ERF 2005 · October 16-21, 2005 · Norfolk, Virgina

estuarine interactions:
biological-physical feedbacks and adaptations

Research and screening models for science and management - Integrated assessment of ecological balance and sustainability in coastal zones

ERF 2005, 18th Biennial Conference of the
Estuarine Research Federation
Norfolk, Virginia
SYM-06 - Managing River Basins and Estuaries:
an International Assessment of Approaches
and Progress. October 18th 2005

J.G. Ferreira, S.B. Bricker, A.M. Nobre, J.P. Nunes, X. Yan, X.L. Zhang, M.Y. Zhu

http://www.eutro.org

Topics

- **Pressure-State-Response** 2
- **Screening models for PSR** 3
- **Scenario analysis** 3
- **A framework for research models** 8
- **Research and screening models** 3

Slides

19+2

Huangdun Bay, China

Coastal eutrophication
Pressure-State-Response

Drivers
- Agriculture – loss of fertilizer, etc
- Urban discharges (sewage)
- Industrial discharges
- Atmospheric deposition
- Internal (secondary) sources (e.g. P from sediments)
- Advection from offshore (e.g. N and P, certain types of HAB)

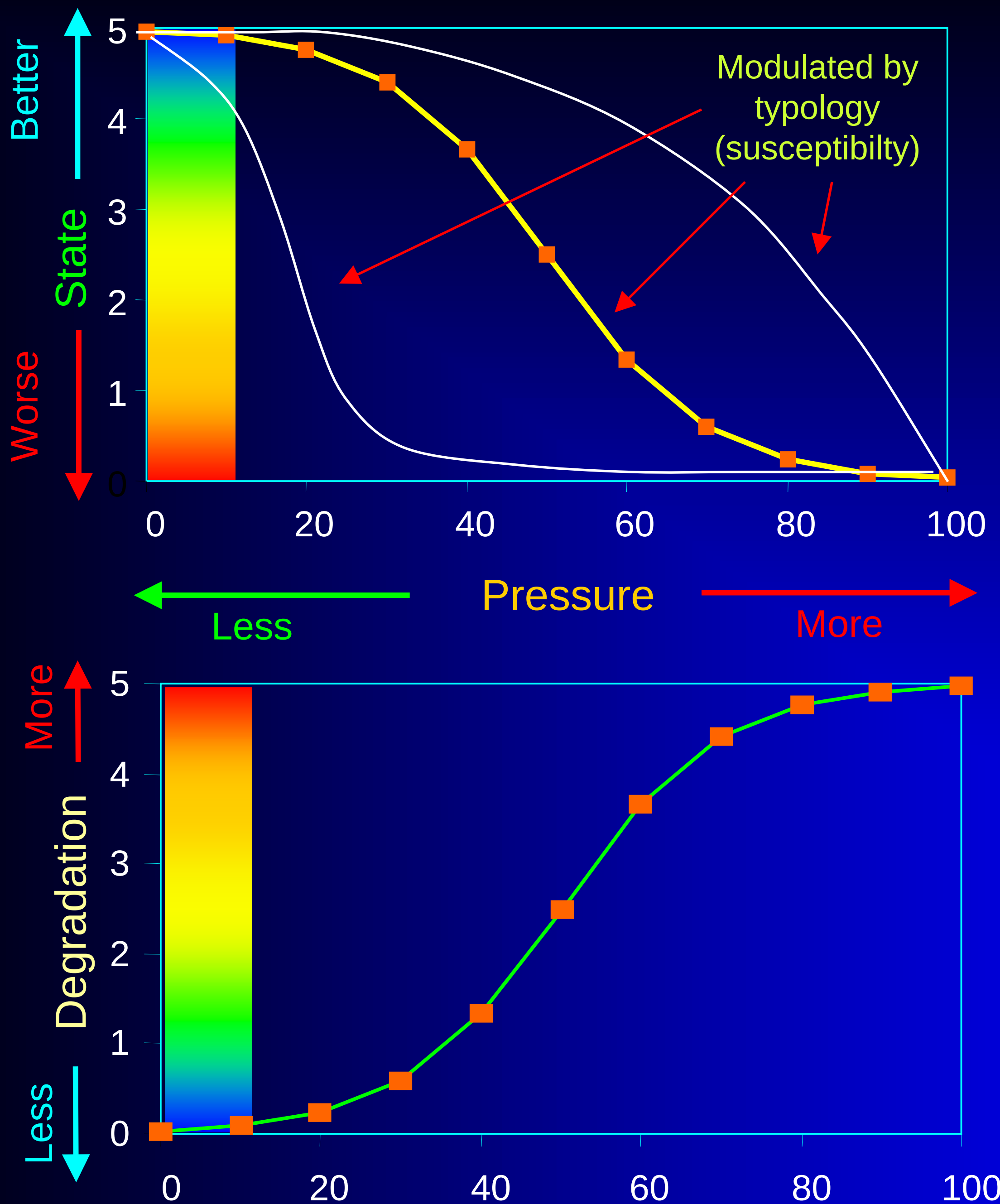
Pressure
- N and P loading to the coastal system
- HAB phytoplankton “loading” from offshore

State
- Primary symptoms
  - Decreased light availability
  - Increased organic decomposition
  - Algal dominance changes
- Secondary symptoms
  - Loss of SAV
  - Low dissolved oxygen
  - Harmful algae

Response
- Fertilizer reduction
- WWTP (sewage, industry)
- Emmission controls
- Sediment dredging etc
- Time...
- Interdiction (e.g. HAB events)

