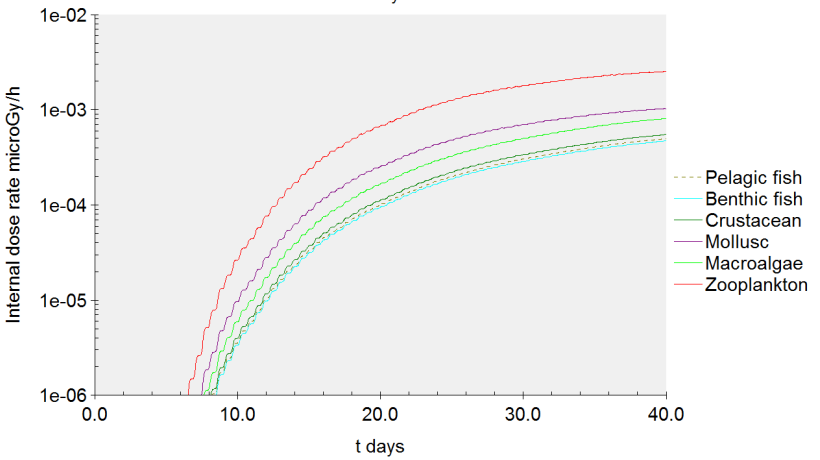




^{137}Cs

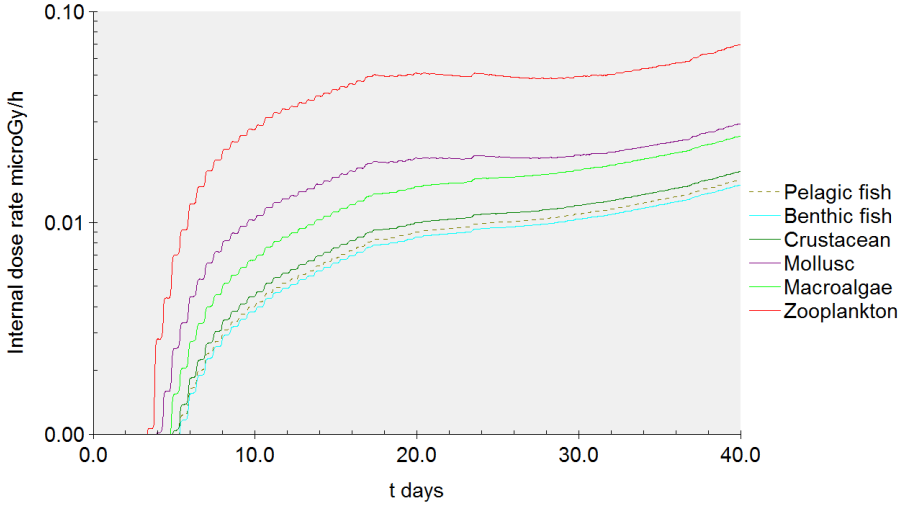
Computed with D-DAT model

J. Vives i Batlle, R.C. Wilson, S.J. Watts, S.R. Jones, P. McDonald, S. Vives-Lynch, Dynamic model for the assessment of radiological exposure to marine biota, Journal of Environmental Radioactivity

