Systems Approach Framework
System Design

Josianne G. Støttrup
Grete E. Dinesen

jgs@aqua.dtu.dk

www.baltcoast.net

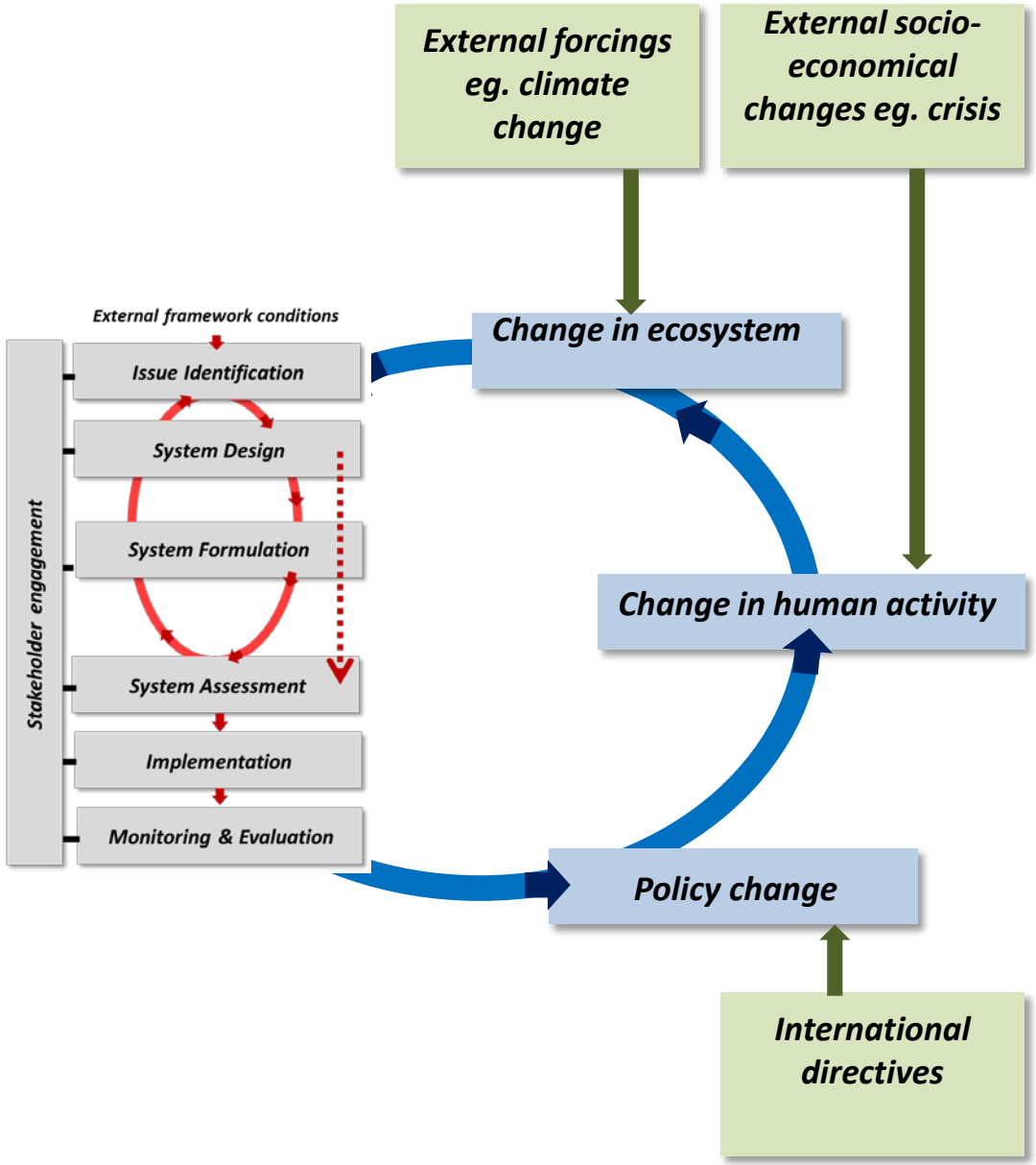
A SYSTEM APPROACH FRAMEWORK FOR COASTAL RESEARCH & MANAGEMENT

BONUS-BaltCoast received funding from BONUS (Art 185), funded jointly by the EU and Baltic Sea national funding institutions

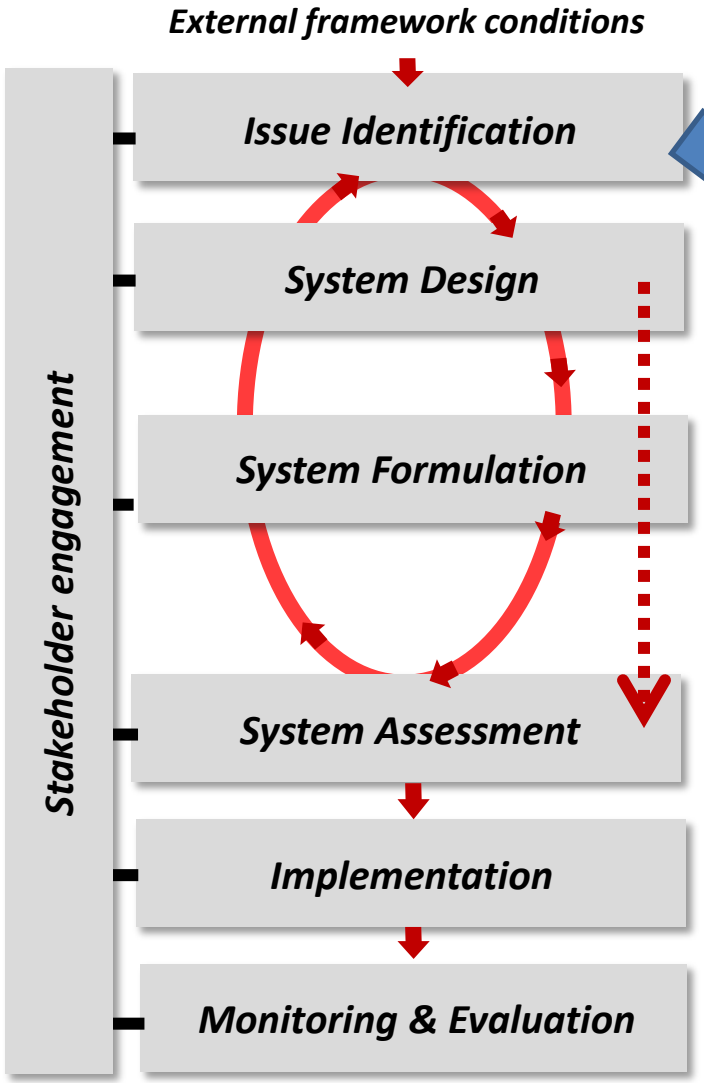
Systems Approach Framework

The SAF ICM loop:

SAF with the ESE assessment

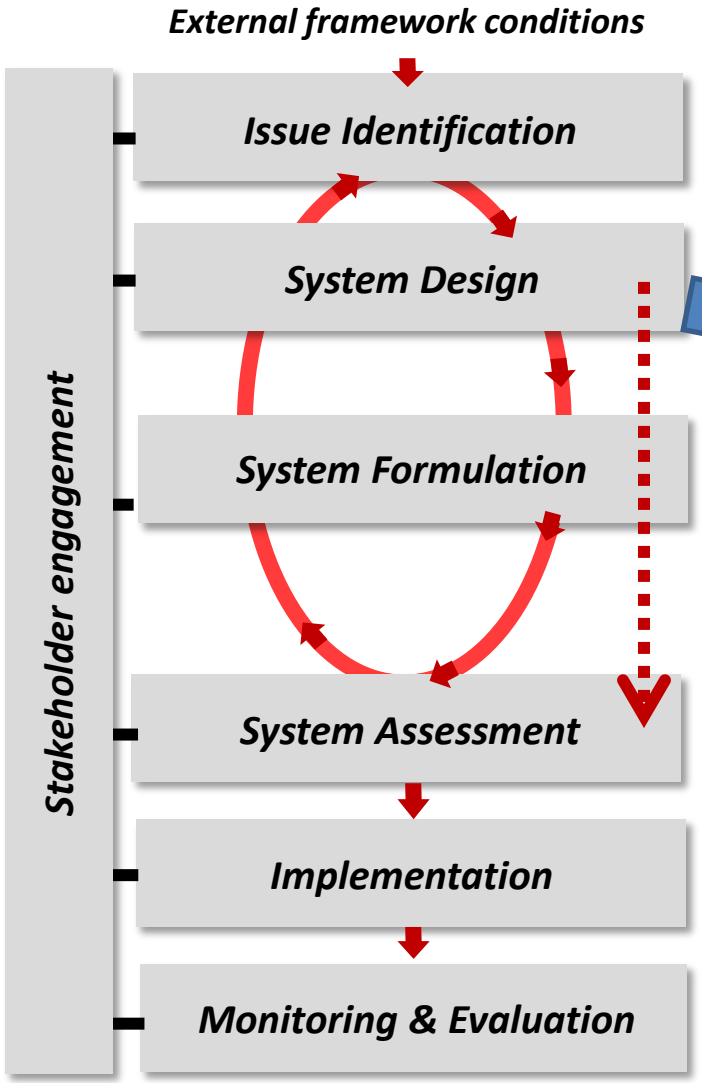


SAF - Issue Identification



- list human activities;
- map institutions and stakeholders;
- list Ecosystem Service;
- engage stakeholders (SH) and conduct consultations;
- map SH preferences;
- prioritise and ID/select issues;
- identify relevant social, economic, environmental components and dependencies (DPSIR, CATWOE).
- history of previous consultation or development

SAF - System Design



- develop a conceptual model;
- assess data availability and model resources;
- re-visit selected issue(s);

IF data is available:

- define administrative and virtual system boundaries and ESE linkages;
- define success criteria and indicators;
- assess the system state (Sustainability & Ecosystem Services);
- discuss and select potential scenarios with stakeholders;
- identify external hazards;

SAF - System Design

Develop a conceptual model

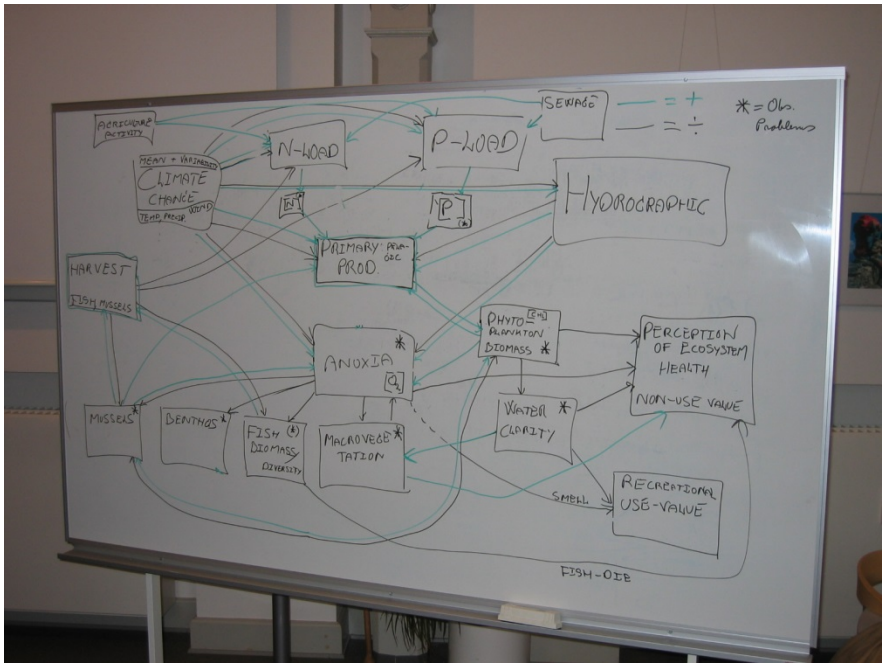
- draw up a conceptual model
- define the virtual system (geographic, economic, social and administrative boundaries)
- problem scaling
- linkages between the three ESE components

SAF - System Design

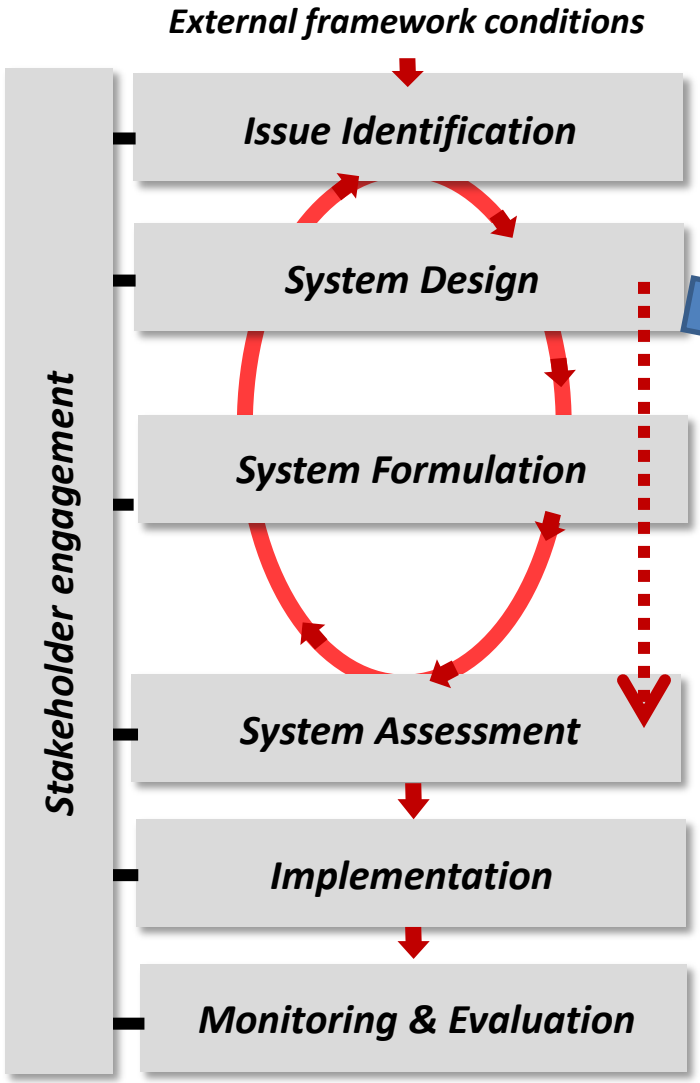
Drafting a conceptual model.

