MODELLING AND ASSESSMENT OF POLLUTANTS IMPACT ON MARINE ECOSYSTEMS

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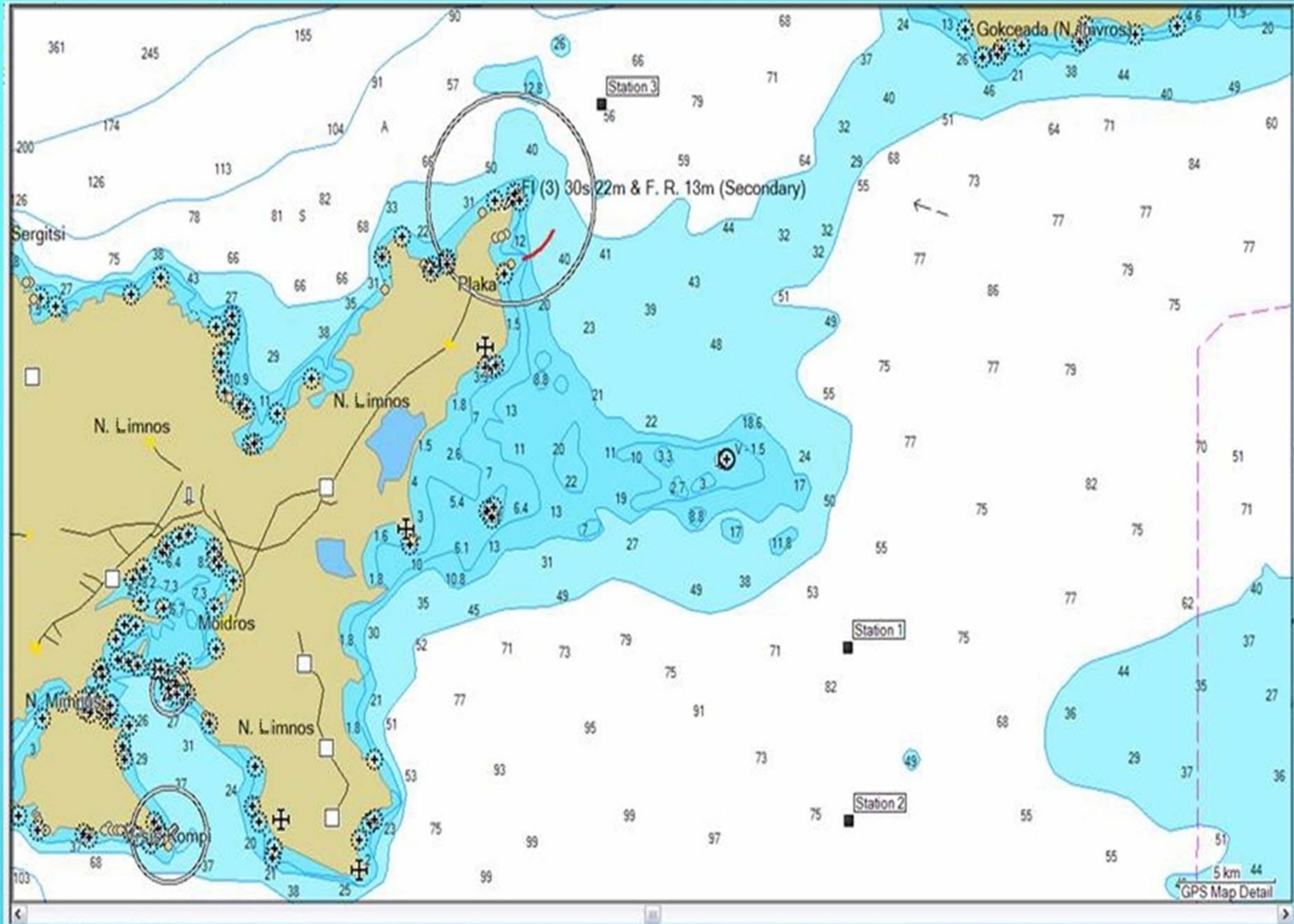
The map of the region



General modelling description-the physical issue

- **General deterministic model developed to simulate the time-dependent behaviour of potential pollutants**
  (^{137}Cs and heavy metals (especially Cu, Ni, Mn)) in the Aegean Sea.

