GERMAN FEDERAL INSTITUTE FOR RISK ASSESSMENT

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Bundesinstitut für Risikobewertung

Multi-compartment modelling – a tool to assess exposure of different organism groups to oil components

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What to do in case of marine oil spills?

Oil spills at sea impair coastal areas, marine ecosystems and human health.

Spill managers have to

- choose effective spill response measures
- minimize the damage to the environment and human health.

➔ Choice to be made

- use of dispersants
- or other response measures

https://response.restoration.noaa.gov/sites/default/files/styles/gallery_active_image/public/images/vicki.loe/skimming.OWJA_.jpg
https://www.micfil.net/hp/portals/0/uploads/pages/micfil-its-time-to-go-green-01.jpg

Situation on the German coast?

German North Sea coast is characterized by the “Wadden Sea”

- large intertidal mud flats
- salt marches
- important area for breeding and migrating birds
- recreational area
- UN World heritage site

https://www.waddensea-worldheritage.org/resources/wadden-sea-world-heritage-map

Spill response in Germany

Central Command for Maritime Emergencies

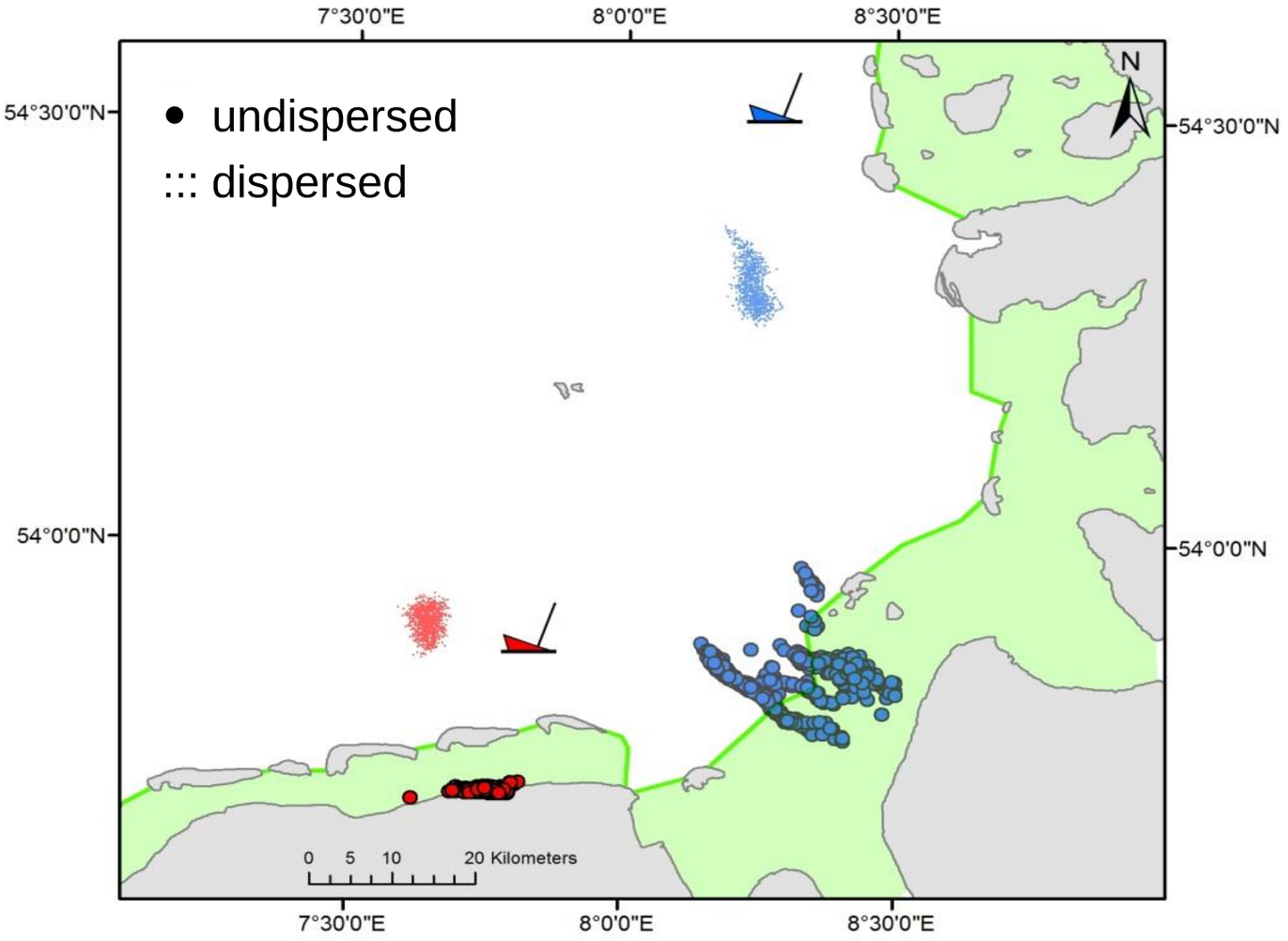
- Analyze situation
- Initiate drift modelling using real time information on wind and currents
- Consult sensitivity maps
- Coordinate Operation and Resources
  (own capacities + Navy, Police, Rescue and tug boats etc.)

Environmental Expert Group to provide input concerning environmental and health aspects for preparedness and planning

→ Priority: Mechanical Recovery

Use of dispersant possible if detrimental effects of the oil can be reduced

Modelling of environmental distribution /drift



Drift of undispersed/dispersed oil after 2 hypothetical accidents

Scenario 1: •:::

Scenario 2: •:::

Often North/Western Winds

➔Wind pushes oil slicks towards the coast.

Dispersion of oil will reduce the wind drift.

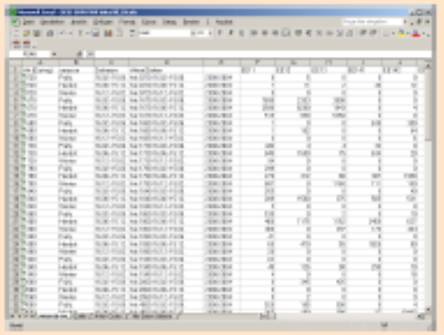
➔ Dispersants can reduce the amount of spilled oil entering the World heritage site and reaching the shore.

