Theme 4: Pollution, prevention, detection and mitigation

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http://modb.oce.ulg.ac.be/GHER/welcome.html

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[a]with contributions from Ch. Lancelot, A. Wilmotte, E. Toorman, RACE project, M. Grégoire, E. Delhez, MUMM WWW pages

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- ***Introduction***
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Focus

- Vast topic
  - ⋆ Accidental pollution
  - ⋆ Dumping
  - ⋆ Eutrophication
  - ⋆ Invasions of alien species
  - ⋆ Toxic and harmful algae
  - ⋆ Chemical and bacterial contaminents
  - ⋆ Nuclear pollution
- Little personnal experience on North-Sea pollution
- Input from some Belgian scientists (7), but not all of them (remember Alberto's numbers)

Probably a biased and very fragmented view...

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MARPOL

MARine POLlution: extension of OILPOL. International convention 1973/78 within IMO concerning ship related pollution

- Annex I: Prevention of pollution by oil
- Annex II: Control of pollution by noxious liquid substances
- Annex III: Prevention of pollution by harmful substances in packaged form
- Annex IV: Prevention of pollution by sewage from ships
- Annex V: Prevention of pollution by garbage from ships
- Annex VI: Prevention of Air Pollution from Ships
- Enforcement

Recent actions: double hulls

WFD

The Water Framework Directive (EU, 2000): aim is that (allmost all) surface water bodies shall have (at least) "good ecological status", defined as only a small deviation form natural conditions, as indicated by a set of quantifiers that include phytoplankton abundance.

OSPAR www.ospar.org

OSPAR 1992 convention, guiding international cooperation on the protection of the marine environment of the North-East Atlantic. Follow-up and combination of

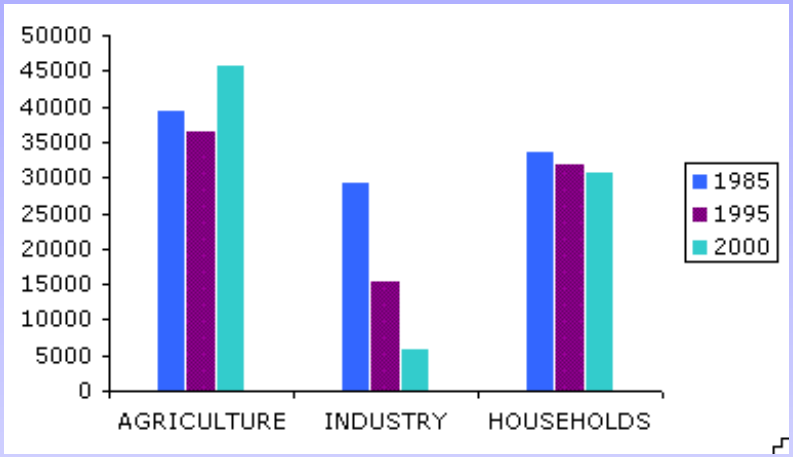
- 1972 OSLO convention on dumping waste at sea
- 1974 Paris Convention on land-based sources of marine pollution

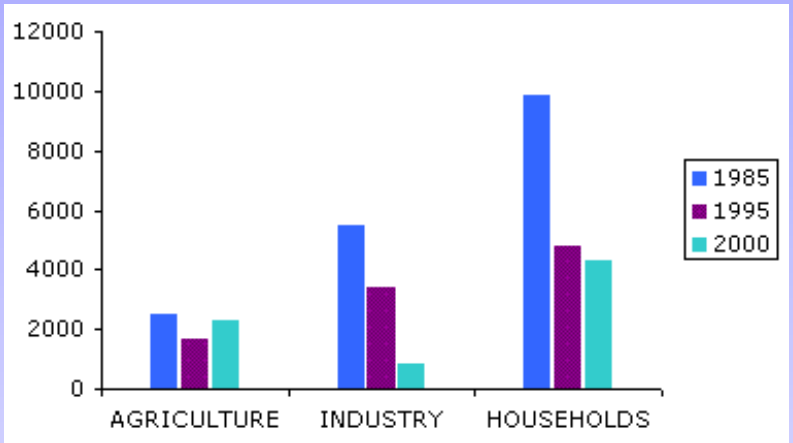
The work applies the ecosystem approach to the management of human activities. It is organised under six strategies:

- Protection and Conservation of Marine Biodiversity and Ecosystems
- Eutrophication
- Hazardous Substances
- Offshore Oil and Gas Industry
- Radioactive Substances
- Monitoring and Assessment

OSPAR

As part of OSPAR, commitments have been made to reduce the input of nutrients in the sea by 50% as of the reference year of 1985.





Evolution of the Nitrogen and Phosphor input (in tons) during the 1985-2000 period

Note the decrease in industrial and domestic discharge compared to agriculture. No comment.

MUMM WWW pages

Other

Other international conventions: LC (dumping), ASCOBANS (cetaceans), SCHELDT/MEUSE (coordination obligations of WFD), NSC (North Sea Conference), UNICP (United nations)
National level

- The "EEZ" act relating to Belgian's exclusive economic zone in the North Sea
- The "MMM" act on the protection of the marine environment in sea areas under Belgian jurisdiction.
- Regulations on ballast waters and invading species

MUMM WWW pages

ECO-QO, according to OSPAR

- Ecological Quality (EcoQ): Ecological quality of the surface water is an overall expression of the structure and function of the aquatic systems, taking into account the biological community and natural physiographic, geographic and climate factors as well as physical an chemical conditions including those resulting from human activities
- Ecological Quality Objective (EcoQO): desired level of EcoQ relative to the reference level
- EcoQO reference level has been defined as the level of EcoQ where the anthropogenic influence on the ecological system is minimal

Typically, OSPAR's criteria for recognizing eutrophication include levels of winter nutrient and mean and maximum chlorophyll concentration. EcoQO are taken 50% or more from natural, baseline or reference.

Criteria to be an EcoQO indicator

- Easily understood by non-scientists and those who make decision based on indicators
- Sensitive to human activity that can be managed
- Response in time close to this activity
- Easy to measure, with low relative error
- Mostly sensitive to human activity and low sensitivity to other causes of changes
- Easily measurable on a large zone on which the EcoQO is applied
- Based on a data-set allowing to determine realistic objectifs

The, EcoQO need also monitoring protocols and notification rules.

Examples of EcoQO

1.1 Biomass of commercial fish

2.1a Tendancy of porpoises

2.2 Accidental captures of porpoise

9.1.1 Winter content in nutrients

9.1.2 Chlorophylle a

9.1.3 Phytoplankton species indicating eutrophication

9.1.4 Oxygen

9.1.5 Zooplankton mortality due to eutrophication

- etc

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Prevention

Essentially via

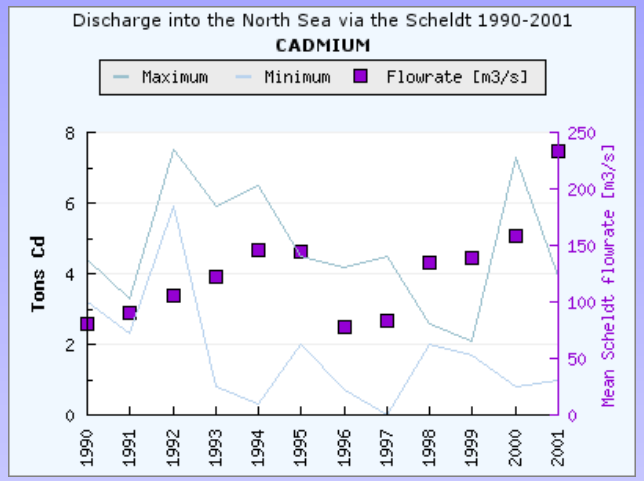
- risk assessment (see presentation of A. Volckaert)
- control

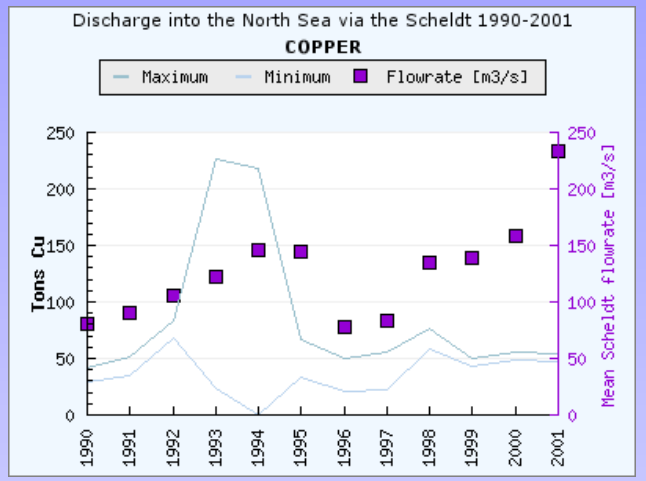
Detection

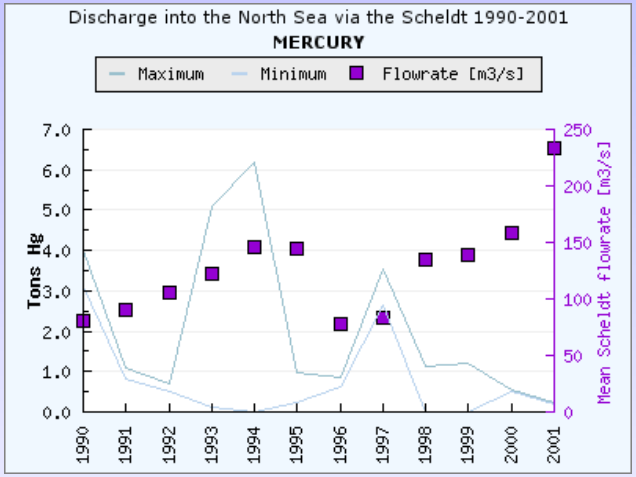
VLIZ In August 2002 the VLIZ started monitoring 10 stations on the Belgian Continental Shelf. The ”Zeeleeuw” is used every month to take water samples and CTD casts. The samples measure the turbidity, nutrient content and chlorophyll a concentrations. These parameters are eventually determined in collaboration with research groups that perform analyses. In this manner, the VLIZ hopes to provide coastal research with the necessary information and data. In the long term a time series of data will be collected that should contribute to an improved management of the Belgian coastal waters.

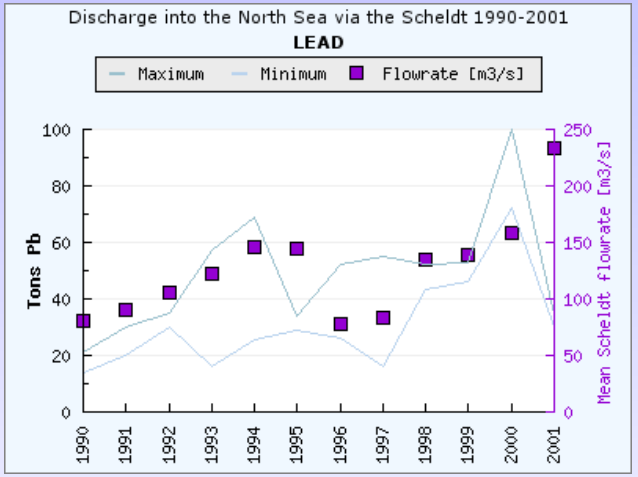
MUMM Numerous measurements are taken at sea from the oceanographic vessel Belgica and numerous observations of the sea are made using airborne instruments or equipment carried on satellites.
MUMM is part of the Coast Guard strucure laid out by the cooperation agreement of July 8, 2005 which goal is to coordinate operational aspects of actions taken by the Belgian State with respect to the sea.

Discharges









MUMM WWW pages

Mitigation and enforcements

La structure Garde Côtière coordonne le contrôle de l'application et le respect des réglementations en vigueur. Elle intervient en tant que structure uniforme intégrée. Elle garantit la coordination des actions des autorités dans les ports et les zones marines et côtières qui relèvent de la compétence des autorités fédérales et régionales. Les principes de base de la Garde Côtière sont :

- égalité entre les diverses parties
- respect des compétences légales
- utilisation optimale de l'infrastructure et des moyens afin d'éviter des frais d'investissement doubles

Activité autorités en mer

- Protection et gestion de l'environnement marin
  - ⋆ contrôle des ressources vivantes et de la pêche
  - ⋆ contrôle des ressources non vivantes
  - ⋆ contrôle des îles artificielles, d'installations et d'ouvrages
  - ⋆ contrôle des zones marines protégées
  - ⋆ contrôle des déversements en mer
  - ⋆ contrôle des activités autorisées et mandatées
  - ⋆ contrôle de la pollution de l'eau
  - ⋆ intervention lors de pollution marine et développement de plans opérationnels
- Missions scientifiques
  - ⋆ remote sensing et observation du ciel
  - ⋆ assistance lors du monitoring de l'état et de la qualité du milieu marin
  - ⋆ réaliser des analyses des risques
  - ⋆ évaluation des effets sur l'environnement des événements marins
  - ⋆ monitoring permanent des effets sur l'environnement des activités rendues obligatoires par les permis
  - ⋆ monitoring des mammifères marins

Scientific managment by MUMM

- engager l'avion d'observation pour estimer l'ampleur et la gravité des conséquences d'une catastrophe pour le milieu marin
- mettre l'avion d'observation à disposition du on-scene commander pour l'accompagnement des navires anti-pollution
- engager le navire océanographique BELGICA et/ou le bateau de surveillance TUIMELAAR pour des prélèvements et le monitoring des effets d'une catastrophe sur l'environnement
- Prédiction du comportement des pollutions et évaluation de leurs incidences environnementales en mer du Nord et sur la côte belge
- fournir un avis quant aux techniques et mesures les plus appropriées pour combattre la pollution et limiter l'impact d'une catastrophe sur le milieu marin
- donner l'autorisation de l'utilisation de produits dispersants
- contrôle de l'extraction de sable et gravier, du déversement de boues de dragage et d'autres activités économiques en mer nécessitant une autorisation
- traitement des demandes d'autorisation et de permis et avis au ministre compétent
- intervention auprès des cétacés et autres mammifères marins en danger ou échoués dans les eaux côtières

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Prevention

- Scenario calculation for future changes (see mitigation)
- Development of models
- Upstream assessment and actions (e.g. collaborations with river-model developpers)

Detection

- Improved analytical methods (see also Monitoring presentation by A. Borges)
- Remote sensing developments (e.G. Belcolour, Recolour projects)
- Definition of new indicators (see also ICZM)

Cyanobacteries as indicators

Determination of the molecular diversity and community structure of cyanobacteria

- Primary producers of importance in the aquatic food chains
- Indicators of environmental changes, human impacts, pollutions
- Brackish and freshwater species producing cyanotoxins
- Cyanobacterial mats on the shores influence bacterial biodegradation of oil spills (ex. Saudi Arabia)

Riverine origin of picocyanobacteria in coastal waters of the Arctic Sea (Waleron et al., 2007, FEMS 59: 356-365)

A. Wilmotte, Centre of Protein Engineering-Cyanobacteria, University of Liège, Chemistry B6, 4000 Liège

Mitigation

Input for presentation only on Modelling.

Sediments as pollution carrier/reservoir

Cohesive sediments

- Clay capturing heavy metals and other pollutants.
- Area of river mouths with harbours and industrial activities are

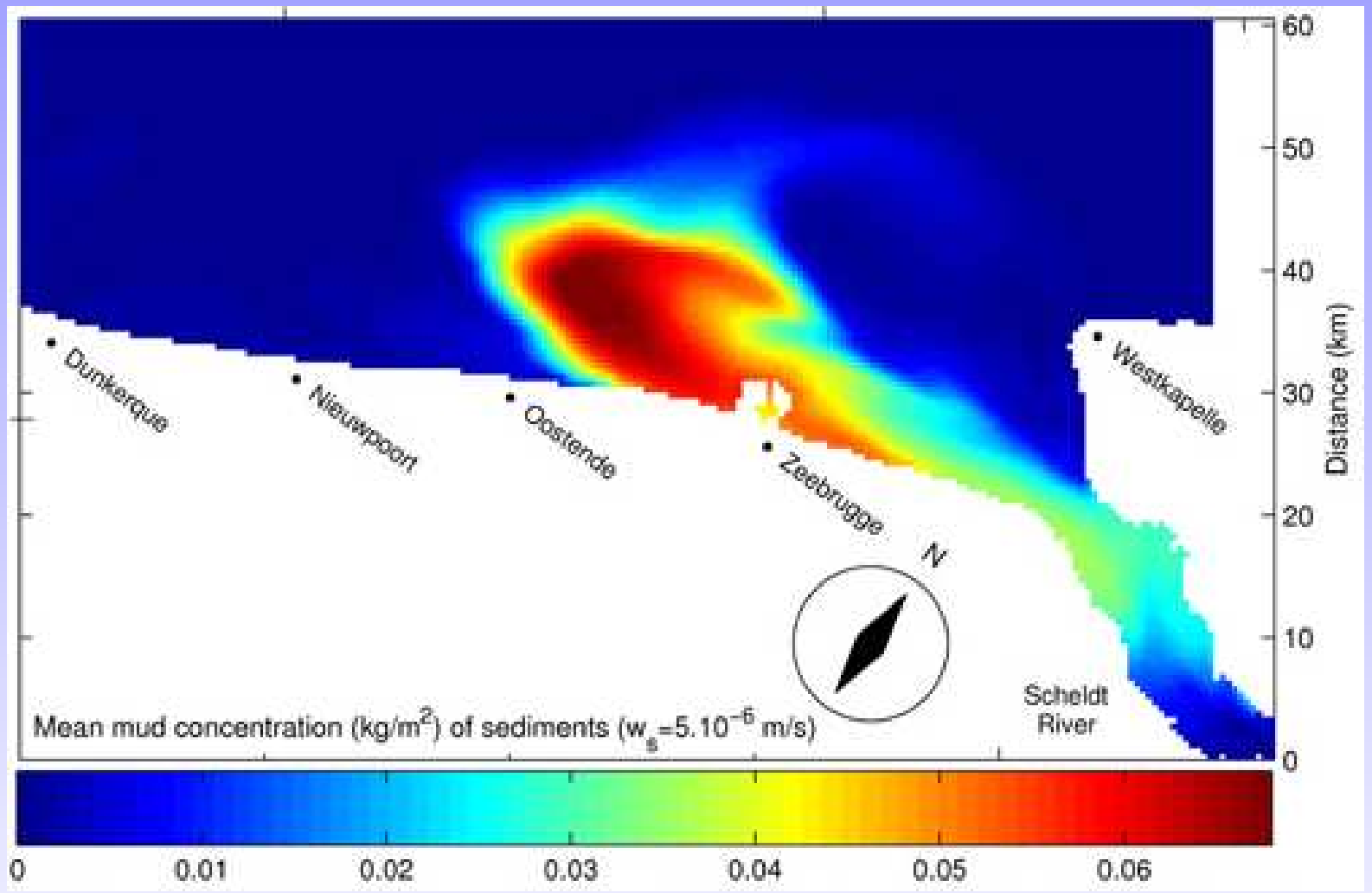
Prediction of the transport of cohesive sediments is thus very important for the dispersion of the attached pollutants.
Studies of K.U.Leuven Hydraulics Laboratory (process models and implementation in large-scale models)

- sediment-turbulence interaction
- flocculation, sedimentation and consolidation
- liquefaction and fluidisation
- fluid mud flow and mud rheology
- erosion and biomediation
- mud-wave-current interaction

E. Toorman: Cohesive Sediment Mechanics Research @ the Hydraulics Laboratory KUL

http://www.kuleuven.be/hydr/CohesiveSed.htm

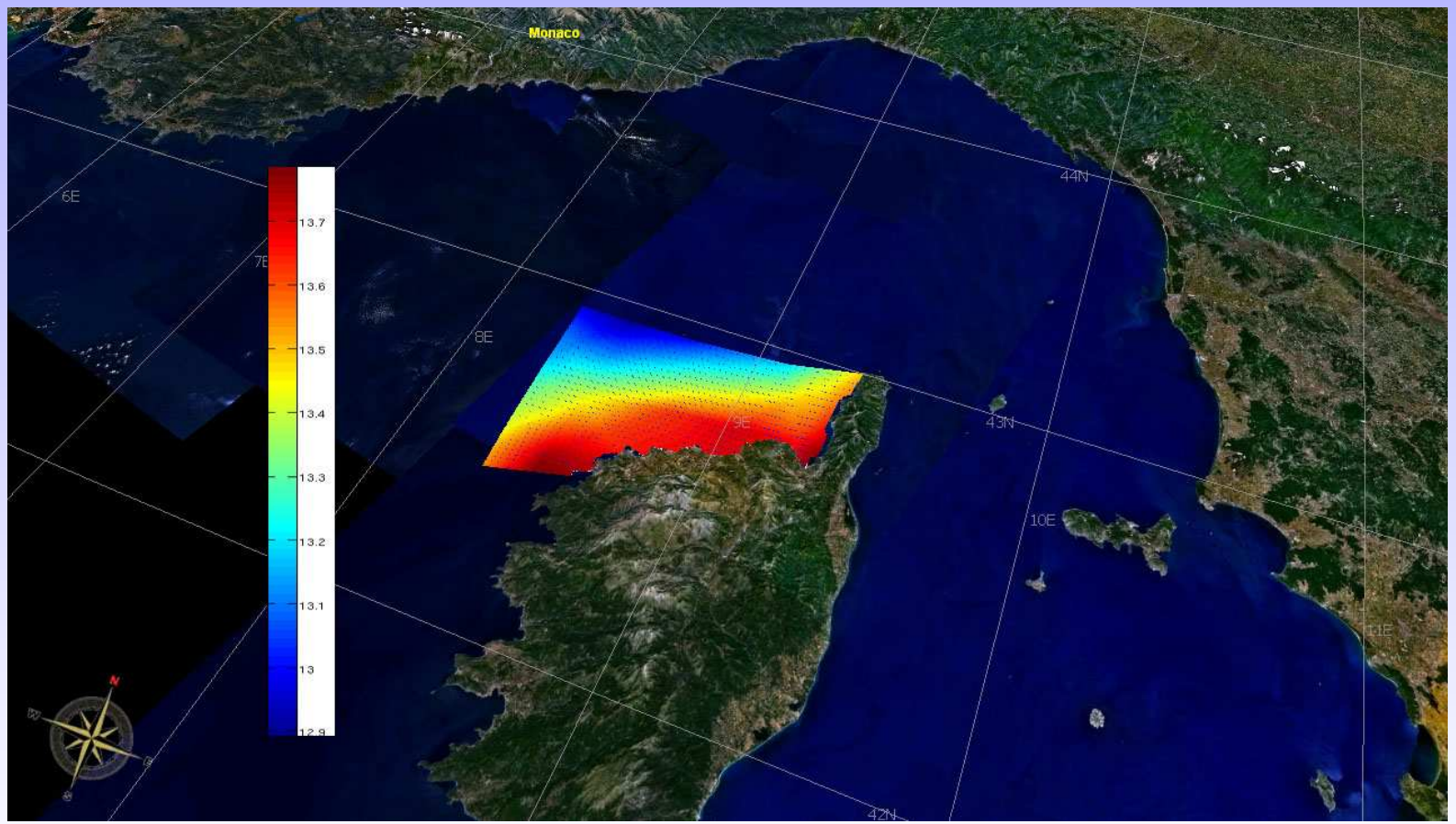
Transport of sediments & contaminants in the BCZ



⇒ PAI : Tracing and Integrated Modeling of Natural and Anthropogenic Effects on Hydrosystems, ULB-VUB-ULg-UCL-MRAC-UPMC(Paris 6)

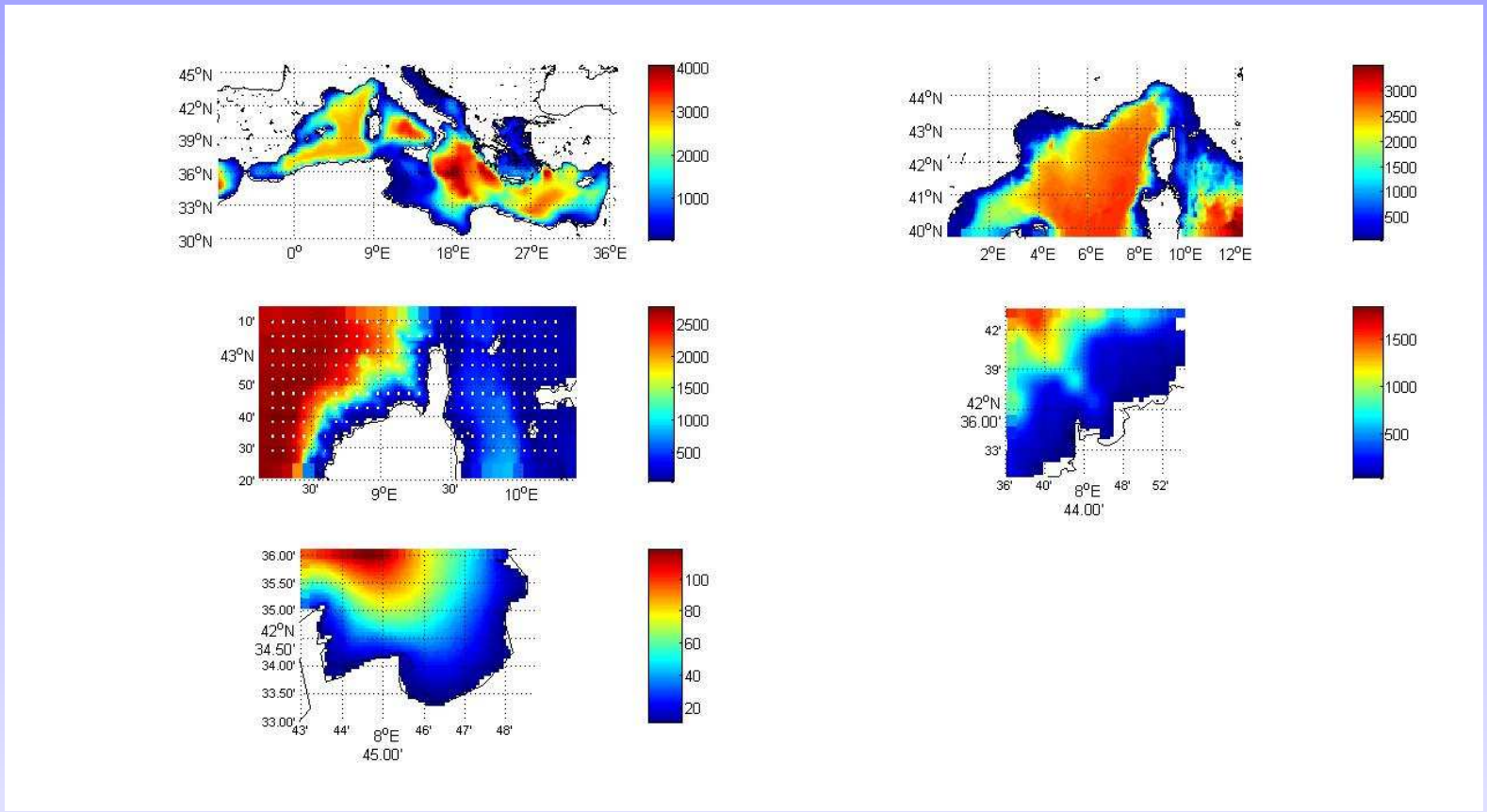
Coupled 3D physical biochemical models

RACE project: The detection and prediction of changes in coastal ecosystems integrating data collection, the development of statistical tools and 3D interdisciplinary models used conjointly with specific diagnostic tools tailored to management purposes



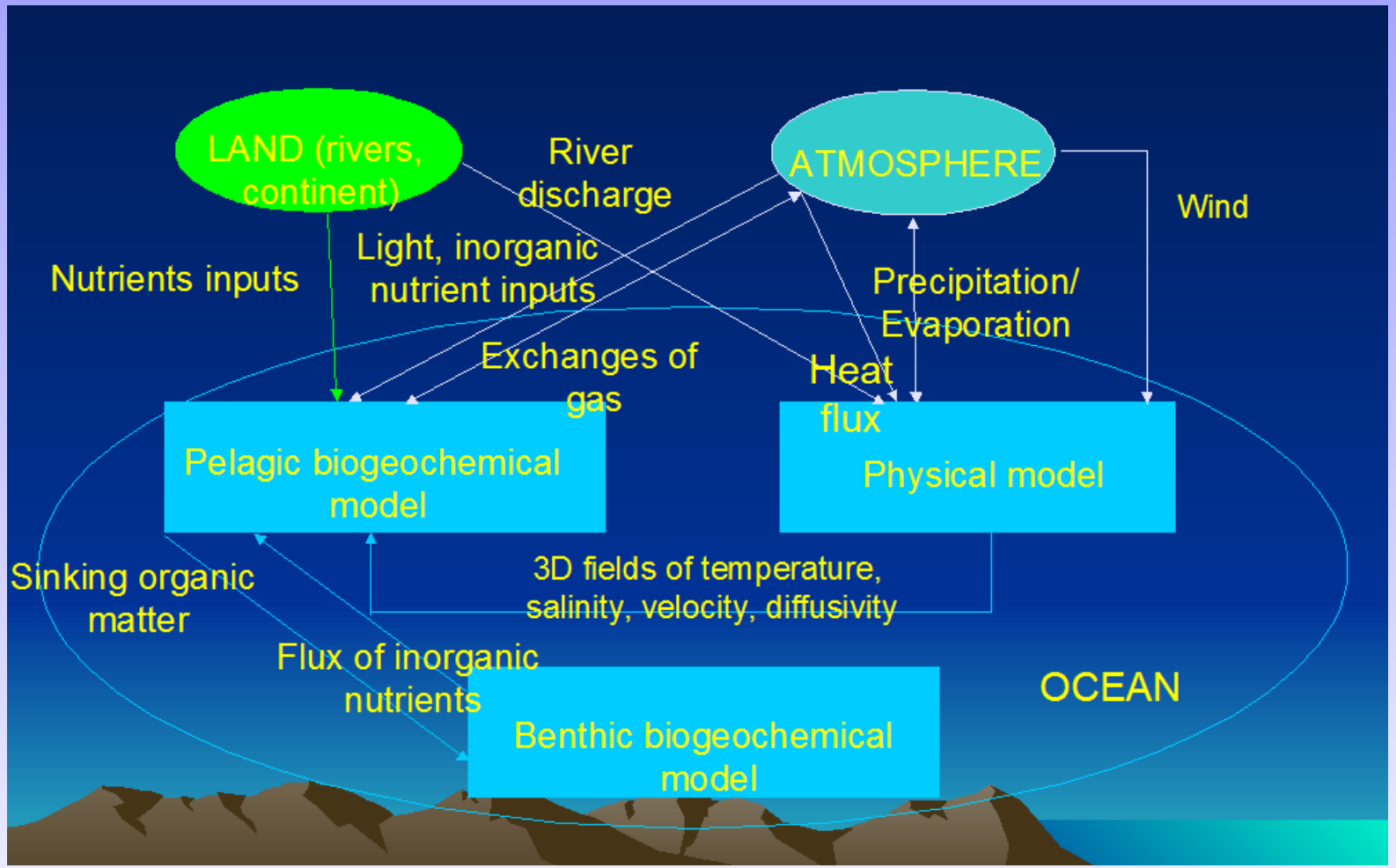
Grégoire, Delhez, Beckers: MARE

Nesting



MARE-ULg

The elaboration of ecosystem models specific for regions with anthropogenic sources of nutrients



MARE-ULg

MARE developments

- Development of complex multivariate statistical tools to analyse model outputs and long time series of data
- the development and validation of scientifically based diagnostic tools (indices at experimental level and model information on residence times, turnover rates etc) tailored to management purposes. These purposes of these diagnostic will be to extract pertinent and easily understandable indicators from the huge amount of information obtained from numerical models and data bases.
- the quantitative assessment of the variability of the ecosystem and its sensitivity to meteorological and anthropogenic influences

Sites under study :

- The Mediterranean Sea, and in particular, the Ligurian Sea and the Bay of Calvi
- The Black Sea
- The North Sea (and adjacent coastal regions)

These 3 sites were chosen for 2 reasons:

- Contrasting physical and ecological characteristics : oligotrophic vs eutrophicated / open vs semi-enclosed
- Availability of large data bases to validate the mathematical tools; the methodology can be applied to other coastal regions

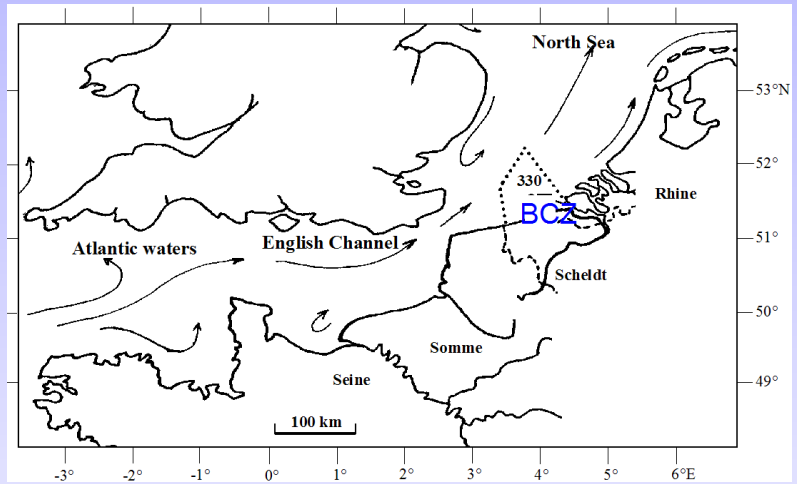
The development of data assimilation tools to improve the performances of hydrodynamical and ecosystem models (Kalman Filter)

MARE-ULg

Mitigation of eutrophication in the Belgian Coastal Zone (BCZ): the river-sea continuum

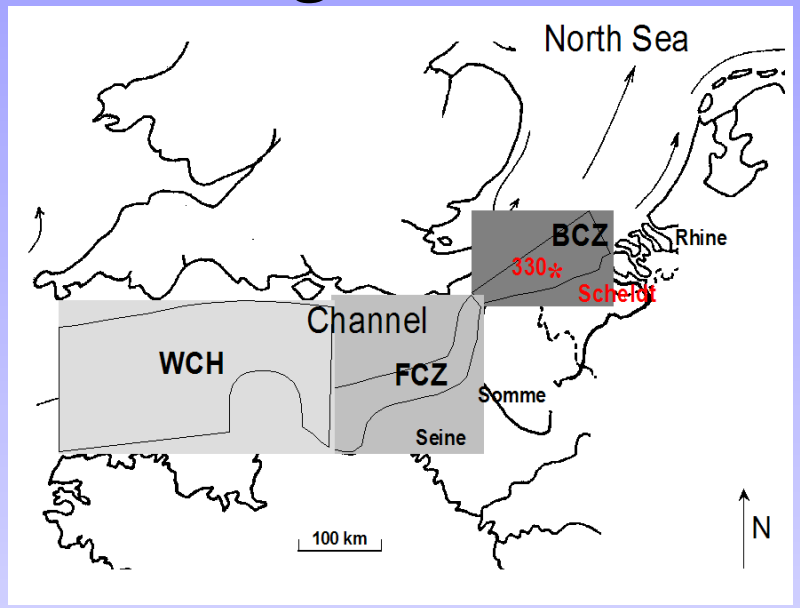
BCZ ecosystem:

- Direct and transboundary NP inputs
- Dominance and accumulation in spring of unpalatable Phaeocystis colonies
- ECO-QO based on on maximum grazable colony size (diameter: 400 μm) and field records: 150 mgC m^{-3}

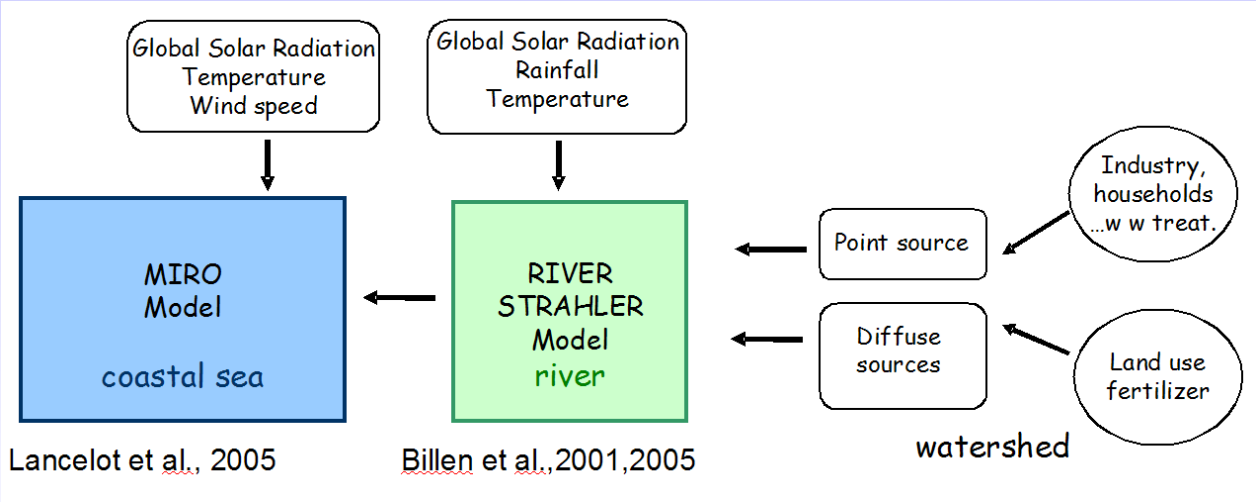


C. Lancelot, Ecologie des Systèmes Aquatiques ULB, Funding: Belgian Science Policy: SSD: AMORE-III (Advanced Modeling and Research on Eutrophication) ULB-MUMM-UMH-ILVO IAP: THIMOTHY (Tracing and Integrated Modeling of Natural and Anthropogenic Effects on Hydrosystems:The Scheldt River Basin and Adjacent Coastal North Sea ULB-VUB-ULg-UCL-MRAC-UPMC(Paris 6) EU-FP6 IP THRESHOLDS (coord. Carlos Duarte, CSIC Spain; ULB as PI (C. Lancelot, W. Hecq))

Understanding and mitigating eutrophication in BCZ: coupling a river model (RIVERSTRAHLER) to the MIRO ecological model

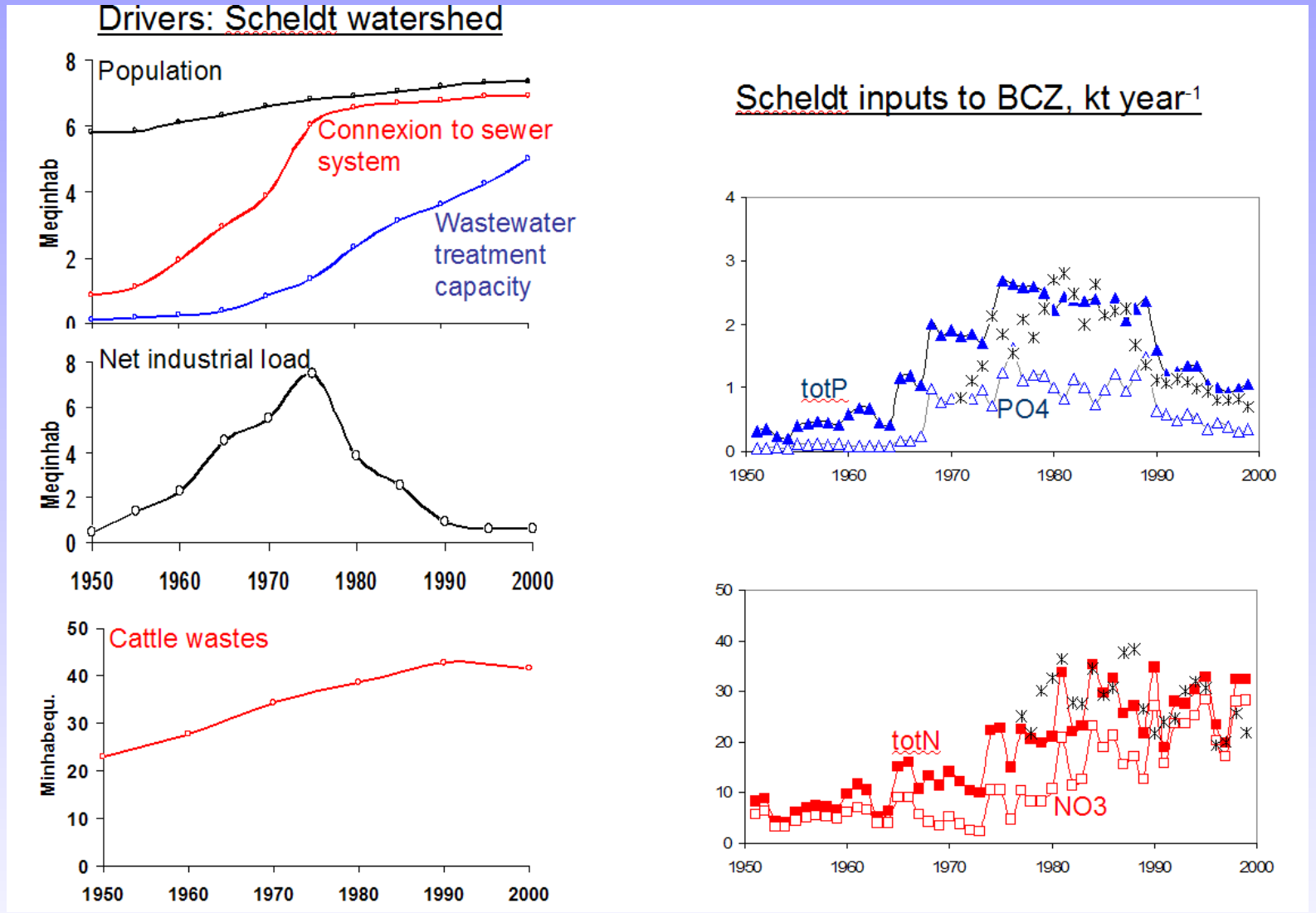


1950-2000
historical reference: pristine
WFD application: 2015



C. Lancelot

Results 1: Changing nutrient delivery to BCZ over the last 50 years



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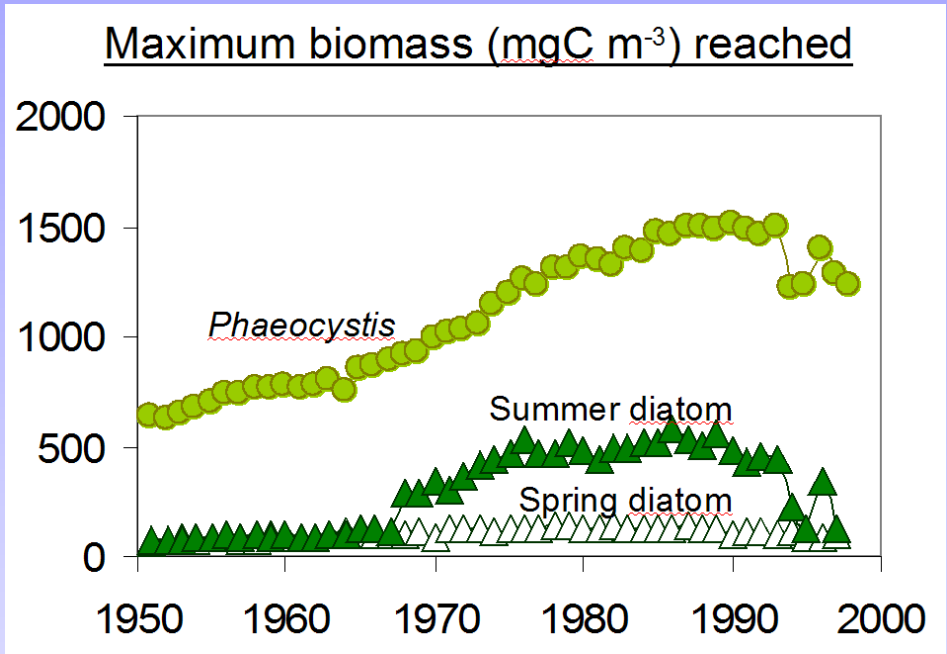
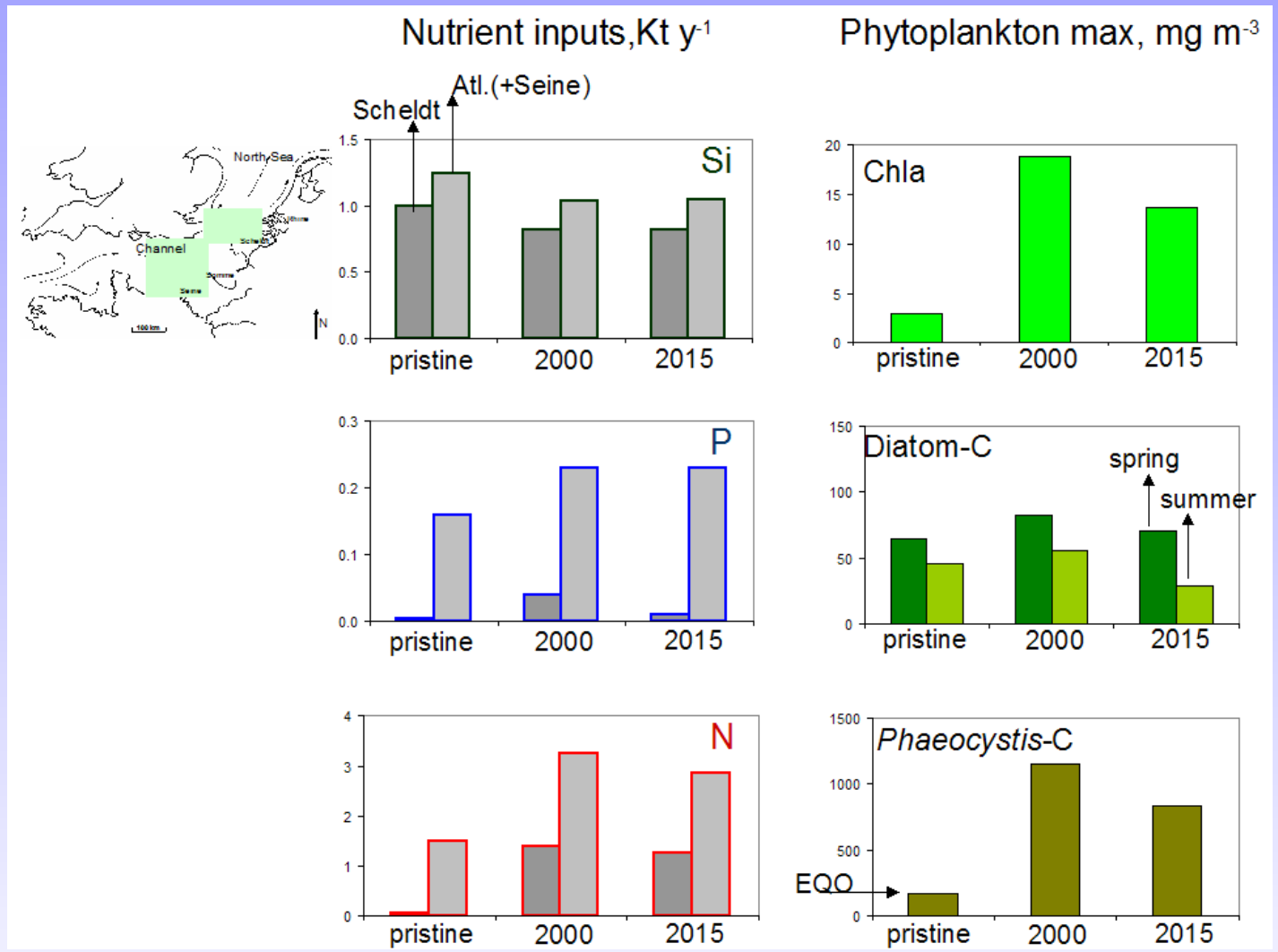
Results 2: BCZ ecosystem response: ecological analysis

Maximum biomass (mgC m^{-3}) reached



- 1950: Phaeocystis colonies already blooming above EQO-QO (150 mgC m^{-3})
- 1960-1989: increase of both N and P loads was beneficial to both Phaeocystis and summer diatoms
- Since 1989: decrease of P but maintenance of elevated N loads → decrease of diatom summer blooms but little effect on Phaeocystis. The latter was controlled by N loads

Past, Present and Future ecological trends



Decrease of Phaeocystis blooms needs decrease of N inputs by both the Seine and Scheldt

C. Lancelot

CART

- Complex models produce huge amounts of data that are difficult to analyze
- End-users require simple answers / figures

$\Rightarrow$ **C**onstituent oriented **A**ge and **R**esidence time **T**heory

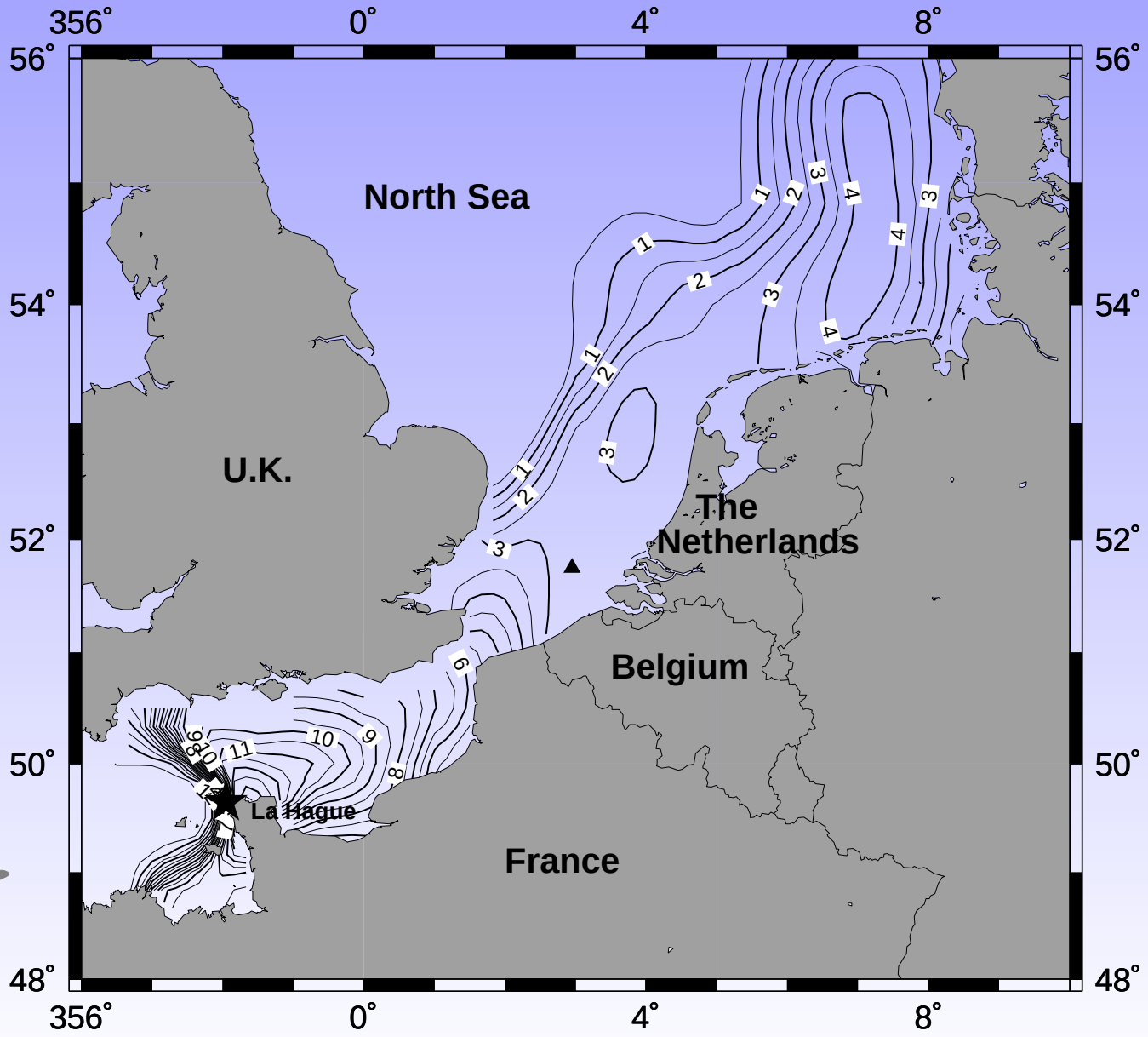
Development of diagnostic tools (age, residence time, exposure time, transit time,. . .) to characterize the **rate of transport and functioning** *of the marine system*

http://www.climate.be/CART

A collaboration ULg-UCL

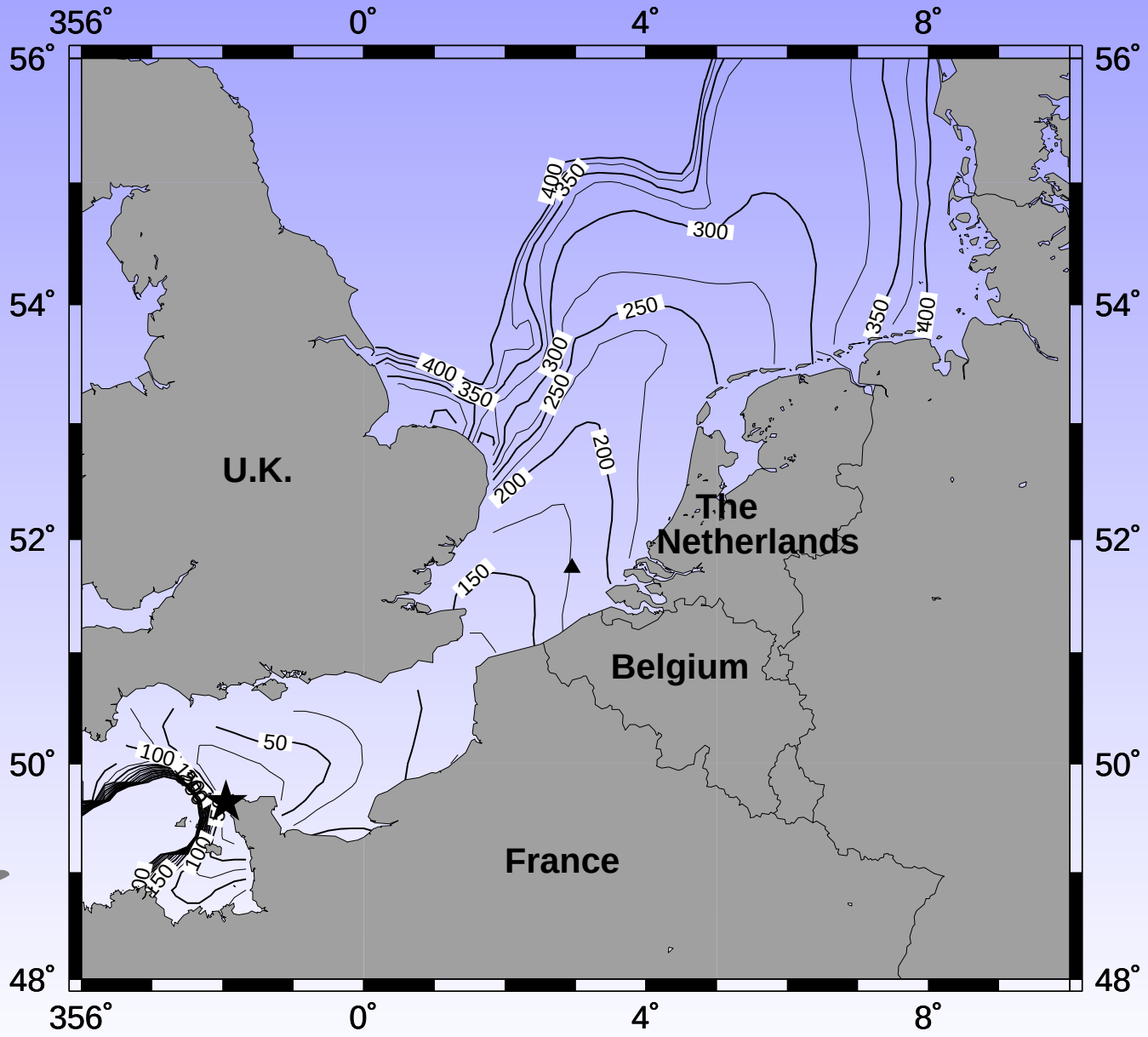
E. Delhez, E. Deleersnijder

^{99}Tc in the North Sea - Conc.

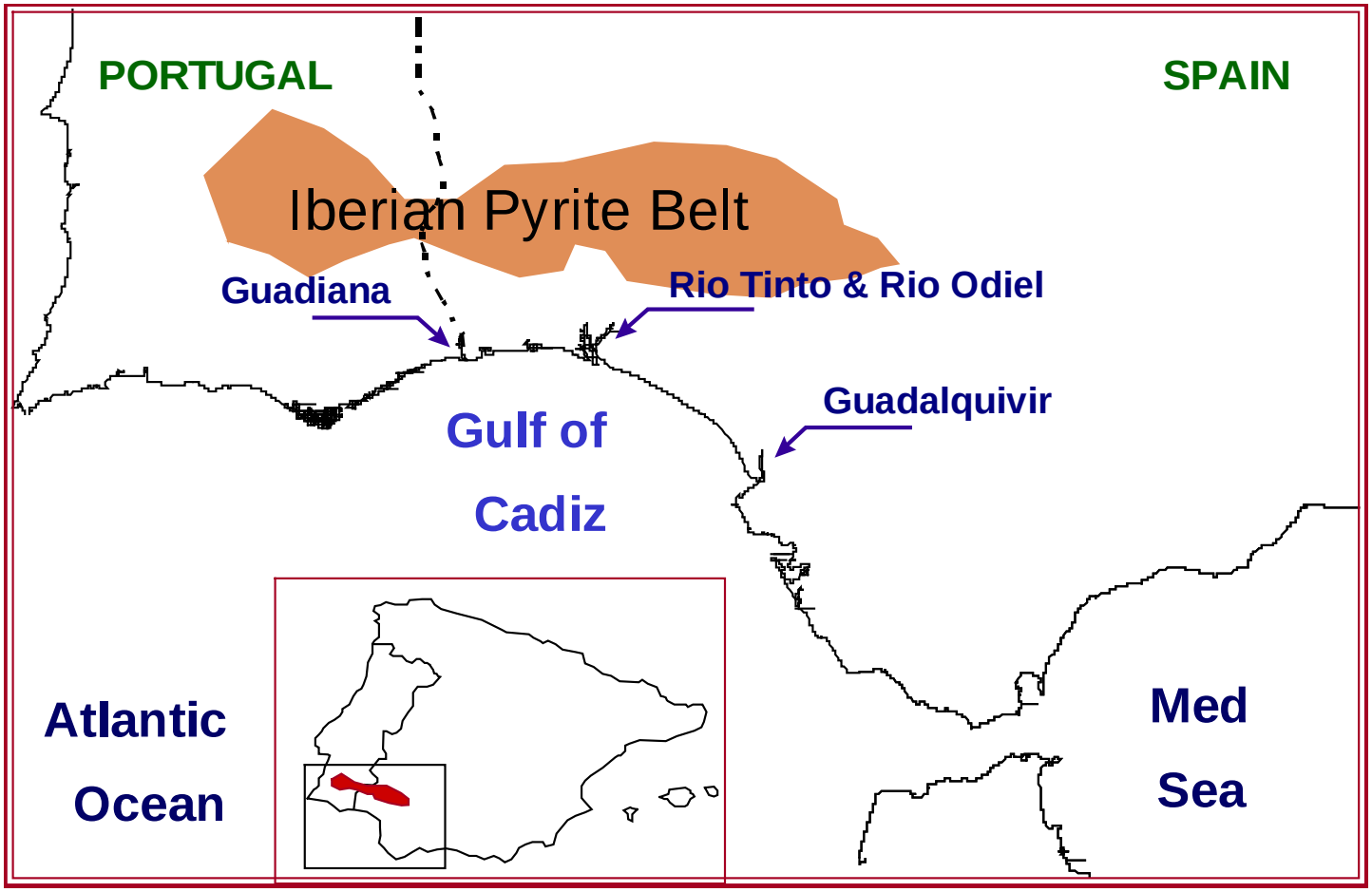


March
1985
Bq/m^3

^{99}Tc in the North Sea - Age



Age and heavy metals



Age and heavy metals

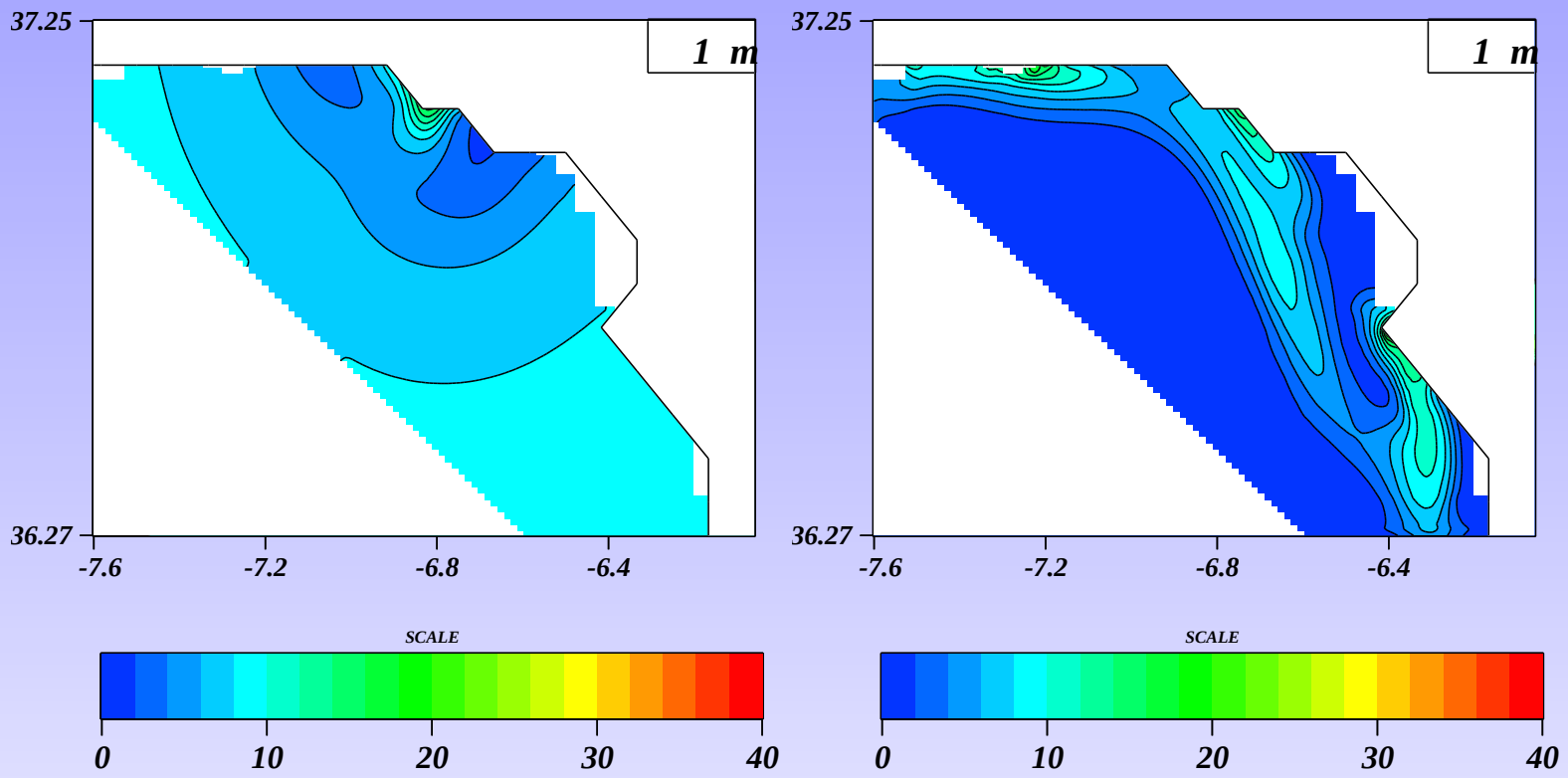


Figure 1: Co distribution from field data (left panel, μM) and best model fit of the three river sources (right panel) for cruise T2; concentrations in nM.

Beckers, Achterberg, Braungart, 2007

Misfit

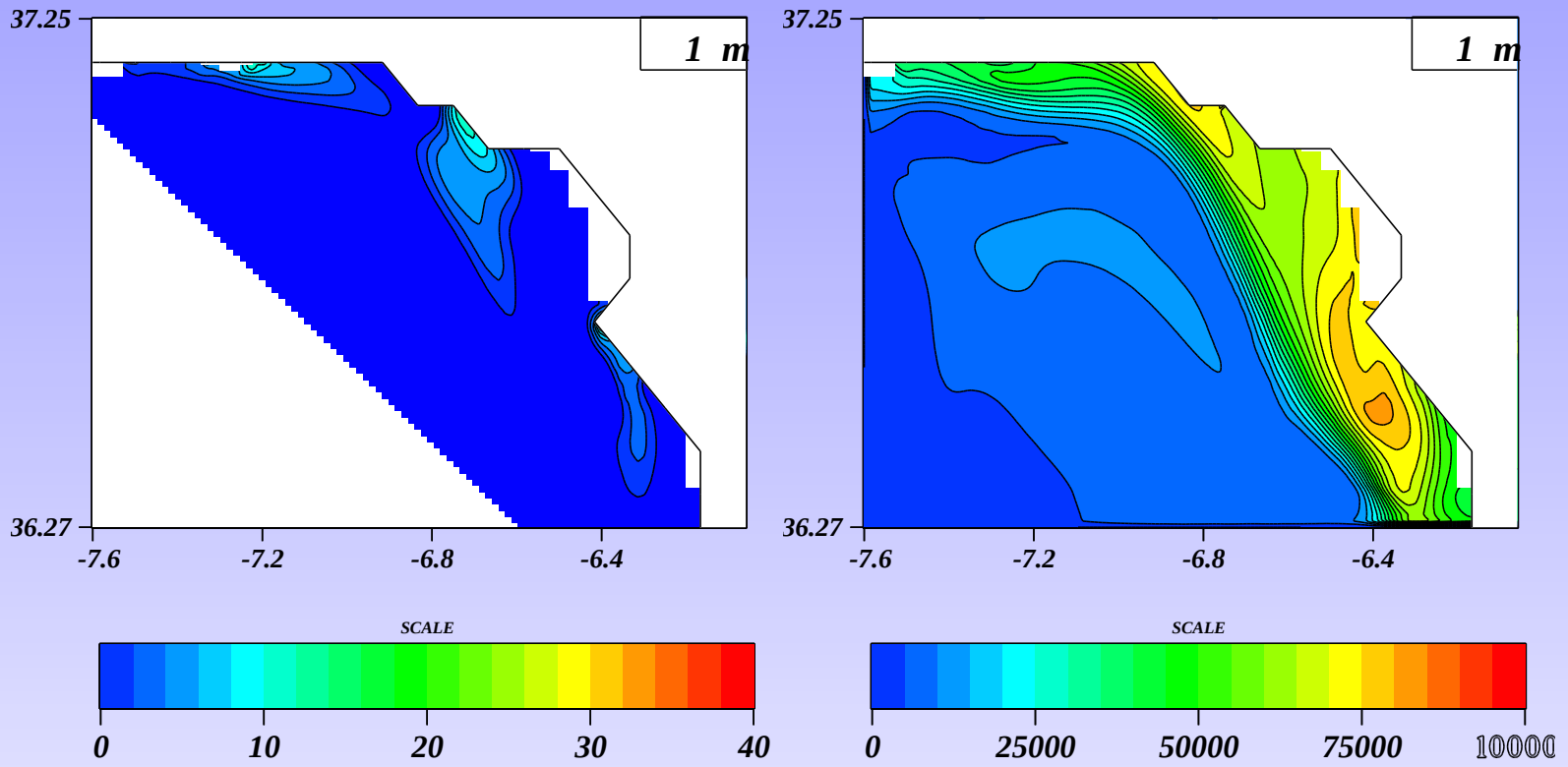


Figure 2: Co misfit (left panel) sediment tracer (right panel)

Beckers, Achterberg, Braungart, 2007

Age

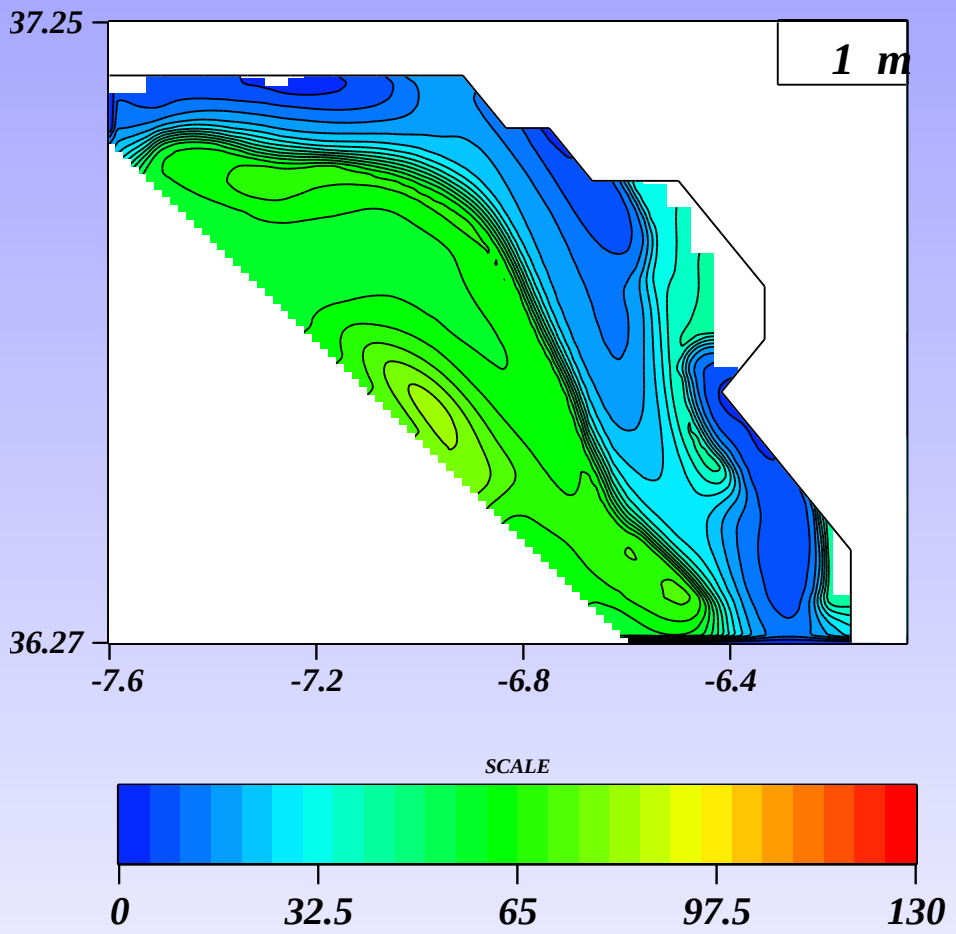
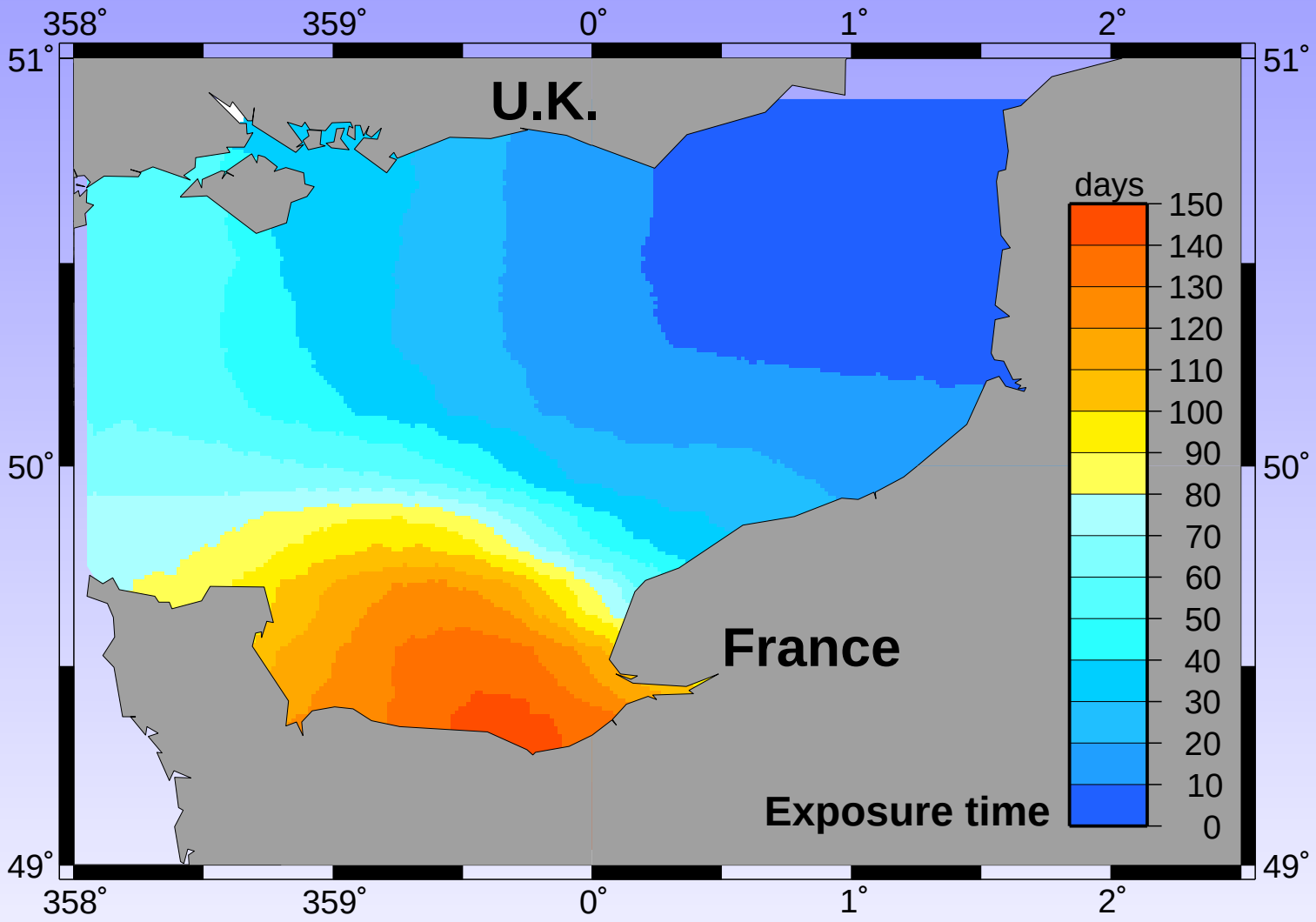


Figure 3: Age of combined sources (in days)

Beckers, Achterberg, Braungart, 2007

Exposure time



Exposure time in the Eastern English Channel (days)
Snapshot on 15/08/1983 - Surface value

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Non-conclusions

Some randomly picked topics requiering developments

- Development of indicators
- Further increasing interdisciplinarity (see also ICZM presentation of K. Belpaema)
- Intermittent processes (episodic events) impact (e.g. resuspension of sediment)
- Tools and data to separate climate-change effect, natural variability and local antrophogenic effects
- Easily accessible data-set (transnational)

Unless additional input is received Coastal-WIKI contribution is (in my opinion) not yet ready.


ERICSSON
YES
Ctrl
Alt
Delete
Microsoft