



**BlueAdapt**

**Towards good ecological  
status at Archipelago Sea –  
coastal modelling perspective**

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# **FICOS coastal model**

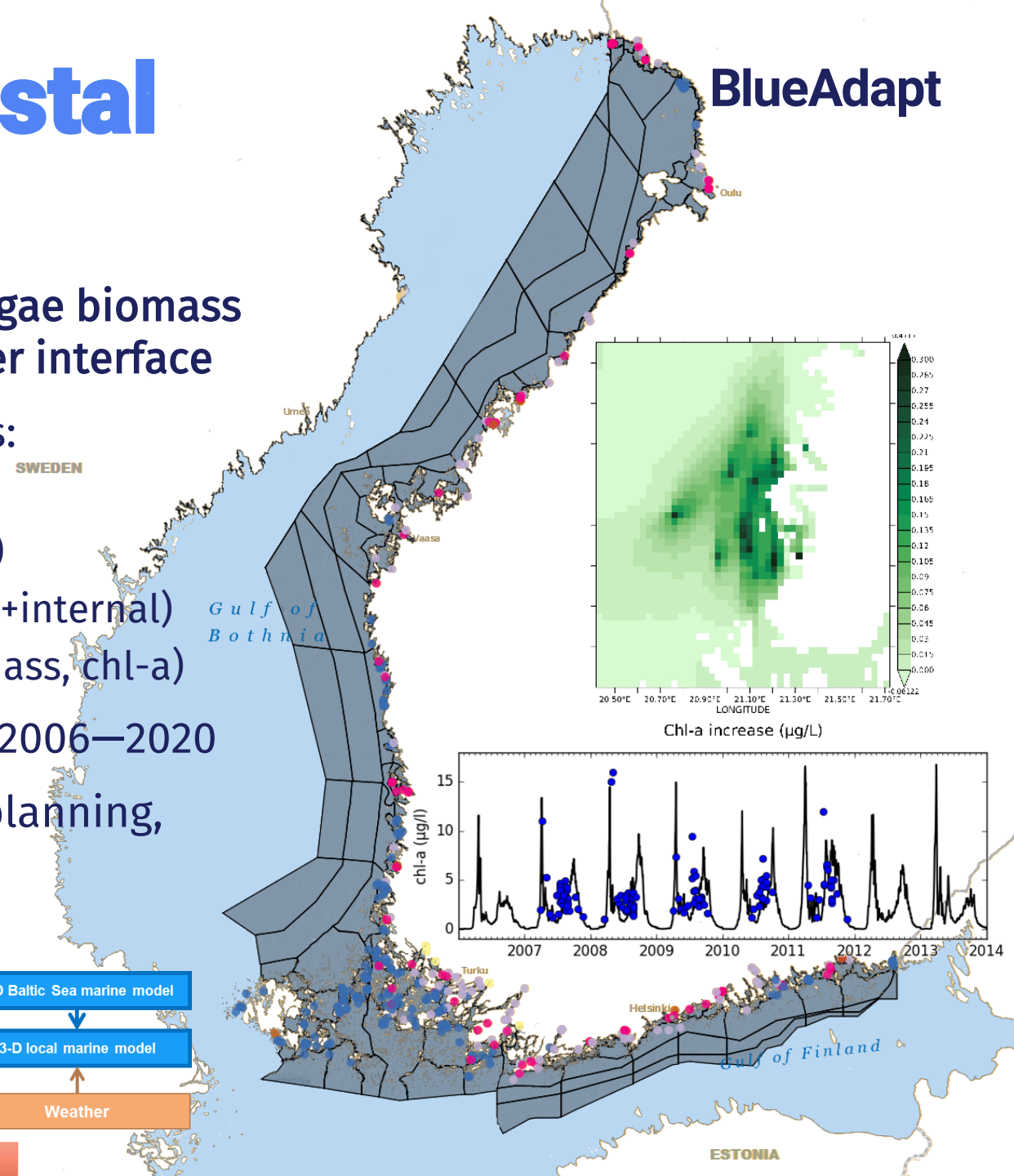
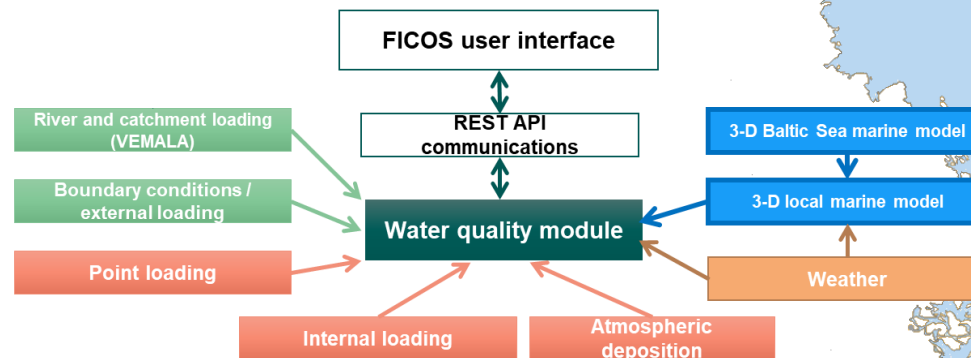
## **Overview and model integration**