Sensitivity maps

monitoring data

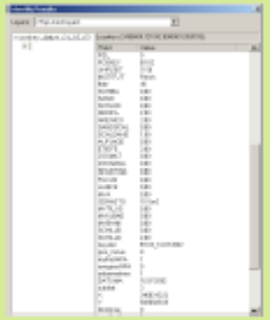
birds : resting, migrating, moulting
(tables and GIS-files)

- species presence
- maximum of pairs



remote sensing-/ field mapping:
(shapefiles)

- musselbanks
- seagras meadows

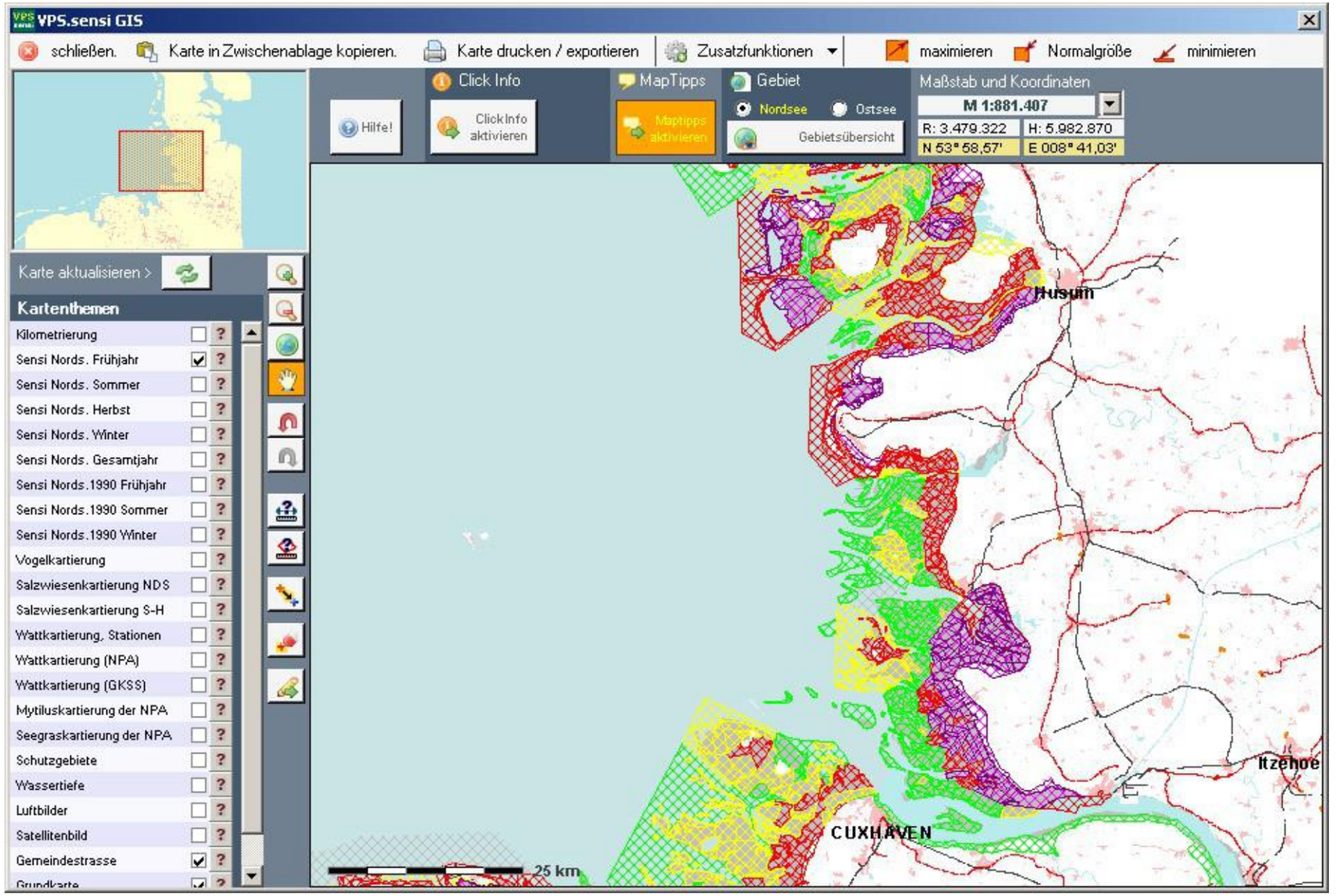


