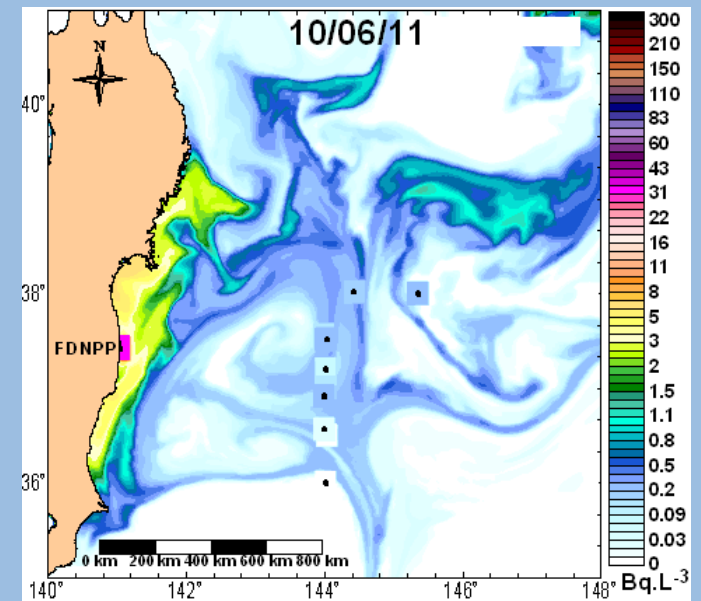
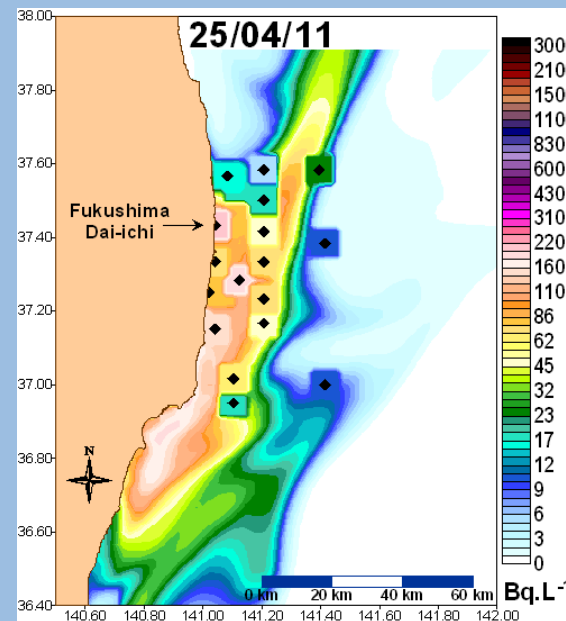
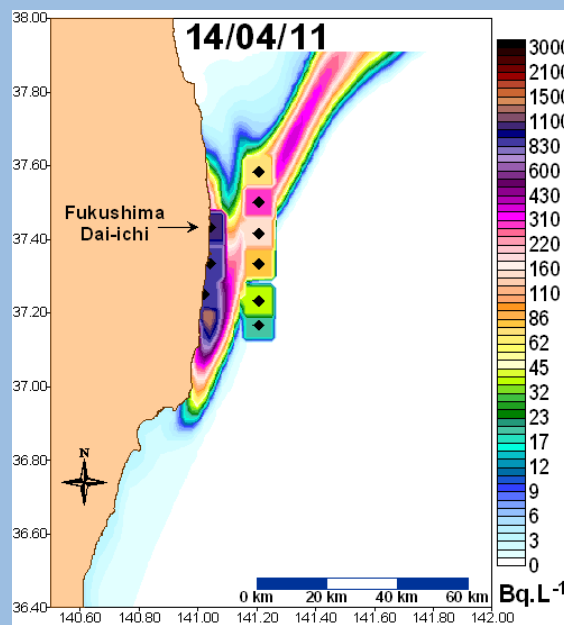


