NATURENS RIGE
Ringkøbing-Skjern Kommune

LONGLINE ENVIRONMENT

SEGES INNOVATION

Coastal Water Council - Stakeholder Board Meeting

Ringkøbing, April 21st, 2023

Modelling of Ringkøbing Fjord to support policy-makers for compliance with the EU Water Framework Directive

Leonard Bernard-Jannin

Longline Environment Ltd.
http://longline.co.uk/rksk

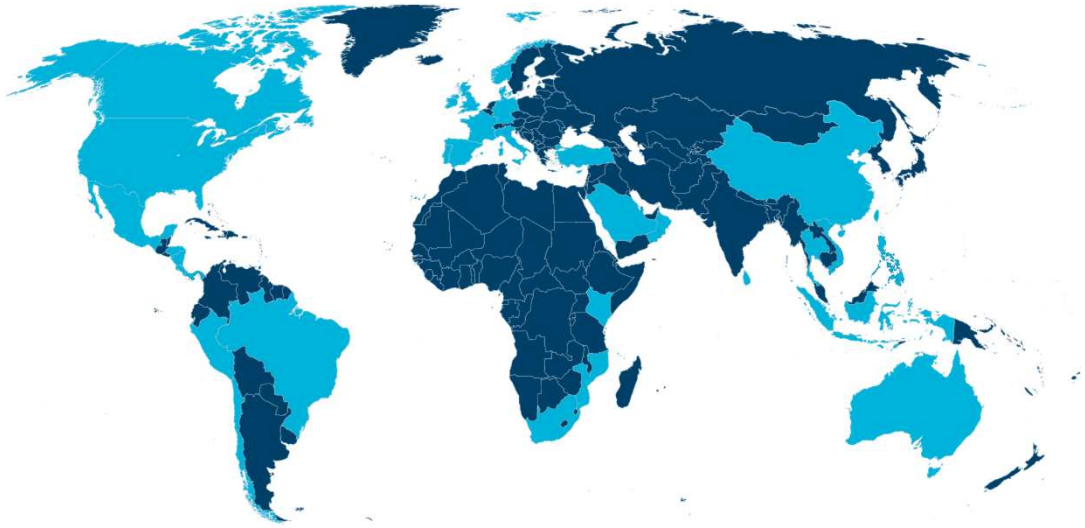
Longline Environment presentation

Longline Environment is a technology firm specialized in modelling, data, and risk solutions, providing value-added outcomes for stakeholders.

The Longline team is made up of highly qualified staff with a track record in the private, public, and academic sectors, combining expertise in:

- **hydrology,**
- **oceanography,**
- **ecosystem modelling and analysis,**
- **and environmental management.**

A portfolio of projects in over 40 countries for farmers, regulators, insurers and research & development



Europe

United Kingdom, Norway, France, Italy, Netherlands, Germany, Spain, Portugal, Cyprus, Denmark, Turkey.

Americas

United States, Canada, Mexico, Belize, Costa Rica, Nicaragua, Honduras, Panama, Brazil, Chile, Peru.

Asia

China, Vietnam, Thailand, Indonesia, Philippines, Malaysia, Singapore, Australia, Sri Lanka, Saudi Arabia, Qatar, Oman, Taiwan.

Africa

South Africa, Kenya, Mozambique, Rwanda, Cabo Verde.

Track record

GOVERNANCE | RISK | ENVIRONMENTAL INTELLIGENCE

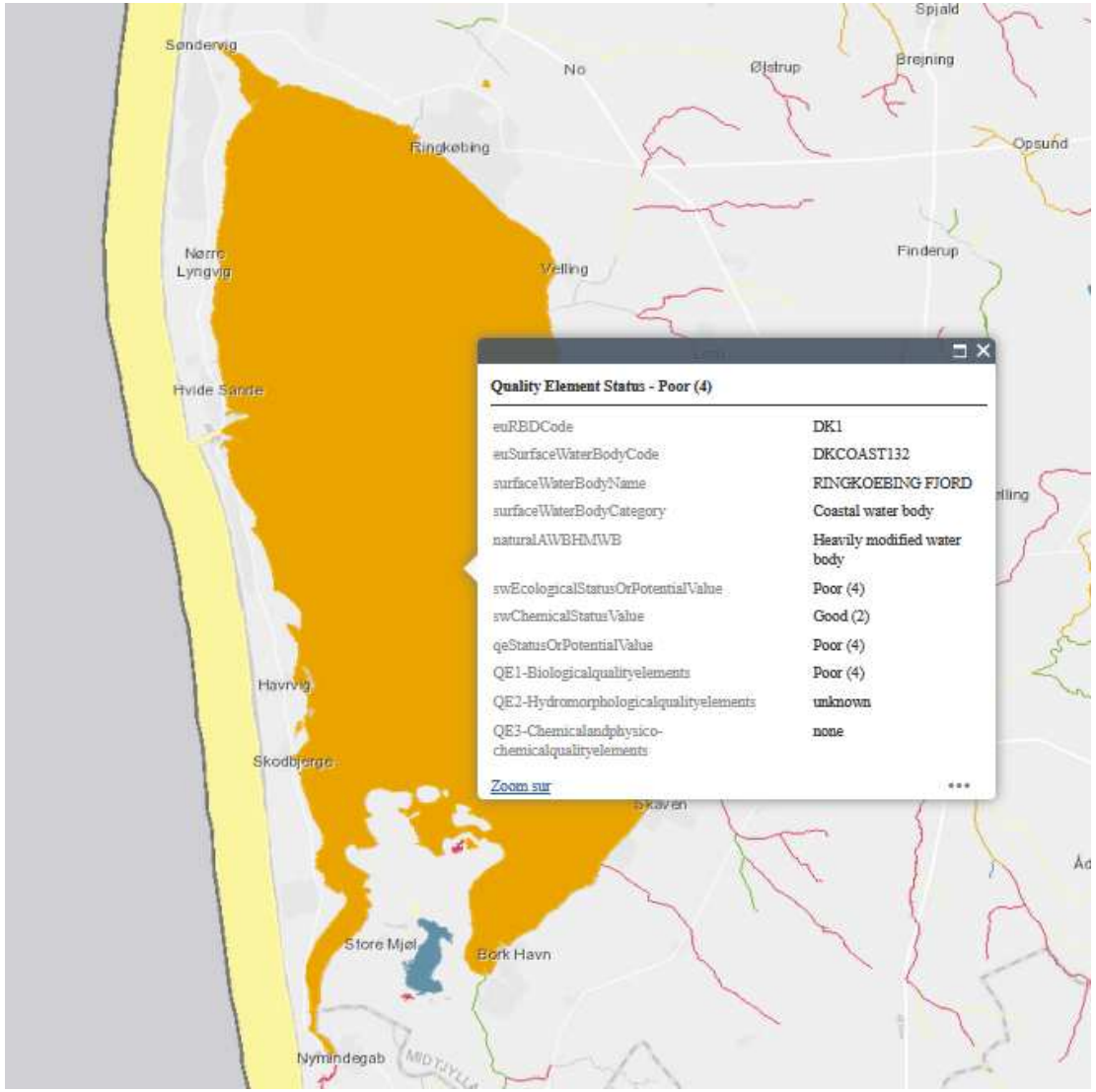
Water quality in Ringkøbing Fjord

- Water Framework Diretive (WFD) classification:
  - Heavily Modified Water Body (HMWB)
  - **Ecological potential value: poor (target: at least good)**

    Økologisk potentiale: Ringe

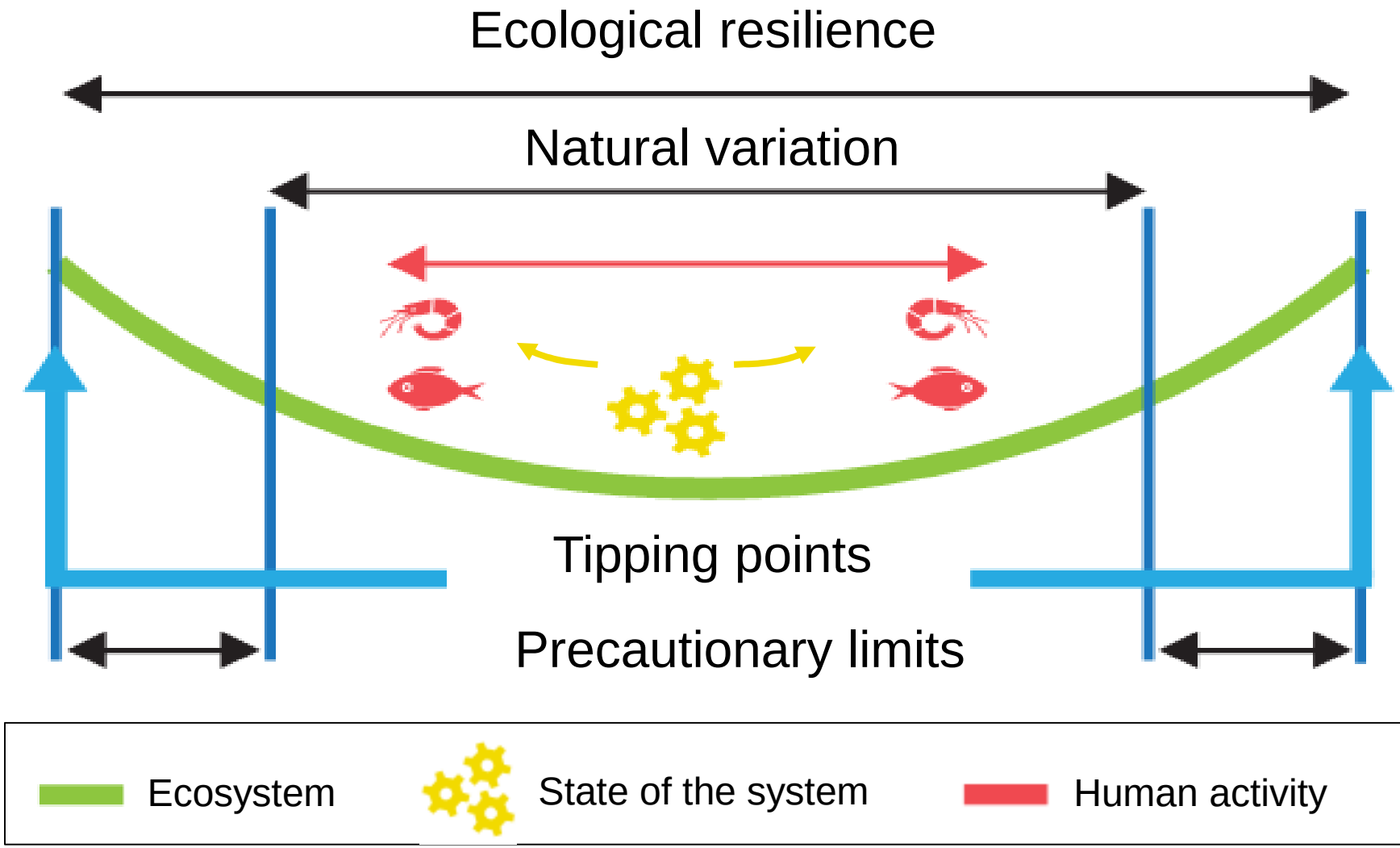
- The classification results from complex interactions between pressure from land, connection with the sea, physical characteristics, environmental drivers and biota.