Consistancy

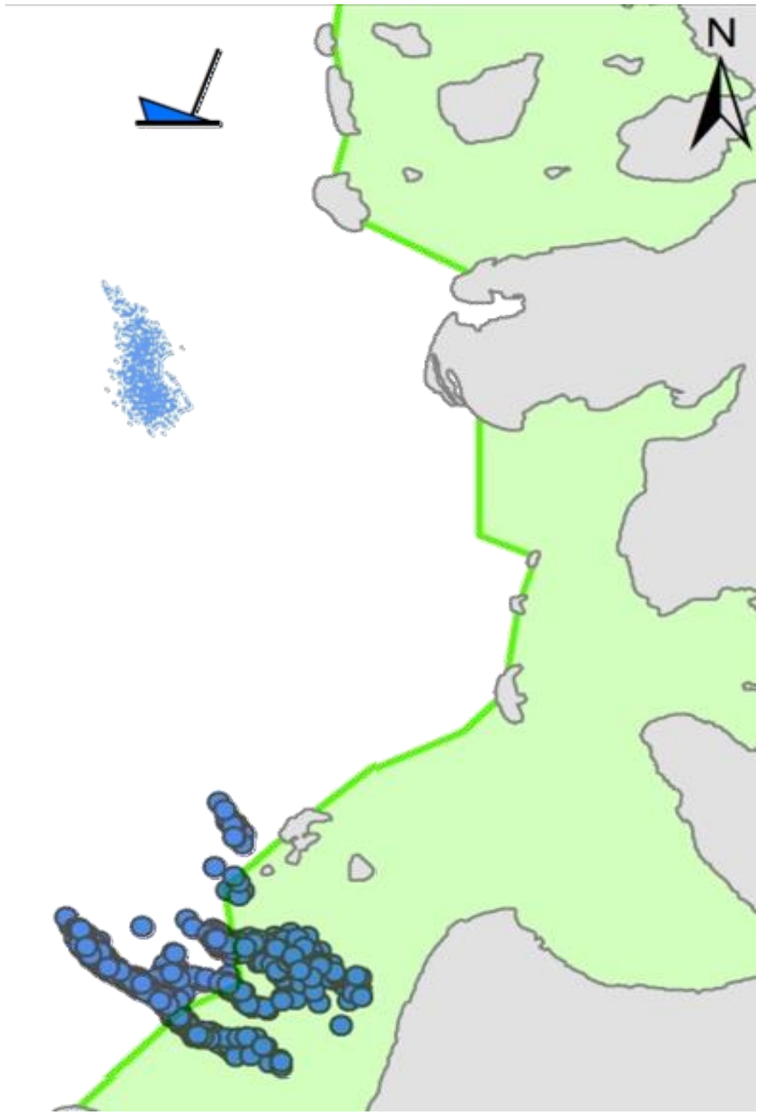
saltmarshes

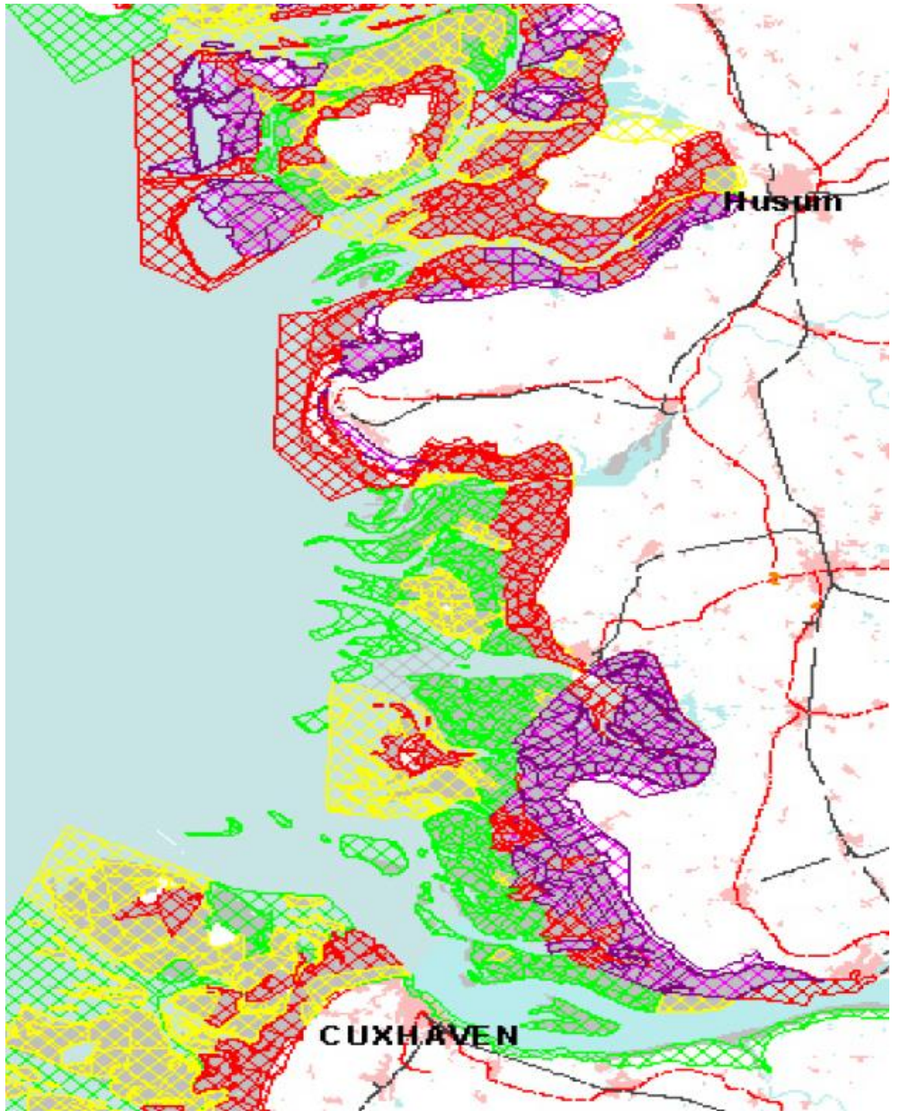
- morphology
- ecol. status

Sensitivity maps for coastal ecosystems (season dependent)



Combining Drift prediction with sensitivity map





Net Environmental Benefit Analysis (NEBA)