The first draft can be drawn on a whiteboard, back of a serviette, etc. Try to identify all state variables and processes for the Issue

Start to identify data availability



SAF - System Design



- develop a conceptual model;
- assess data availability and model resources;
- re-visit selected issue(s);

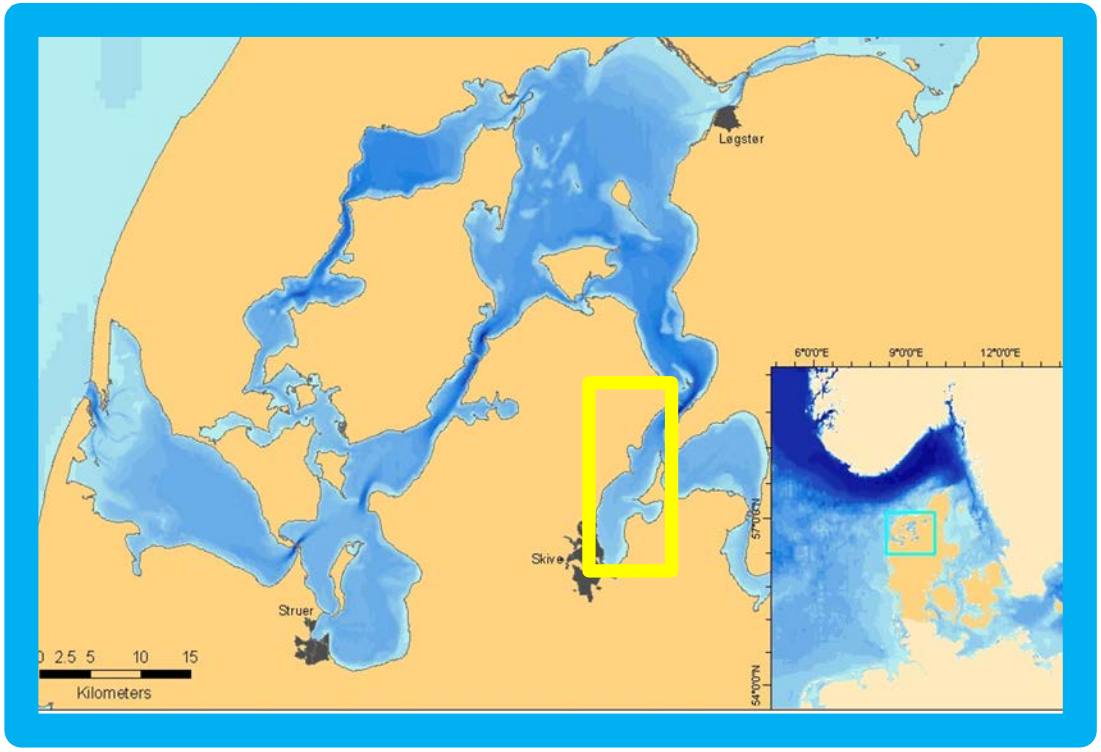
IF data is available:

- define administrative and virtual system boundaries and ESE linkages;
- define success criteria and indicators;
- assess the system state (Sustainability & Ecosystem Services);
- discuss and select potential scenarios with stakeholders;
- identify external hazards;

SAF - System Design

- **Define administrative and virtual system boundaries and ESE linkages**. Data availability may affect the definition of system boundaries.

- EXAMPLE: Data would need to be scaled down to the level of the ecological component, if the ecological component cannot be at the same scale as the



Geographic & virtual System

The Whole Fjord: Social & Economic components

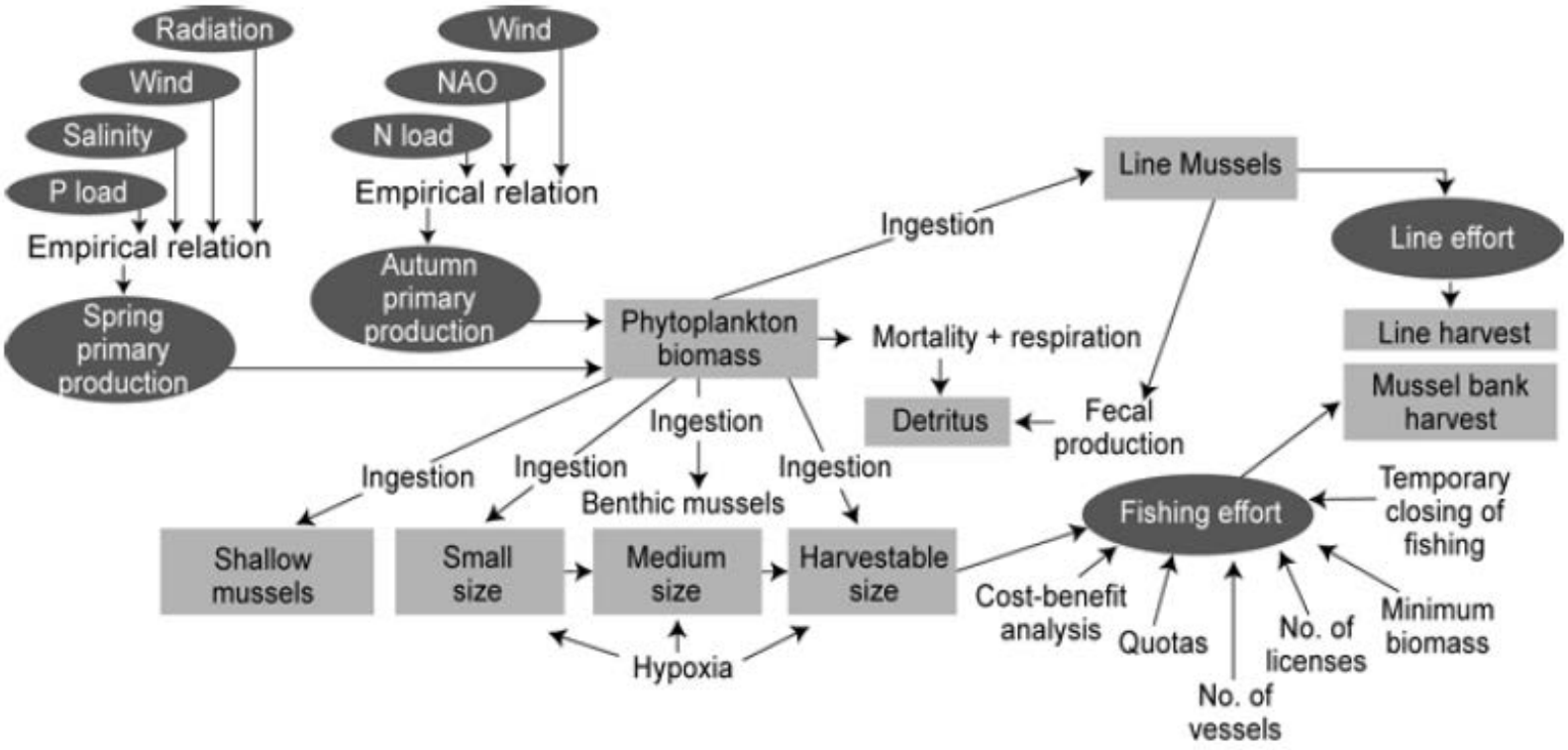
Skive Fjord: Ecological component

Dinesen, Støttrup et al. 2011

SAF - System Design

- Define state variables – check data availability – these are the grey boxes in the example below
- Define processes – circles and arrows in example

Fig. 2. Conceptual diagram of the bioeconomic model. Gray boxes represent state variables; circles and arrows represent processes.