- **Full Navier-Stokes equations for transient, three-dimensional turbulent flow, heat and mass transfer.**

- **For radioactive ^{137}Cs and the above mentioned heavy metals the model capabilities are demonstrated by applying it at the northeast region of the island of Lemnos, in the NE Aegean Sea.**

- **Solution method:the finite-volume method. IPSA(Interphase Slip Algorithm).**

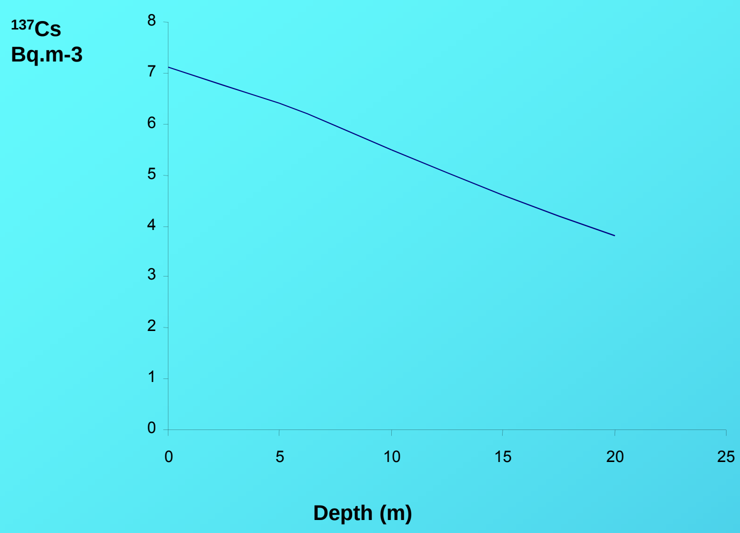
- **CFD code PHOENICS.**

- **Silicon Graphics Origin 200 machine (4 CPU R 10000),Pentium IV, 2.4GHz, 512 MB.**

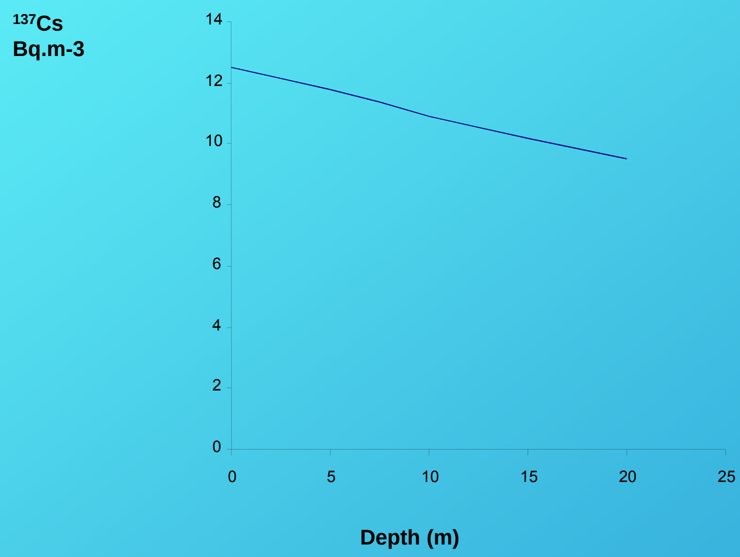
- **Hydrodynamic dispersion and turbulence diffusion (sea surface, water column) of ^{137}Cs (activity concentrations Bq m^{-3}). Use of experimental data in a limited depth of the water column and horizontal dispersion data, during winter and**
- **summer time period.**
- **Estimation of the external dose rates received per unify habitats of marine organisms.**
- **Hydrodynamic dispersion and turbulence diffusion (sea surface, water column) of heavy metals,especially Cu, Ni, Mn. Use of summer period concentrations published data (concentrations nM) *.**

*** The measurements indicated higher values of 137Cs during this season together with the fact that there exist more published data for heavy metals for this time of the year**