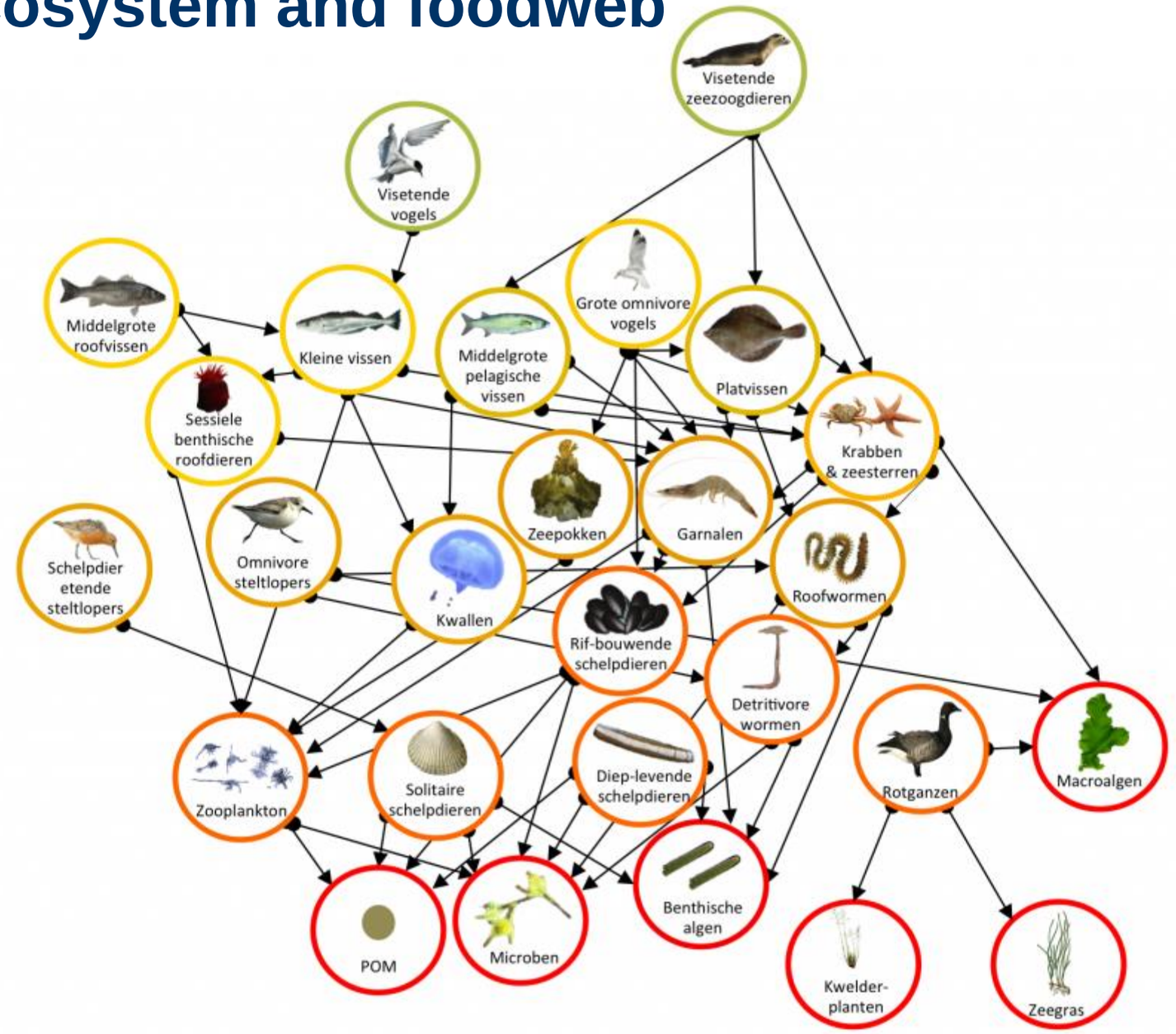
A benefit is assumed if oil is kept outside of the sensitive areas by the use of dispersant.

What can be expected if oil is shifted between different sensitive zones within the zones?

- How does the use of dispersants influence the environmental fate of oil components?
- How is the exposure of different organism groups altered?
- How is the human exposure modified?

➔ Can dispersant use be an option inside the sensitive zones?

Complex ecosystem and foodweb



http://penyu.nl/wp-content//WaddenSeaFoodweb_penyu_nl_.png

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Multiple exposure pathways

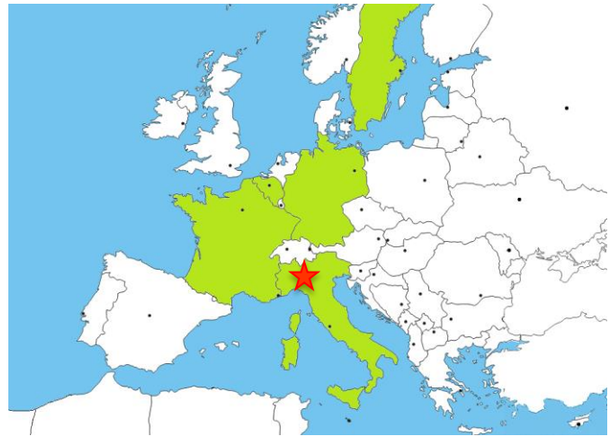
Exposure via

- water phase
- food
- dermal contact
- inhalation

potentially relevant for environmental targets

and humans

EU Project life vermeer



Combining

MERLIN EXPO

Multi-compartment exposure model

- simulation of the fate of chemicals in environmental systems and in the human body

VEGA

QSAR-toolbox

- prediction of properties of chemical substances with in silico methods

life Sphera

→ Single decision-making index for risk assessment (exposure and hazard)

Case study on dispersant use

Modelling of

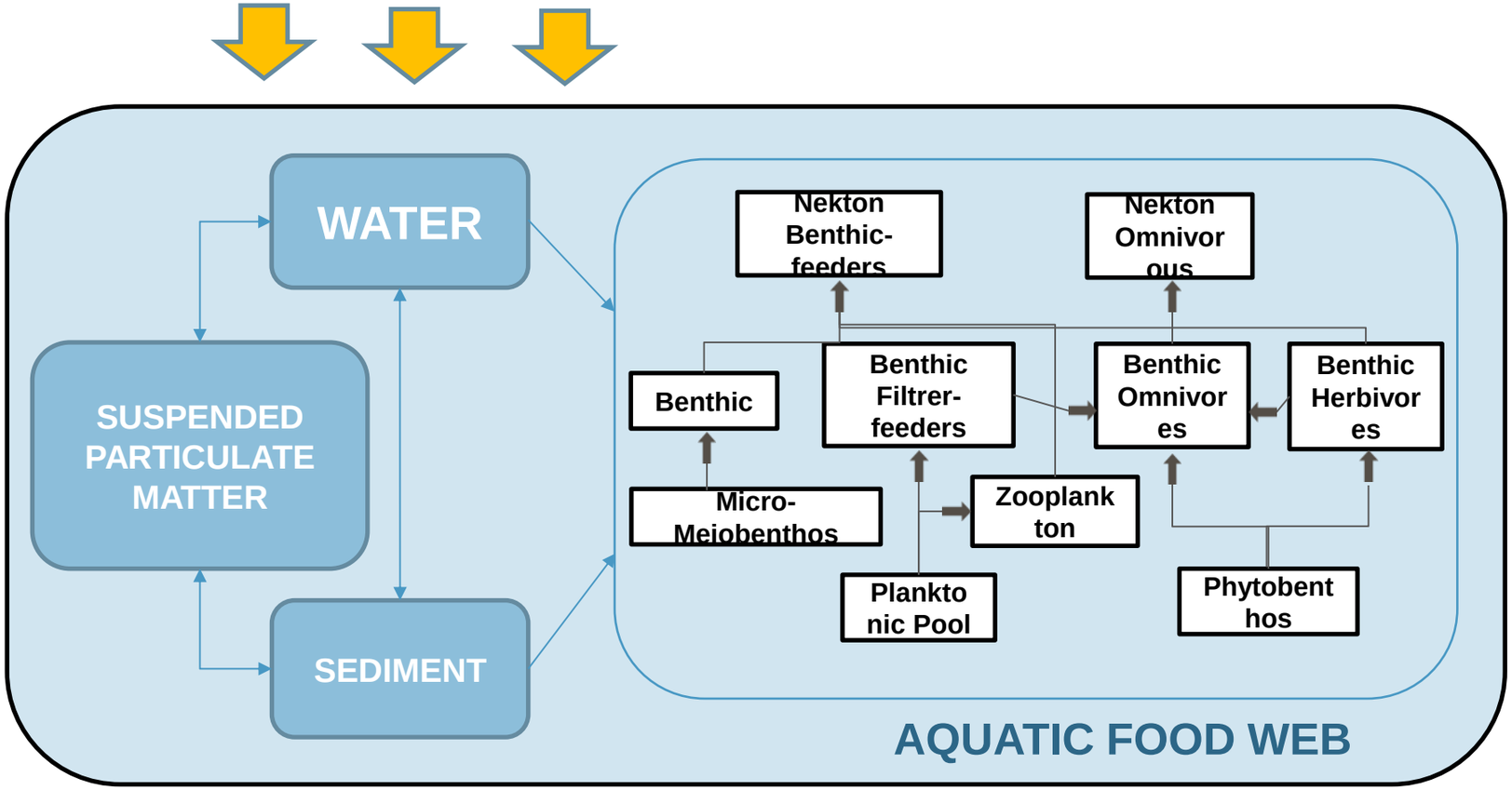
- distribution of oil components between environmental compartments
(water, surface slick, sediment)