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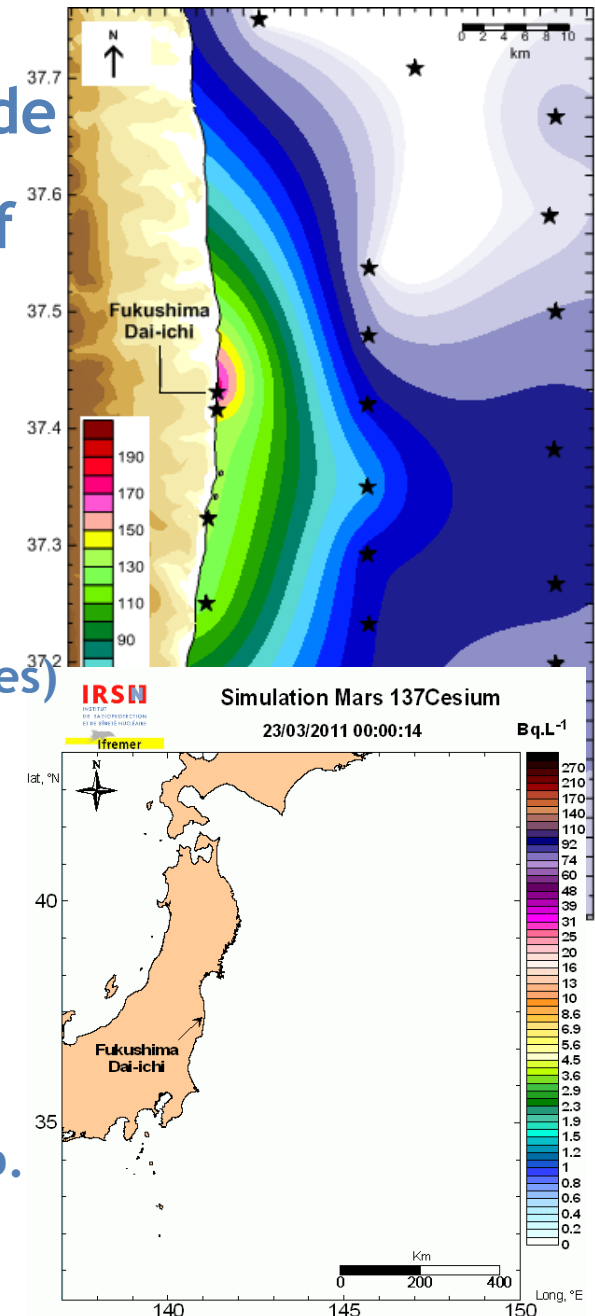
# CHALLENGES IN AQUATIC MODELING IN CASE OF ACCIDENTAL RADIOACTIVE DISCHARGES IN THE MARINE ENVIRONMENT

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## Challenges in aquatic modeling

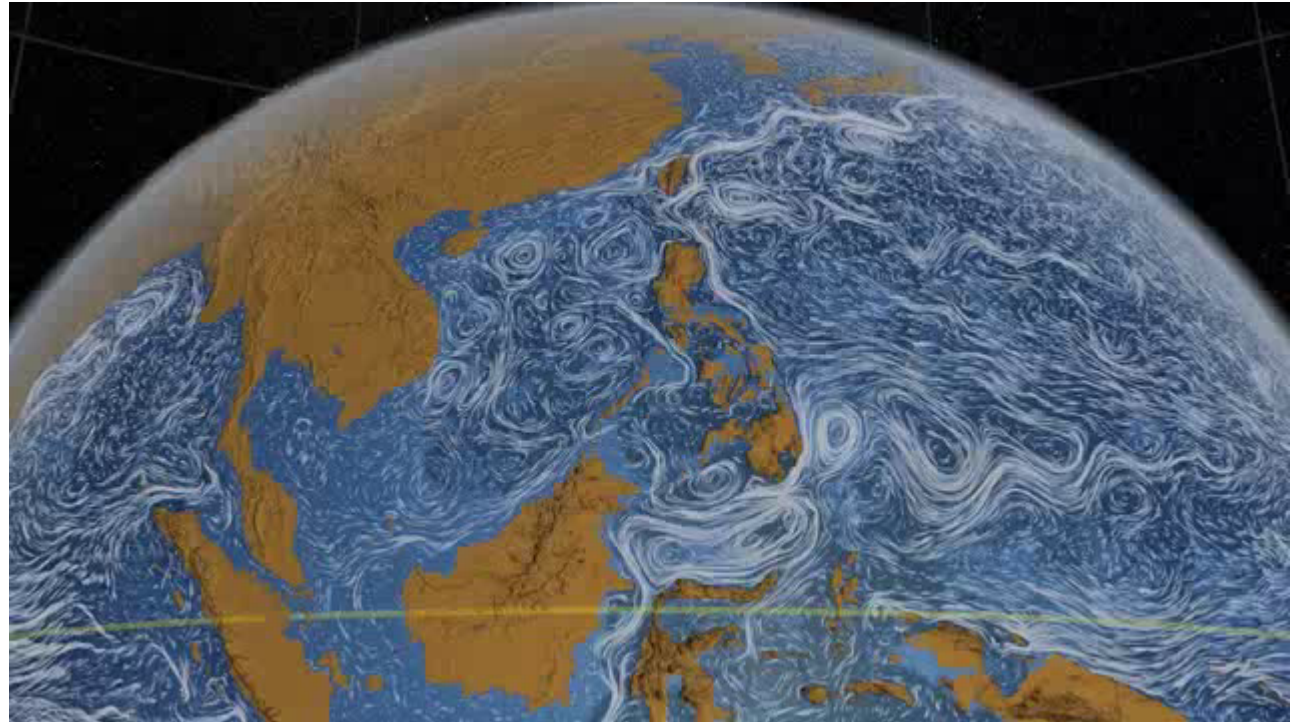
- ☞ in situ concentration measurement data provide robust information at the time and locations of sampling, so it's a snap shot of the picture but
  - ☞ how much between sampling location ?
  - ☞ before/after sampling?
- ☞ modeling provides tools to fill the gaps(inventories)
- ☞ to carry out hindcast/forecast
- ☞ it involves
  - ☞ hydrodynamic dispersion
  - ☞ transfers between seawater and sediment and biota comp.
  - ☞ sediment transport