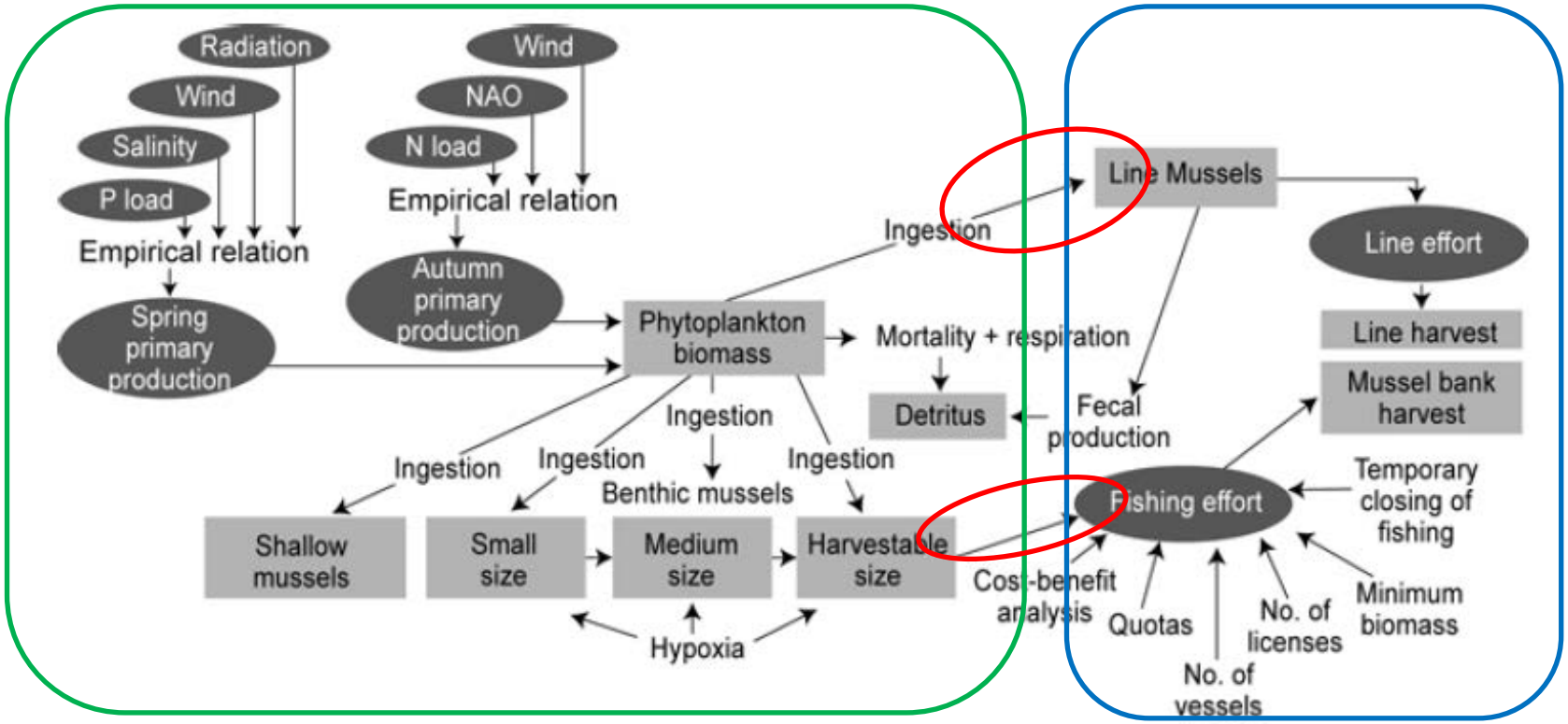


Dinesen, Støttrup et al. 2011
Timmermann, Dinesen, Støttrup et al. 2014

SAF - System Design

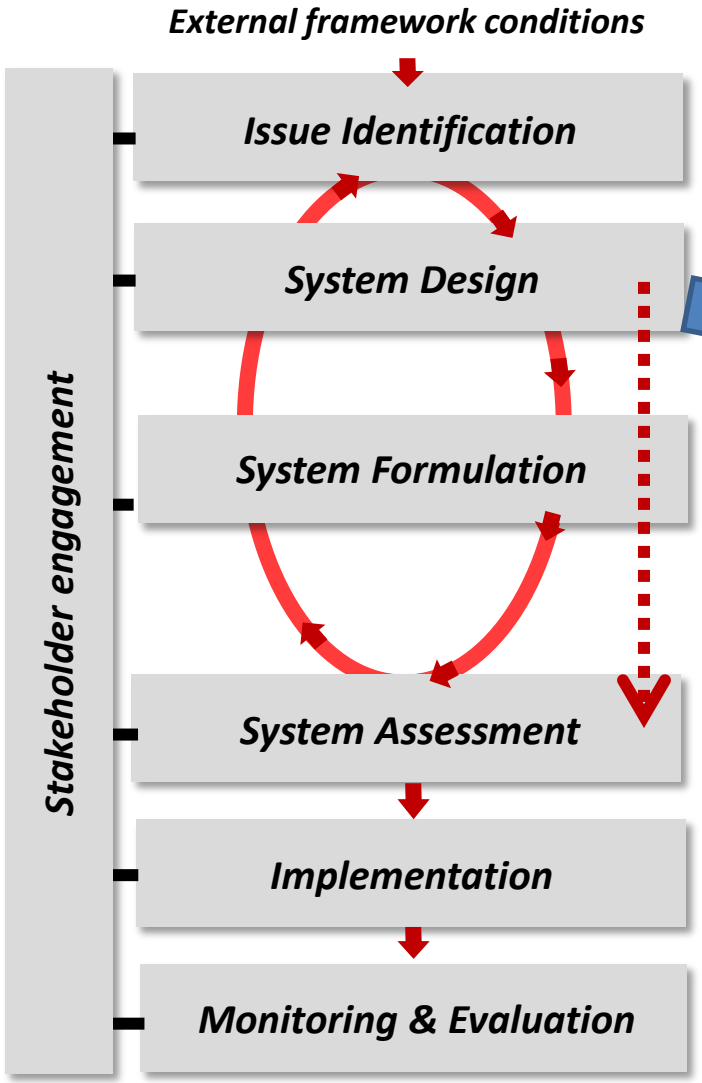
- **Define ESE linkages**; links between ecological and economic components

Fig. 2. Conceptual diagram of the bioeconomic model. Gray boxes represent state variables; circles and arrows represent processes.



Dinesen, Støttrup et al. 2011
Timmermann, Dinesen, Støttrup et al. 2014

SAF - System Design



- develop a conceptual model;
- assess data availability and model resources;
- re-visit selected issue(s);

IF data is available:

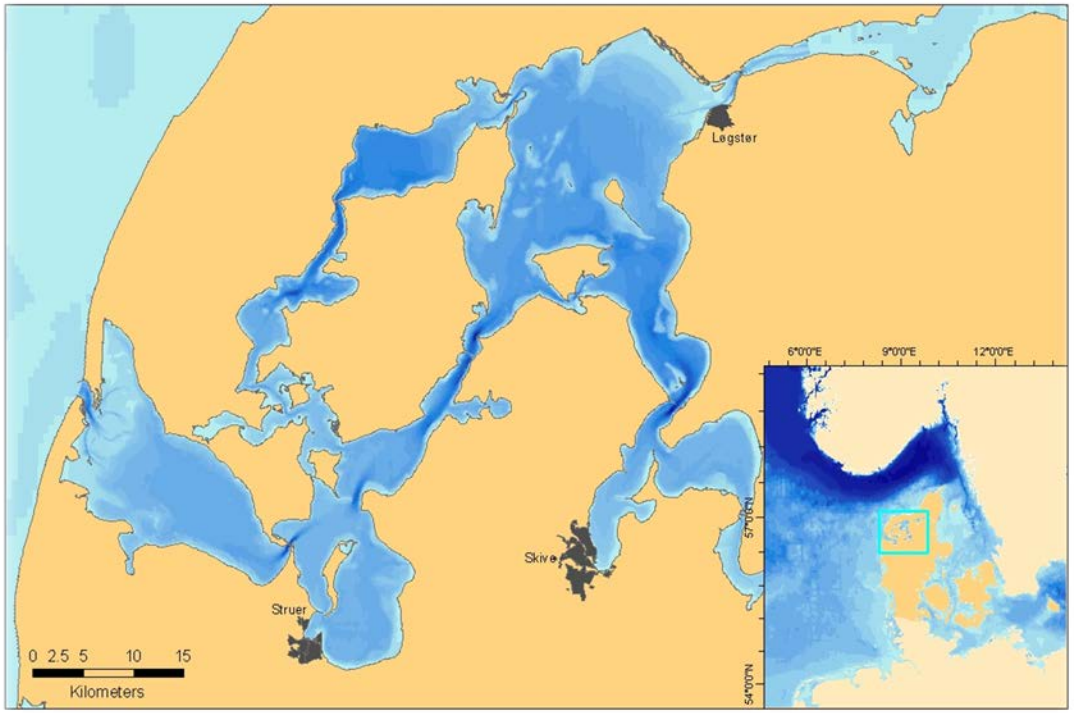
- define administrative and virtual system boundaries and ESE linkages;
- define success criteria and indicators;
- assess the system state (Sustainability & Ecosystem Services);
- discuss and select potential scenarios with stakeholders;
- identify external hazards;