- **Objective 1**: provide a thorough understanding of the interactions between the catchment, the fjord, and the sluice
- **Objective 2:** Offer insights into how the stakeholders can work together effectively to achieve the targets set by the WFD
- **Objective 3:** Support policy makers in achieving these targets, ensuring both social and environmental sustainability



A review of the classification criteria and indicative measures required to move Ringkøbing Fjord from Poor to Good is critical.

Change in aquatic systems

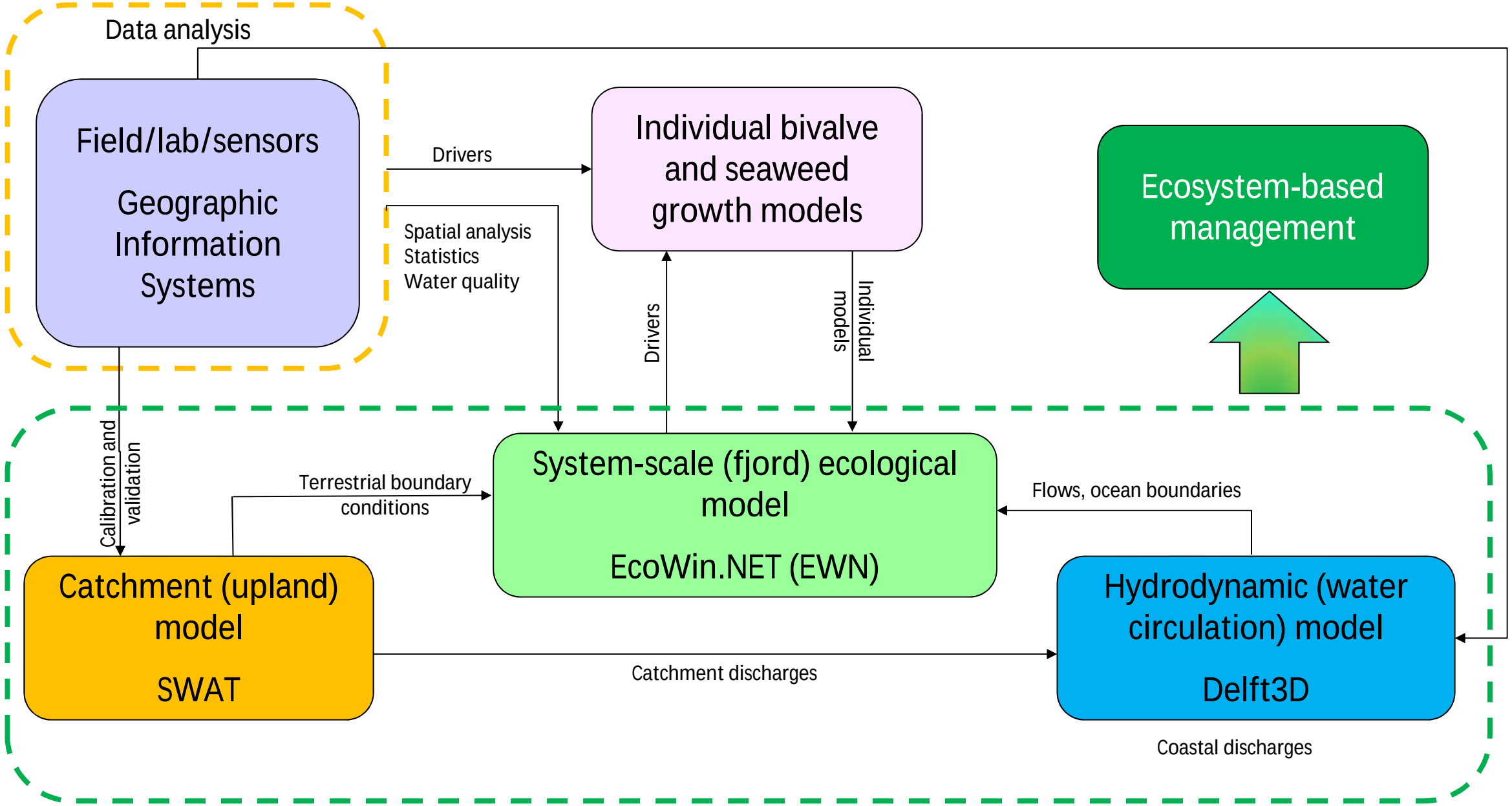


Water managers must deal with systems that are constantly changing.

If there is a nutrient problem—how can we fix it?

- We must fix the problem together as a society, we cannot fix it by moving agriculture abroad
- We must choose the correct approach: if it's a hard question, let us look at less simple answers

A bulk reduction of nitrogen is unlikely to succeed, a regional approach for a range of catchments would help to understand what works where



SUCCESS framework – models for integrated management

Why use a modelling framework?

- **Scenario Analysis**: Modelling enable assessment of the impact of multiple scenarios before implementing costly (socially and economically) measures, ensuring informed decision-making.

- **Load estimation:** Models can estimate data in areas and times where direct measurement is not possible, enabling accurate predictions and reducing data gaps.

- **Understanding of processes:** Models help in identifying and quantifying the key processes that drive ecosystem dynamics, leading to a better understanding of ecosystem status and informing conservation strategies.

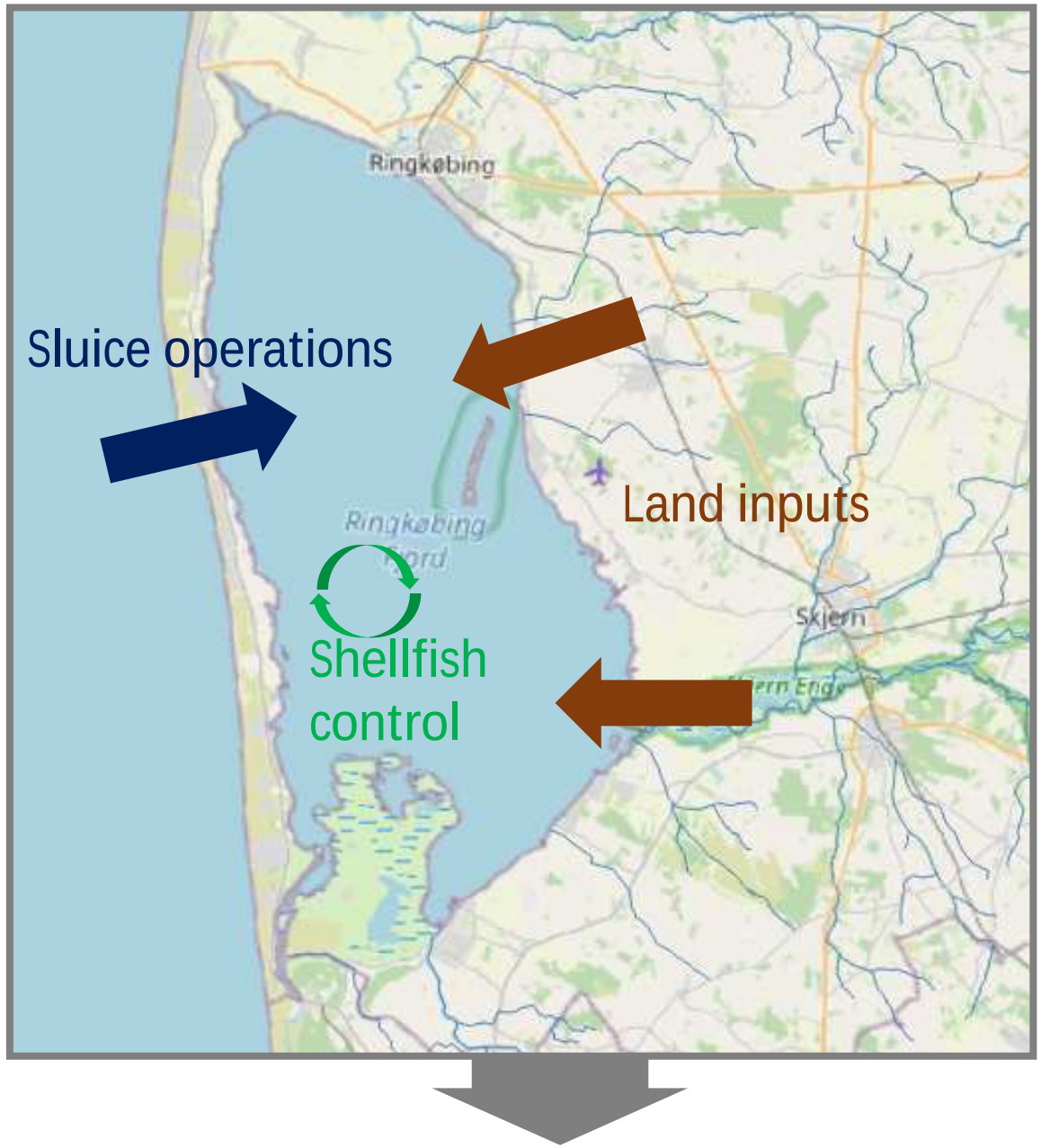
A comprehensive approach to connect all the elements: land inputs, fjord hydrodynamics and ecosystem, connection between the fjord and the North Sea.