video by NASA of surface flows in the NW-Pacific Ocean

☞ hydrodynamic models  
potentially available  
worldwide

- ☞ bathymetry
- ☞ open boundaries forcing
- ☞ **source term**
- ☞ **validation**



☞ in case of an accidental situation

- ☞ inventory of the observed increase in the marine area
- ☞ Example: Fukushima accident (Major input :  $27E15$  Bq of  $^{137}\text{Cs}$ )

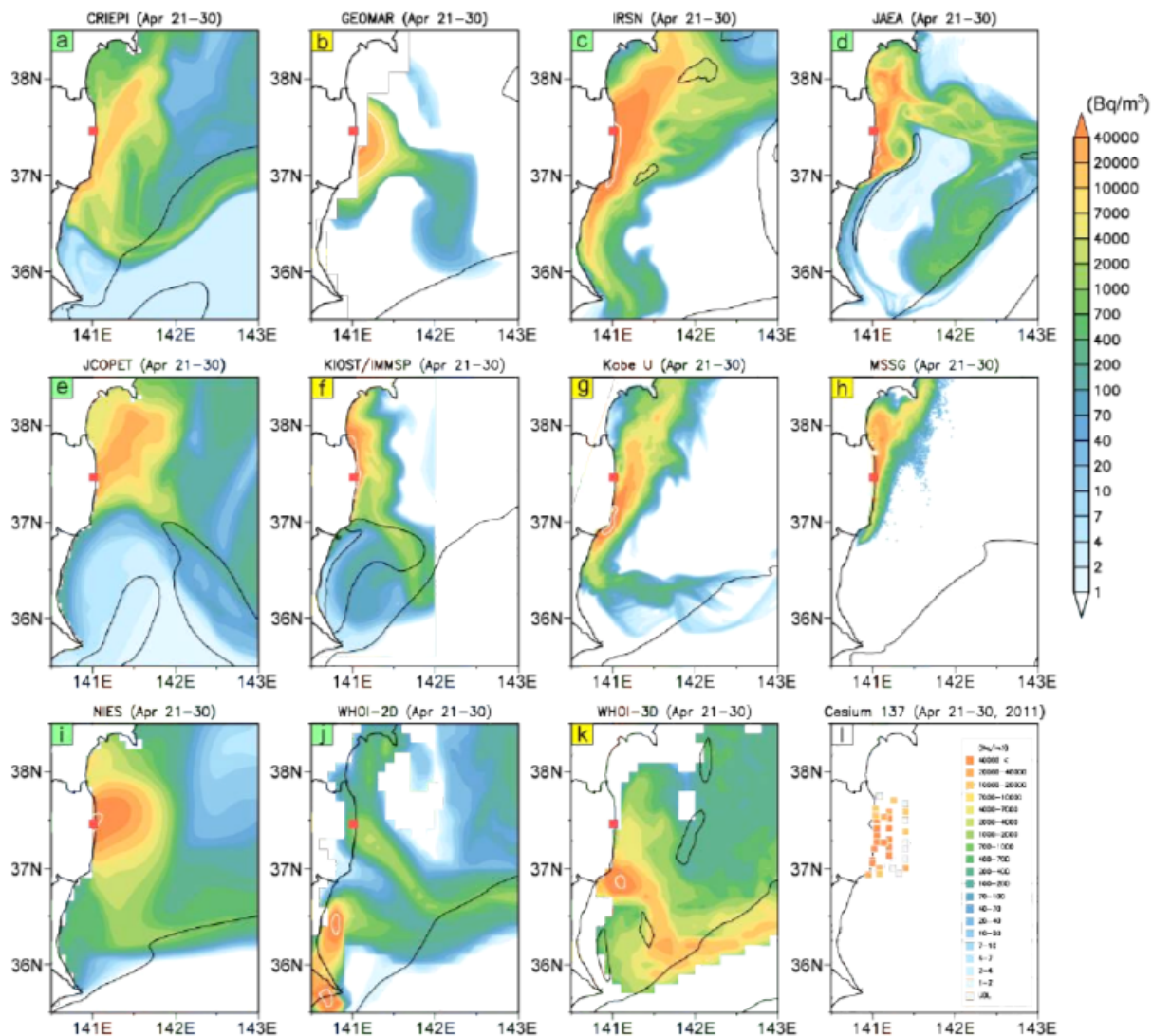
# Intercomparison of available models by the Science Council of Japan