The model vertical profiles of ^{137}Cs

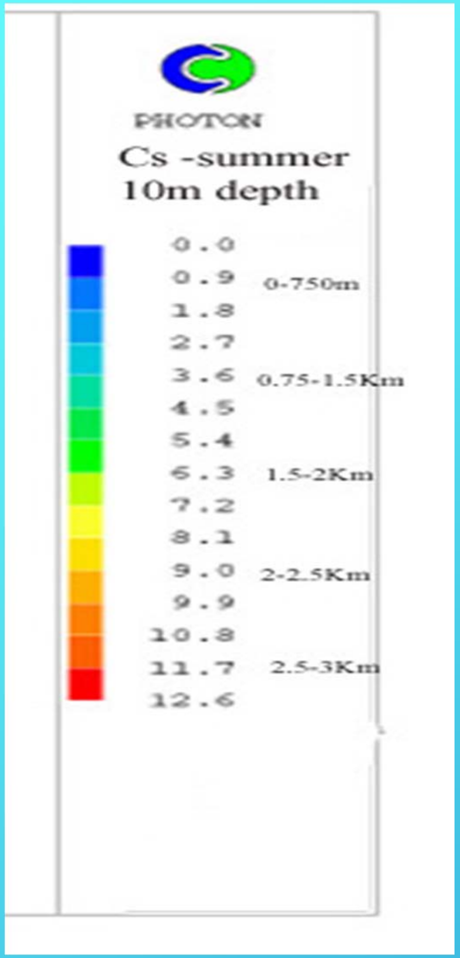


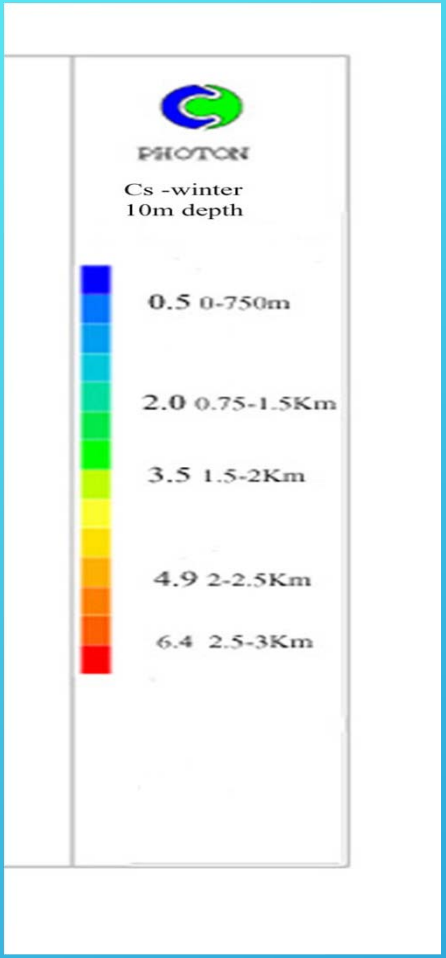
The model vertical profiles of ^{137}Cs based on the winter data of ^{137}Cs activity concentrations



The model vertical profiles of ^{137}Cs based on the summer data of ^{137}Cs activity concentrations

137Cs (surface-depth-distance from the shores -Bq/m3)





CALCULATION FORMULAE

A1. Activity concentration in organism based on activity concentration in sea water

Activity Concentration in water [(mBq/l)x10-3] X Concentration Factor = Activity Concentration in organism (Bq/kg wet mass)

A2. External dose rate estimations based on sediment and sea water activity concentrations

Sediment

$$D = 9.58 \times 10^{-14}\ As(^{137}Cs)\ \ Gy/s$$

Where : $As(^{137}Cs)$ Activity Concentration of ^{137}Cs in sediment (Bq/kg)

Sediment – Sea water interphase

$$D = 4.79 \times 10^{-14}\ [As(A)^{137}Cs + As(B)^{137}Cs]\ Gy/s$$

$As(A)^{137}Cs$ Activity Concentration of ^{137}Cs in seawater (Bq/l)

$As(B)^{137}Cs$ Activity Concentration of ^{137}Cs in sediment (Bq/kg)

Sea water

$$D = 9.58 \times 10^{-14}\ As(^{137}Cs)\ \ Gy/s$$

Where : $As(^{137}Cs)$ Activity Concentration of ^{137}Cs in sea water (Bq/l)