- uptake and bioaccumulation of oil components in different organism groups

➔ Comparison of exposure of different receptors with/without dispersant use

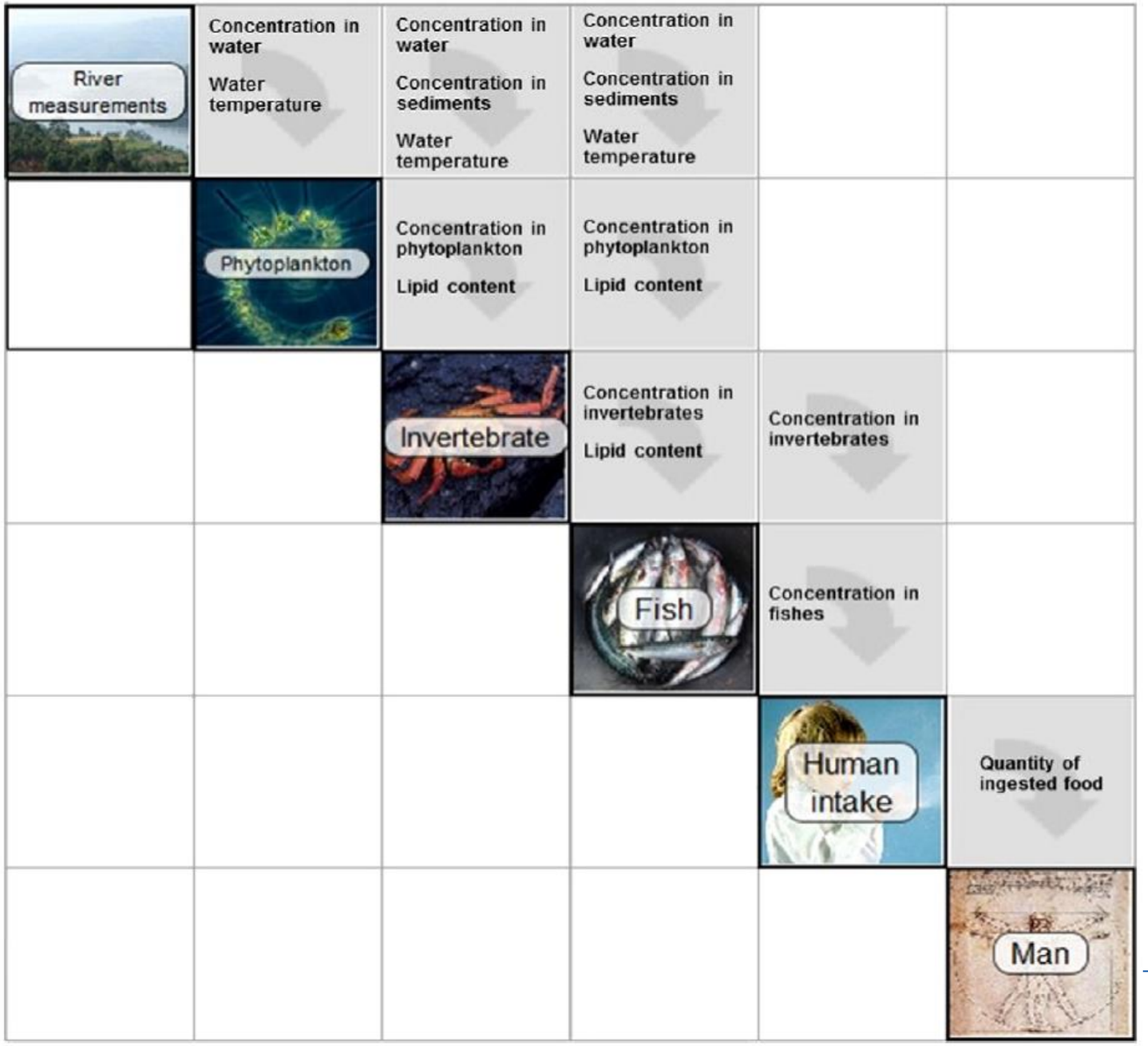
➔ Estimation of relative effect in organism groups