3 months dispersion.  
<sup>137</sup>Cs concentrations averaged on  
 10 days from 21 to 30 April 2011

The order of magnitude is consistent

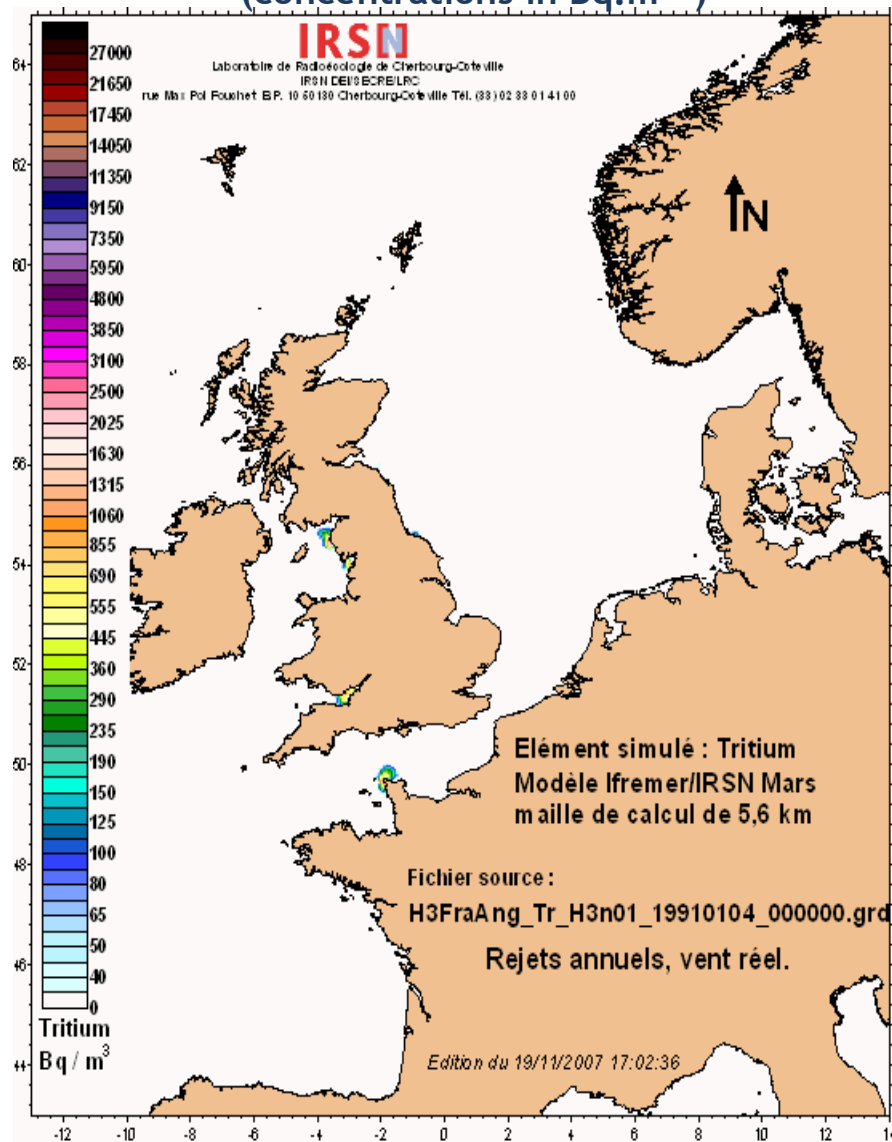
But none of the available models had  
 been previously validated with the  
 proper resolution and frame size.

Therefore, it is not possible to get a  
 deterministic simulation of the  
 changes in radionuclide  
 concentrations in seawater.

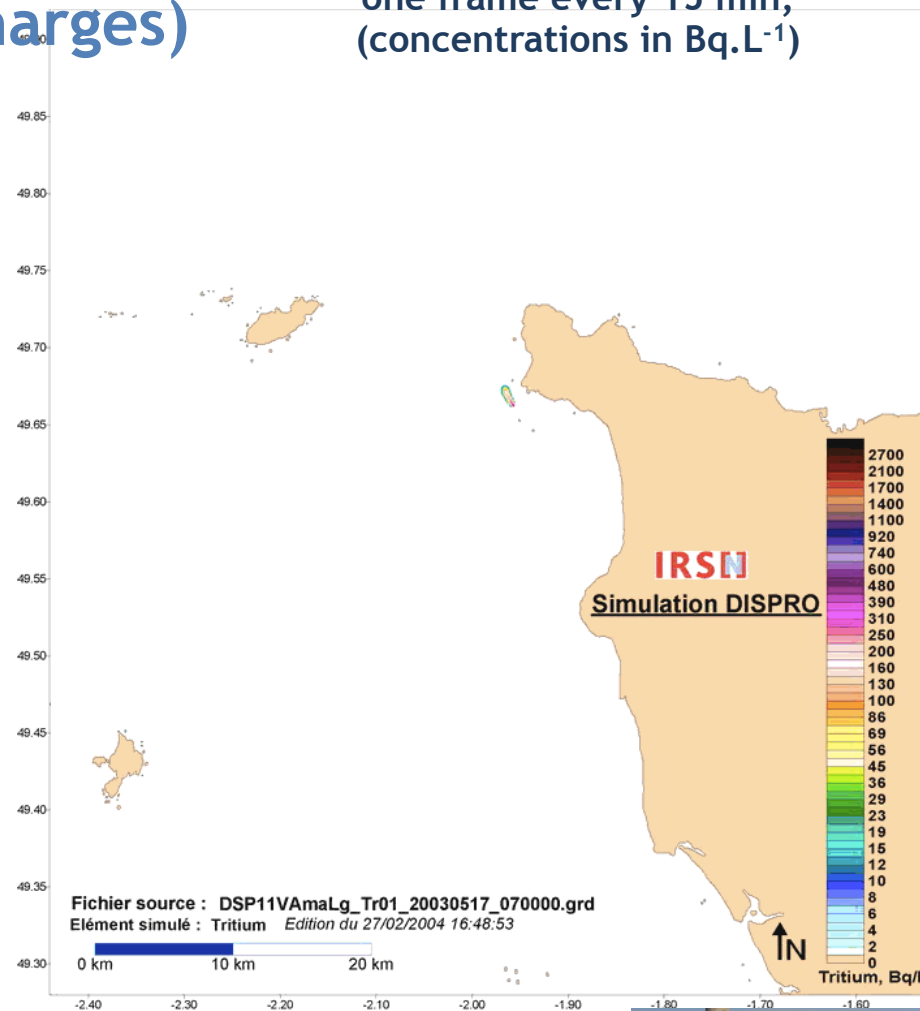


the Channel Sea (controlled discharges)

Real discharges and meteorology, one frame every 10 days,  
(concentrations in  $Bq.m^{-3}$ )



one frame every 15 min,  
(concentrations in  $Bq.L^{-1}$ )



Pascal BAILLY DU BOIS  
Validation involved matching with  
several tens of thousands measurements.  
**Difference** between calculation and  
observation is **<50%**.



## transfers between seawater and sediments

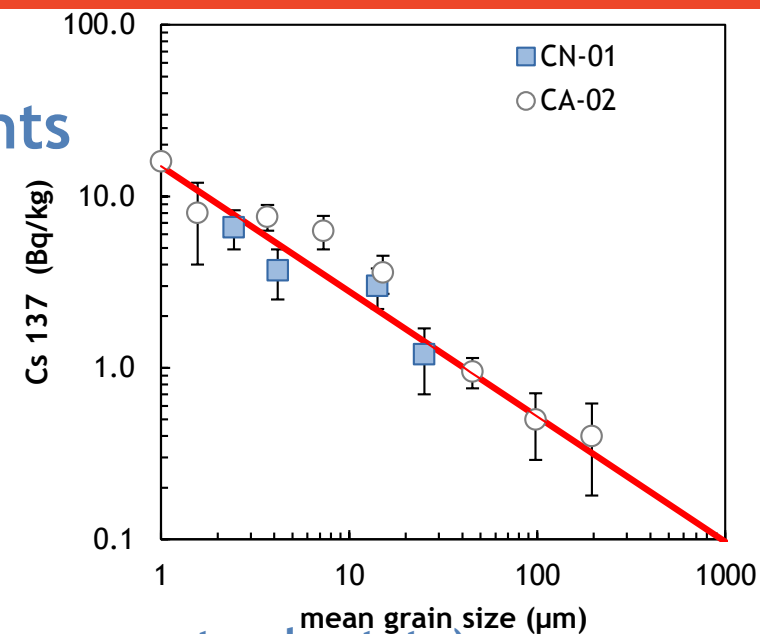
- interaction with suspended matter (SM)
- behavior of particles