Expected outcomes

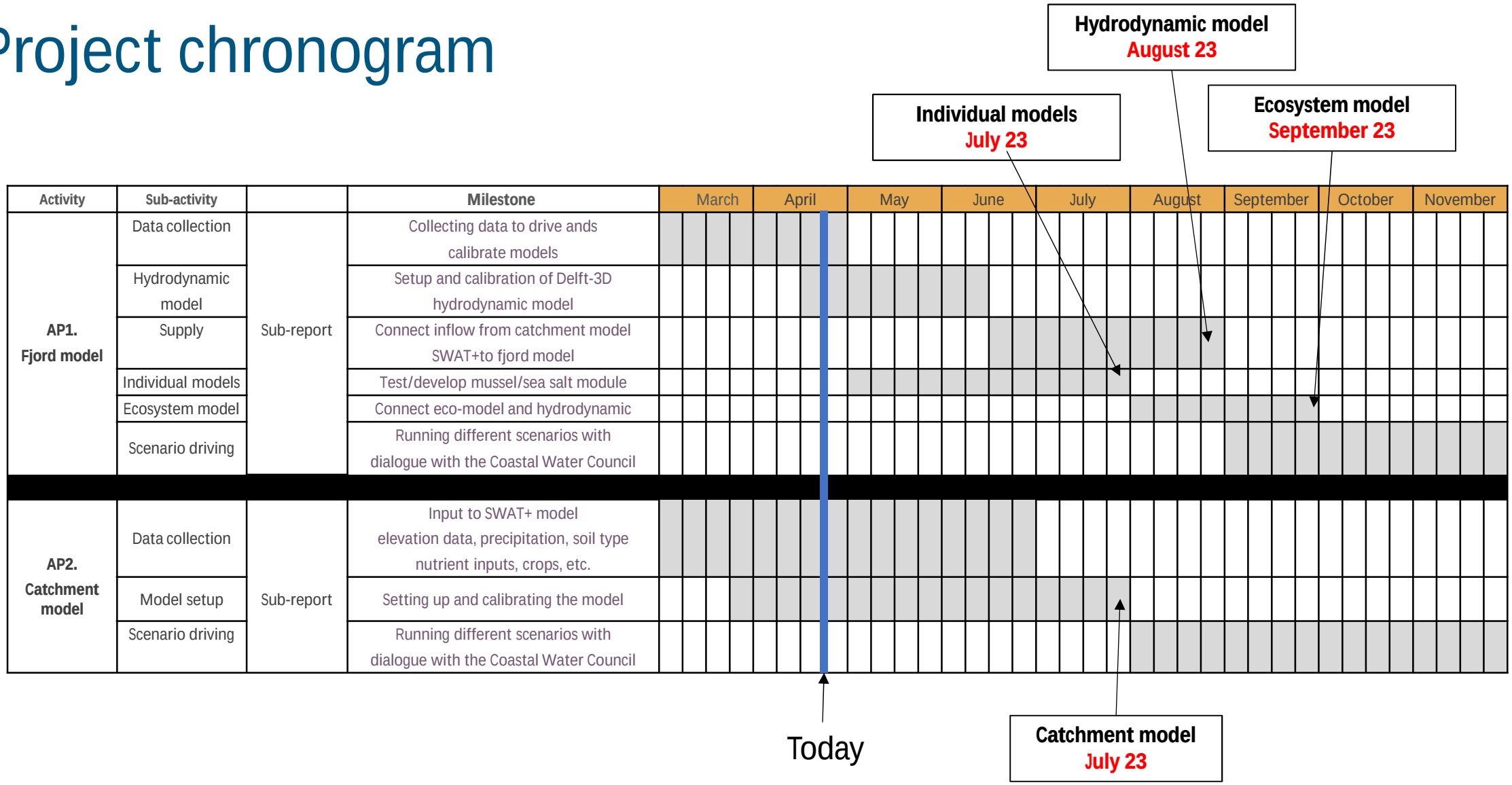
- Better understanding of the Ringkøbing Fjord ecosystem:
  - Sources and fluxes of nutrients
  - Transformation rates
  - Eutrophication control by shellfish

- Impact of mitigation practices on WFD classification:
  - Land management
  - Sluice operations
  - Shellfish density

- The model will support policy makers in making informed decisions about ecosystem management and resource allocation.



Project chronogram



Activity	Sub-activity		Milestone	March	April	May	June	July	August	September	October	November
AP1. Fjord model	Data collection	Sub-report	Collecting data to drive ands calibrate models									
	Hydrodynamic model		Setup and calibration of Delft-3D hydrodynamic model									
	Supply		Connect inflow from catchment model SWAT+to fjord model									
	Individual models		Test/develop mussel/sea salt module									
	Ecosystem model		Connect eco-model and hydrodynamic									
	Scenario driving		Running different scenarios with dialogue with the Coastal Water Council									
AP2. Catchment model	Data collection	Sub-report	Input to SWAT+ model elevation data, precipitation, soil type nutrient inputs, crops, etc.									
	Model setup		Setting up and calibrating the model									
	Scenario driving		Running different scenarios with dialogue with the Coastal Water Council									

Regular meeting every 1-2 months with the coastal board to check on progress

Coastal Water Council - Stakeholder Board Meeting

Ringkøbing, April 21st, 2023

Catchment modelling

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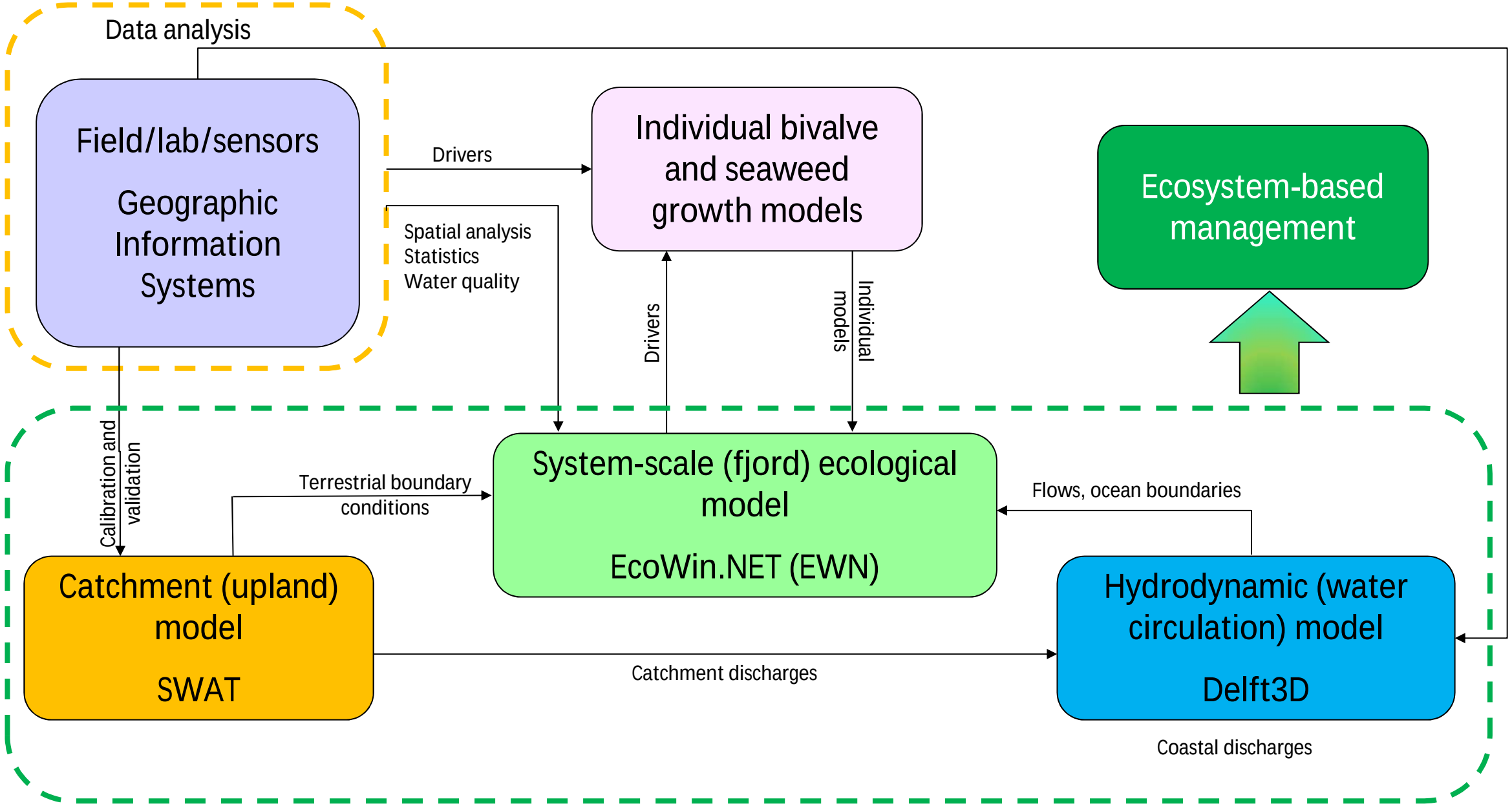