Existing model on the Venice lagoon

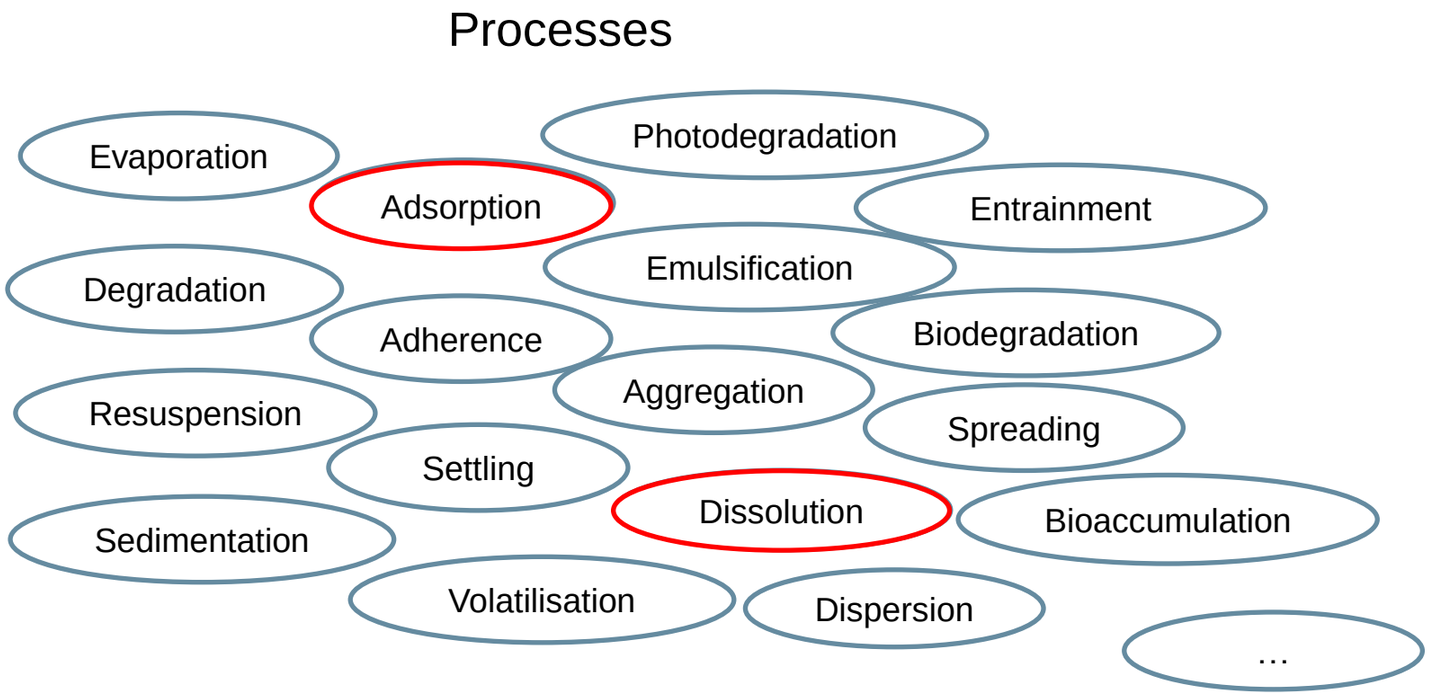


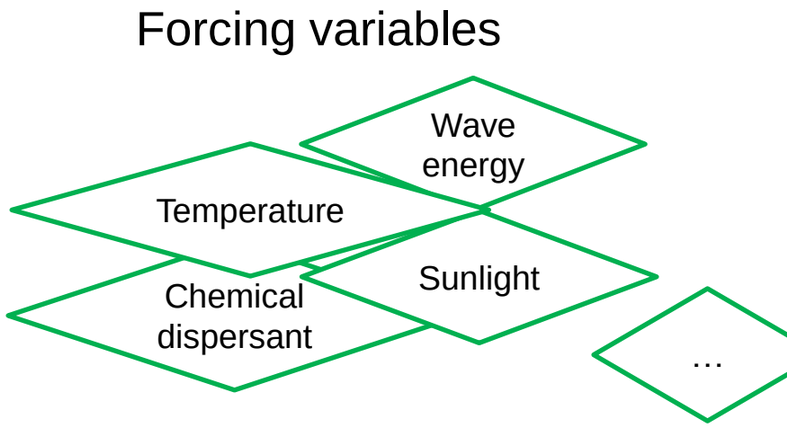
Exposure scenario representation in MERLIN-Expo