## Actual flaws

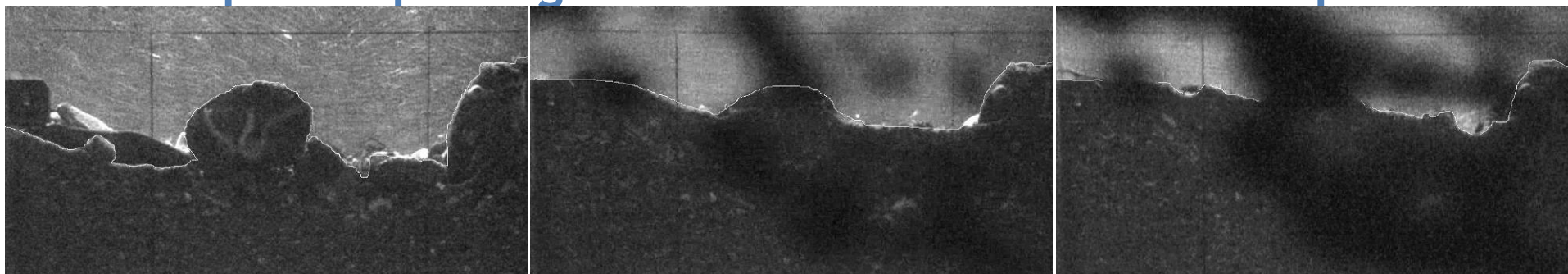
- relationship with grain-size: not considered
- kinetics of transfer: not included in  $K_d$  concept (assumes steady-state)

## Challenges

- SM concentration and size/nature of particles?
- kinetics (non steady-state)
- transport of multiclass size sediment particles



Example: Exploring multiclass size sediment transport



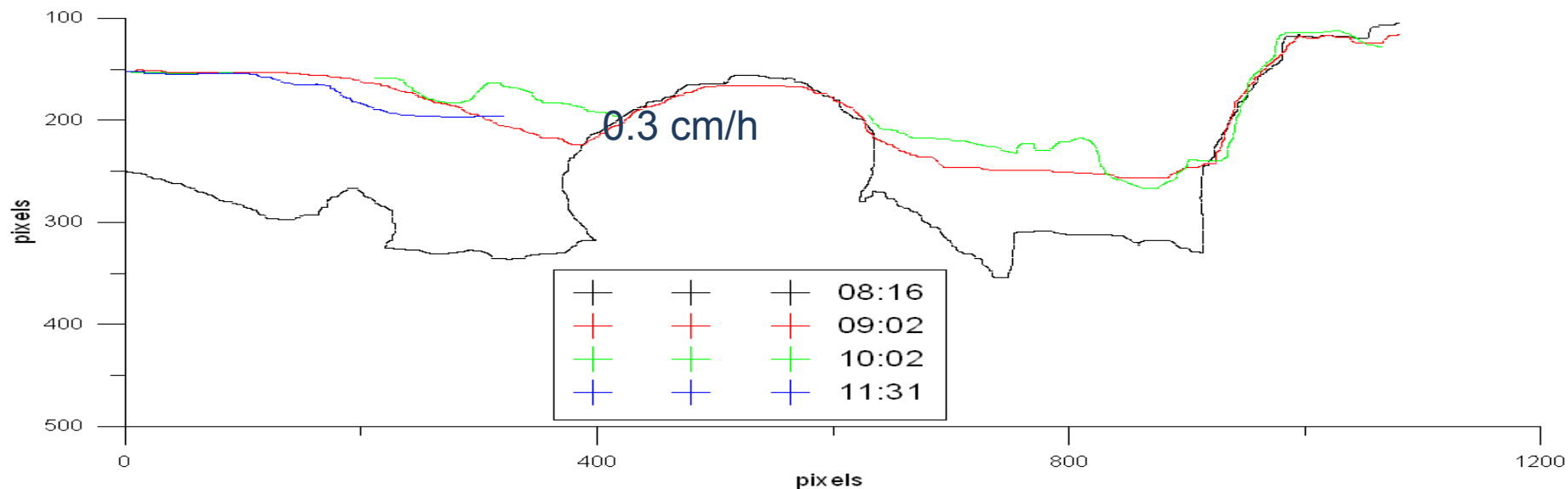
water/seabed  
interface

time T  
08:16

time T + dt  
09:02

time T + dt'  
10:02

Determination of **deposition or erosion** flux during a time interval dt:



## ☞ transfers between seawater and marine species

- ☞ direct pathway (exchanges between seawater and biota)
- ☞ trophic pathway (through feeding, food chains -> recursive problem)

## ☞ Actual flaws

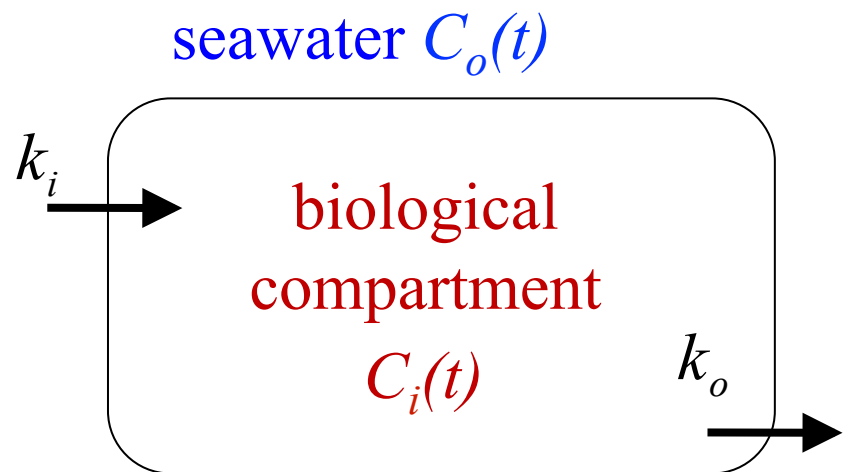
- ☞ kinetics of transfer: not included in CF concept (assumes steady-state)
- ☞ parallel contributions of both pathways

## ☞ Challenges

- ☞ dynamic transfer (CF,  $tb_{1/2}$ )
- ☞ trophic route



dynamic transfer from seawater to one compartment



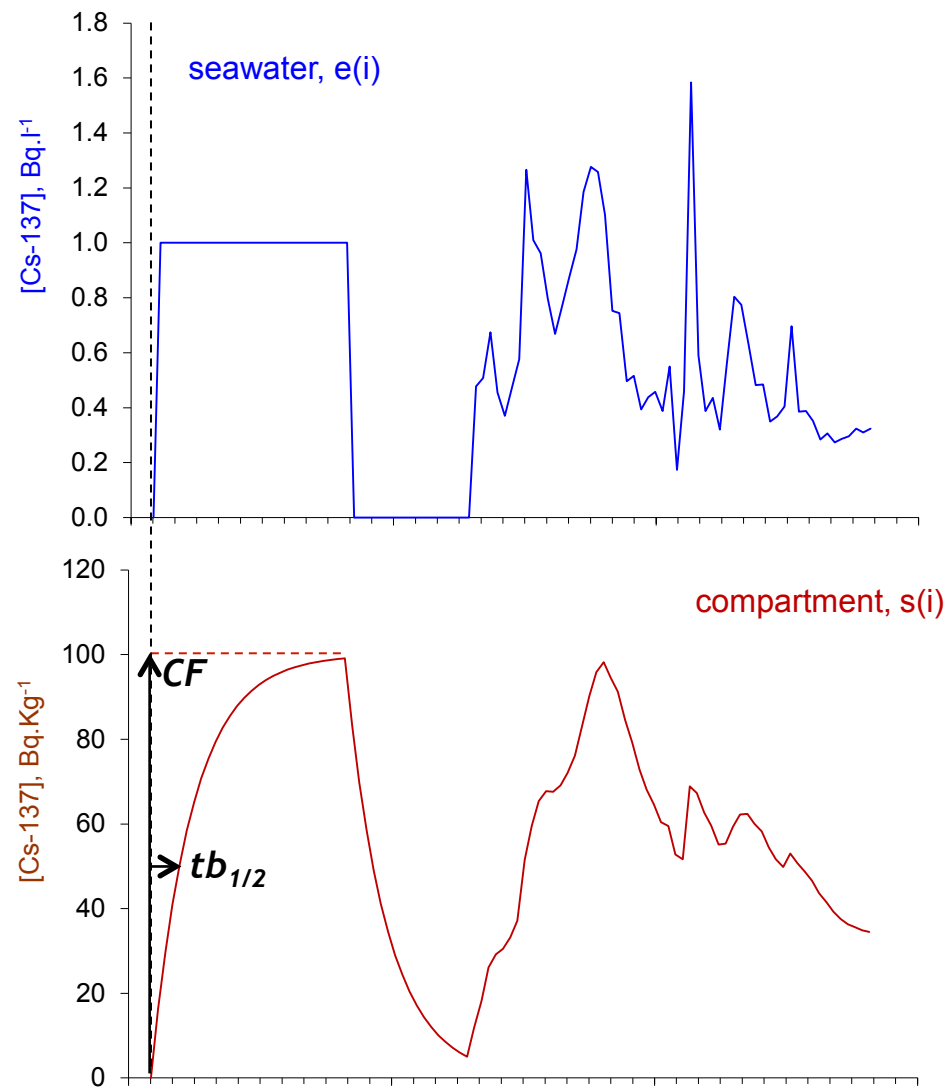
$$\frac{dC_i(t)}{dt} = k_i \cdot C_o(t) - k_o \cdot C_i(t)$$