Species-concentration factors-external dose rates

Habitat	**Species**	**Sea Depth (m)**	***Concentration Factor***	***Activity Bq kg^{-1}***	***Concentration (wet mass)***	***External dose rates (μGy d^{-1})***	
				Summer	***Winter***	***Summer***	***Winter***
Demersal (Organisms live on sediment)	*Arnoglossus laterna*	200m -400m	1.08 x 10^2	1.08	0.41	157 10^{-4} – 168 10^{-4}	157 10^{-4} – 168 10^{-4}
Demersal – Pelagic (Organisms live deep in water)	*Pagellus erythrinus*	20m – 420m	2.3 x 10^2	2.30	0.87	79 10^{-4} -85 10^{-4}	79 10^{-4} - 84 10^{-4}
	Mullus barbatus	10m – 420m	0.65 x 10^2	0.65	0.25	79 10^{-4} -85 10^{-4}	79 10^{-4} - 84 10^{-4}
	Boops boops	From coast to 350m depth	5.77 x 10^2	7.27	4.10	1 10^{-4}	0.6 10^{-4}
Pelagic	*Spicara flexuosa*	-130m	0.73 x 10^2	0.92	0.52	1 10^{-4}	0.6 10^{-4}
(Organisms live few meters under the water surface)	*Sardina pilchardus*	-180m	6.54 x 10^2	8.24	4.64	1 10^{-4}	0.6 10^{-4}
	Trachurus trachurus	100m-200m &600m	1.12 x 10^2	1.41	0.79	1 10^{-4}	0.6 10^{-4}

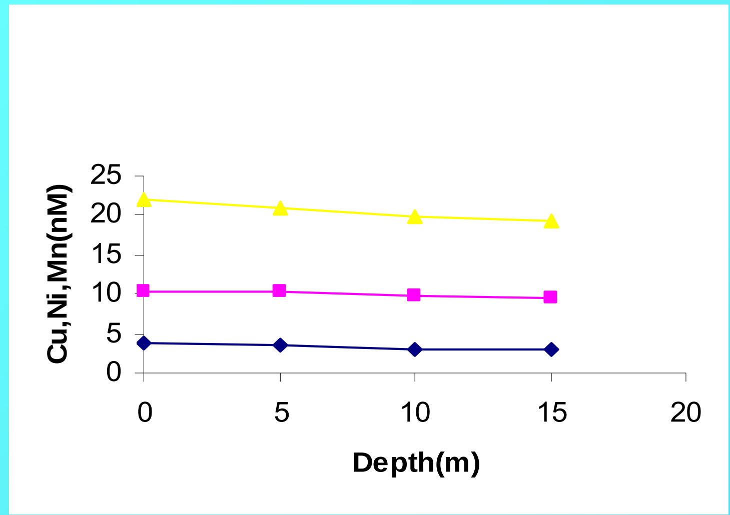
Results and Discussions

- The effects of the dose rates received by marine biota depend on the radiosensitivity of the exposed organism. In terms of the conceptual model of organism response to the environmental pollutants and their possible effects, the estimated dose rates lie to the "uncertainty zone", that means no detected effects. Nevertheless, the above environmental impact analysis assesses only the ionizing radiation, whereas the possible synergetic action of other environmental stressors has not been taken into account.
- For comparison reasons it is mentioned that the corresponding values of dose rates due to natural gamma radiation for the Greek marine environment are in the range of $0.326\ 10^{-4}$ – 0.05 μGy d^{-1} in sea water.

For further discussion in the agenda

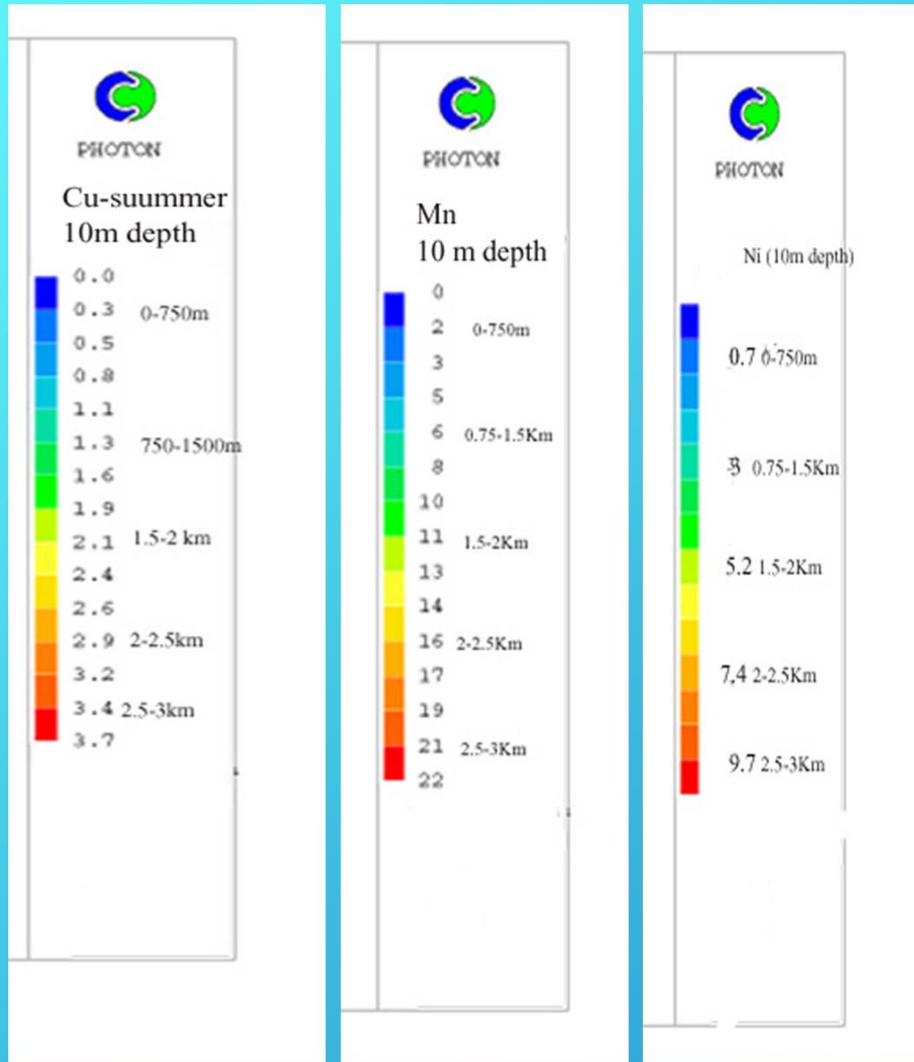
- Sensitive tools for detecting the effects of pollutants to marine organisms
- Methods and techniques for the source apportionment of the final effects to marine organisms