SUCCESS framework – models for integrated management

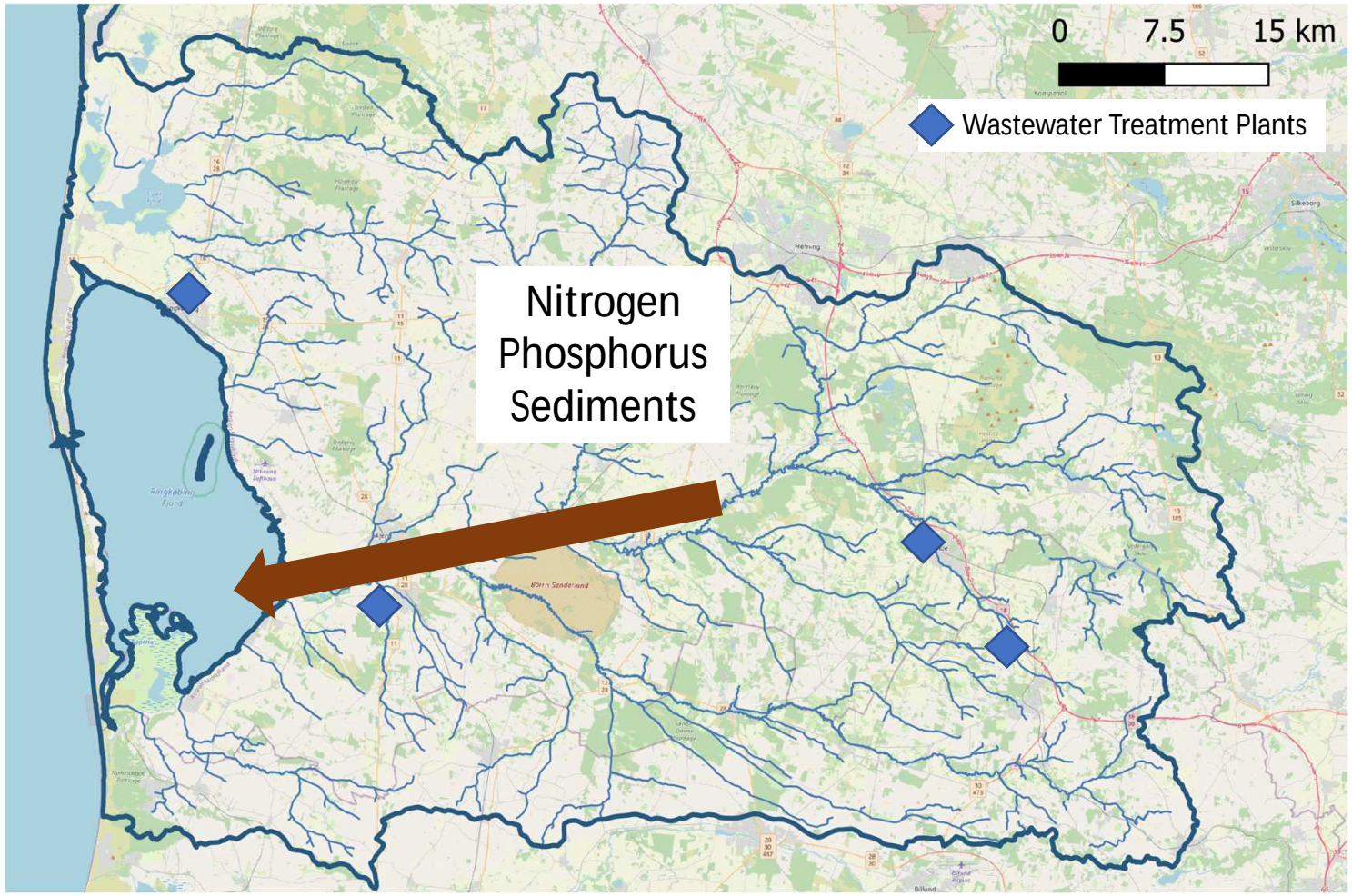
Objectives

Simulate loads entering Ringkøbing Fjord system:

- Water
- Sediments
- Nutrients (Nitrogen and Phosphorus)

Taking into account:

- Real agricultural practices
- Urban sources (wastewater treatment plants)
- Groundwater fluxes
- Other sources (bank erosion)

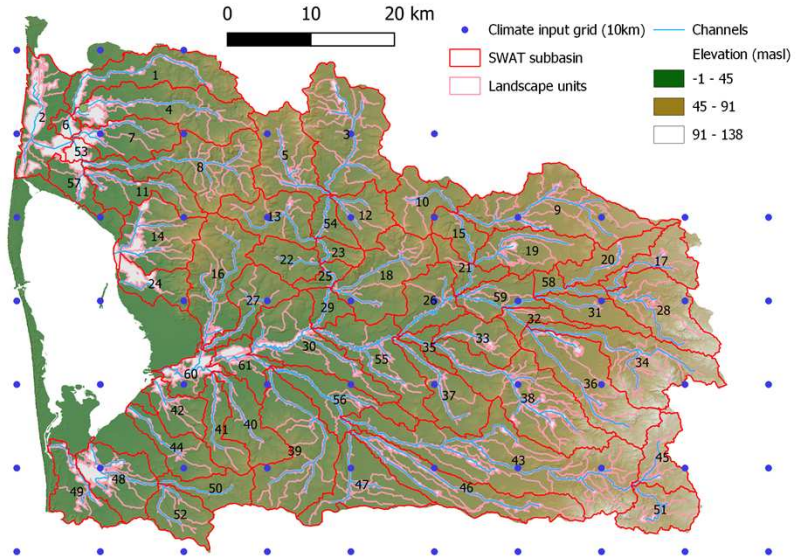


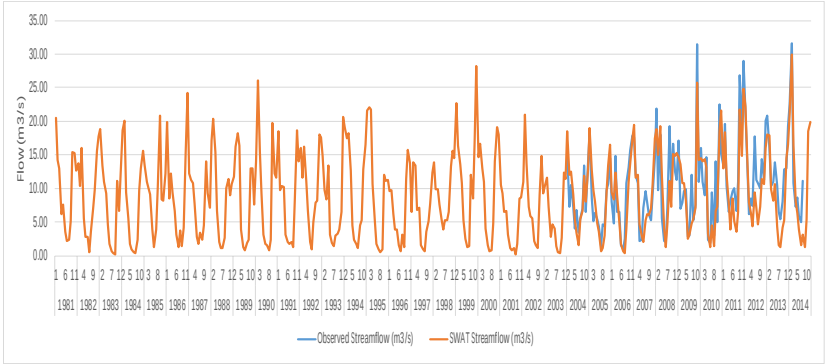
Catchment model: SWAT+

- SWAT = Soil and Water Assessment Tool

- Eco-hydrological model (USDA)
  - Semi-distributed (spatially)
  - Physically based
  - Continuous daily outputs

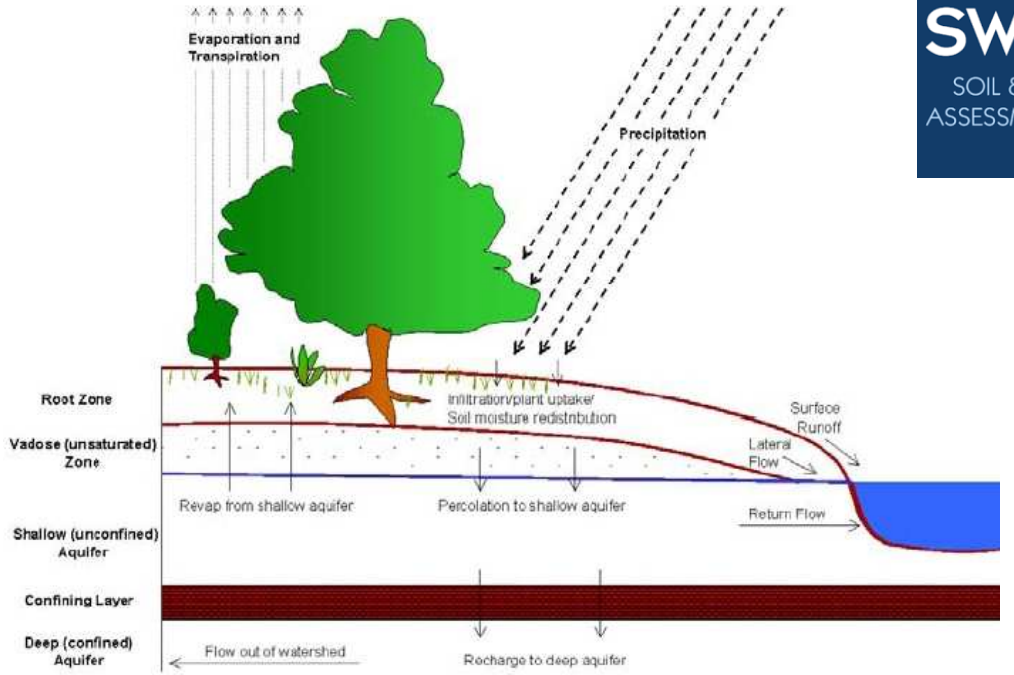
- A tool
  - simulate the quality and quantity of surface and groundwater
  - predict the environmental impact of land use, land management practices, and climate change.

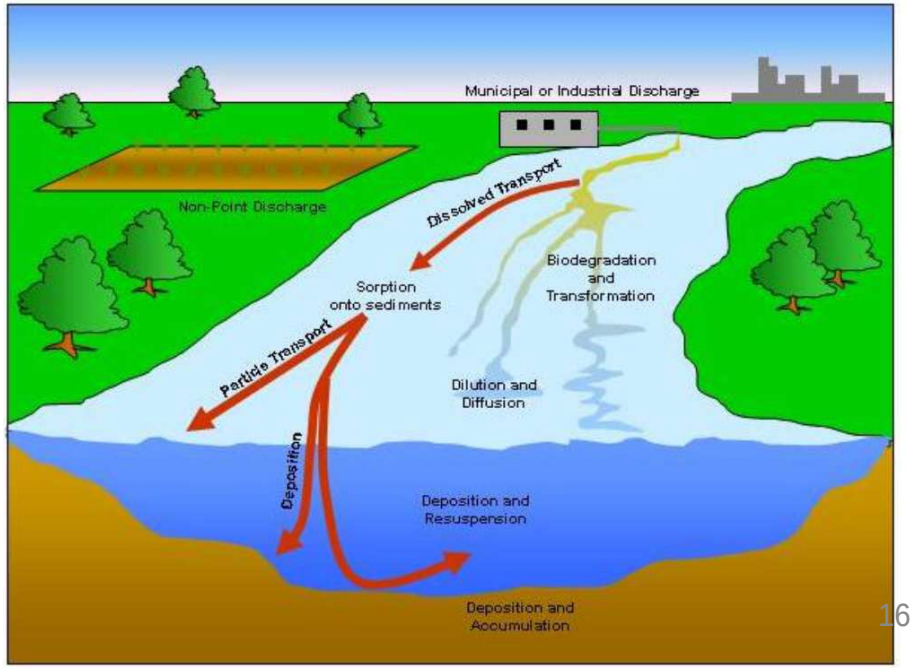




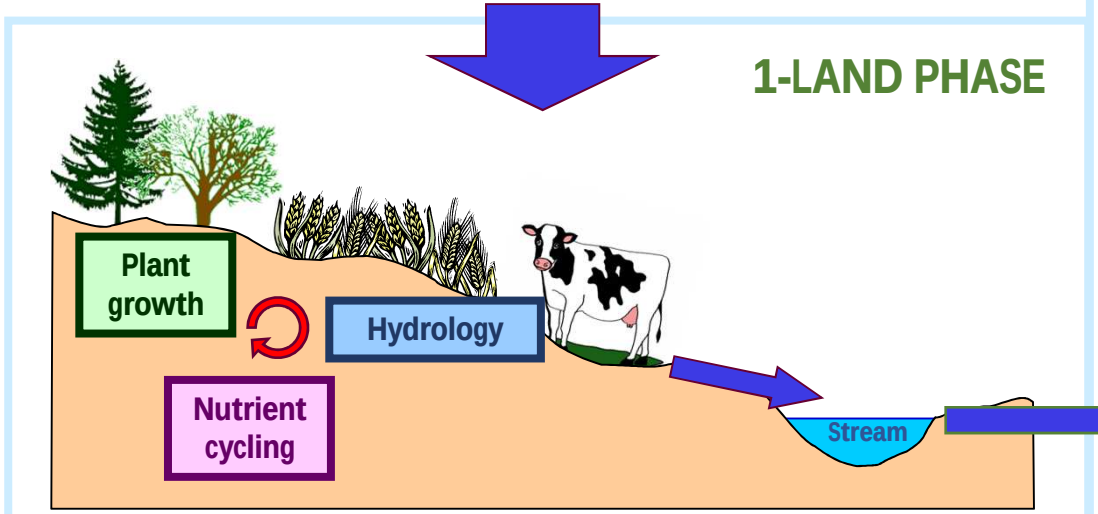
What does it simulate?

- Water balance
  - Surface runoff, Soil water, Groundwater fluxes
- Water quality
  - Nutrients (N,P) /Pesticides/Bacteria/Carbon cycles
  - Algae/oxygen in streams
- Erosion and Sediment transport
- Vegetation growth
- Management practices
  - crops (irrigation, fertilization, harvest, grazing)
  - urban areas, septic tanks, filter strips
- Reservoirs/lakes

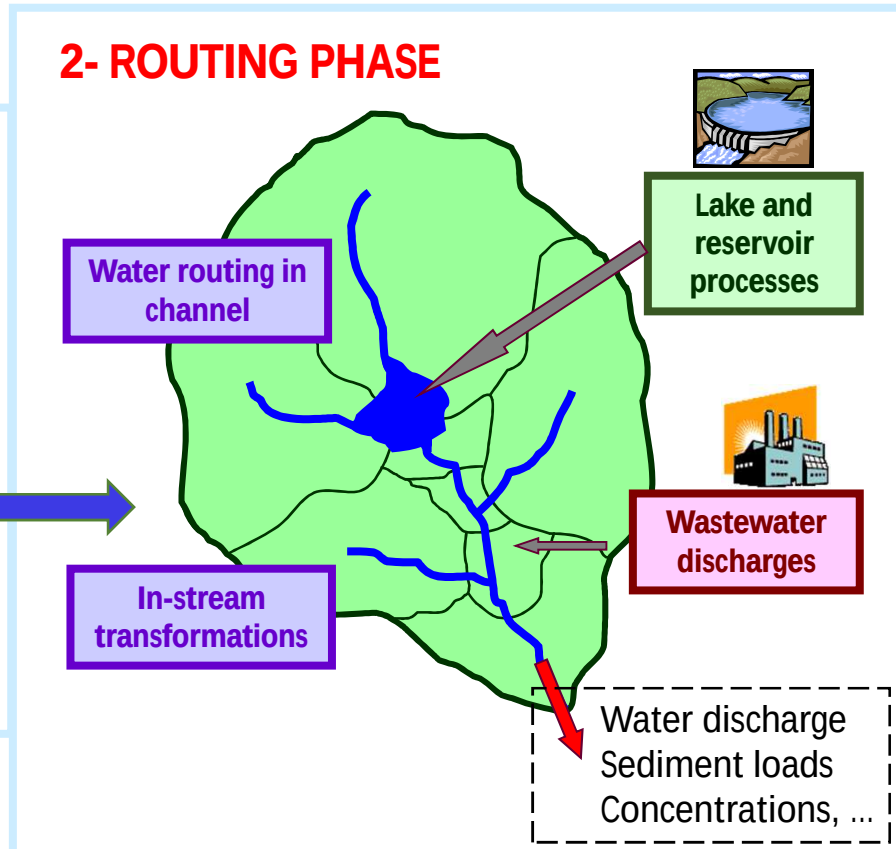




Model structure



Simulation of nutrients loads at the field scale.



Simulation of water and nutrients circulation at the catchment (Afvandingsområde) scale.

Data requirements

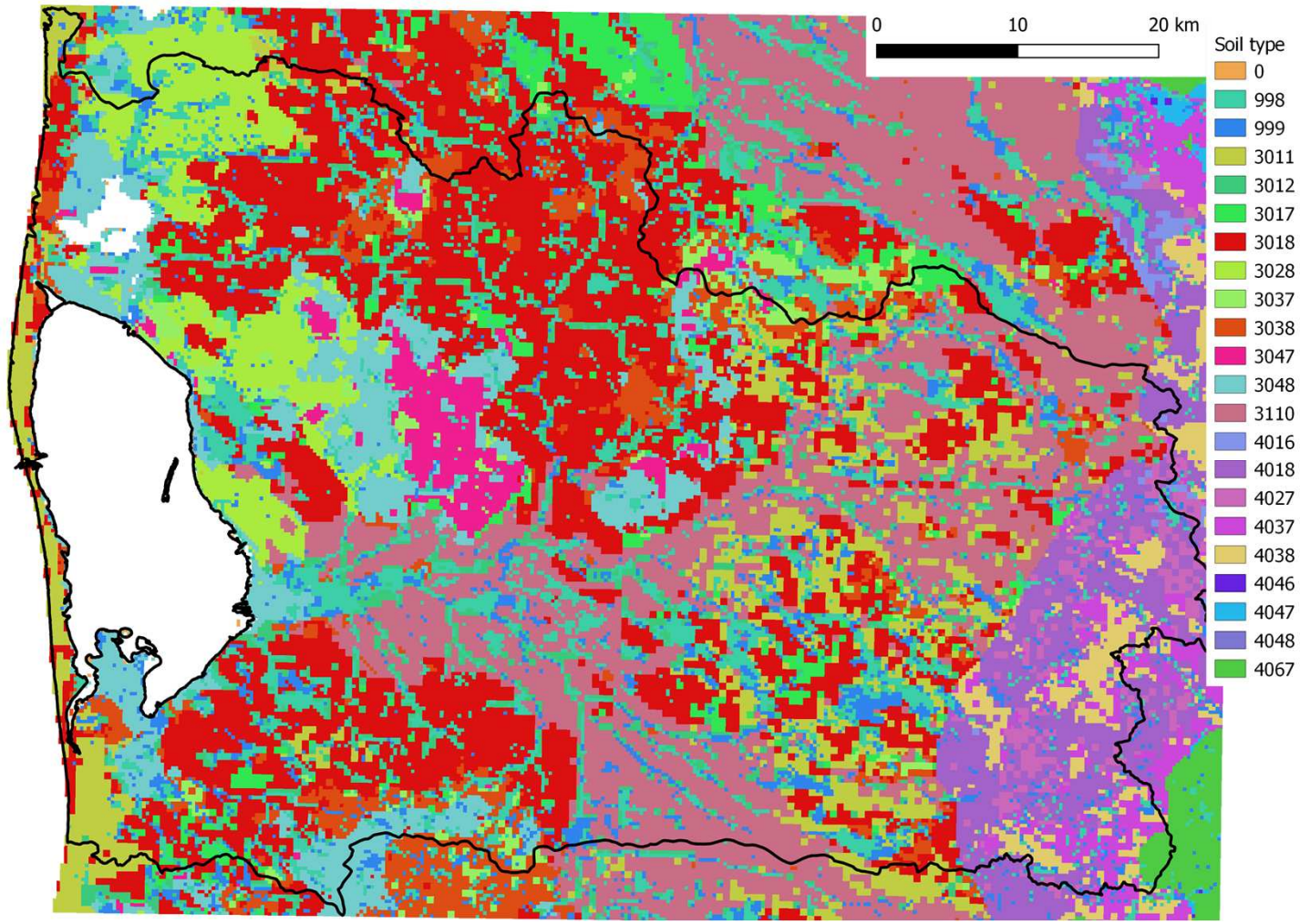
The model is developped based on the best available data:

Status	Dataset	Rationale
Completed	Elevation map	Model driver
Completed	Soil map	Model driver
Completed	Land use map	Model driver
In progress	Agricultural practices	Model driver
Completed	Daily meteorological data	Model driver
Completed	Observed streamflow (Vandføring)	Calibration/Validation
Completed	Observed water quality (nitrogen and phosphorus concentrations)	Calibration/Validation

Information processed by the model

Information used for the tuning of the model and its verification

Ringkøbing catchment: soil type



Good information on soil type

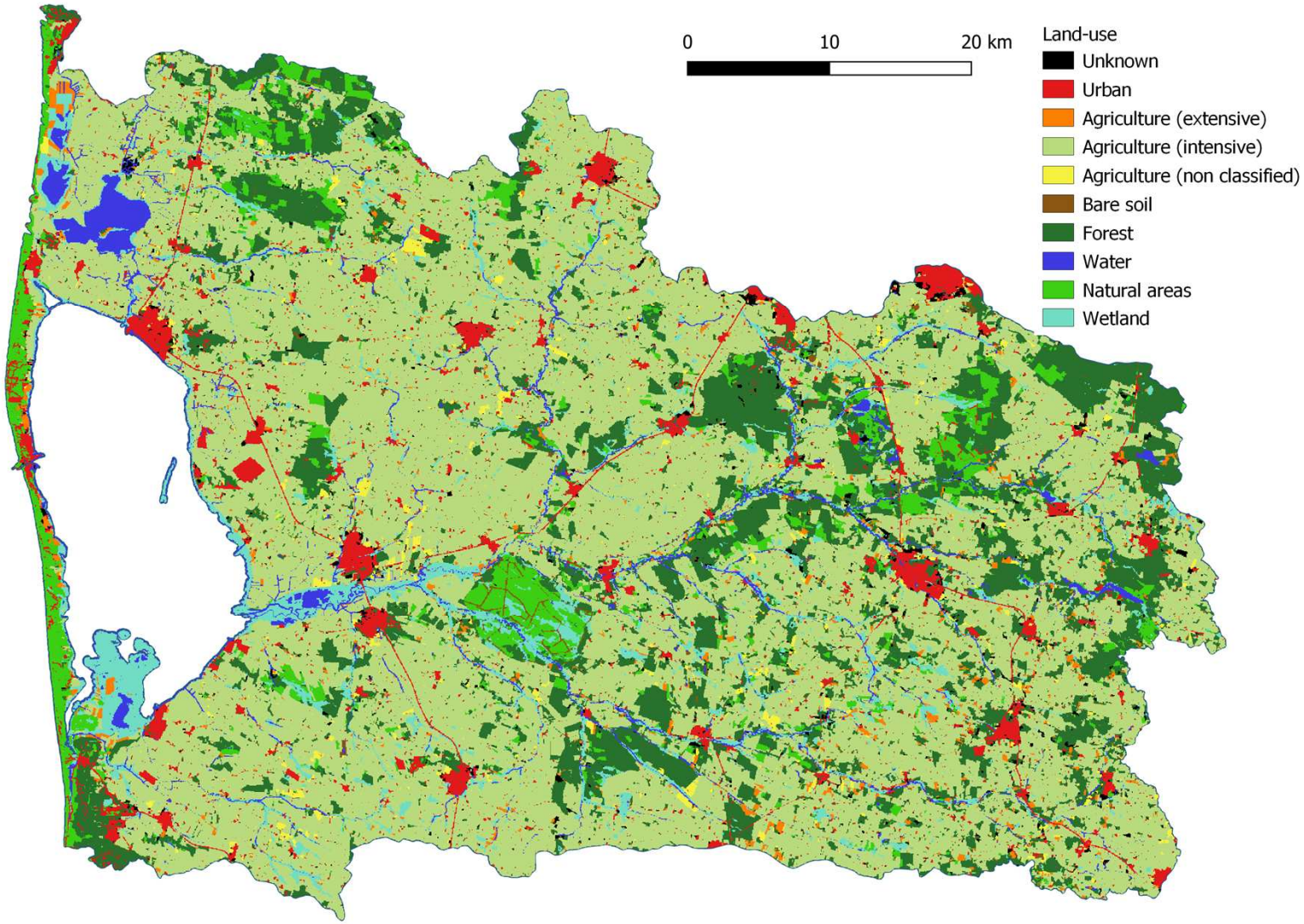
DK3018	27%	Sandy	72%
DK3110	16%		
DK999	15%	Wetland soils	
DK3048	7%	Sandy-clay	
DK3011	7%	Sandy	

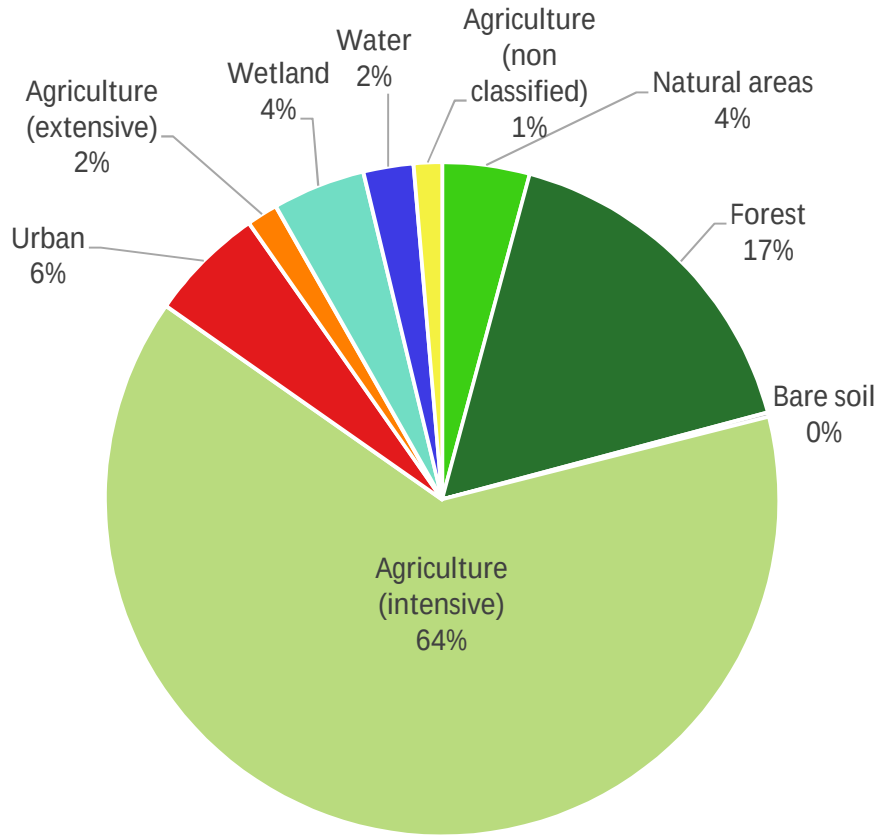
For each type of soil, we have information on its physical properties:

- Depth
- Texture (sand, silt, clay)
- Water retention
- Permeability

Total area: 324642 ha (3246 km^2)