Pressure-State relationships and typology

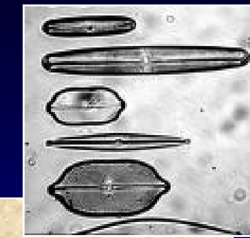
State as a function of pressure



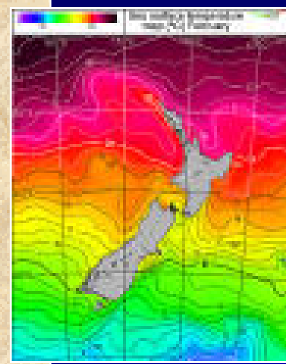
Degradation as a function of pressure

PSR - Evaluation of State

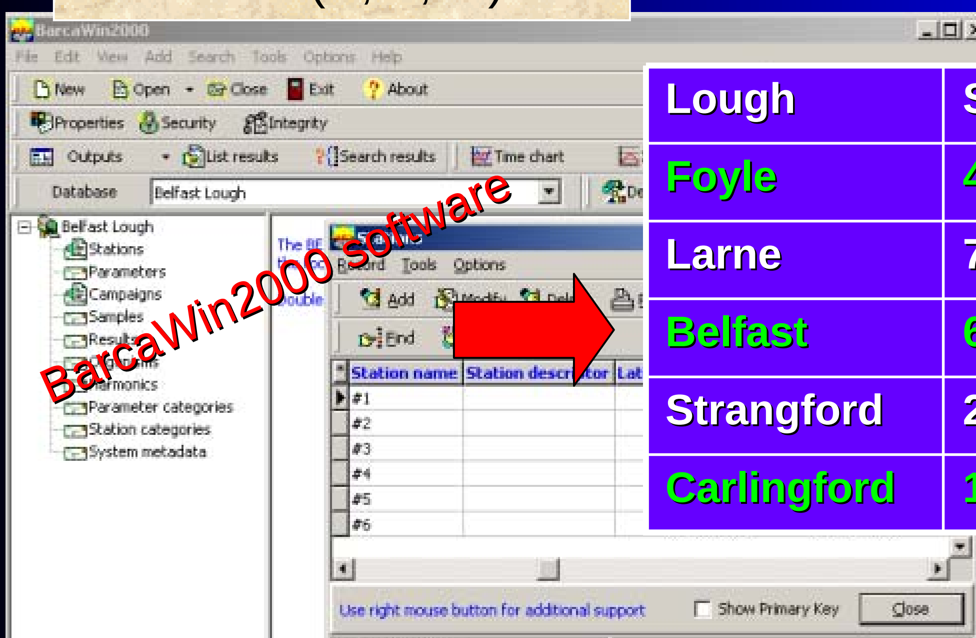
Northern Ireland Sea Loughs



Physico-Chemical
- Temperature
- Salinity & conductivity
- Lighrt extinction
- Dissolved oxygen
- Suspended matter
- POM, POC
- Nutrients (N, P, Si)



Biological
- Chlorophyll *a* & Phaeopigments
- Phytoplankton species
- Benthic invertebrate fauna
- SAV
- Macroalgae



Lough	Stations	Samples	Parameters	Results
Foyle	42	3284	105	23673
Larne	7	84	13	814
Belfast	63	7514	78	40565
Strangford	22	3043	98	19992
Carlingford	113	4912	273	34171

~ 140,000 results

Sanggou Bay – ASSETS Application

ASSETS: HIGH

Indices	Methods	Parameters	Rating	Level of expression	Index
Overall Human Influence (OHI) ASSETS: 5	Susceptibility	Dilution potential	High	Low susceptibility	LOW
		Flushing potential	Moderate		
	Nutrient inputs		Moderate		
Overall Eutrophic Condition (OEC) ASSETS: 5	Primary	Chlorophyll *a*	Low	Low	LOW
		Macroalgae	*No Problem**		
	Secondary	Dissolved Oxygen	No Problem	Low	
		Submerged Aquatic Vegetation	No Problem		
		Nuisance and Toxic Blooms	No Problem		
Determination of Future Outlook (DFO) ASSETS: 3	Future nutrient pressures	Future nutrient pressures remain the same			NO CHANGE

Estuary Characteristics:

Population (X 10^3)	200
Nutrient loading (tN y^{-1})	400
Mean depth (m)	7.5
Mean tidal range (m)	1.5
Water residence time (d)	20

Main issues and impacts:

Cultivation of scallops, oysters, kelp – high summer bivalve mortality from disease

Huangdun Bay – ASSETS Application

ASSETS: POOR

Indices	Methods	Parameters	Rating	Level of expression	Index
Overall Human Influence (OHI) ASSETS: 1	Susceptibility	Dilution potential	Moderate	Moderate susceptibility	HIGH
		Flushing potential	Moderate		
	Nutrient inputs		High		
Overall Eutrophic Condition (OEC) ASSETS: 3	Primary	Chlorophyll *a*	High	Moderate	MODERATE
		Macroalgae	*No Problem**		
	Secondary	Dissolved Oxygen	No Problem	Moderate	
		Submerged Aquatic Vegetation	Unknonwn		
		Nuisance and Toxic Blooms	Moderate		
Determination of Future Outlook (DFO) ASSETS: 1	Future nutrient pressures	Future nutrient pressures increase			WORSEN HIGH

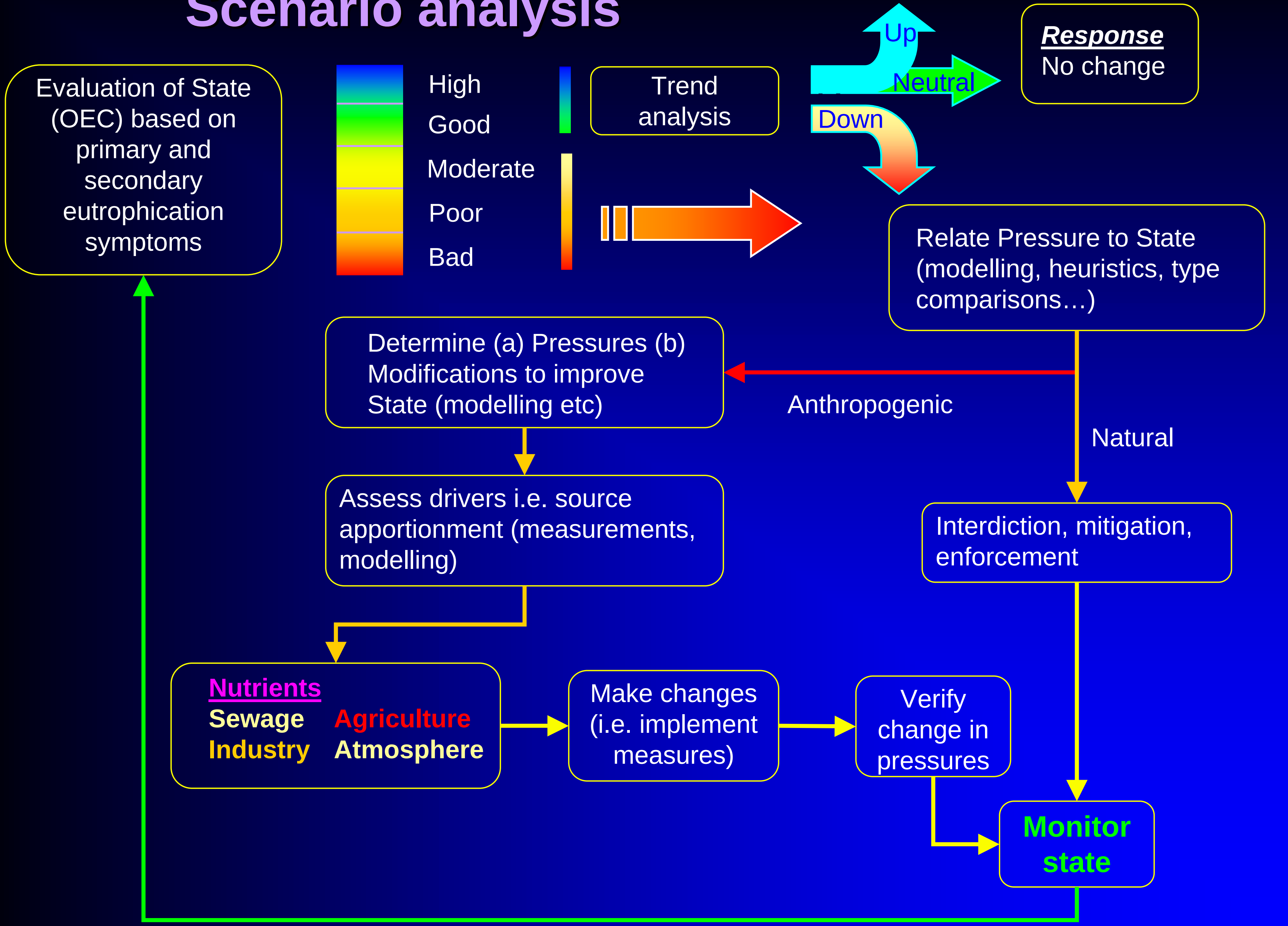
Estuary Characteristics:

Population (X 10^3)	500
Nutrient loading (tN y^{-1})	463
Mean depth (m)	8
Mean tidal range (m)	3.9
Water residence time (d)	30

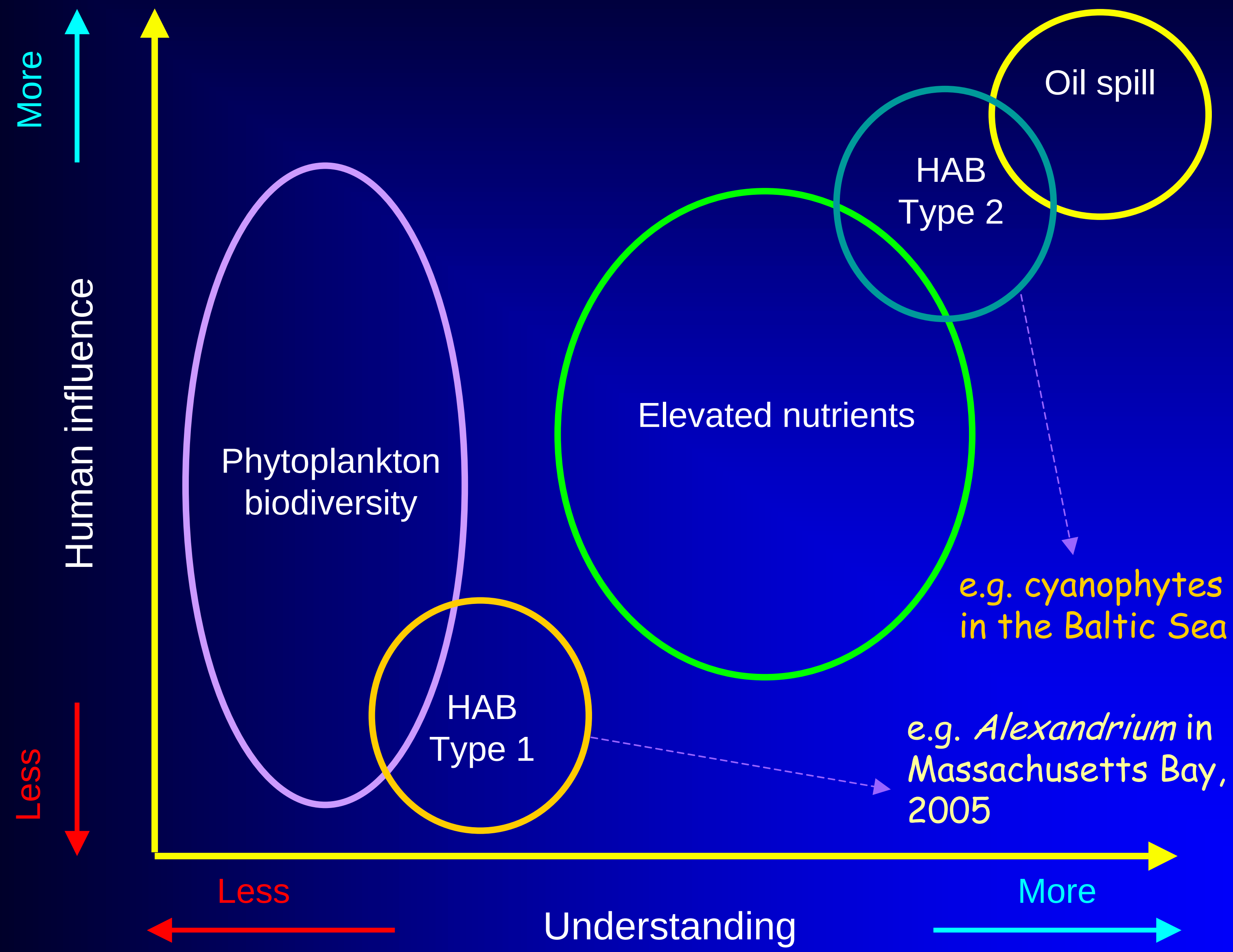
Main issues and impacts:

Outer channel influenced by the Changjiang plume, aquaculture of finfish, oysters, *Enteromorpha*, and *Porphyra*