# FICOS – Finnish Coastal Nutrient Load Model

BlueAdapt

- Integrated nutrient load transport and algae biomass growth modelling tool with a browser user interface
- Combines many models and data sources:
  - 3-D marine model (NEMO, COHERENS)
  - VEMALA nutrient load model (catchments)
  - Nutrient loading data (point+atmospheric+internal)
  - Integrated water quality code (algae biomass, chl-a)
- Covers the Finnish coast for model years 2006–2020
- Used for research, coastal management planning, impact assessments





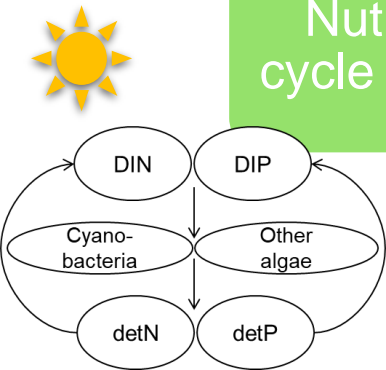
# FICOS operating principle

- River and catchment loading
- Point loading
- Atmospheric deposition
- Internal loading

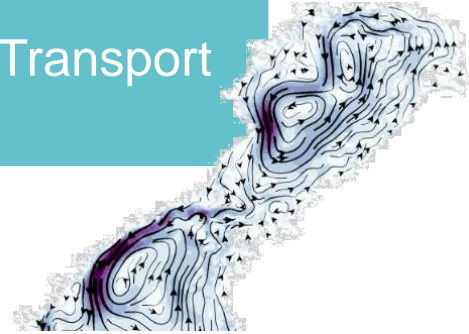
Nutrient loading

1 day

Nutrient cycle model

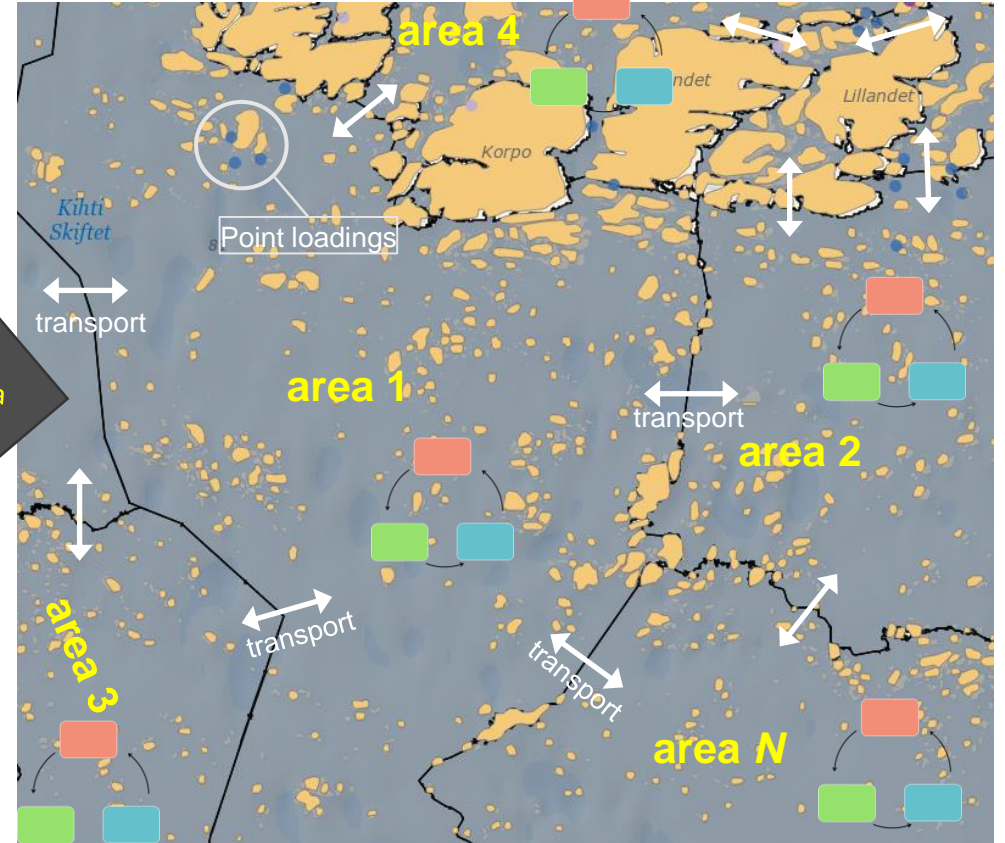


Transport



Currents from marine model  
Picture: Elina Miettunen

Process repeats for each area

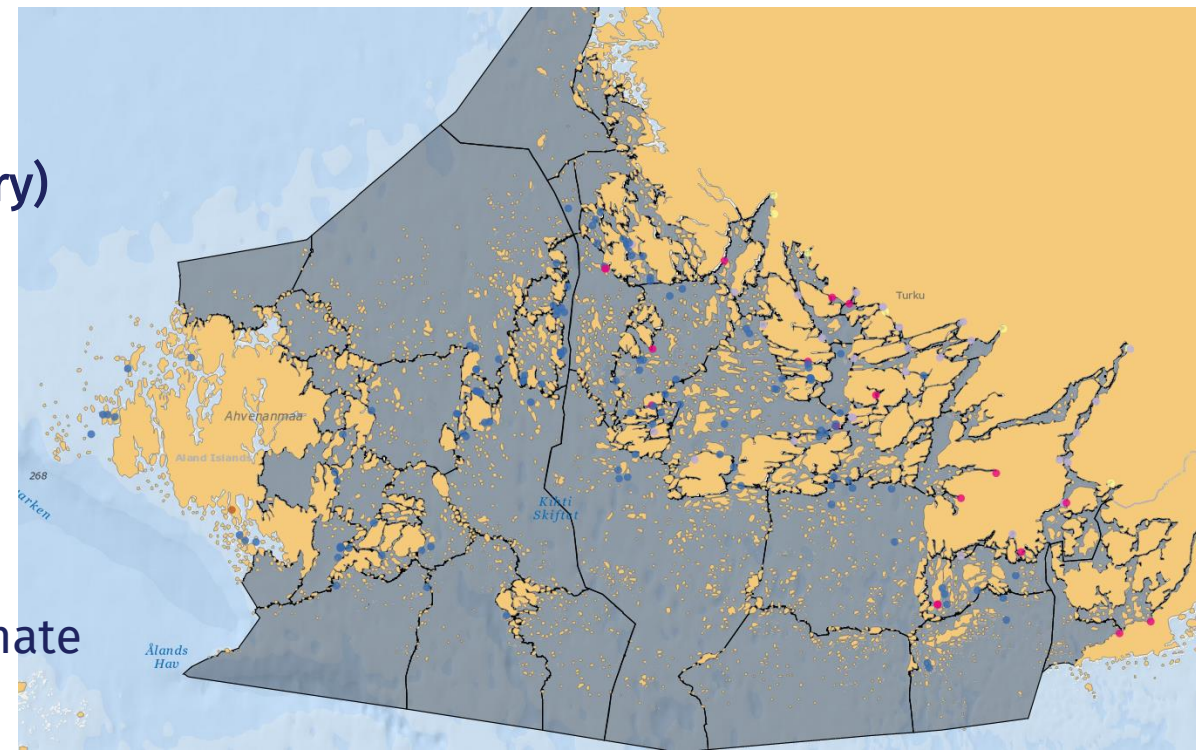
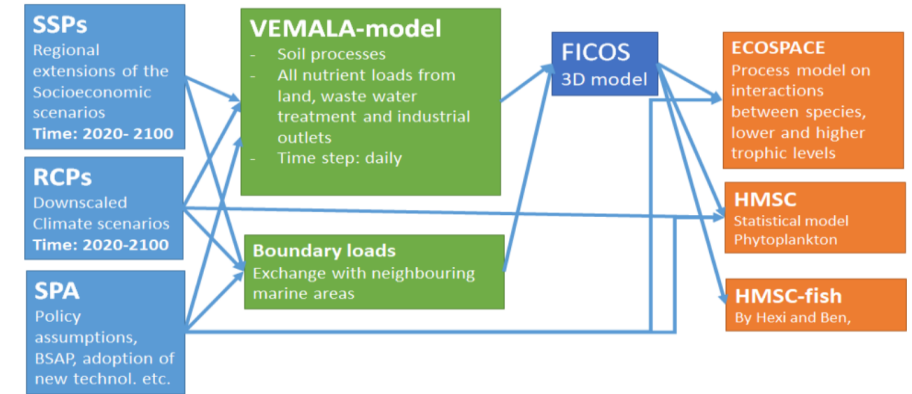