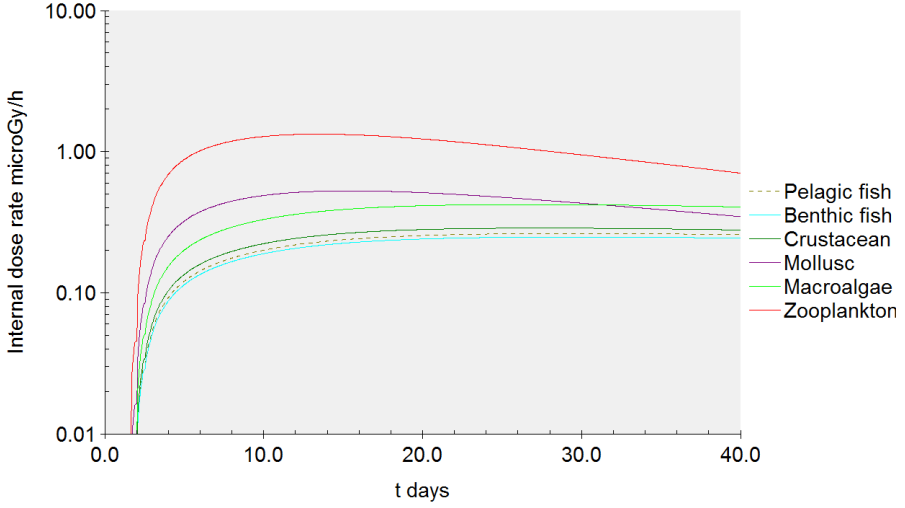
Dose to biota

- The **dose estimation** was done **based on** the assumption of **stationary biota**. However **it can be improved** by coupling the model **with a Particle tracking model**.

Dose to biota



Particle tracking approach

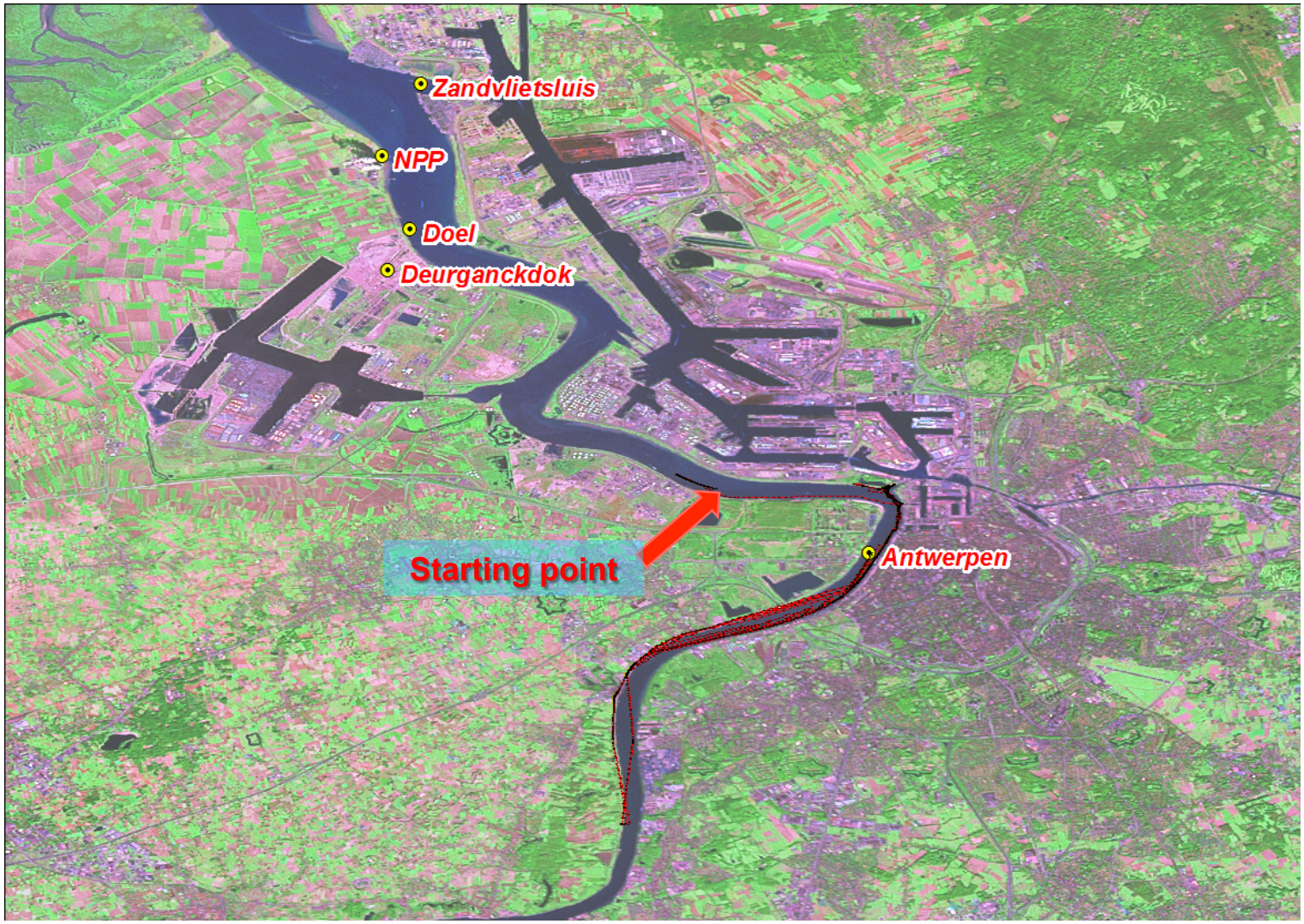


Static approach

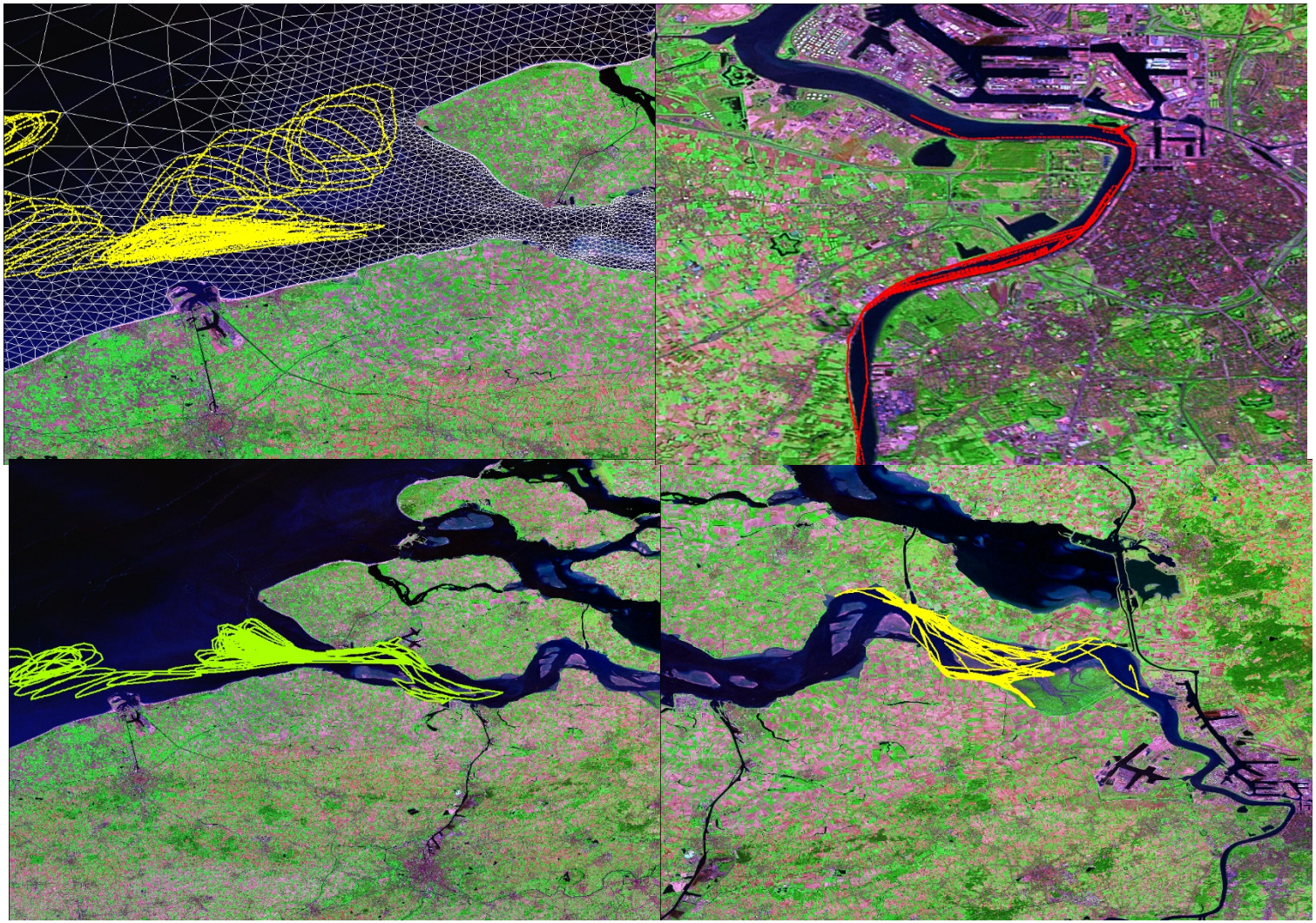
Computed with D-DAT model

J. Vives i Batlle, R.C. Wilson, S.J. Watts, S.R. Jones, P. McDonald, S. Vives-Lynch, Dynamic model for the assessment of radiological exposure to marine biota, Journal of Environmental Radioactivity

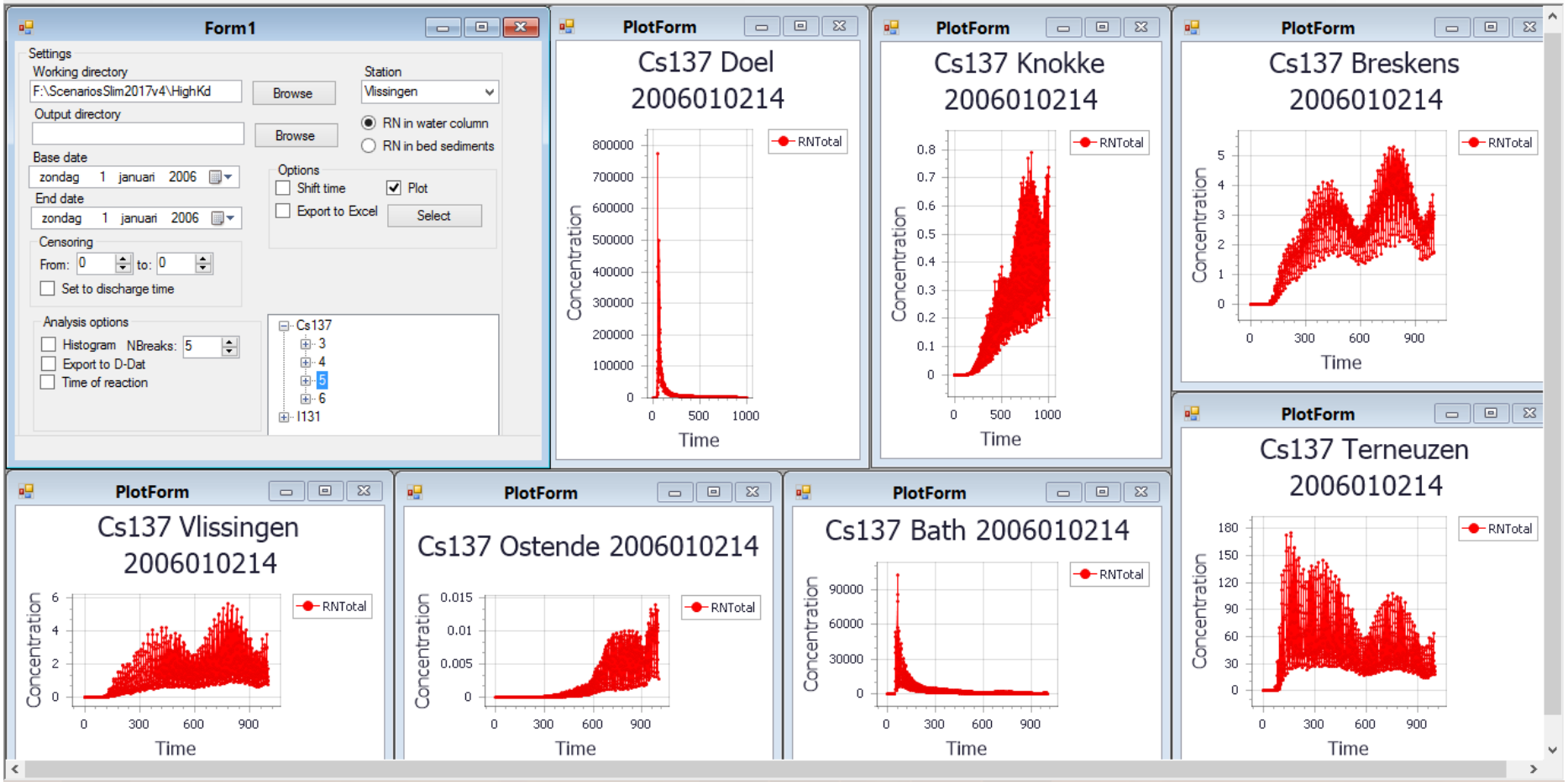
Dose to biota-Particle tracking



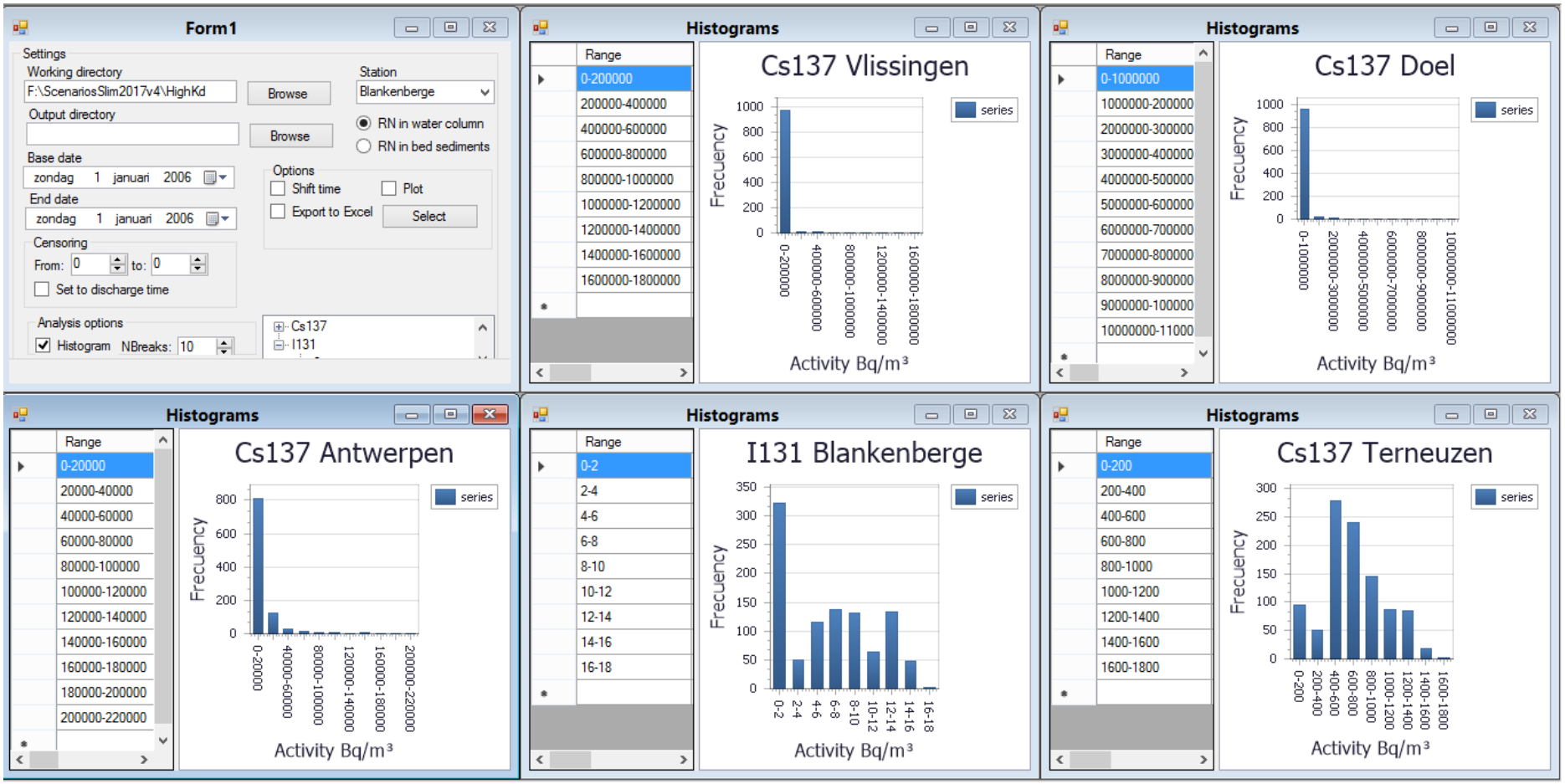
Dose to biota-Particle tracking



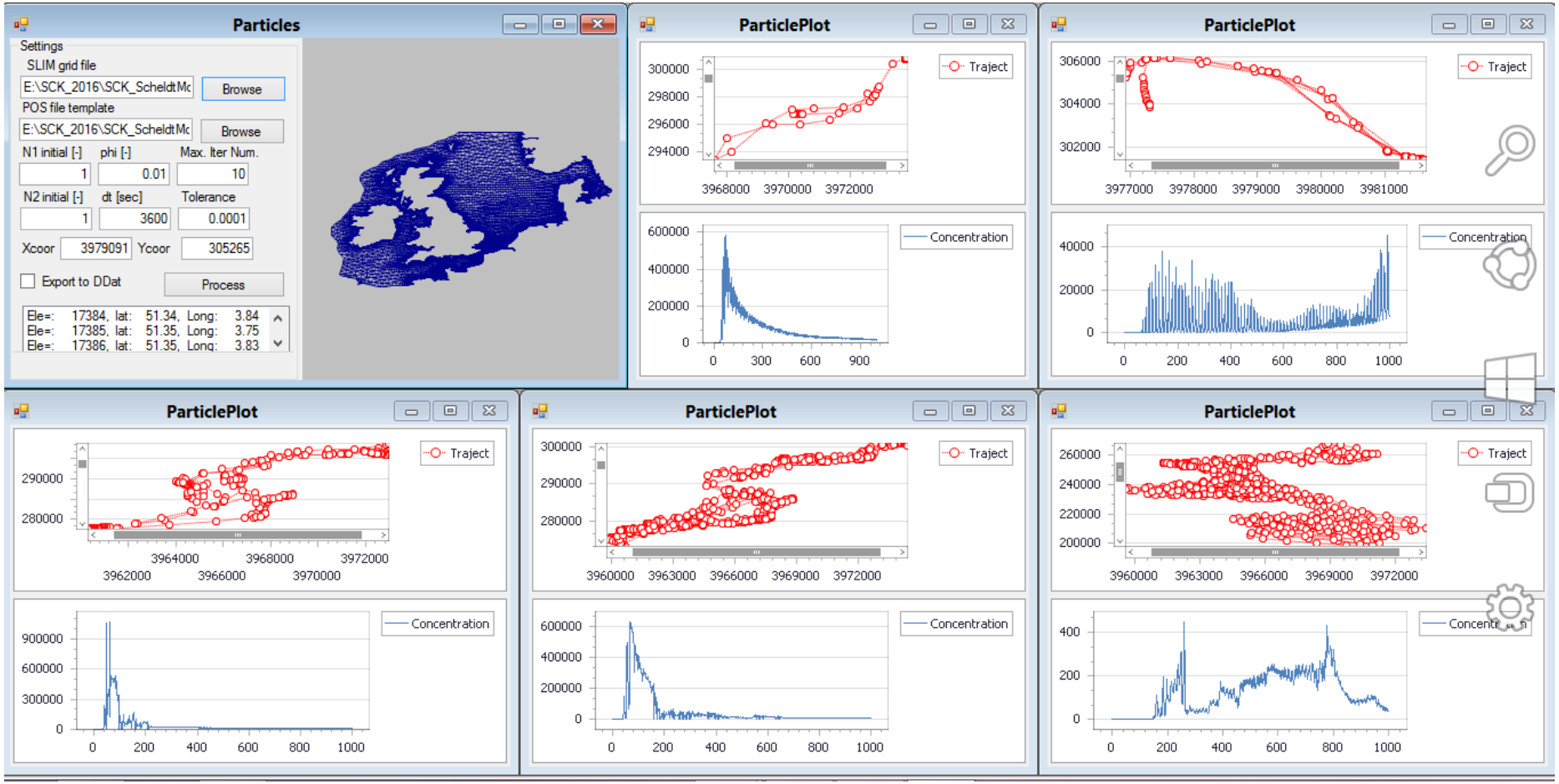
DSS tool Development



DSS tool Development



DSS tool Development



Conclusions

- SLIM-RN model has the required flexibility for fast impact assessments
- The Partition coefficient shows an important effect on the magnitude of the activity in the water column
- The influence of the tides on the RN distribution is stronger near the discharge point but it reduces at the mouth of the estuary
- The zone with the highest activity remains around ±10 km from the discharge point
- Scenario 5 shows limited impact on the aquatic biota
- This studies tries to bridge the gap between research model and assessment tool

Thank you very much for your attention

SCK•CEN
Studiecentrum voor Kernenergie
Centre d'Etude de l'Energie Nucléaire
Belgian Nuclear Research Centre

Stichting van Openbaar Nut
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Foundation of Public Utility

Registered Office: Avenue Herrmann-Debrouxlaan 40 – BE-1160 BRUSSELS
Operational Office: Boeretang 200 – BE-2400 MOL

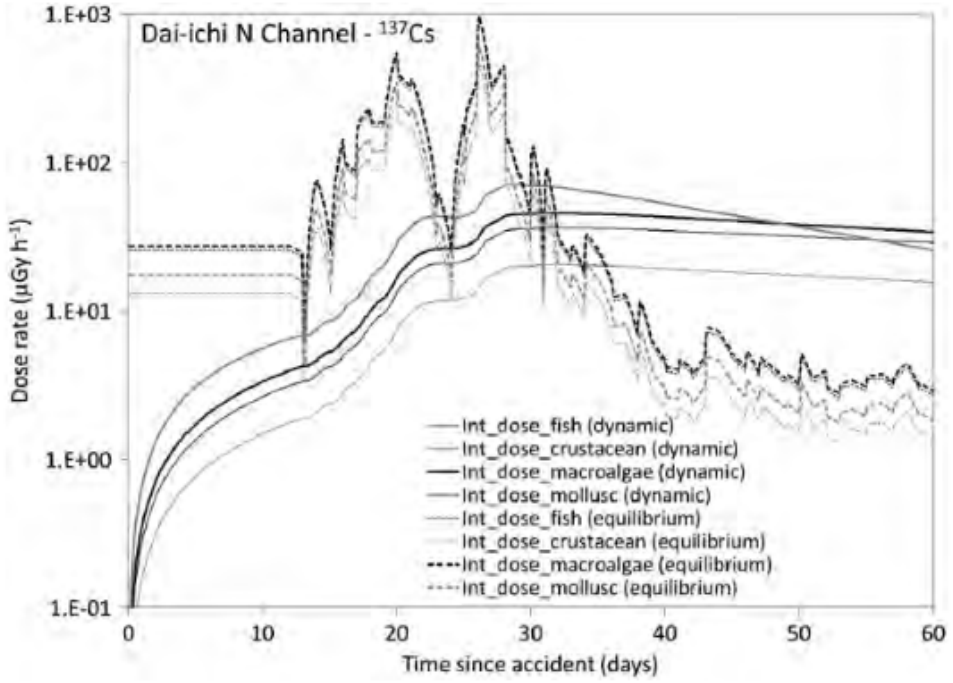

Fig. 3. Modelling predictions for the Fukushima Daiichi northernmost discharge point.