Ringkøbing catchment: land use

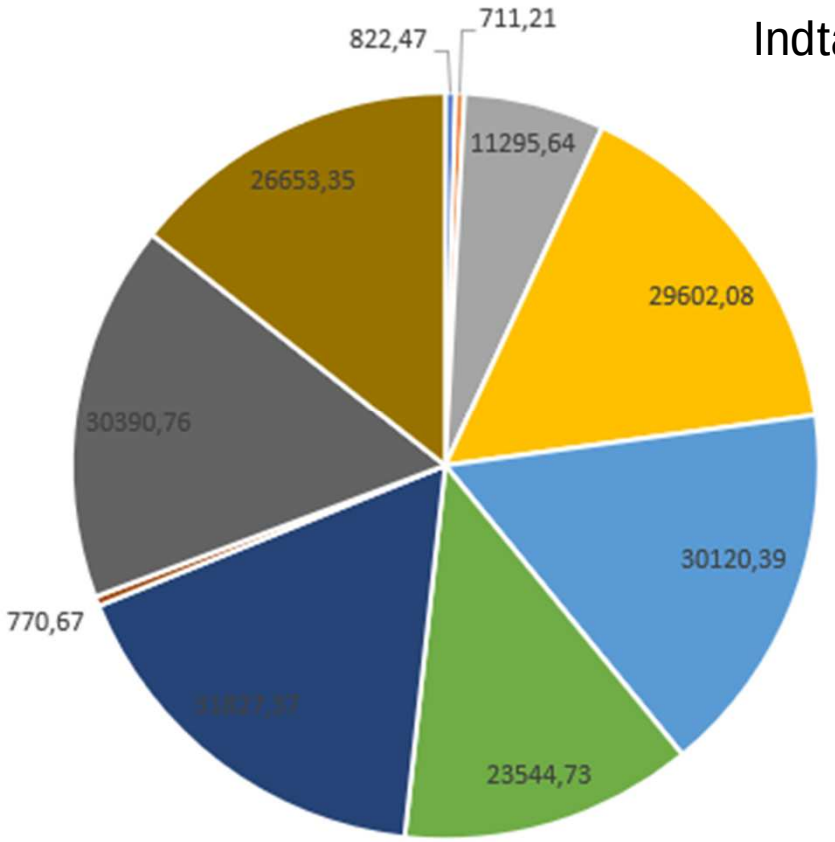




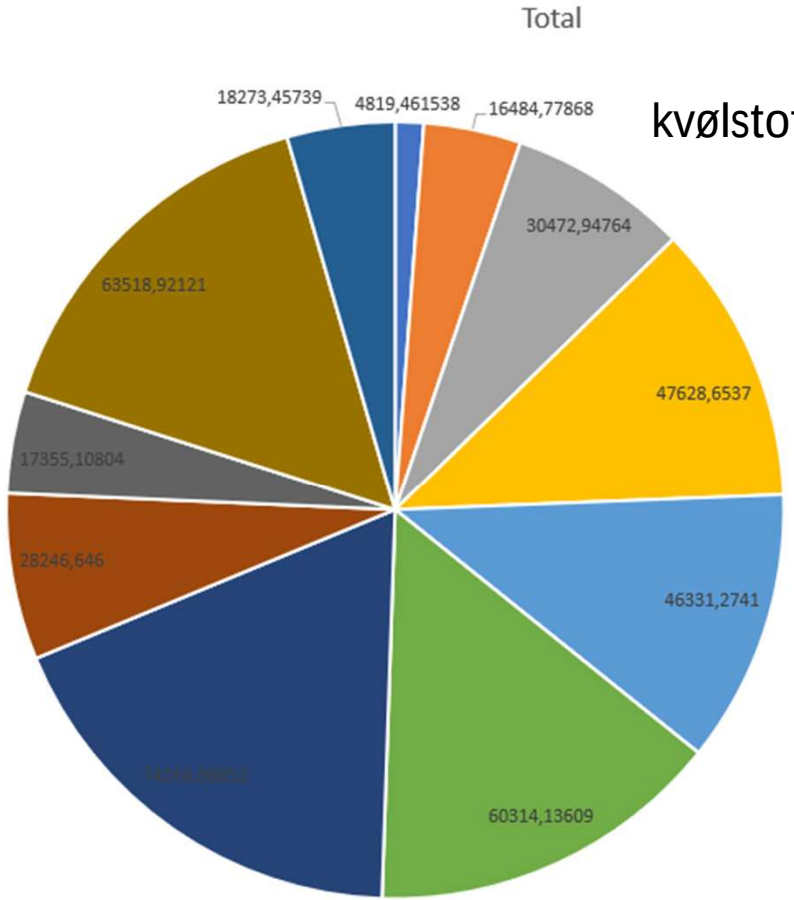
Total area: 324642 ha (3246 km^2)

VP2b2013 Arealanvendelse

Agricultural practices



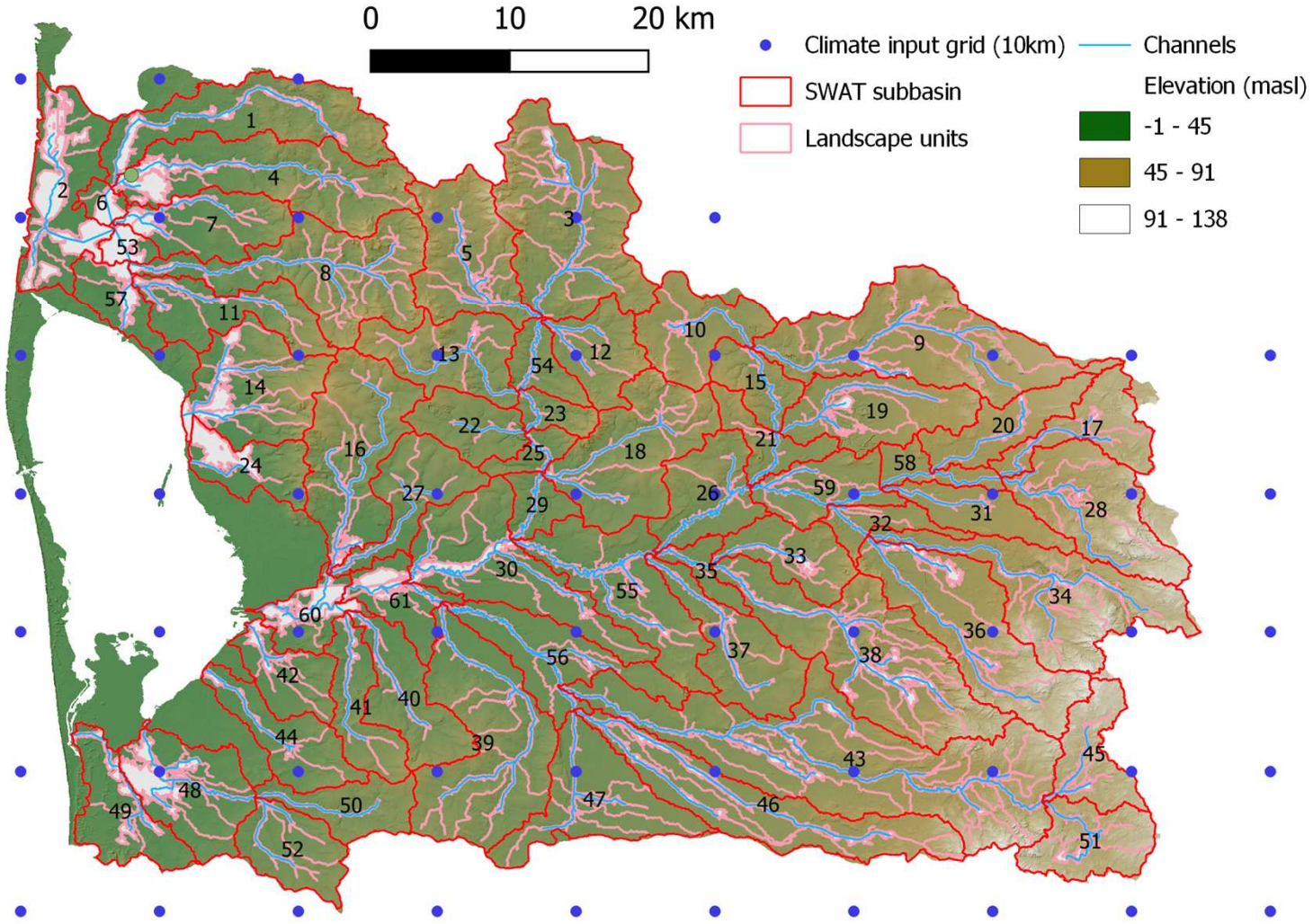
Indtareal



kvølstofforbrug

Need information from local farmers to implement real agricultural practices (crop rotation, fertliser application)

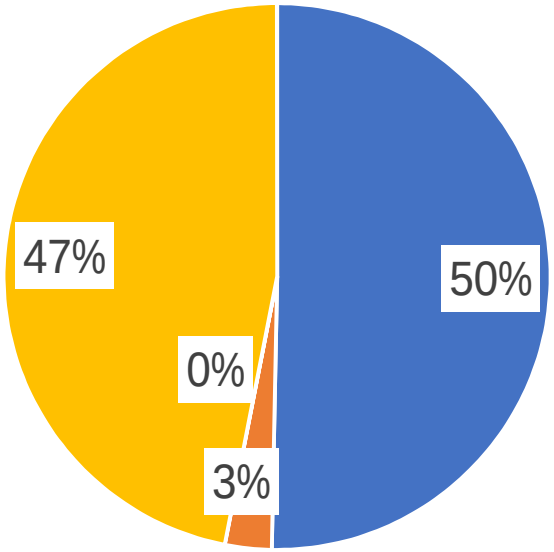
Model setup



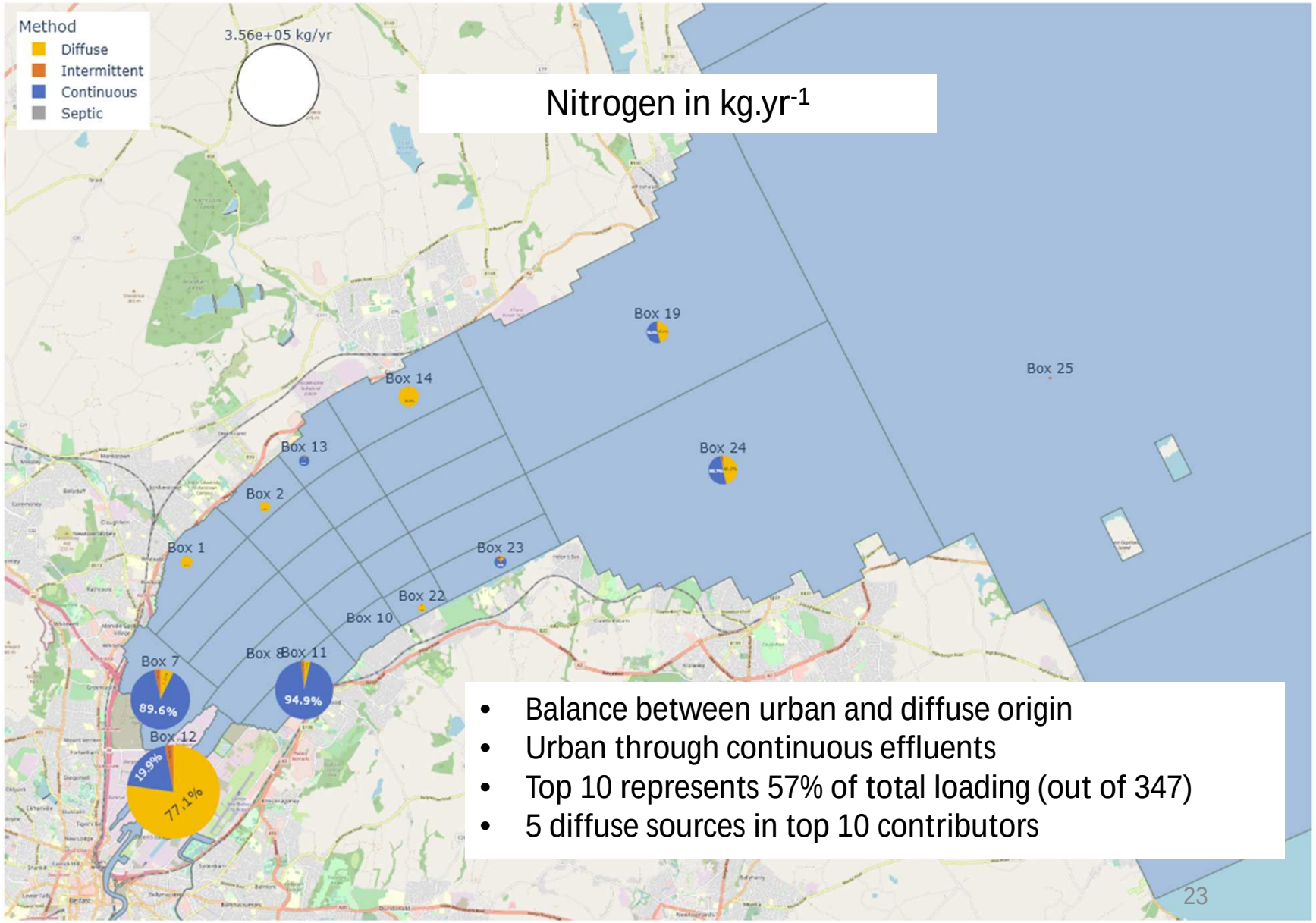
Delineation characteristics:

- 61 subbasins
- 189 channels
- 3814 HRUs (field scale)
- 9 discharge points into the Fjord

Example of source apportionment (Belfast, UK)



- Continuous (FEs)
- Intermittent (CSOs) — urban
- Septic Tanks
- Diffuse → agriculture



- Balance between urban and diffuse origin
- Urban through continuous effluents
- Top 10 represents 57% of total loading (out of 347)
- 5 diffuse sources in top 10 contributors

Potential for scenarios – catchment model

- Agricultural practices
  - Crop rotation
  - Fertiliser inputs (timing, quantities, composition)
  - Grazing (stocking densities, calendar)
  - Irrigation

- Land use change
  - Wetlands restoration

Scenarios have the potential to impact the catchment model in different ways, and it is essential to study their effects to develop sustainable and resilient water management strategies.

Conclusions and next steps

- The catchment model is developed for Ringkøbing catchment in order to estimate nutrient loads entering the fjord.
- The model will take into account the various land-uses and management practices and can be used for estimating the impact of scenarios related to land management.
- The model is setup, the next step is the calibration: tuning of the model and verification that simulated results correspond to the observations.

Discussion: scenarios for the ecosystem modelling framework

- Three types of scenarios
  - Catchment scenarios (agriculture practices, wetland restoration)
  - Sluice practices scenarios (connection with the North Sea)
  - Shellfish control scenarios

- Only a limited number of scenarios can be run during the project. The models will be made available to the project partners to allow different scenarios to be analyzed.

Spare slides


Kystvande
Stærkt modificerede vandområder
Naturlige vandområder
Aalborg
Aars
Skive
Viborg
Rønders
Struer
Holstebro
Herning
Silkeborg
Ringkøbing
Ikast
Grindsted
Vejle
Kolding
Varde
Odense
Ribe
Nyborg
Vojens
Tønder
Flensburg
Kappeln
Schleswig
Slagelse
Ringsted
Roskilde
Helsingør
Hillerød
Helsingborg
Malmö
Lund
Landskrona
Trelleborg
Ystad
Ängelholm
Halmstad
Falkenberg
Ljungby
Växjö
Värnamo
Gislaved
Jönköping
Nybro
Karlskrona
Rønne
ETRS89 ØST / Nord
179915.0 ,6423146.3
WGS84 Bredde / Længde

Metadata review

Summary (2015-2020)

Year	Catchment loadings	Sluice inflow	Fjord nutrients	Fjord benthic (Mya arenaria)	Fjord CTD	Fjord particulate	Boundaries nutrients	Boundaries particulate
2015	wettest year							no data
2016			low N, no P data	less data			No P data	no data
2017						no data		no data
2018	dryest year					no data		no data
2019			very high Chla	low density	lowest salinity, high fluorescence	no data		no data
2020	wet, large peakflow	missing data			highest salinity	no data		no data

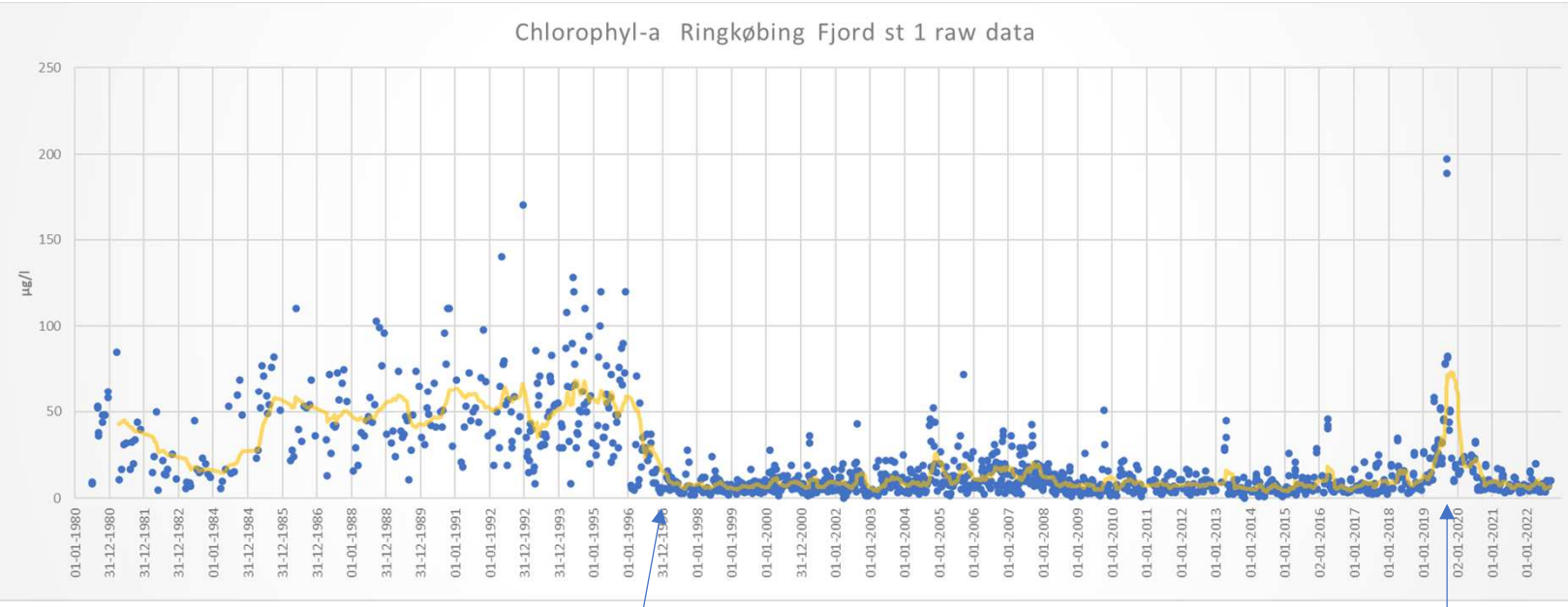
1 – Model development

- Loop over the same year during 10 years to ensure stability of the model
- Select the most “average” year to represent the typical system behaviour and the year with sufficient data available for model setup and calibration/validation: **2017**

2 – Model application

- The model can be use to explore the impact of different scenarios (catchment loadings, sluice inflow, trophic control);
- and can be run for a specific year (2019) to analyse specific ecosystem interactions.

Algal bloom - 2019



1997: new sluice practices

2019: Algal bloom

- Low salinity
- Death of *Mya arenaria*
- No nutrients removal
- Algal bloom