Scenario analysis

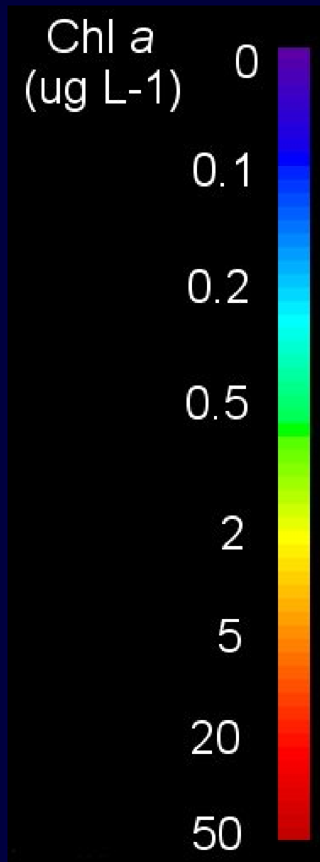


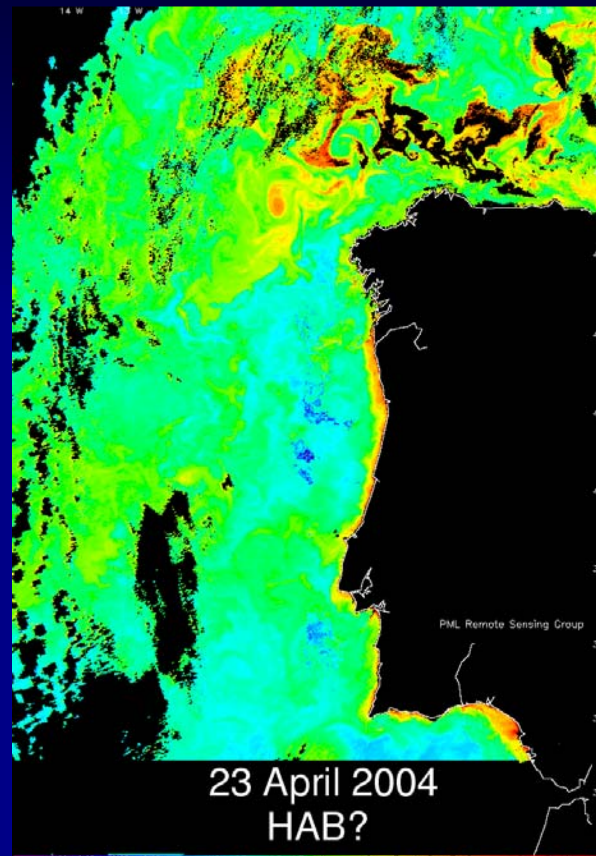
Human influence and uncertainty



Harmful Algal Bloom(?)

Advection to the coast from offshore fronts





PML Remote Sensing Group

courtesy Plymouth Marine Laboratory, UK

http://pml.ac.uk/

Multi-sensor discrimination of harmful algal blooms, P. I. Miller, J. D. Shutler, G. F. Moore and S. B. Groom, *Remote Sensing and Photogrammetry Society annual conference RSPSoc 2004*, 7-10 September 2004, Dundee U.K.

Ecosystem modelling
Components and integration

Drivers and Pressure

Remote sensing
Land use, classification, but also water use (e.g. aquaculture structures)

Catchment models
Based on topography, hydrography, land use, export coefficients etc. Provide “climatological-scale” data on e.g. nutrient pressures

State

Hydrodynamic modelling
Few state variables, detailed circulation, fine grid, short time-step, runtime of weeks to months

Databases and GIS
Spatial representation of water quality variables, box definition, assimilation and presentation of results

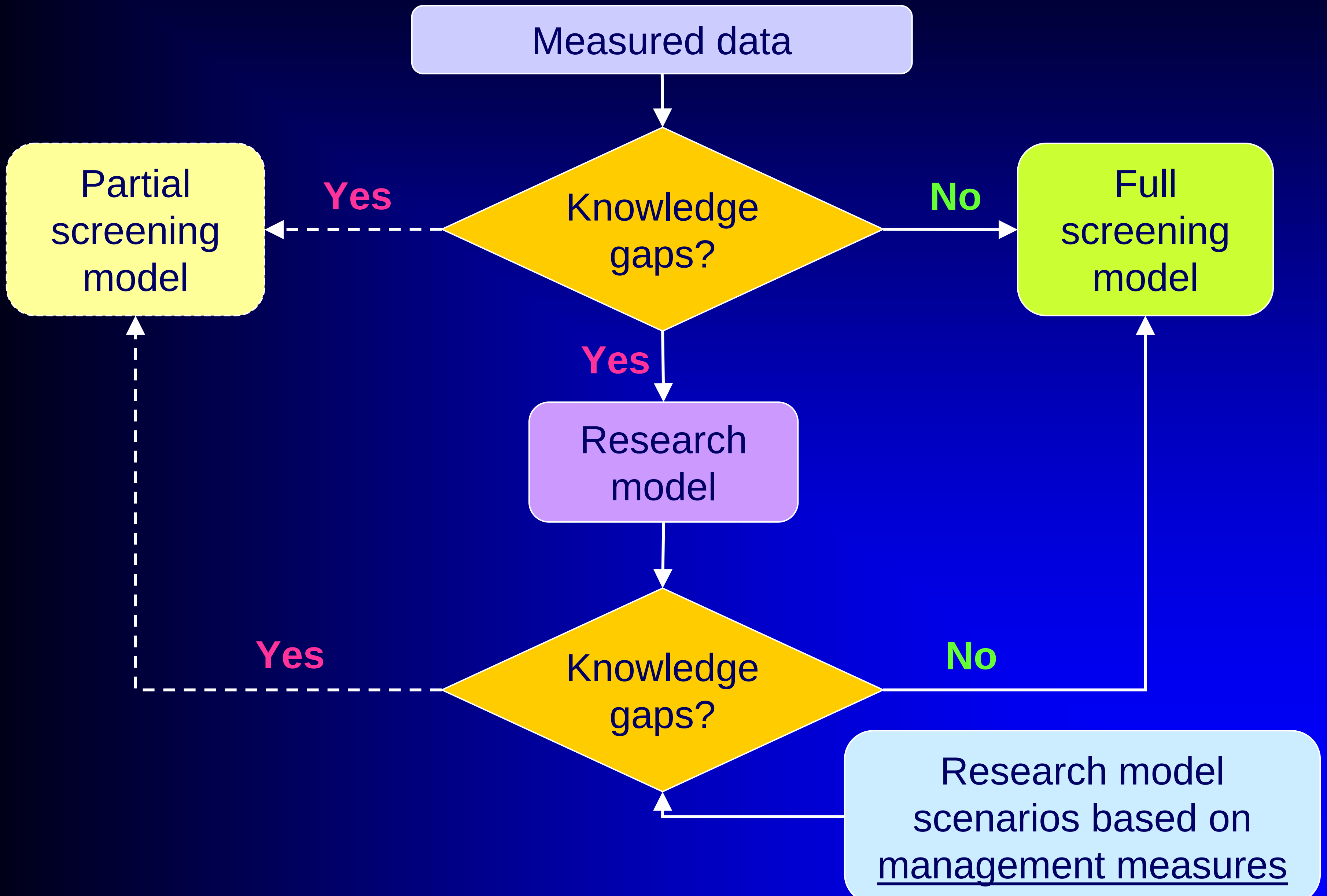
Ecosystem modelling
Many state variables Larger boxes, longer time-step, multi-year runs, link to socio-economic models

Response

Socio-economic valuation
“Spreadsheet” models, based on public questionnaires, and classic equations. Limited feedback to the natural science components

Socio-economic modelling
Dynamic models, multi-year (5-25?) runs. Highly aggregated, feed back into both **Pressure** and **State**. Key issues are scaling and validation