SAF - System Design

- **We need an example: The Limfjord case study: Dinesen et al. 2011**.

What were the Issues her?

1) WFD implementation. How would this impact mussel production in the fjord?
2) NGOs pressing to close mussel fishery with reference to NATURA2000 protection
3) Emerging conflicts between traditional mussel fishers and developing mussel farming



Dinesen, Støttrup et al. 2011
Timmermann, Dinesen, Støttrup et al. 2014

SAF - System Design

- **discuss and select potential scenarios with stakeholders**

What were the **Scenario simuations** chosen by the core group?

1) WFD implementation. How would this impact mussel production in the fjord?

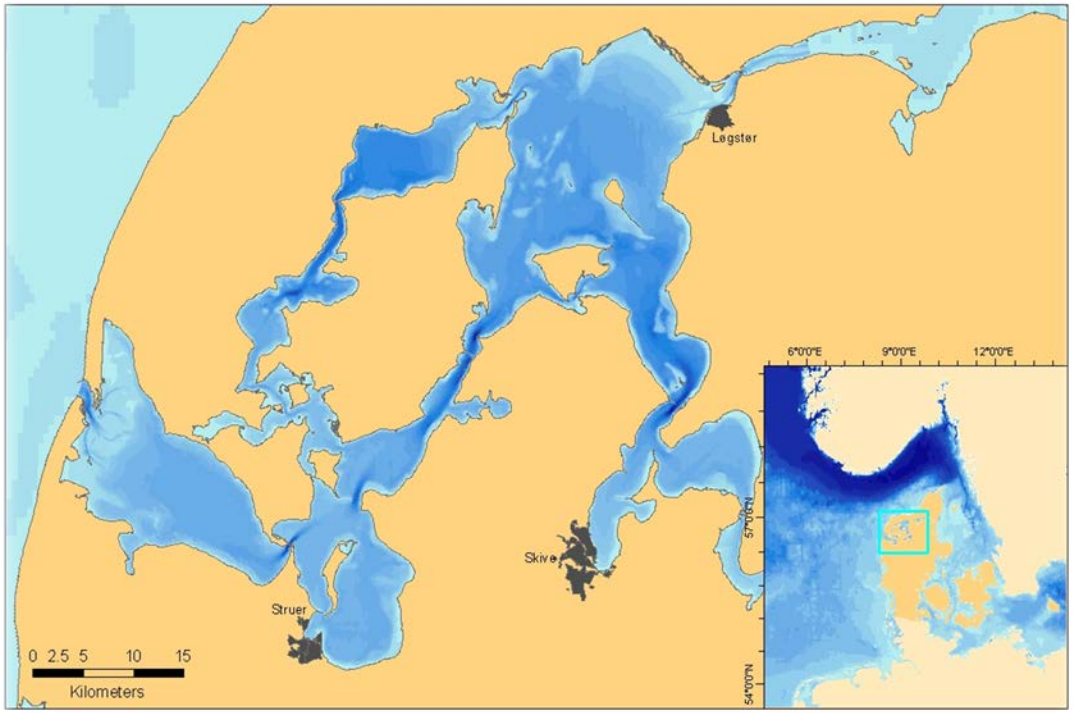
Reductions of total N and P

2) NGOs pressing to close mussel fishery with reference to NATURA2000 protection

Closure of mussel fishery

3) Emerging conflicts between traditional mussel fishers and developing mussel farming

Introduction of mussel farming



The Limfjord case study

Dinesen, Støttrup et al. 2011
Timmermann, Dinesen, Støttrup et al. 2014

SAF - System Design

Define success criteria and indicators.

- This is something we have introduced in Baltcoast recognising the importance of setting goals for any ICM process and having indicators to monitor progress.

- These would be discussed and agreed upon with the stakeholder group and then established by the science team.

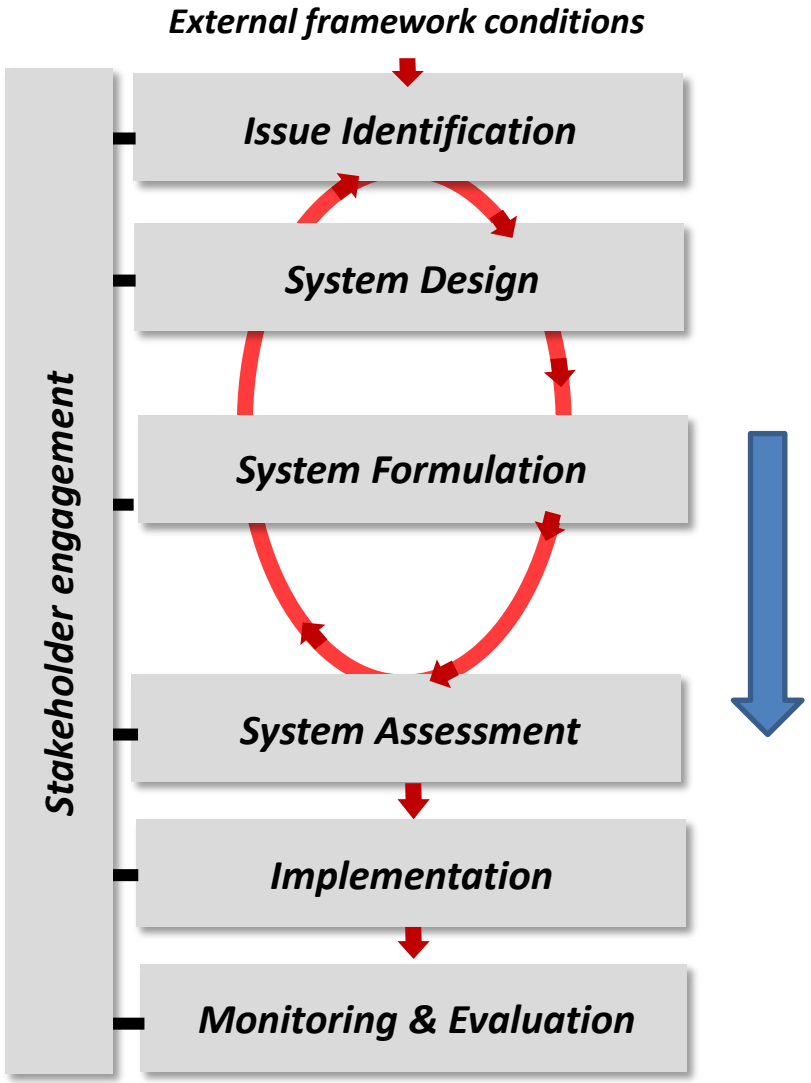
SAF - System Design

Identify external hazards.