**Area** = water formation or grid cell  
**Transport** ⇔ to/from surrounding areas + vertical transport within area  
**Nutrient load** (Vemala+point+internal+atmospheric) is applied to each area



# FICOS Archipelago Sea model in BlueAdapt

- Maximum spatial model resolution ~500 m
- Resolutions used in study cases
  - WFD water formation
  - ~2 km (1 nautical mile)
- Links/inputs built to FICOS
  - Vemala (and Vemala-scenarios)
  - SSPs for nutrient loads (point, atm, boundary)
  - RCPs for sea surface temperature
- Links/outputs built from FICOS
  - HMSC(+fish) & EwE
- Two versions of FICOS used in BlueAdapt
  1. 2006-2014 version for GES scenarios
  2. Updated 2006-2020 version with partial climate change effects for HMSC and EwE linking



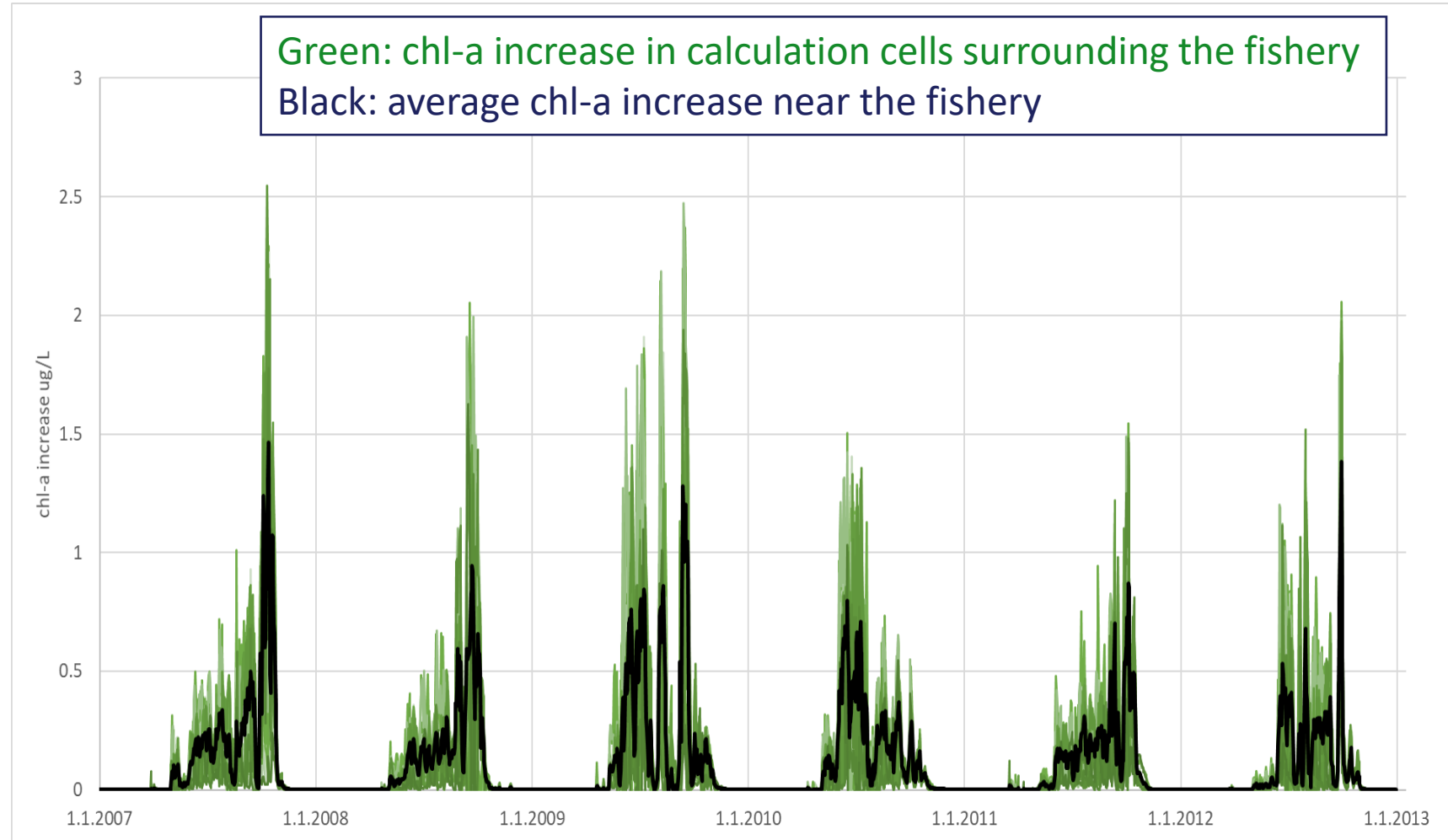
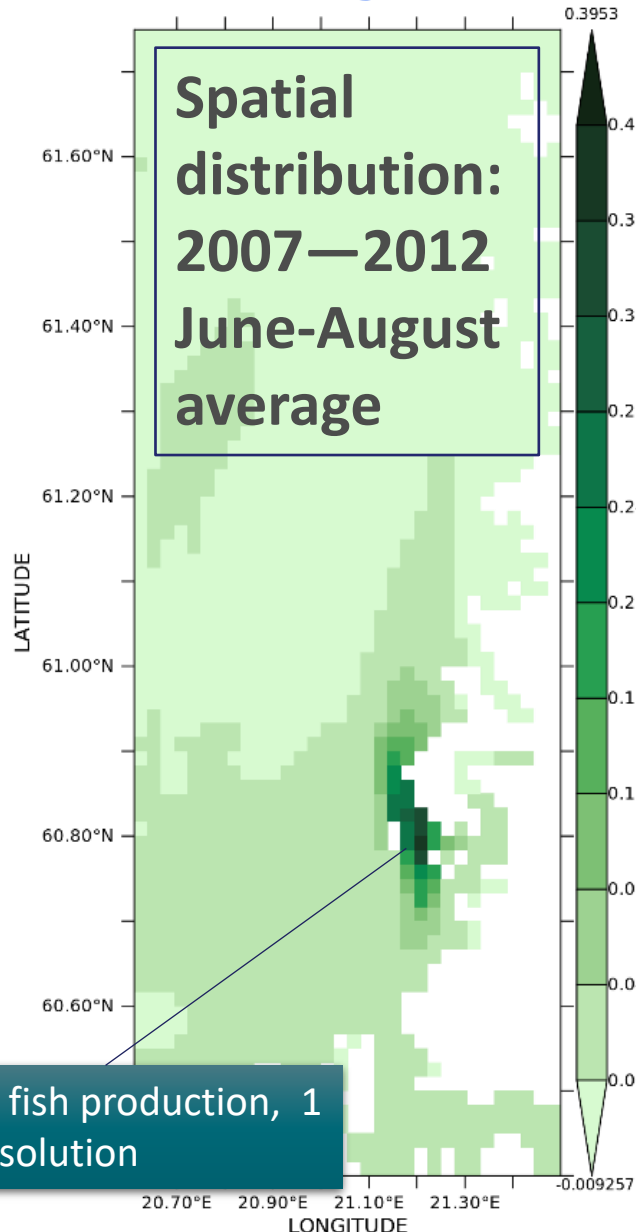


# Modelled scenarios and results



# FICOS example: Fishery induced chl-a change in nearby waters (synthetic study)

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**Temporal distribution: 2007—2012 daily timeseries, multiple points**

2000 t fish production, 1 nmi resolution





# Archipelago sea modelling results from Hyytiäinen et al. (submitted)

- Vemala – FICOS model chain was used and nutrient loading was adjusted to various goals, including BSAP, SSP1 (Pihlainen et al. 2020) and scenarios where the internal loading can be controlled
- Results are chl-a concentrations at stabilized future conditions
- We wanted to see under which circumstances the Archipelago Sea can reach good ecological status, what can be done for nutrient loading in Finland and how “external” loading changes (from everywhere at the Baltic Sea) fit in the picture
- FICOS was used at water formation resolution
- Climate change effect to e.g. sea temperatures were not considered in this study

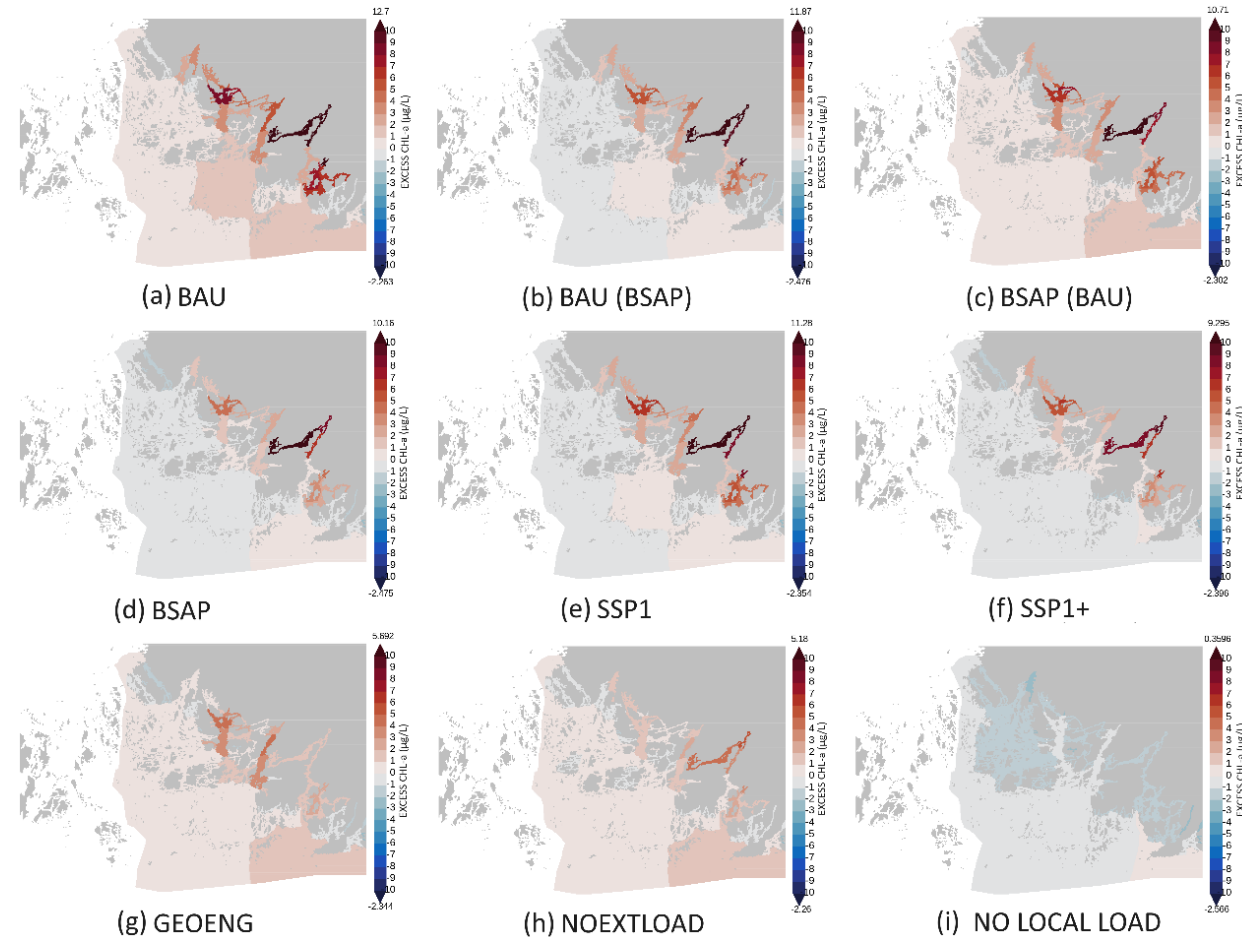
Name	Catchment	Sediment	Atmospheric deposition	Neighbouring sea basins
BAU	current	current	current	current
BAU (BSAP)	current	current	SSP1	BSAP
BSAP (BAU)	BSAP	current	SSP1	current
BSAP	BSAP	current	SSP1	BSAP
SSP1	SSP1	current	SSP1	SSP1
SSP1+	SSP1+	current	SSP1+	SSP1+
GEOENG	current	full control	current	current
NOEXTLOAD	full control	current	current	current
NO LOCAL LOAD	full control	full control	SSP1	BSAP

Modelled scenarios (Hyytiäinen et al., submitted)



# Archipelago sea modelling results from Hyytiäinen et al. (submitted)

- Good news: Good ecological status is reachable at inner Archipelago Sea
- Bad news: No anthropogenic nutrient loading is allowed, geoengineering methods required
- All nutrient reductions help!
- Co-operation between Baltic Sea countries is required to reduce the overall levels of chl-a
- We can directly affect the innermost water formations, however, drastic reductions are required to reach GES using current criteria
- Reductions affect the spring bloom more than summer bloom
- GES criteria might need updating, especially phytoplankton as dominant indicator of ecological state.

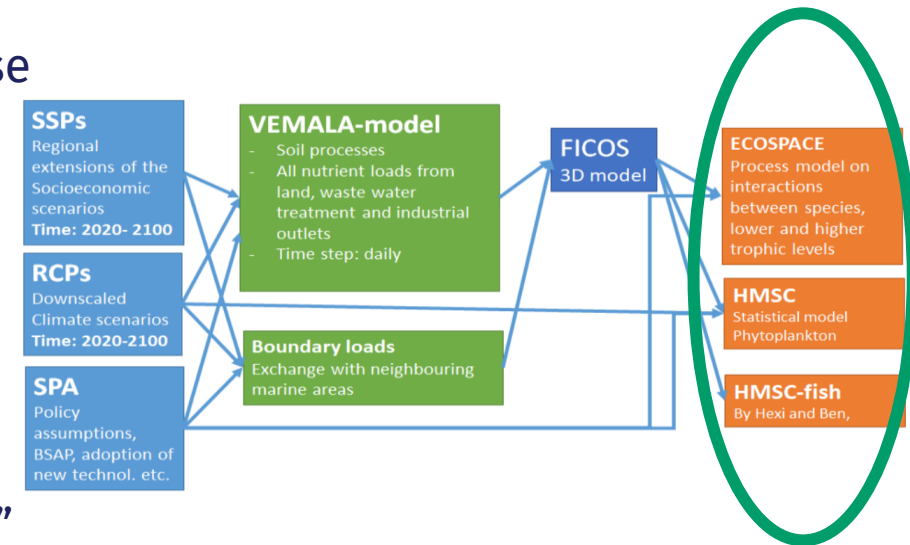


Excess chlorophyll-a ( $\mu\text{g/l}$ ) to the threshold level indicating good ecological status in all scenarios. The concentrations are measured as the average summertime concentration (Hyytiäinen et al.).



# FICOS in a chain from Vemala to HMSC and Ecopath with Ecosim (EwE)

- Three adaptation strategies to climate change for a total of 36 climate/SSP-scenario nutrient load combinations and two base scenarios at the Archipelago Sea
- Nutrient loading in “2051-2060” and “2091-2100” for
  - Catchment loading
  - Atmospheric loading
  - Internal loading
  - Point loading
  - “External” or boundary loading assumed at BSAP levels
- Future state of Archipelago Sea in “2051-2060” and “2091-2100”
- Climate change effects to future sea surface temperature included from two climate models
- Up to 2 km (1 nautical mile) resolution
- **FICOS physical + primary production results feed HMSC and EwE models**
  - Daily values at 2 km and water formation resolutions
  - Monthly values at 2 km and water formation resolutions





# Summary



# Summary and way forward

- **FICOS model was used and improved**
  - Various nutrient loading scenarios used
  - (Partial) climate change effects added to FICOS
  - Chaining with Vemala, HMSC(+fish) and EwE were improved or developed
- **The chained model tool can be used for coastal ecological assessment scenarios**
- **Possible future FICOS developments for increasingly robust scenario work/predictions:**
  - Merging Archipelago Sea NEMO hydrodynamics data to FICOS
  - Dynamic sediment storage module
  - Expanding the boundaries
  - Improving the model chain
    - Further work on FICOS-CLR connection
    - Continuing HMSC and EwE work
    - Vemala-FICOS climate change scenario automations
  - Further exploring the hydrodynamics–climate change coupling
  - Light penetration and turbidity developments in Bothnian Bay



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