The model vertical profiles of Cu, Ni, Mn



Cu, Ni, Mn (blue, red, yellow line, respectively) concentrations versus depth

Heavy metals Cu, Mn, Ni (surface-depth-distance from the shores- mg/kg)



Oil Spills

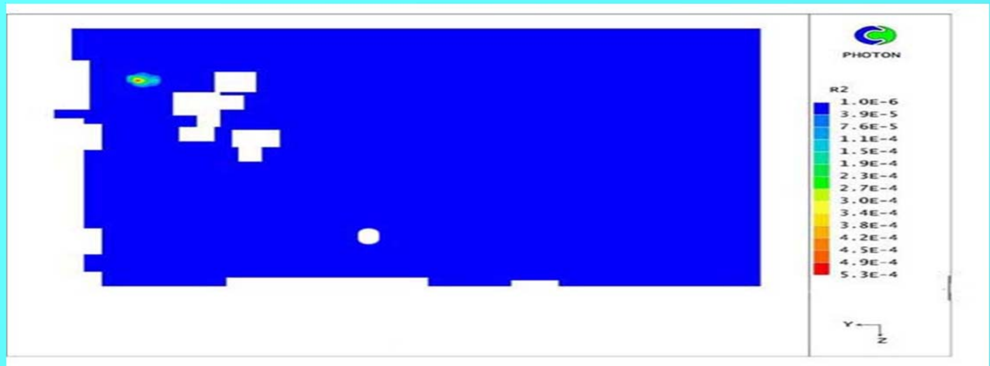
For hypothetical oil spill the model capabilities are demonstrated by applying it at a region in the Northeast Aegean Sea (Carava area at the island of Lesvos).

The model predicts the position of the centre of mass and the shape of the oil spill in time .

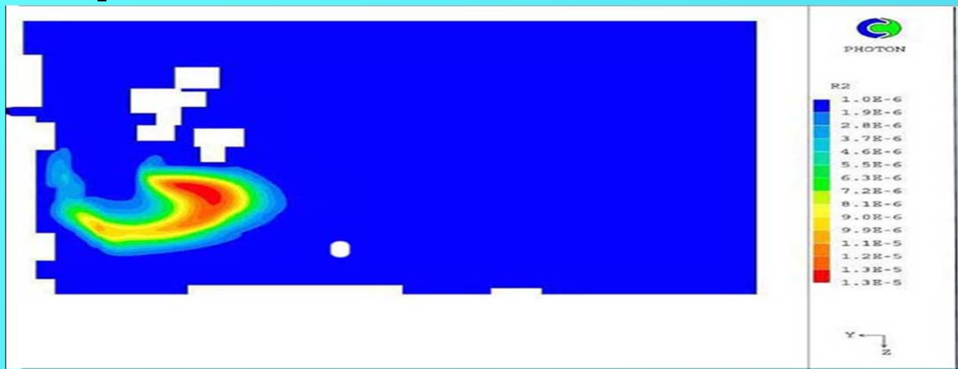
The oil spill is advected by the hydrodynamic field (wind, wave-induced and tidal currents) and is subjected to:

Hydrodynamic dispersion and turbulence diffusion (sea surface and water column); spreading, evaporation, natural dispersion, dissolution, emulsification, photo-oxidation and biodegradation.

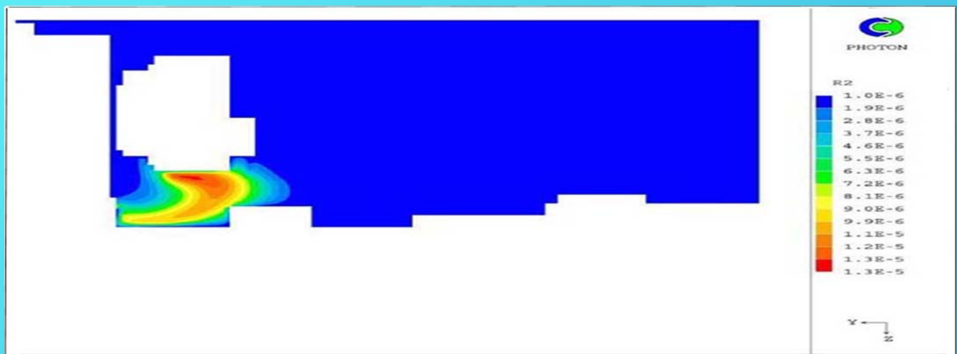
Oil Spills (model results)



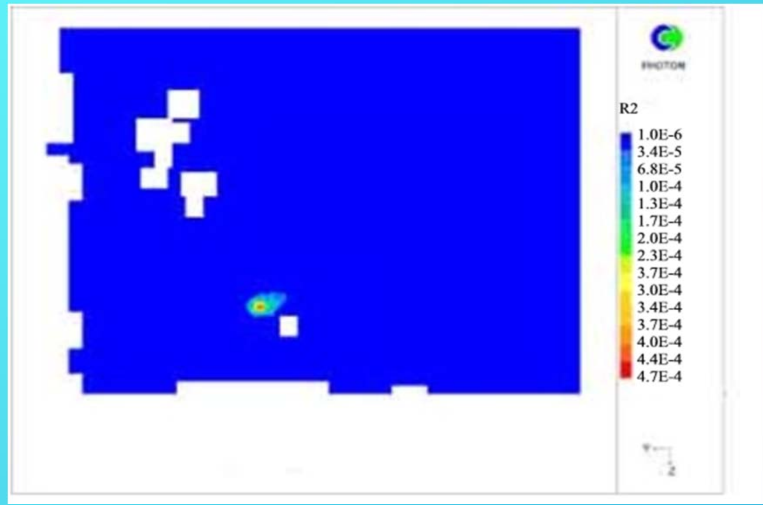
The spill, 10 s after the accident



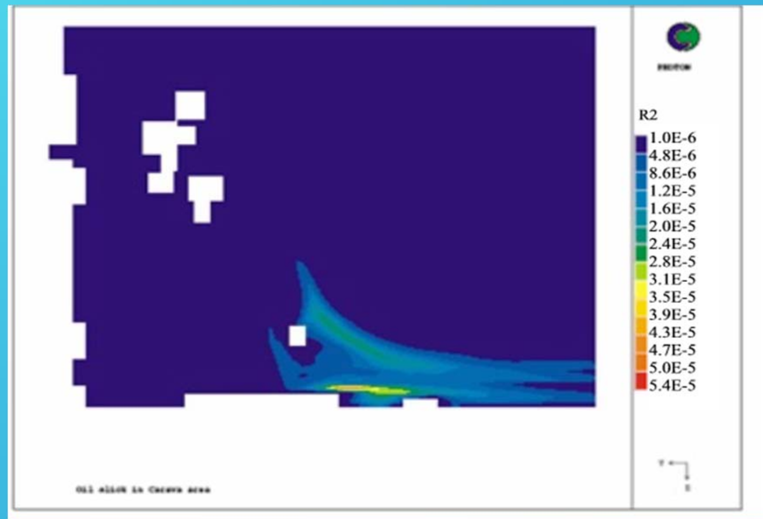
The spill, 6.5 hours after the accident



The spill at a depth of 25m, after 6.5 hrs



The spill at the surface, 10secs



The spill at the surface, after 3.5 hours

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