Relationship between data, research models and screening models



Ria Formosa –ASSETS validation & model scenarios

Index	Methods	Parameters	Value	Level of expression	Index	Notes
Overall Eutrophic Condition (OEC) ASSETS OEC: 4	PSM	Chlorophyll *a* Epiphytes Macroalgae	0.25 0.50 0.96	0.57 Moderate	MODERATE LOW	Field data
	SSM	Dissolved Oxygen Submerged Aquatic Vegetation Nuisance and Toxic Blooms	0 0.25 0	0.25 Low		
Overall Eutrophic Condition (OEC) ASSETS OEC: 4	PSM	Chlorophyll *a* *Epiphytes* Macroalgae	0.25 *0.50* 1.00	0.58 Moderate	MODERATE LOW	Research model
	SSM	Dissolved Oxygen Submerged Aquatic Vegetation Nuisance and Toxic Blooms	0 0.25 0	0.25 Low		28% lower
Overall Eutrophic Condition (OEC) ASSETS OEC: 4(5)	PSM	Chlorophyll *a* *Epiphytes* Macroalgae	0.25 *0.50* 0.50	0.42 Moderate	MODERATE LOW	Model green scenario
	SSM	Dissolved Oxygen Submerged Aquatic Vegetation Nuisance and Toxic Blooms	0 0.25 0	0.25 Low		

Final comments

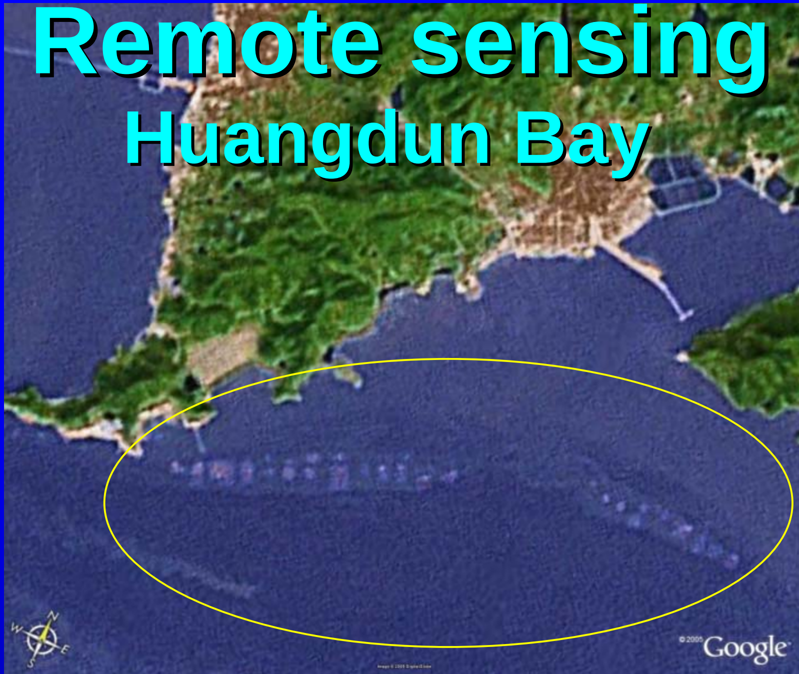
Sanggou Bay, China

Belfast Lough, Northern Ireland

- The application of the PSR framework for coastal eutrophication management was reviewed, highlighting the role of system typology;
- Examples of the results of highly aggregated eutrophication assessment models illustrate how this framework may be translated into meaningful indices such as ASSETS;
- Scenario analysis, focusing on management response, requires a combination of tools and must account for variable uncertainties related both human and natural factors;
- Research models provide a promising approach to the examination of scenarios and PSR dependencies – however the methodology is highly interdisciplinary;
- Field and experimental data, research models and screeening models should be used as complementary tool set, allowing complex science to be distilled into simpler assessment procedures which inform water management;
- Scientists often think everyone should understand what they do, although they frequently do little to simplify or explain.

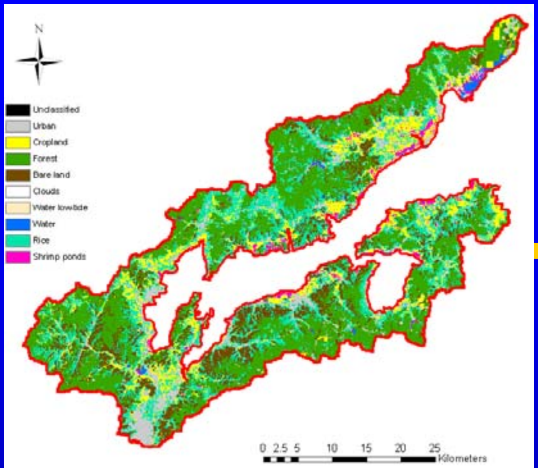
http://www.eutro.org

Remote sensing
Huangdun Bay

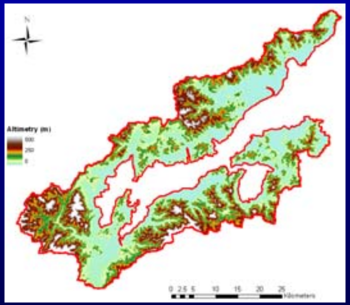


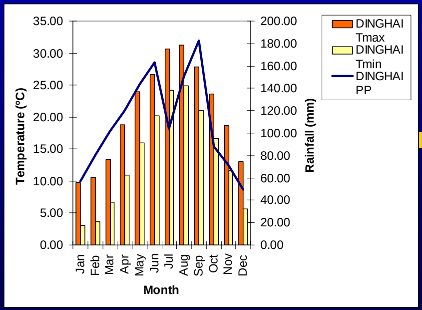
Modelling of drivers and pressures

Huangdun Bay

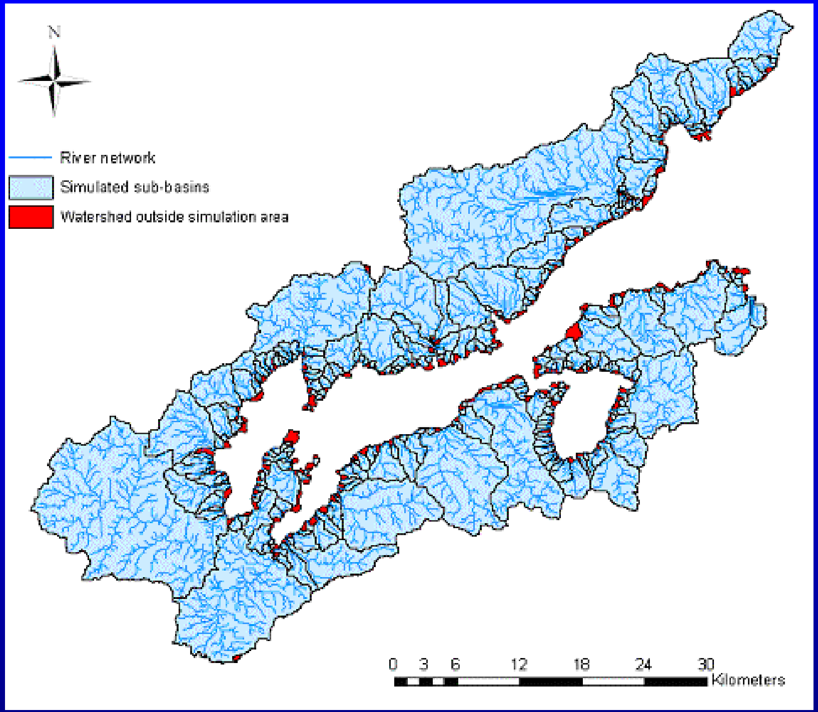


Human parameters: land use, agricultural and fertilization practices, effluent discharges, etc.





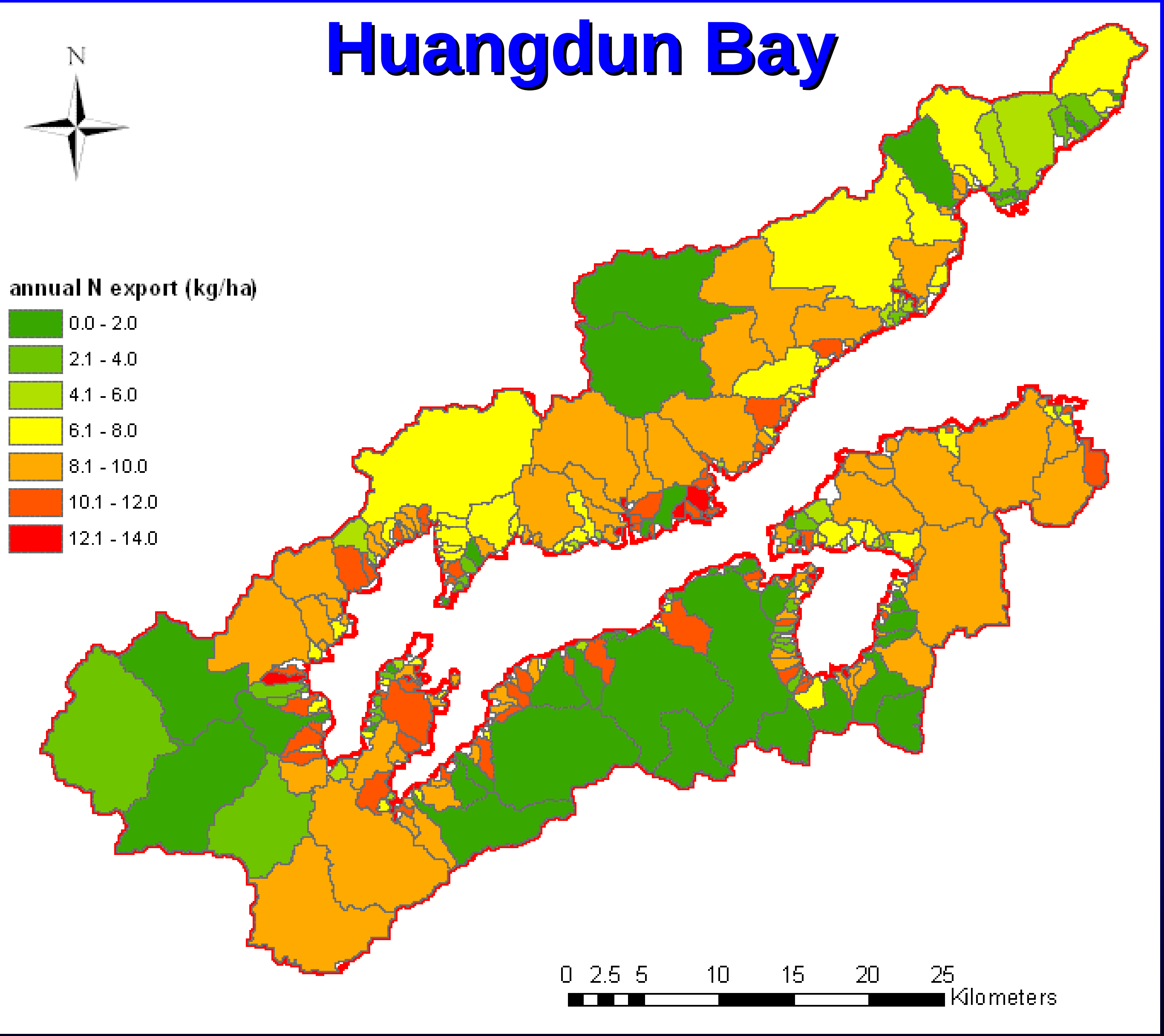
Physical parameters: altimetry, soil data, climate patterns, etc.



Model: routing of water and nutrients from source watersheds to aquatic system

Results: map of nutrient sources, nutrient loads in several points of the bay, etc.

Annual nitrogen loading

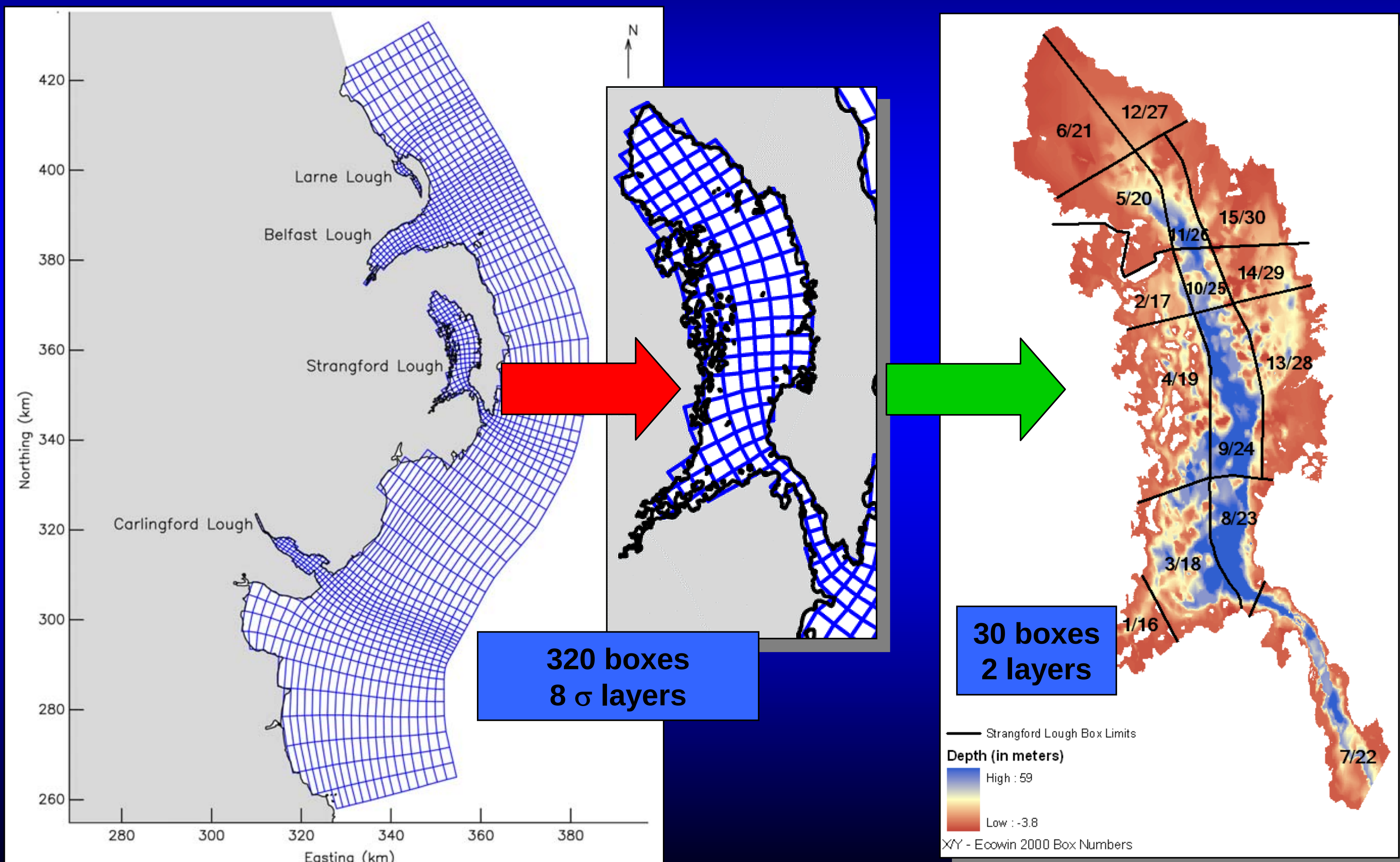


Model coupling: Spatial aggregation

Strangford Lough

Delft3D
Hydrodynamic model

EcoWin2000
ecological model



GIS I - Criteria for ecosystem division into EcoWin2000 model boxes

Strangford Lough

Physical data

Homogenous physical conditions for

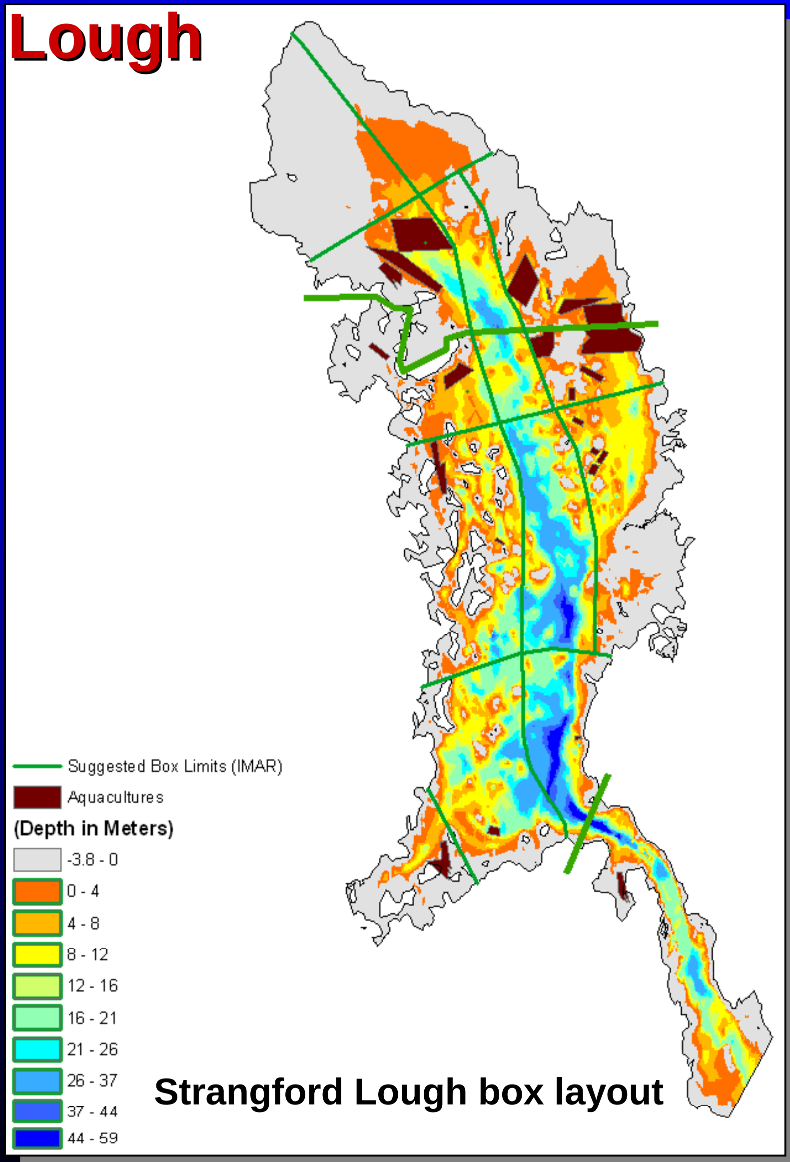
- Morphology
- Currents
- Vertical stratification

Water bodies defined for Water Framework Directive (WFD) implementation

Due to management requirements for EQS, water body boundaries should fit model box limits

Aquaculture sites

When possible include aquaculture areas into boxes (rather than across boxes)

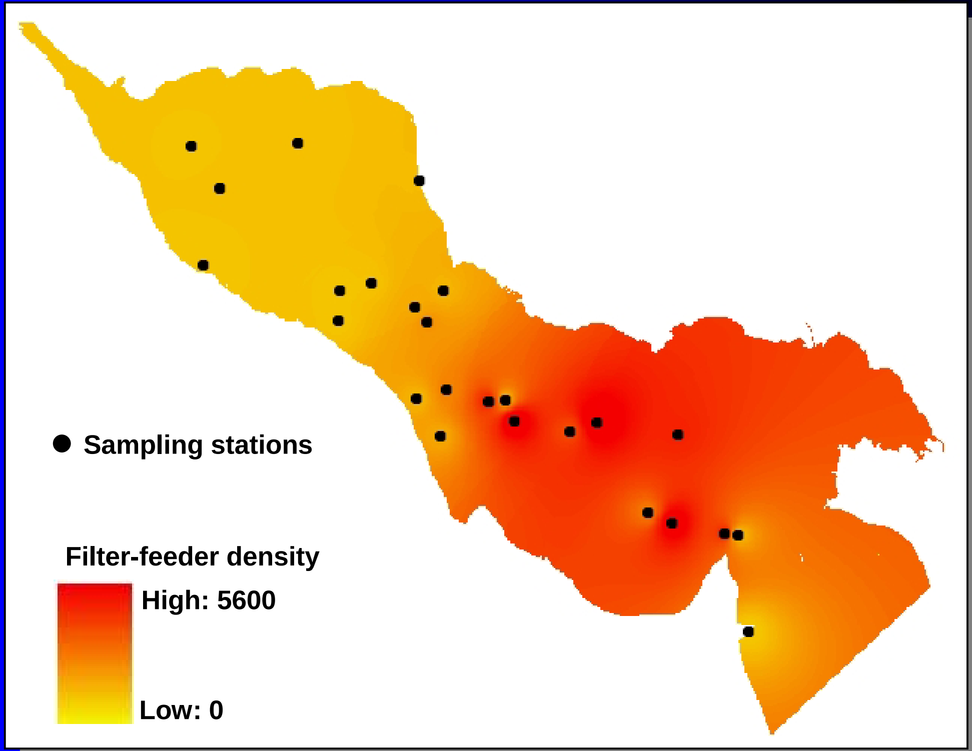


GIS II – Partitioning benthic food supply

Carlingford Lough

Resource partitioning between cultivated and wild populations of filter-feeders

Analysis of the distribution of wild populations in Carlingford Lough



1) Use of historical data (abundance, expressed as number of animals per unit area at each station)

2) Interpolation of GIS surfaces and calculation of the number of organisms for the entire system

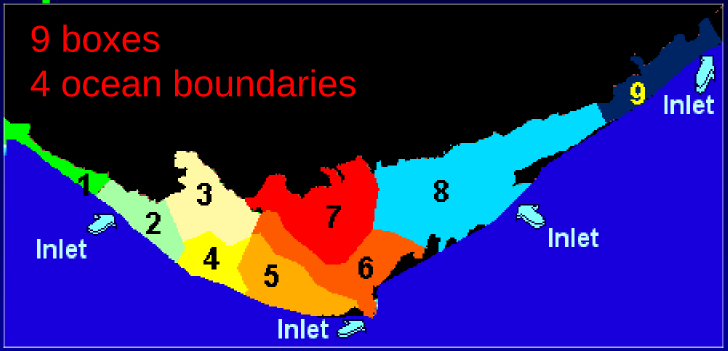
- Discrimination of individuals per species for each model box (only species which are well represented)
- Calculation of the theoretical consumption on the basis of filtration rates
- Aggregation across functional groups (e.g. suspension feeding species)

Estimation of the role of wild populations in partitioning the food resource

Ecosystem modelling

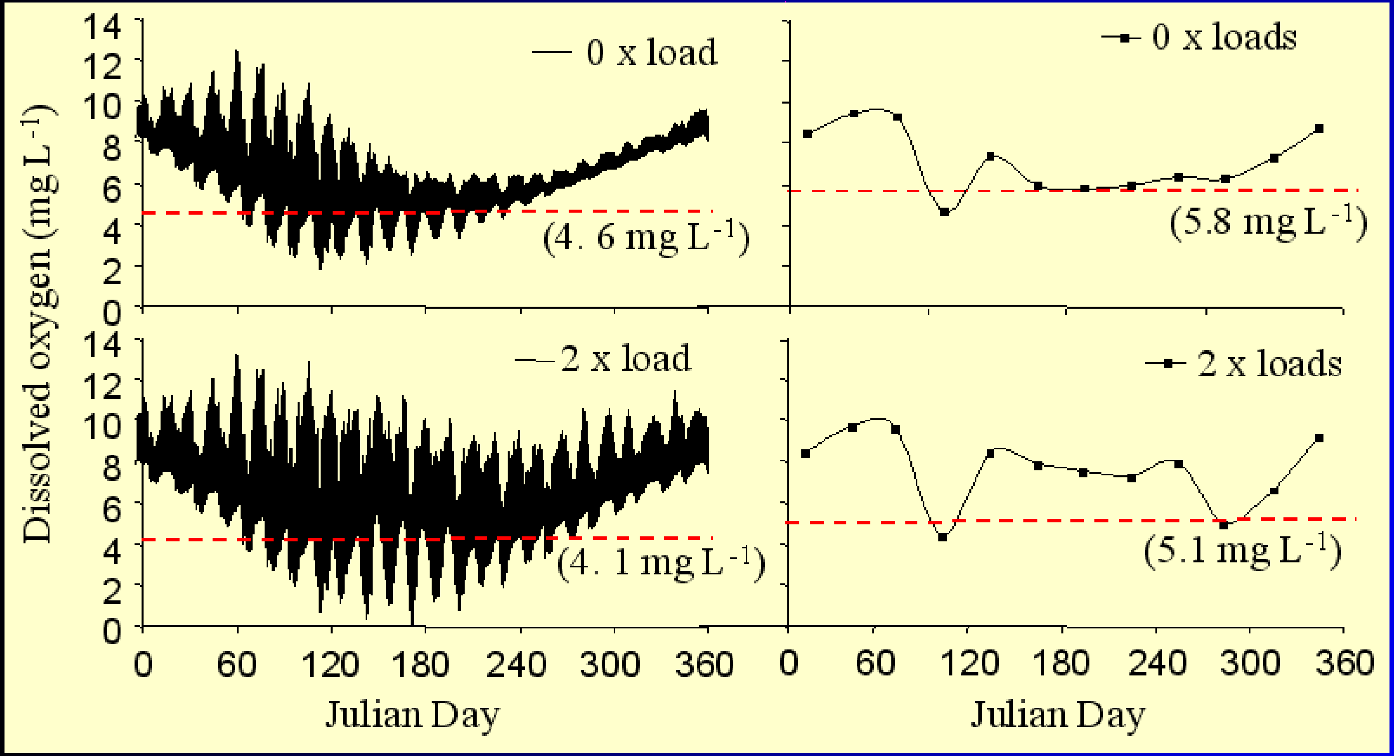
Simulation of dissolved oxygen using different boundary loads

Spatial domain



Research model outputs

Complete dataset | **Monthly sub-sampling**



Percentile 10 value

Percentile 10 value