$$C_i(t) = \frac{k_i}{k_o} \cdot C_o(t) \cdot [1 - \exp(-k_o \cdot t)]$$

$$s_{(i)} = a \cdot s_{(i-1)} + b \cdot e_{(i)}$$

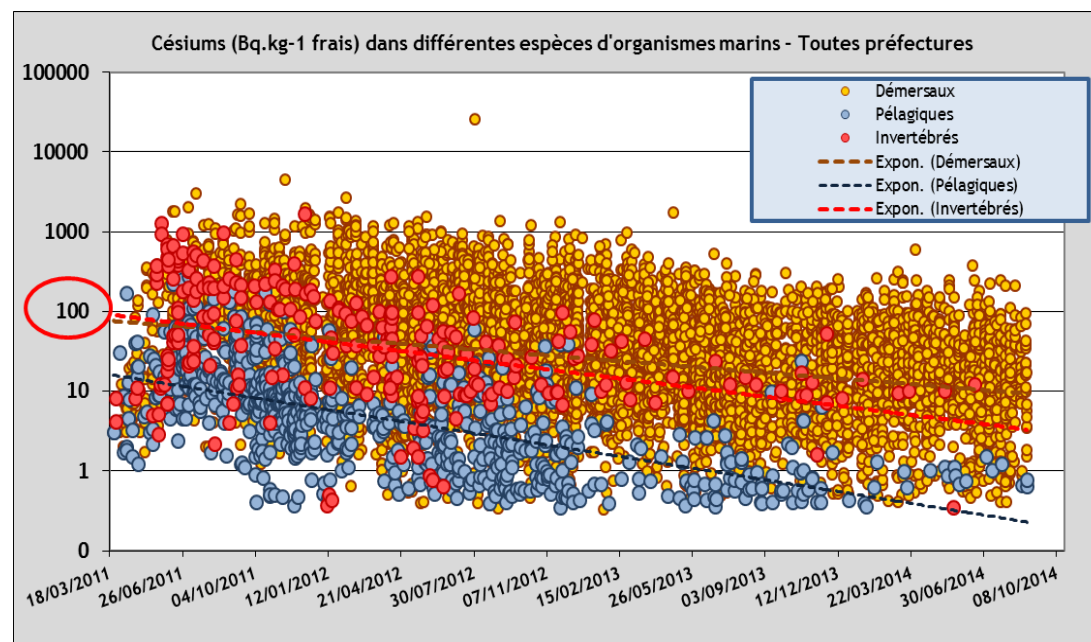
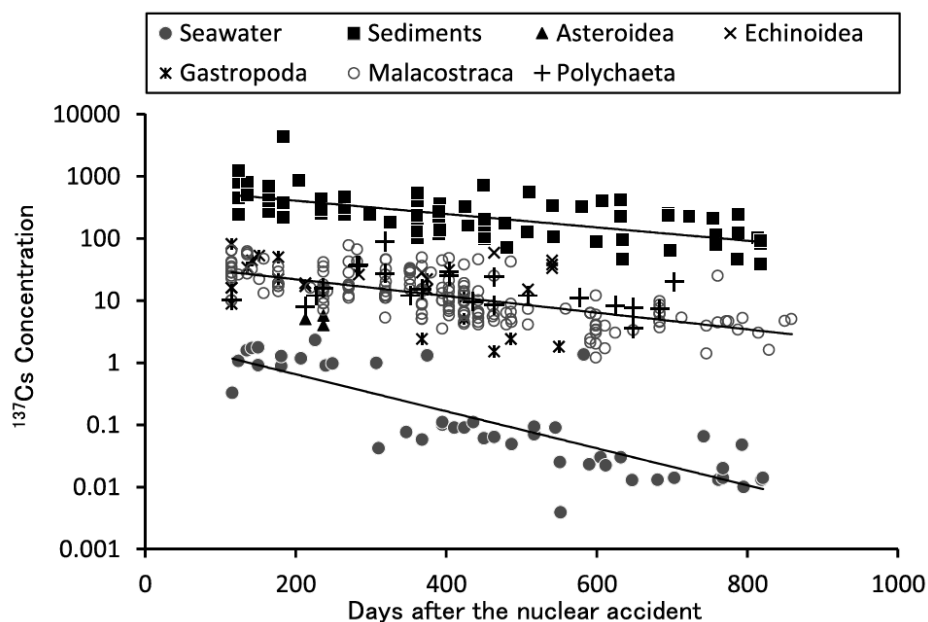
(CF and  $tb_{1/2}$  are related to  $a, b$ )

(J. Envir. Radioact. 2003, 65:91-107)



## 👉 lessons learned from Fukushima accident

- 👉 decrease in Invertebrates contamination is slower than in fish
- 👉 decrease in fish contamination is slower in demersal species compared to pelagic



(Sohtome et al., *J. Envir. Radioact.* 2014, 138:106-115)

(Arnaud M., IRSN, personal communication)

## 👉 Focus is needed on the influence of the trophic pathway

## ☞ Acknowledgments

- ✓ **Laboratoire de Radioécologie de Cherbourg-Octeville (SERIS)**
  - Pascal BAILLY DU BOIS,
  - Philippe LAGUIONIE,
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