In this example they could be:

- hypoxic events
- market prices/demand

Systems Approach Framework



From the System Design one moves down to the next steps.

The next steps will be introduced to you over the next days.

However, to give you a bit of an overview, I will take you through the Limfjord example that completed a SAF through to the System Assessment step

SAF - System Formulation

- Identify and assemble data inputs and variables;

Table 1. Parameter values used in the bioeconomic model simulations.

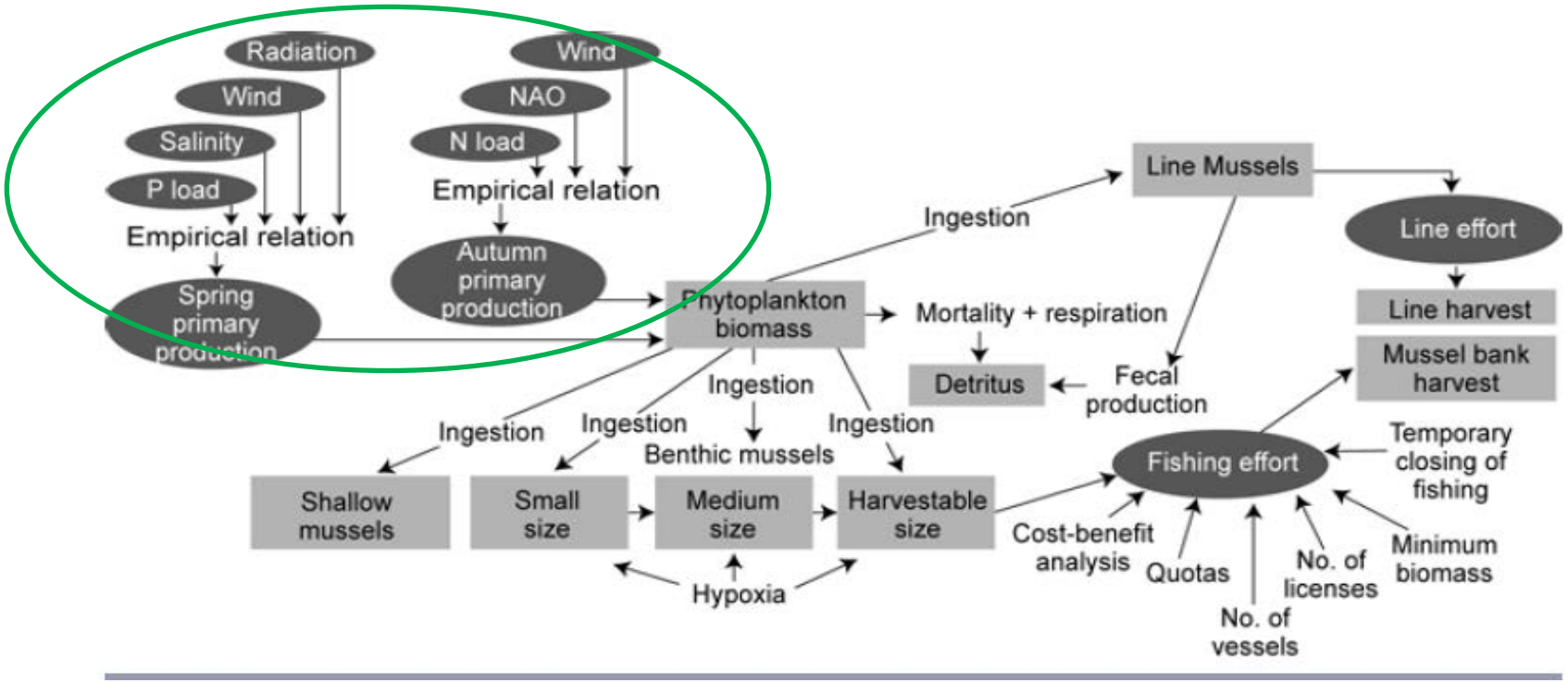
Parameter	Symbol	Value	Units
natural biomass-specific phytoplankton mortality rate	k_p	0.38	1/day
maximum ingestion rates for mussels in group i, $i = 1, ..., 5$	I_{max_i}	0.2, 0.1, 0.05, 0.04, 0.1	mmol C_{phy} /mmol C_{mussel} /day
half saturation constant for ingestion	$K_{1/2}$	20	mmol C/m^3
predation of mussels in group i, $i = 1, ..., 5$	$pred_i$	0.08, 0.01, 0, 0.02, 0	1/day
respiration	r	0.0027	1/day
depletion factor (group 1, ..., 5)	D_i	0.76, 0.76, 0.76, 0.96, 0.95	no dimension
transfer rate from group i to i+1	$transf_{i,(i+1)}$	0.003	1/day
mortality caused by hypoxia	$hypoxia$	0.19	1/day
catchability coefficient	q	0.0049	1/(fishing day)
maximum allowed catch per week	$quota$	45	tons/week/vessel
sales price of wild mussels	$price_w$	150	euros/ton
variable costs	$var.\ costs$	480	euros/fishing day
fixed costs	c_f	8335	euros/vessel/day
minimum mussel biomass	$minBio$	4	kg/m^2
fraction of ingested food that is egested and defecated	eg_i	0.25	1/day
recruitment of mussels	Rec_i	460	mmol C/m^2/year

Timmermann, Dinesen, Støttrup et al. 2014

SAF - System Formulation

- Empirical model used to establish link between N and P loadings and phytoplankton production
- The use of an empirical model here helped to shortcut complex biogeochemical cycling and thus helped to make the ESE model transparent with short computational time thus facilitating stakeholder engagement

Fig. 2. Conceptual diagram of the bioeconomic model. Gray boxes represent state variables; circles and arrows represent processes.