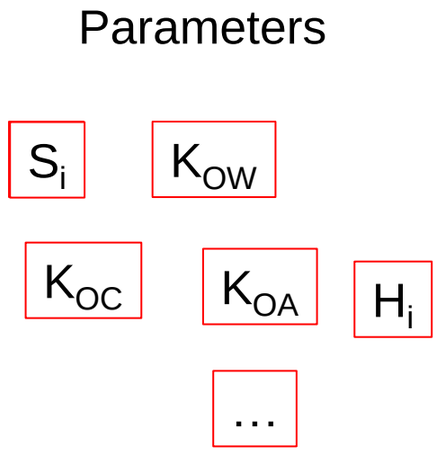
existing model POP bioaccumulation

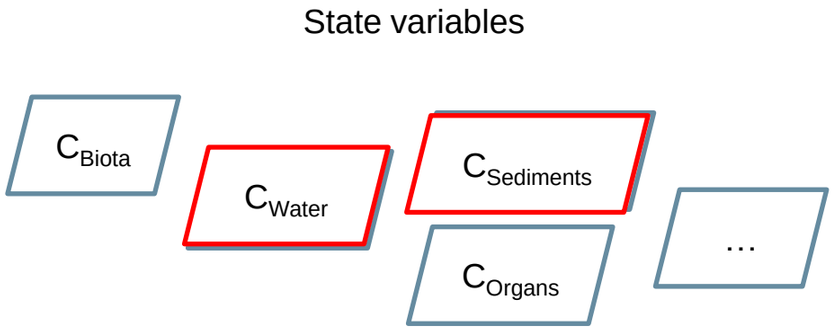


Processes and variables affecting fate of oil in water



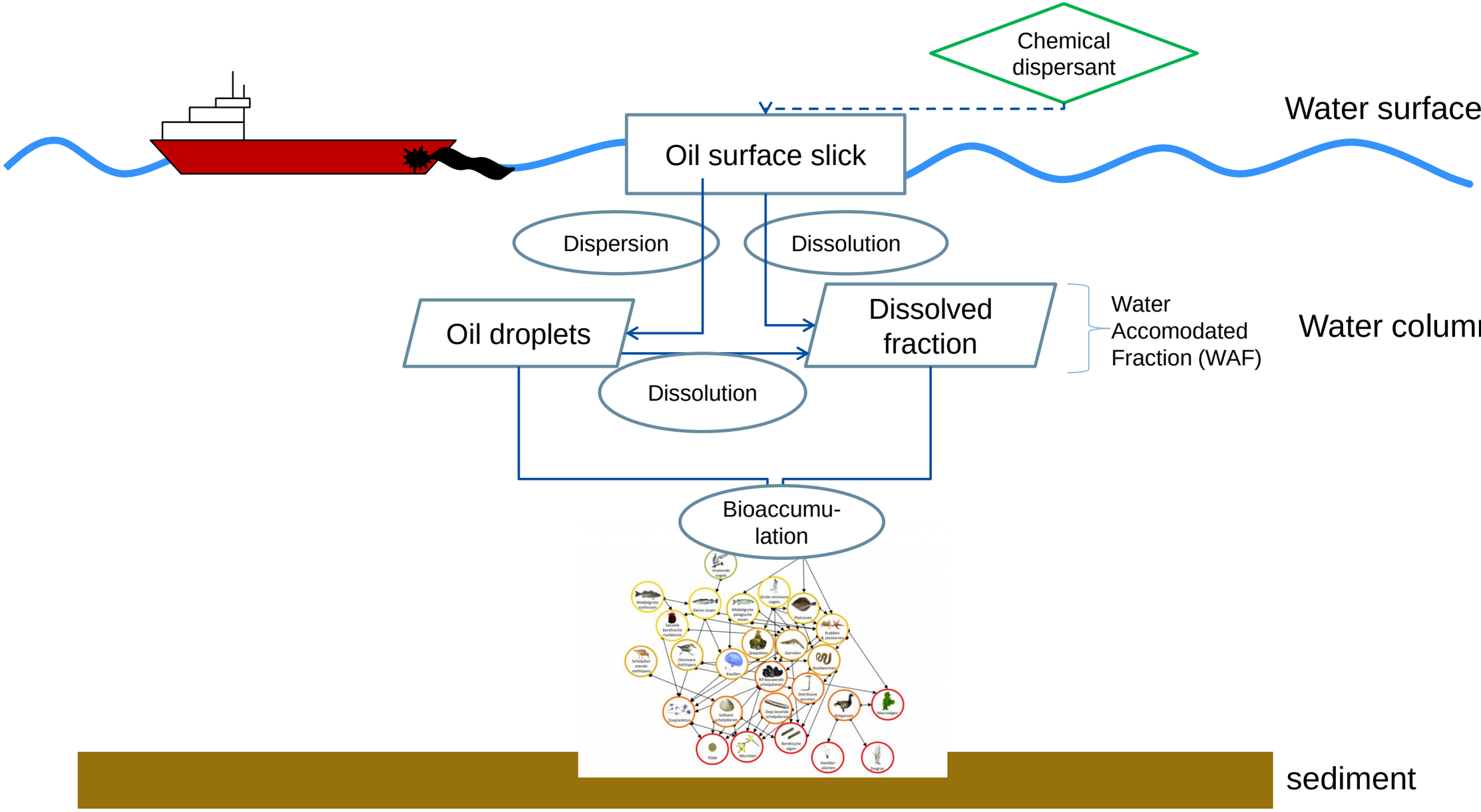




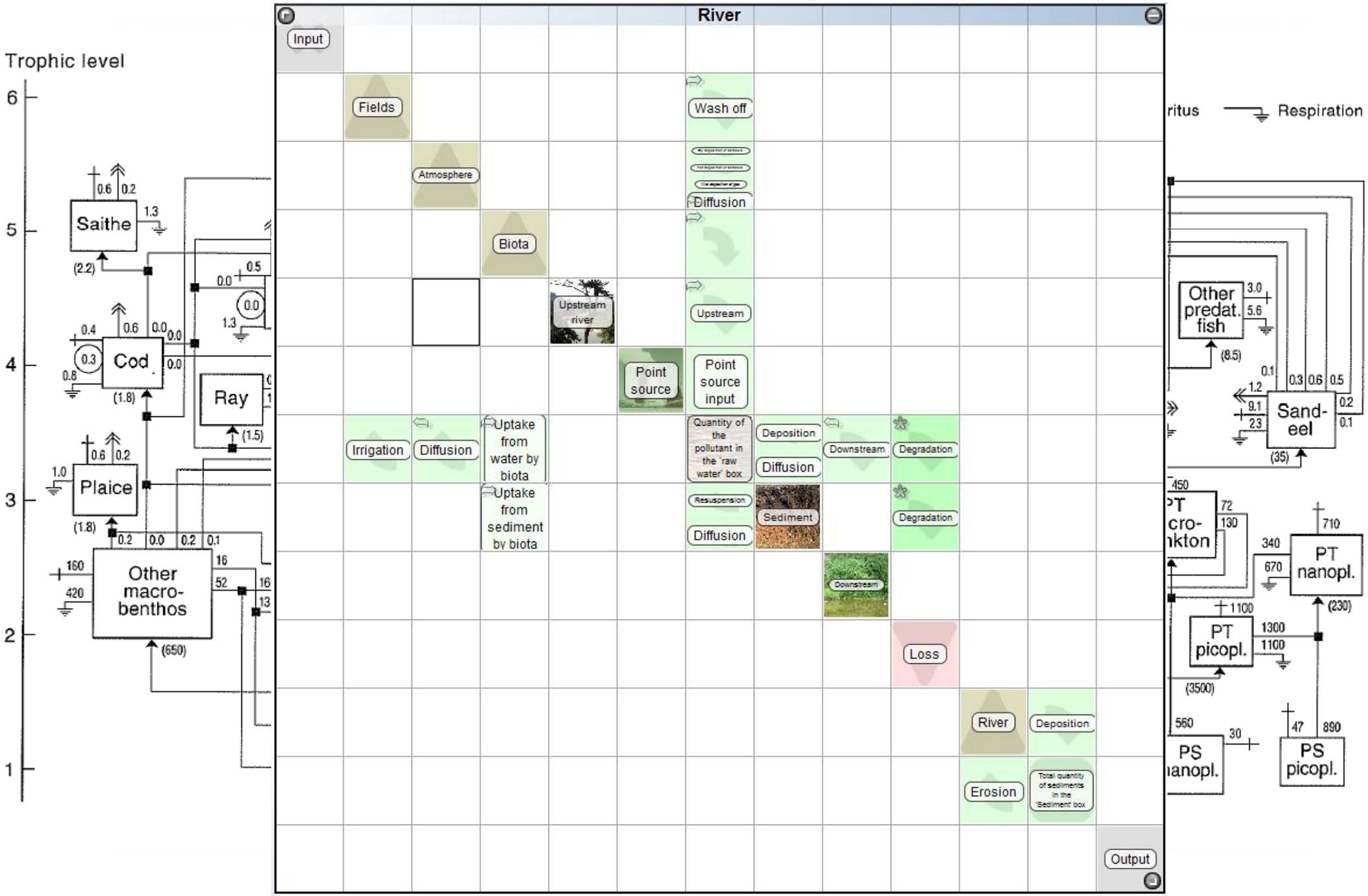


Exposure scenario

General view



Exposure scenario
Food web development



Challanges for the model development

- Introduce additional compartments in model
  - oil surface slick
  - oil droplets
- Simplify food web model to key species
- Define target oil components to be modelled
  - representative compounds for different component groups
  - relevance for toxicity
- Estimate/collect physico-chemical date of modelled compounds
- Select scenarios (specific location of statistical approach, oil types etc.)

➔ Provide advise for the spill response prepardness

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The presented work on the dispersant case study was funded by:

LIFE16 ENV/IT/000167

life vermeer

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What are dispersants? How do they act?

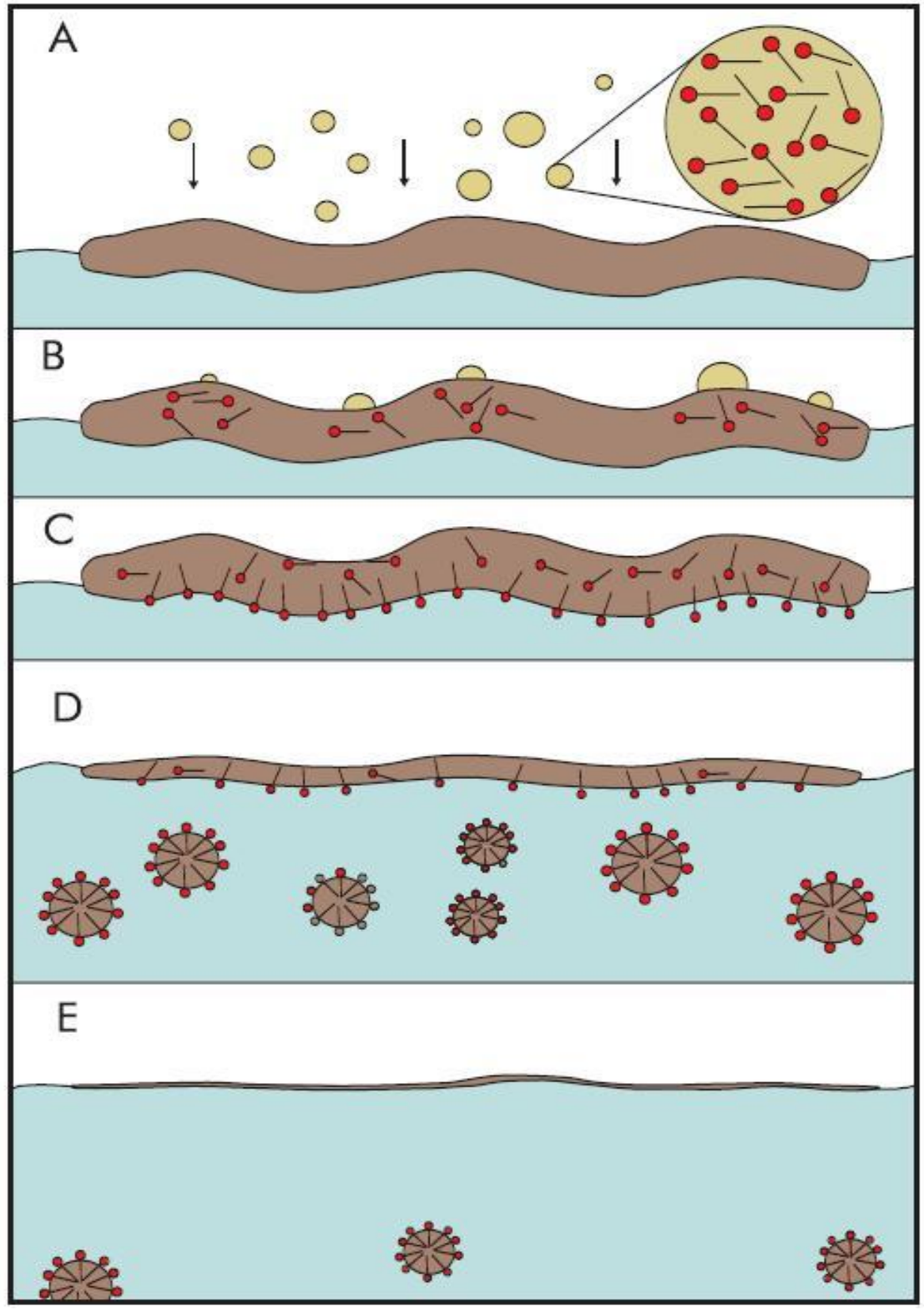
- surfactants in one or more solvents
- reduce the interfacial tension between the oil and the water phase
- enhance break-up of larger oil volumes into little droplets

Pro:

+ reduce surface slick / wind drift of oil / reduce oil reaching shoreline
+ protect sea birds
+ enhance biodegradation

Con:

- higher bioavailability of oil components to pelagic and benthic organisms
- incorporation of oil into sediments



Complex ecosystem and foodweb

Surface water model

Definition of relevant compartments and processes

Inputs/outputs from/to
- ✓*atmosphere*
- ✓*terrestrial system*
- ✓*aquatic biota*

Within system exchanges by
- ✓*Sorption/desorption*
- ✓*Deposition/resuspension*
- ✓*Diffusion*