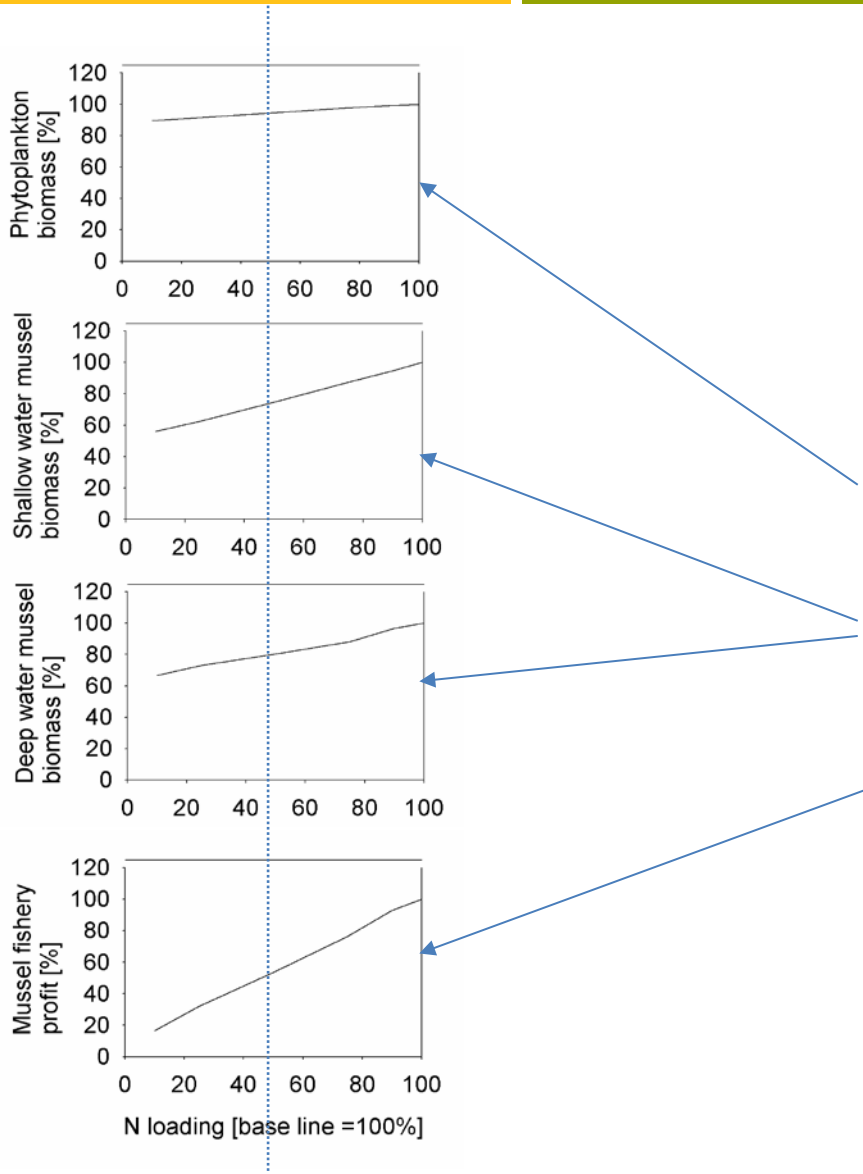


Timmermann, Dinesen, Støttrup et al. 2014

SAF - System Formulation

- Identify and assemble data inputs and variables;
- formulate, document, hindcast/calibrate and validate each of the individual ESE model components (Environmental, Social, Economic) and auxiliary models;
- Link ESE model components into one system model;
- test sensitivity;
- validate ESE model;
- run scenario simulations

SAF - System Assessment



Results of Scenario 1.

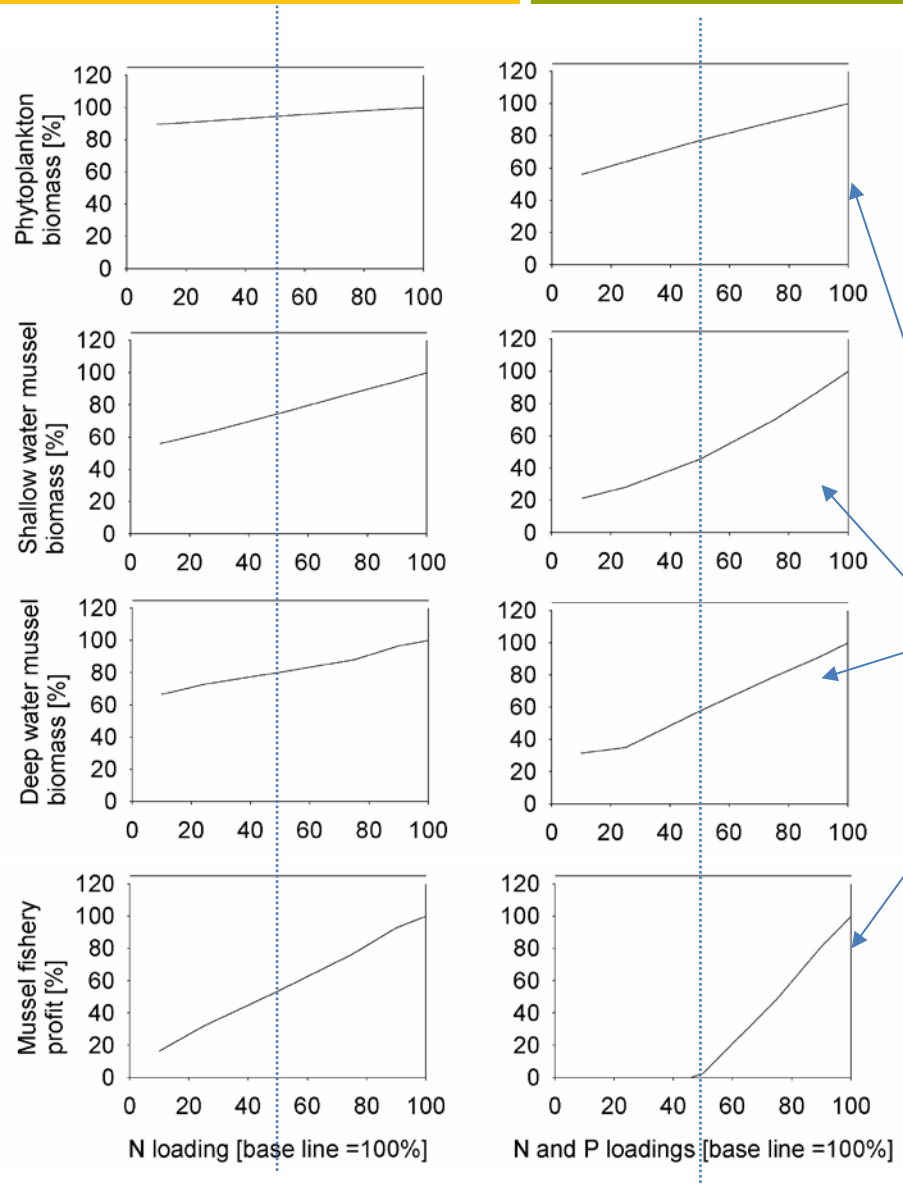
Reduction of total N.

Reductions in N alone to WFD target (47% level) showed:

1. Minor decrease in phytoplankton biomass
2. Decrease (~25%) of shallow and deep water mussel biomass
3. Decrease (~50%) of mussel fishery profit

Dinesen, Støttrup et al. 2011

SAF - System Assessment



Results of Scenario 1.

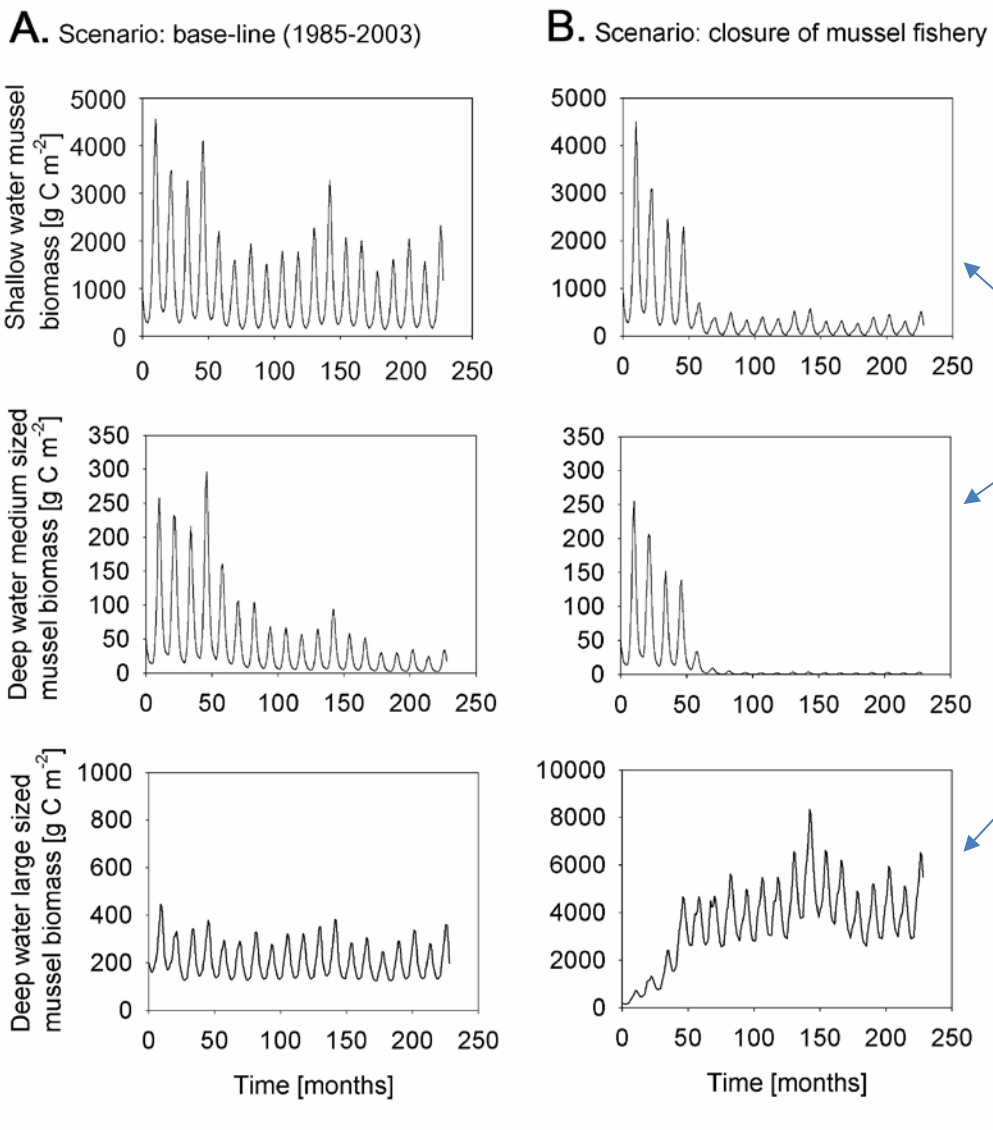
Reduction of total N and P.

Reductions in N and P to WFD target (47% level) showed:

1. Minor decrease in phytoplankton biomass (~20%)
2. Decrease (~50%) of shallow and deep water mussel biomass
3. Almost collapse of mussel fishery

Dinesen, Støttrup et al. 2011

SAF - System Assessment



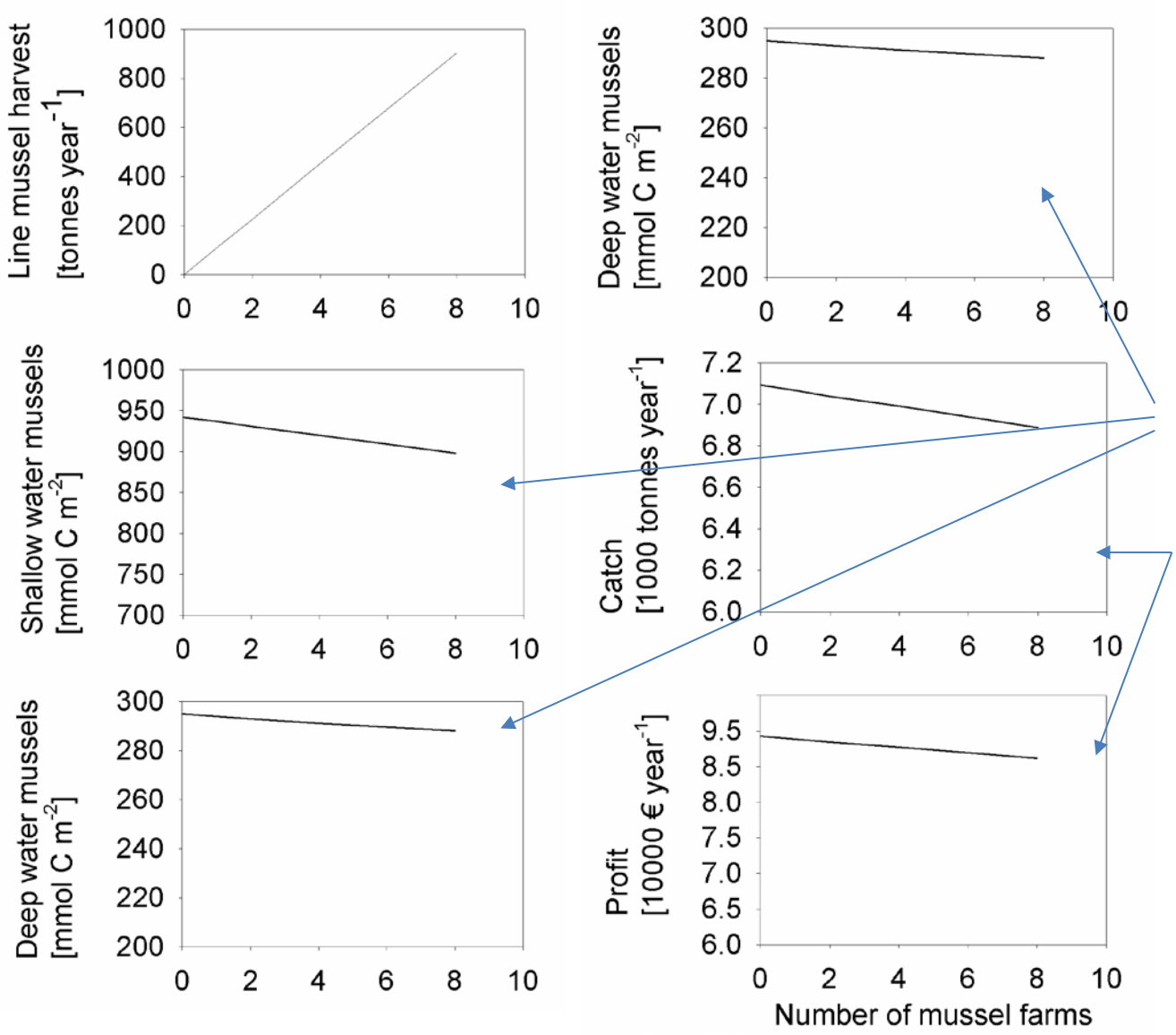
Results of Scenario 2.

Closure of wild mussel fishery

1. A >10 fold decrease in shallow-water and medium-sized deep-water mussel biomass
2. A > 10 fold increase in hitherto fishable mussel biomass
3. An annual profit loss of ~€6.2 million.

Dinesen, Støttrup et al. 2011

SAF - System Assessment



Results of Scenario 3.

Introduction of line mussel culture

1. Little impact on mussel biomass
2. Little impact on the catch and profit of wild mussel fishery

Dinesen, Støttrup et al. 2011

SAF - System Assessment

Scenario simulation results provided

- both recognizable and unexpected results, which stimulated discussion among stakeholders
- credible overview of the ecosystem they were familiar with
- cognition of a higher ecosystem complexity than hitherto understood
- changes in stakeholder perceptions
- **The SAF seems well qualified for developing a common understanding of the needs and consequences of change as part of the public consultation process and merging public and scientific information**



Dinesen, Støttrup et al. 2011

SAF - System Design

Exercise in SAF System Design:

- Group of 3-5 persons (same groups as for Issue Identification exercise)
- You have 60 min to work on this exercise
- For the Issue you had chosen, draw up a conceptual model.
- Use the DPSIR & CATWOE to help you identify all state variables and processes relevant for the Issue
- Draw on a sheet of paper and prepare to present to the whole class within 8-10 min

BONUS BaltCoast

A SYSTEM APPROACH FRAMEWORK FOR COASTAL RESEARCH & MANAGEMENT

BONUS-BaltCoast received funding from BONUS (Art 185), funded jointly by the EU and Baltic Sea national funding institutions

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION