A Model study of the holopelagic scyphozoan jellyfish *Periphylla periphylla* and its trophic impact on plankton production in the Trondheim fjord (Norway).

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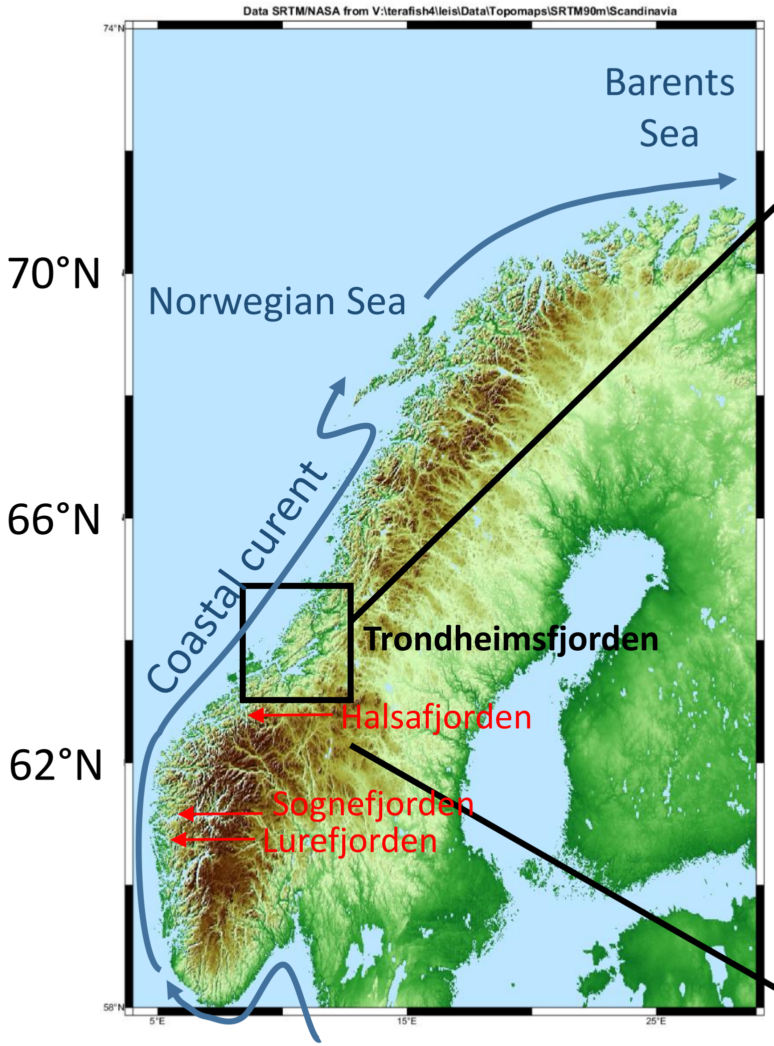
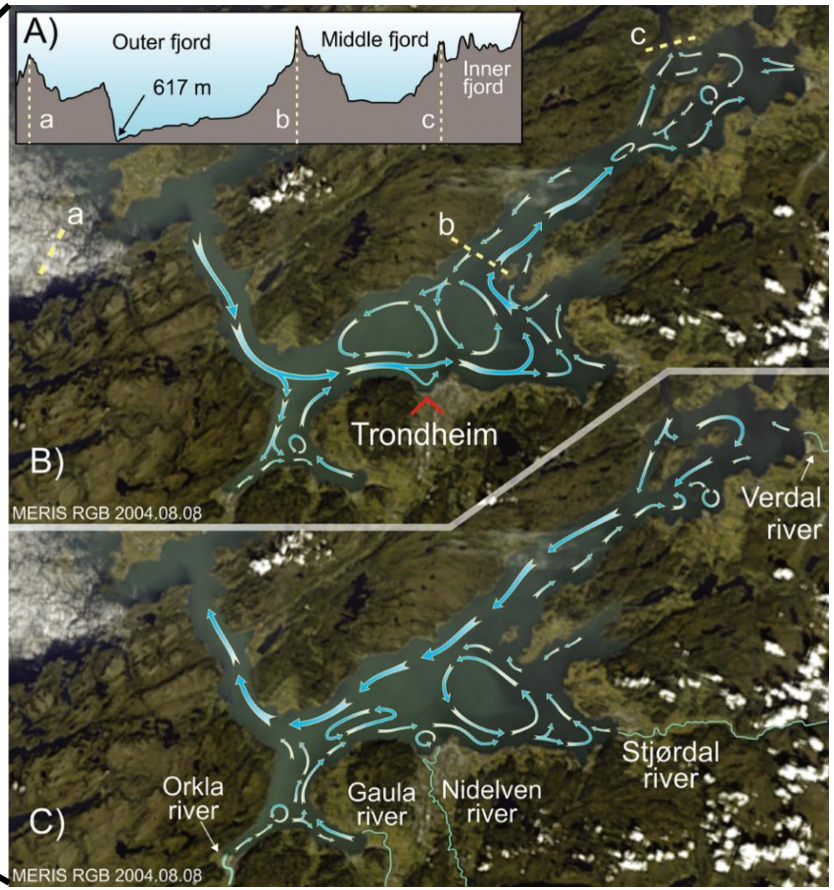
Introduction

- Proliferates in several Norwegian fjords since the 1990's
- Dense populations in the South (Sørnes et al. 2007; Sweetman and Chapman 2011)
- Has reached northern Norway in the recent years (Lofoten area).
- The coastal current is probably the major vector for its propagation northwards
- Those fjords feature sills that may play a role in retaining the biomass and as a reservoir along the coastal path

Norwegian Coastline



Trondheim fjord



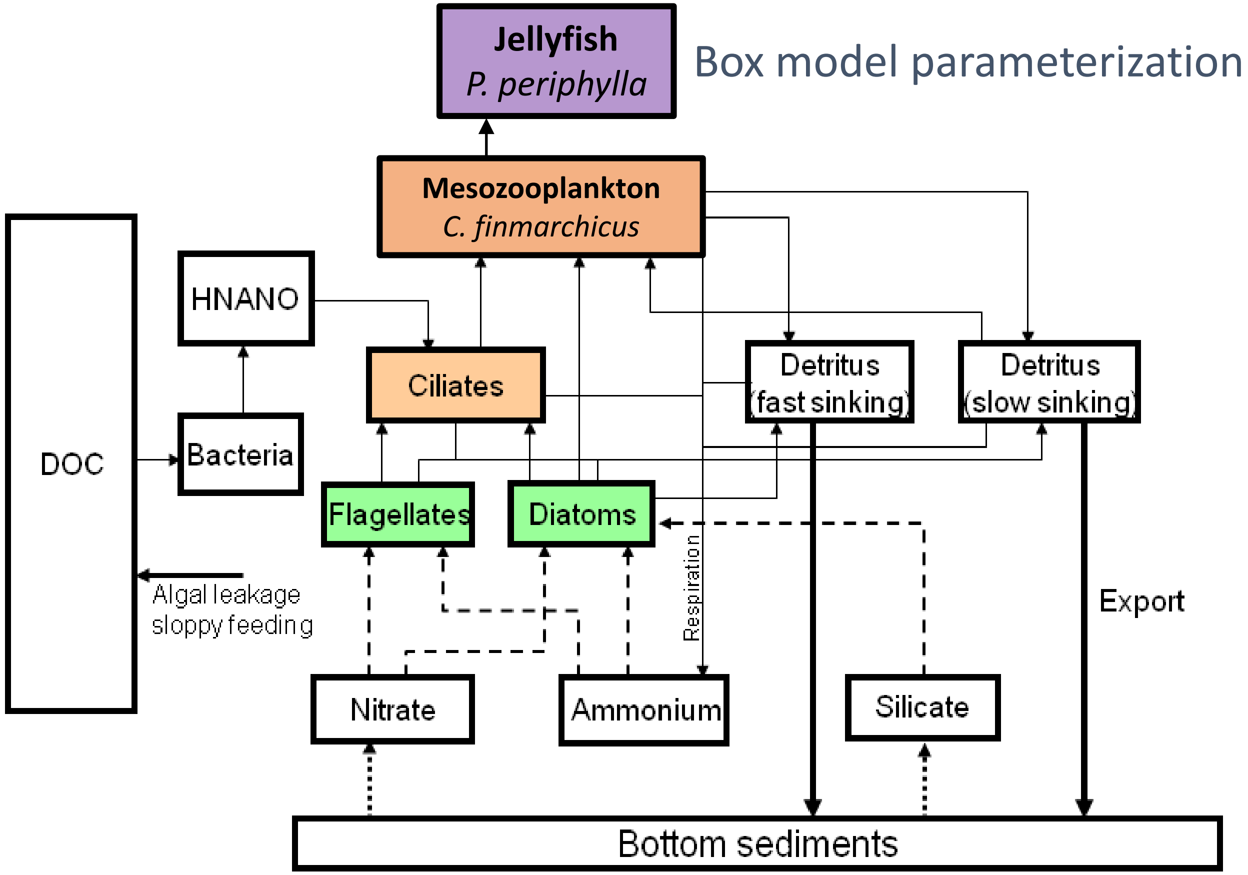
From Volent et al. (2011)

SINMOD Pelagic Ecosystem Model

Fjord Circulation Model
Ellingsen et al. 2004
Uglem et al. 2012

- Nested model system
- Horizontal grid resolution: 160 m
- Vertical layering: z-levels (35)
- Open Boundary condition at the fjord mouth: 800 m coastal model domain for mid-Norway
- River discharge from major drainage basins: Norwegian Water Resources and Energy Directorate Database (www.nve.no)
- Wind fields: downscaled era-interim ECMWF fields (www.ecmwf.int)

Model of lower trophic levels
(This study; adapted from Wassmann et al. 2006)



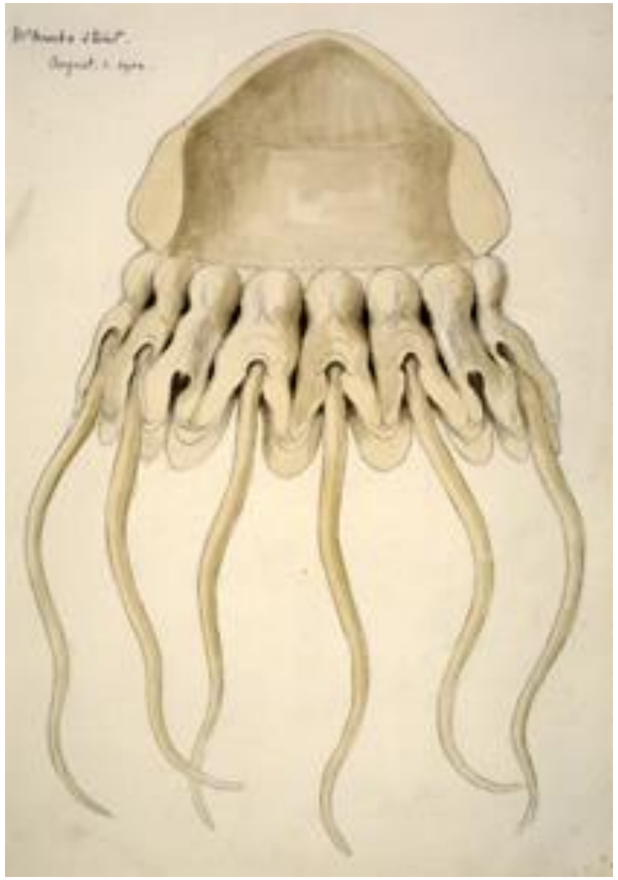
P. Periphylla biology

- *P. periphylla* (Péron & Lesueur, 1809): holopelagic, mesopelagic species
- Long-lived (Youngbluth and Båmstedt 2001).
- The life-cycle: 14 stages described (Jarms et al. 1999, 2002)
  No ephyra stages, direct development into medusae

- **Light** is lethal: Photodegradation of pigmentation (Jarms et al. 2002) - strong negative phototactism

  Below the thermocline in the Lure fjord (6-8°C)
- **Optically conditionned retention** in Norwegian fjords (Sørnes et al. 2007)

- Diet based mainly on calanoid copepods in Norwegian fjords (Sørnes et al. 2008)
- **Limited studies on trophodynamics**



Drawing of *P. periphylla* produced in 1902 by Edward Adrian Wilson (1872 -1912). (www.nhm.ac.uk)

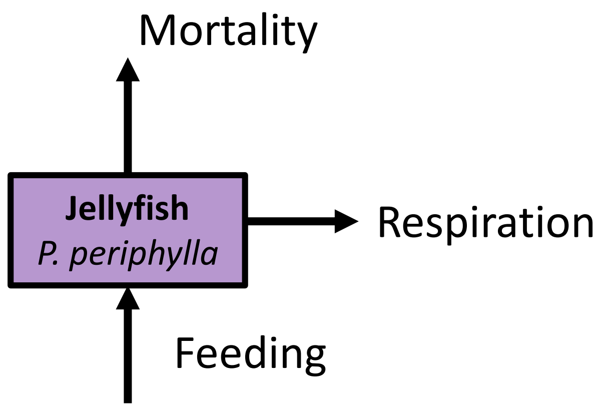
P. periphylla Box-Model setup

Model parameterization

- Carbon content for the mature stage 14D (Sweetmann and Chapmann, 2011)

- Estimates for clearance rates have been formulated by Sørnes et al. (2008)
  The maximum weight specific **ingestion** rate has been fixed starting from values for *A. aurita* (Uye & Shimauchi, 2005), but have been adjusted to a much lower value of 0.02 d^{-1}

- Data on **respiration** rates (Youngbluth and Båmstedt, 2001; Sötje et al. 2007)
  The weight specific respiration rate has been set to 0.004 d^{-1}



Model assumptions

- *P. periphylla* is considered as a top-predator in the Trondheim fjord, i.e. no predation

- Biological processes related to *P. periphylla* are not temperature dependent
  Though, seasonal thermal variability below the thermocline is low

- Thus, a very low mortality rate has been assumed (0.001 d^{-1})

P. periphylla Box-Model setup

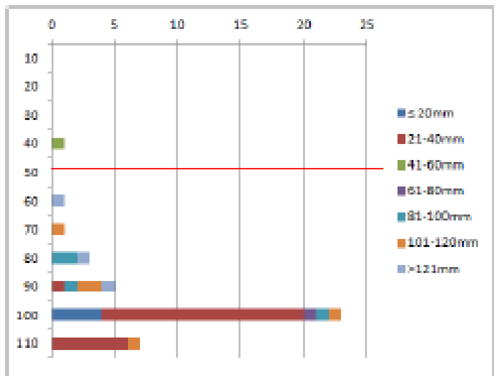
Vertical behavior

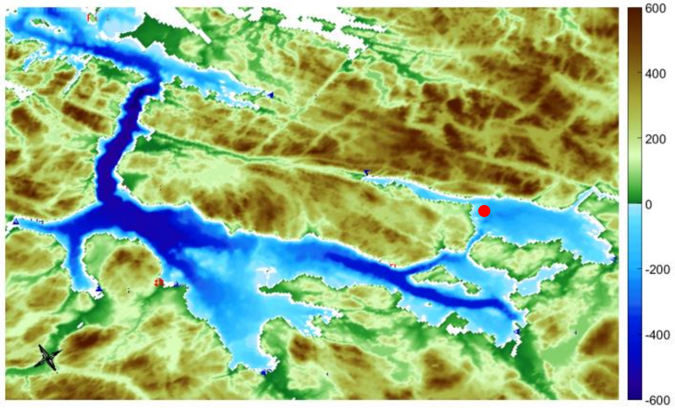
- Seasonal vertical patterns in Lurefjorden (Youngbluth and Båmstedt, 2001)
- Light dependent vertical migration models (Dupont et al., 2009 and Dupont and Aksnes 2010)
- Distribution below 50-70m in the Trondheim fjord:

Modeled occupied vertical range in the water column

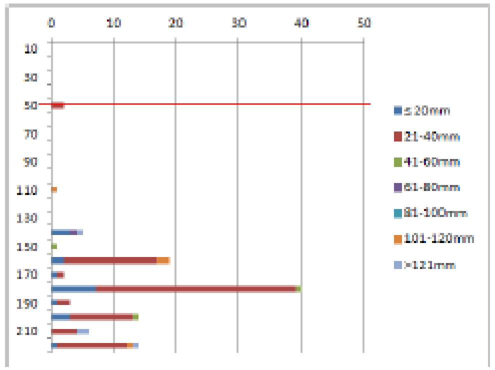
- Model *P. periphylla* is below the thermocline during the spring bloom and remains below 50m
- *P. periphylla* preys upon overwintering *C. finmarchicus* at depth.
- **Reduced vertical overlap between *C. finmarchicus* (0-100m) and *P. periphylla* during the spring period**

a) Station 1, [*a1*], n=30





b) Station 1, [*a2*], n=28



Picture: Solheim (2012)

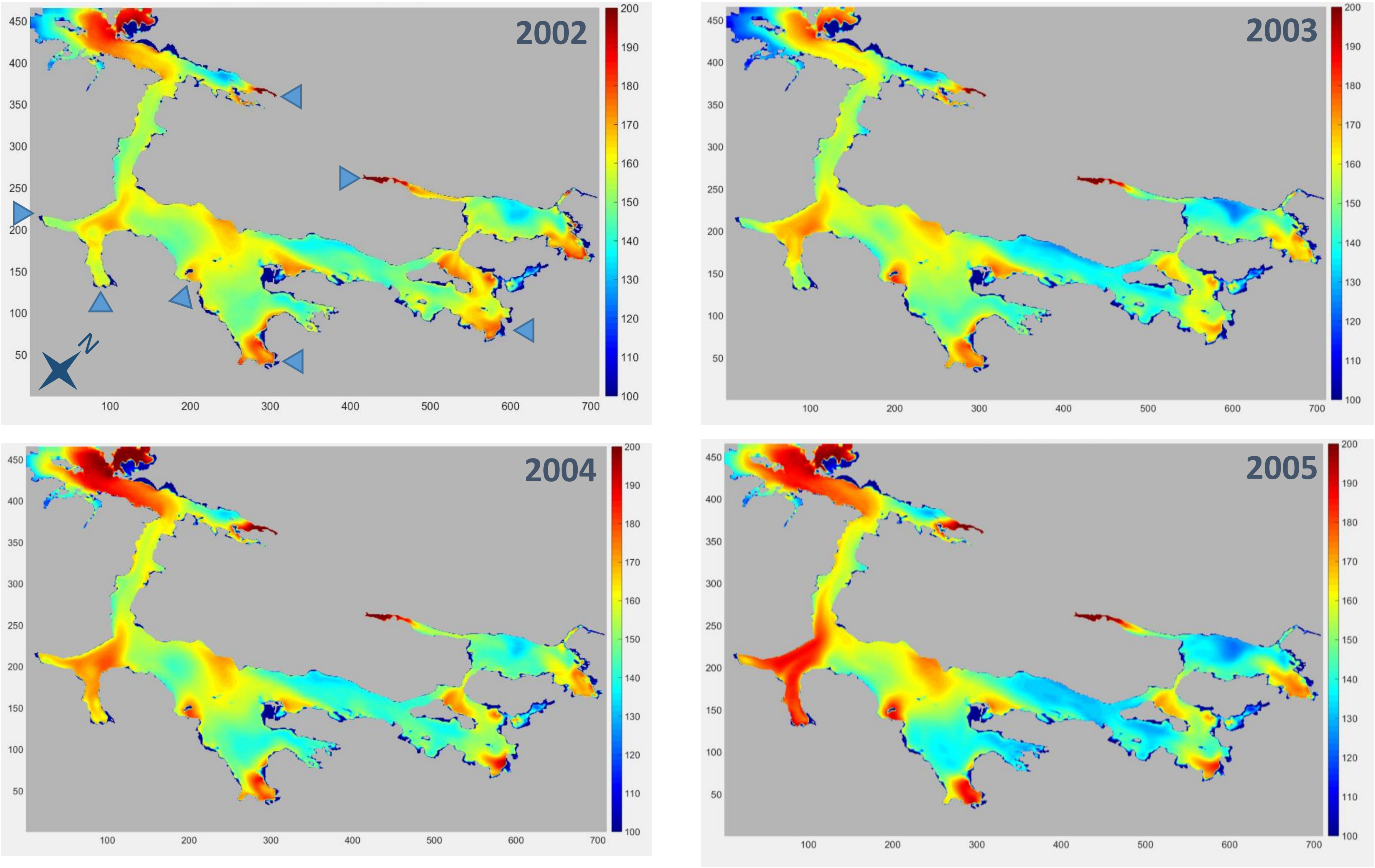
Number and size (Coronal diameter) at each 10 m depth interval
From LVPP profiles (Mork and Båmstedt, unpublished)

Dive	Date	Time start	Time stop	Start coordinates		Max depth (m)
[*a1*]	20.04.2010	09:55:00	10:36:00	63°48.829’ N	10°37.542’ Ø	52
[*a2*]	20.04.2010	14:42:00	15:20:00	63°55.640’ N	11°04.162’ Ø	61

Primary Production

Annual primary production (g C m^{-2} yr^{-1})

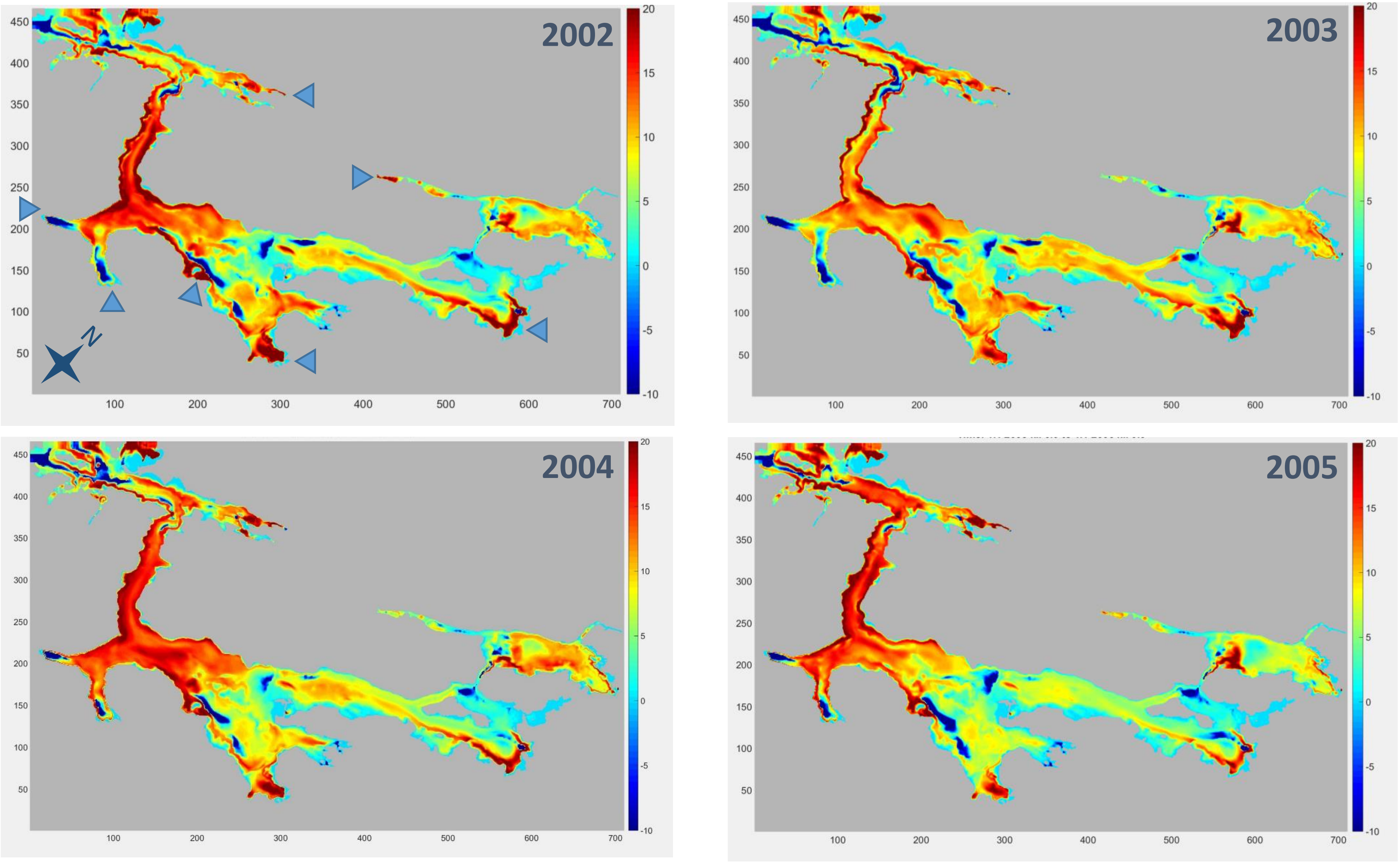
▷: River outflow



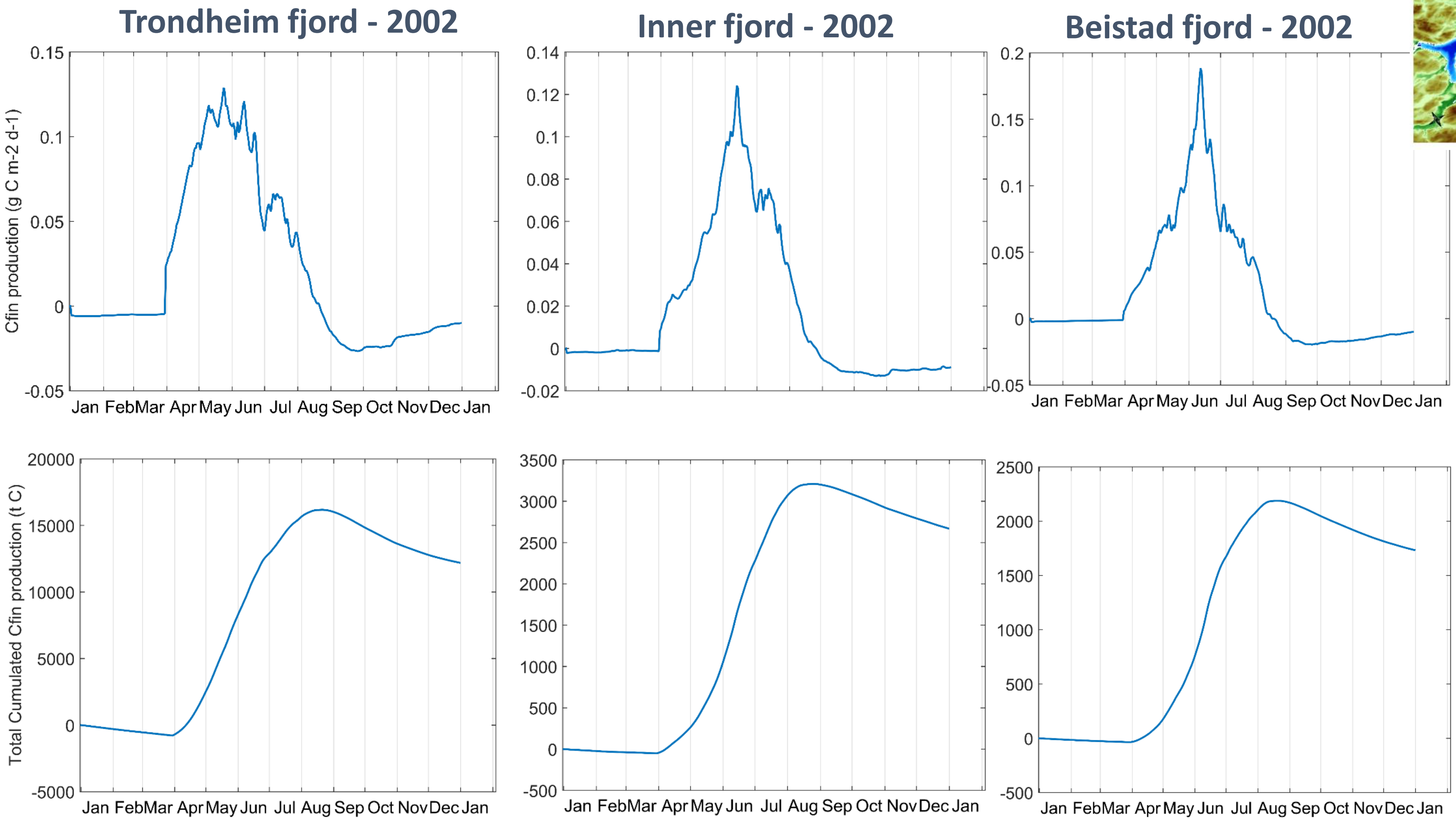
Mesotrophic conditions (Cloern et al. 2014, Nixon's classification, 1995)

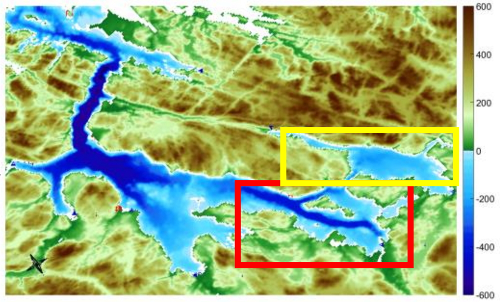
Production of *C. finmarchicus*

Vertically integrated net production (g C m^{-2} yr^{-1}) ▶: River outflow

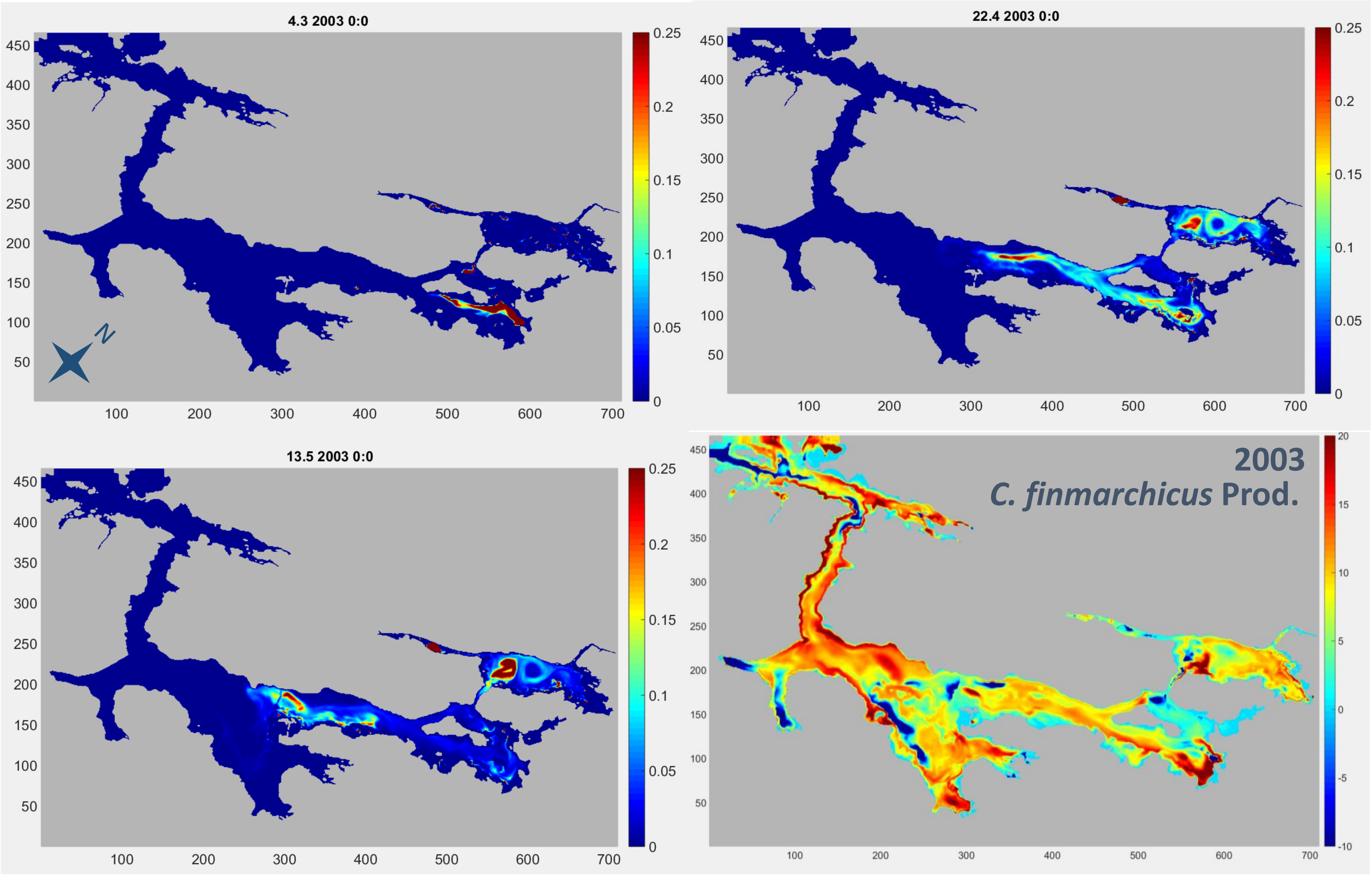


C. finmarchicus production in different sub-basins



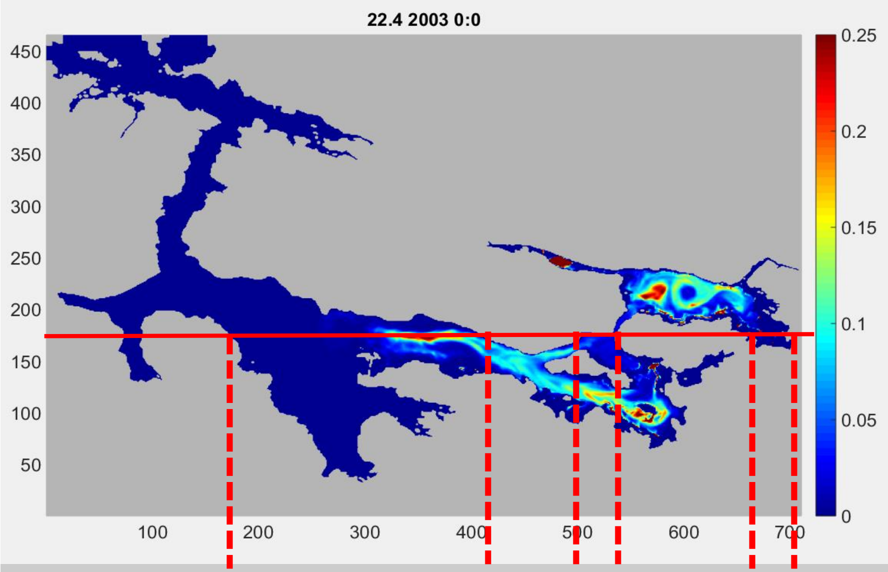


Simulated (I) *P. periphylla* biomass distribution (g C m^{-2})

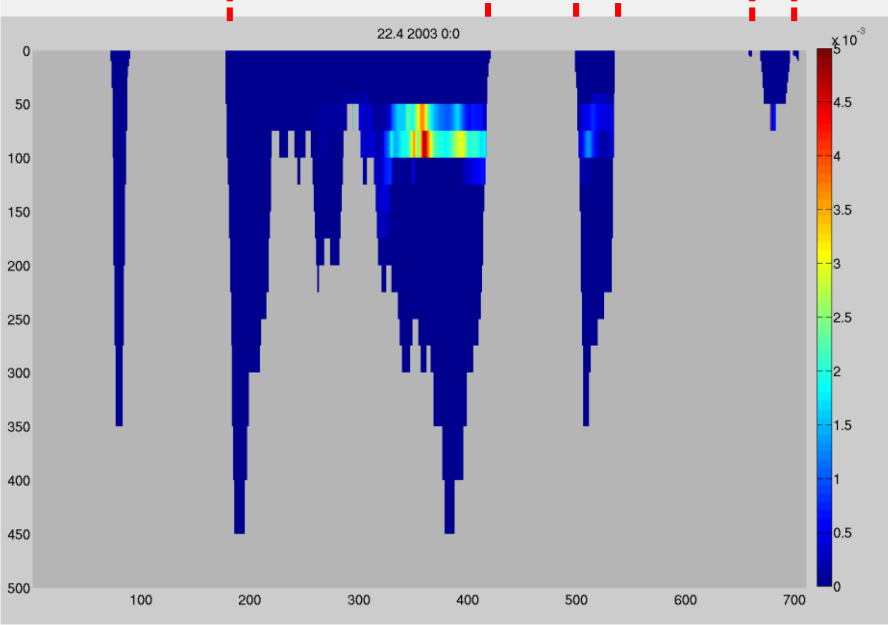


Simulated (I) *P. periphylla* vertical biomass distribution

Biomass concentration **(g C m^{-3})**

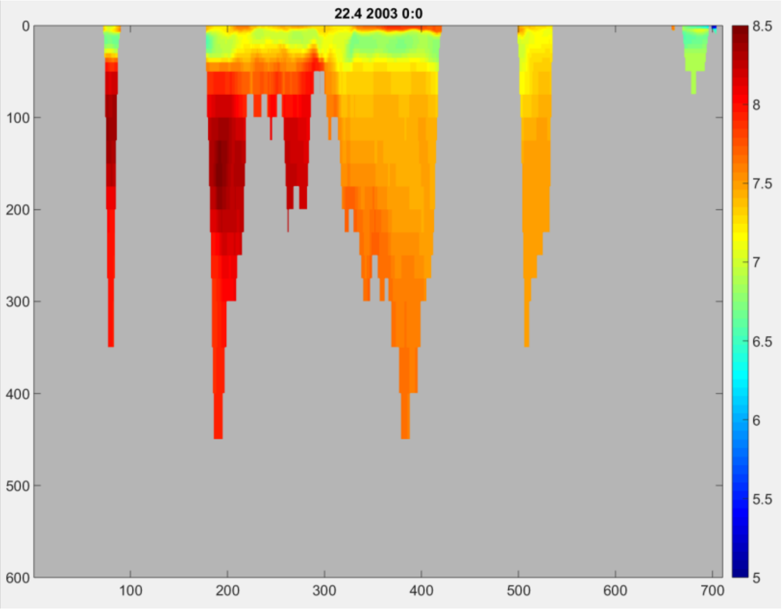


Depth (m)

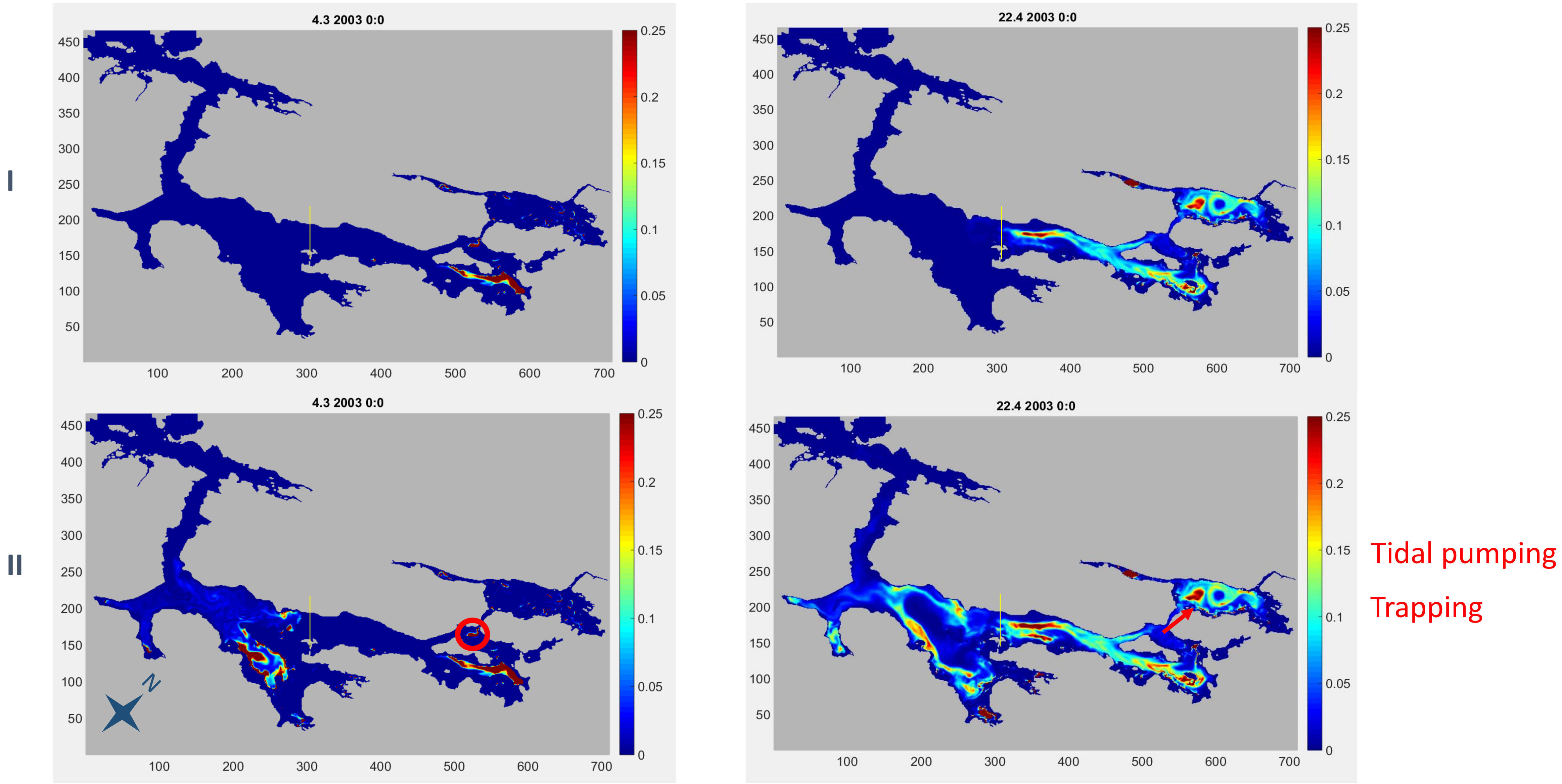


Vertical velocity **(m s^{-1})**

Temperature (**°C**)

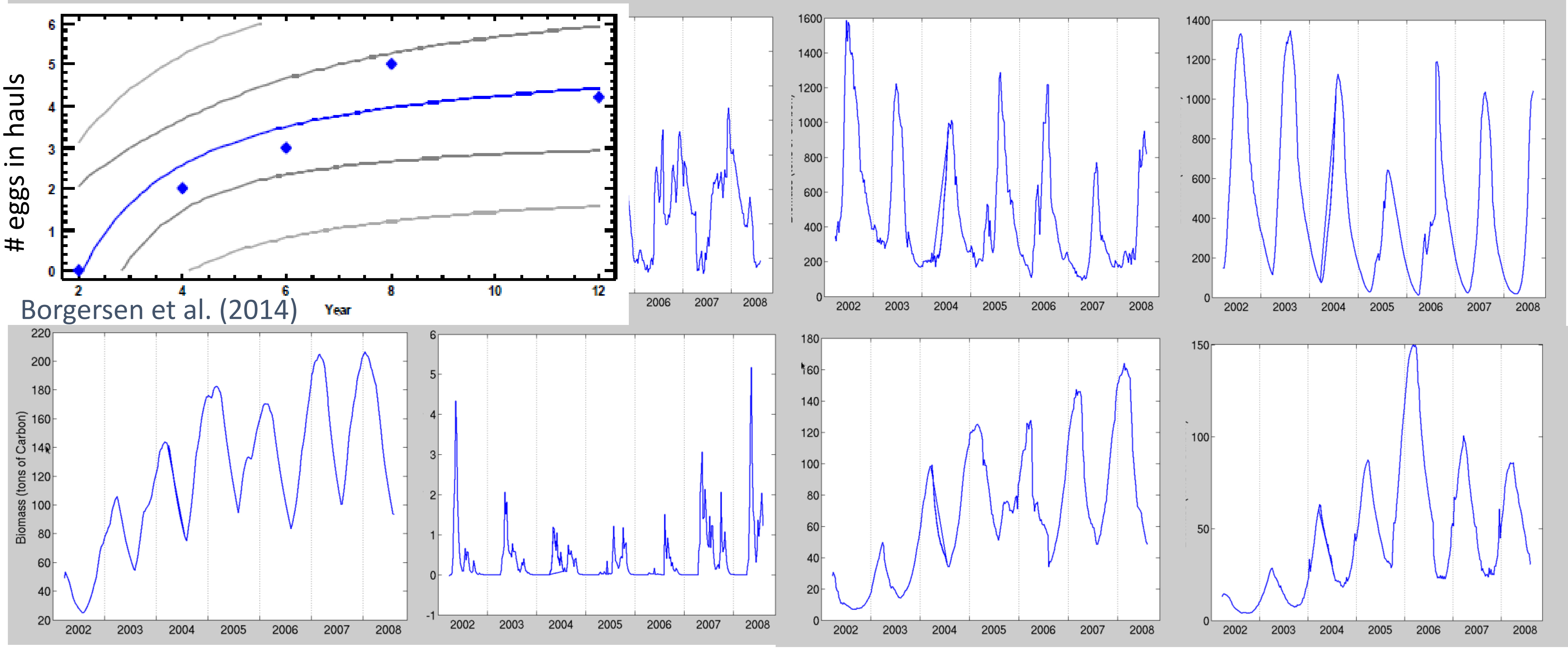


Simulated (I vs. II) *P. periphylla* biomass distribution (g C m^{-2})



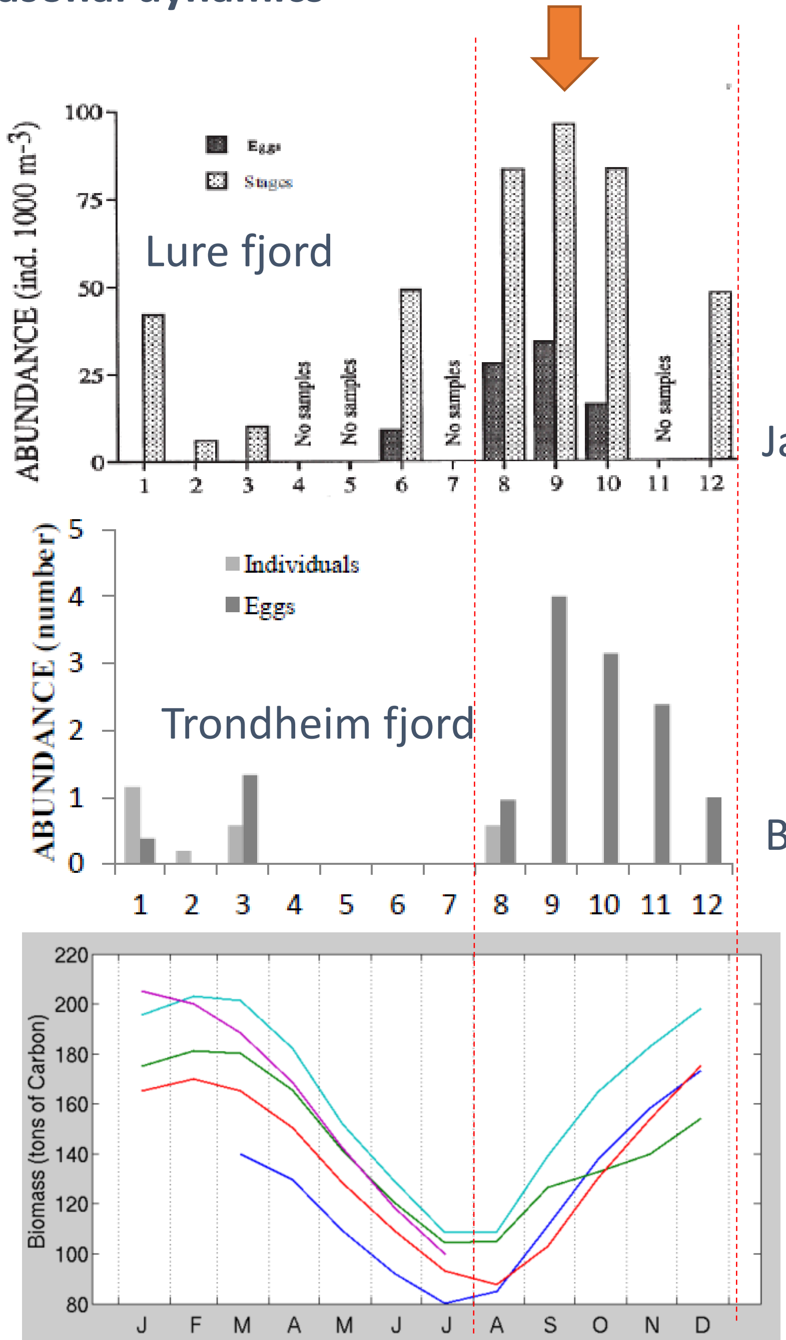
Prey-Predator stocks in different sub-basins (t C)

Trondheim fjord | Outer fjord | Inner fjord | Beistad fjord



Borgersen et al. (2014)

Seasonal dynamics



Jarms et al. (1999)

Borgersen (2012)

Conclusions:

- Model results suggest that the production is mainly sustained from late summer throughout the autumn and early winter
- Carrying capacity in the inner most part of the fjord might be reached
- Loss of biomass at the end of the winter and the productive spring season is due to the limited access to the ressource above the thermocline.

Perspectives:

- Light dependent mechanisms might modulate that response and the strength of the trophic link
- Detailed analysis of spatio-temporal dynamics associated with tidal forcing (waves and eddies)
- Impacts on outward migrating gadoid larvæ

Thank you for your attention!

- Developpement saisonnier
- Relation avec la ressource
- Export d'une fraction de la biomasse
- Scenario

Timeline of Biomass

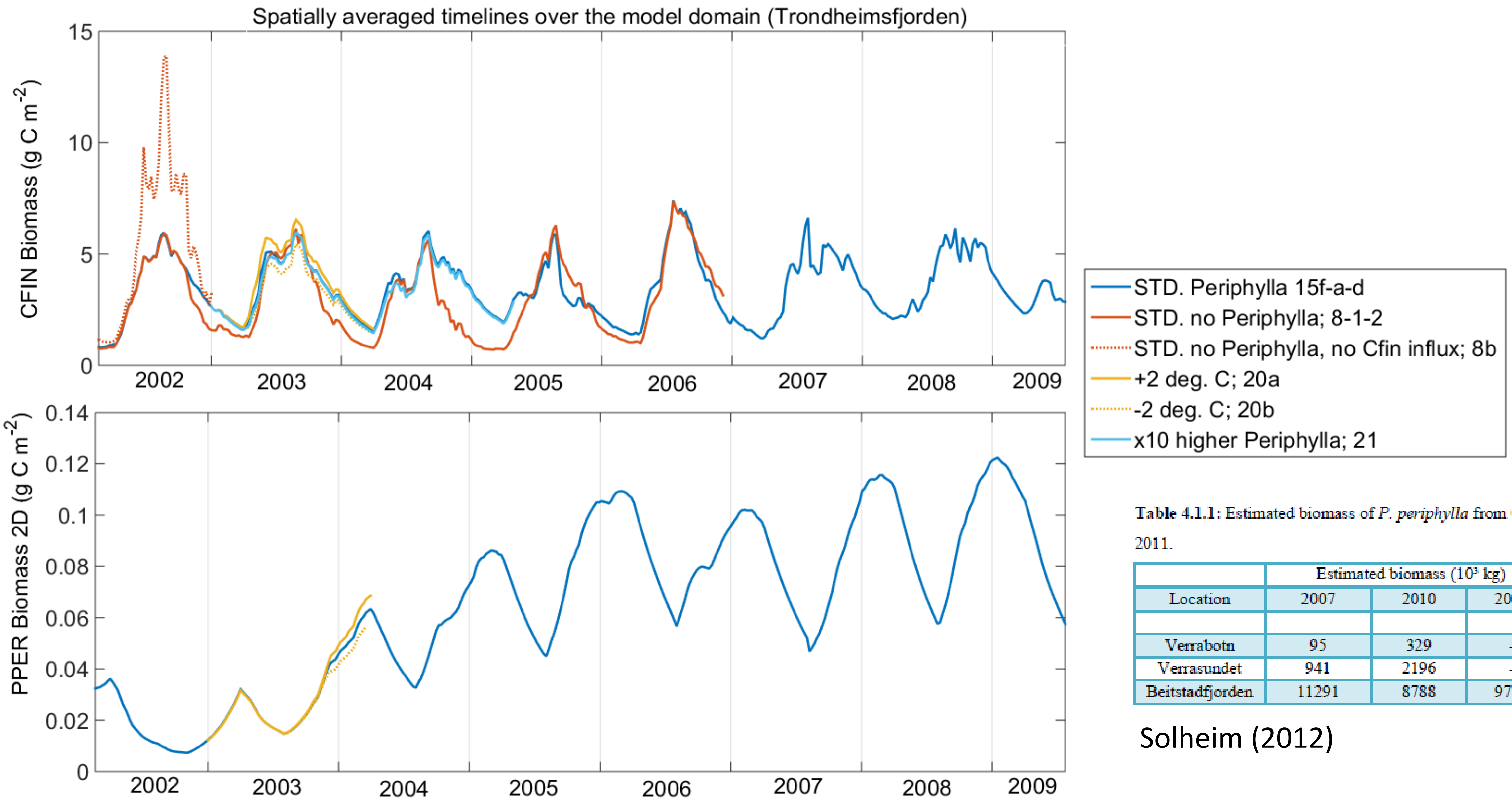
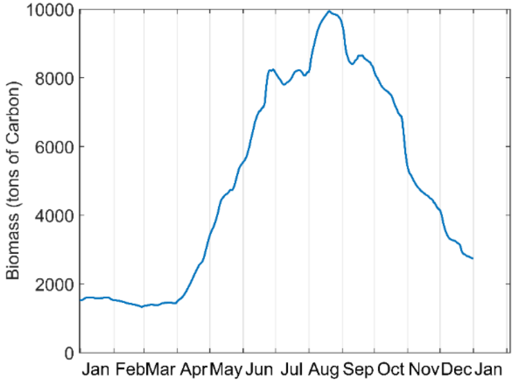


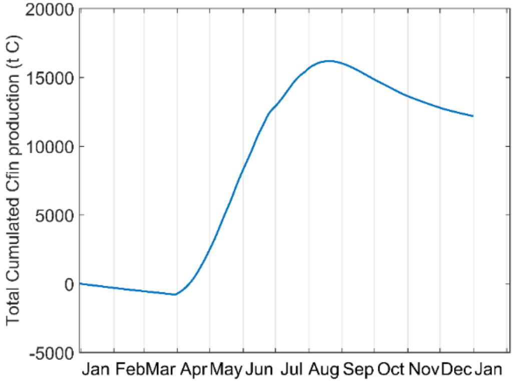
Table 4.1.1: Estimated biomass of *P. periphylla* from October 2007, 2011.

	Estimated biomass (10^3 kg)		
Location	2007	2010	2011
Verrabotn	95	329	-
Verrasundet	941	2196	-
Beitstadfjorden	11291	8788	9753

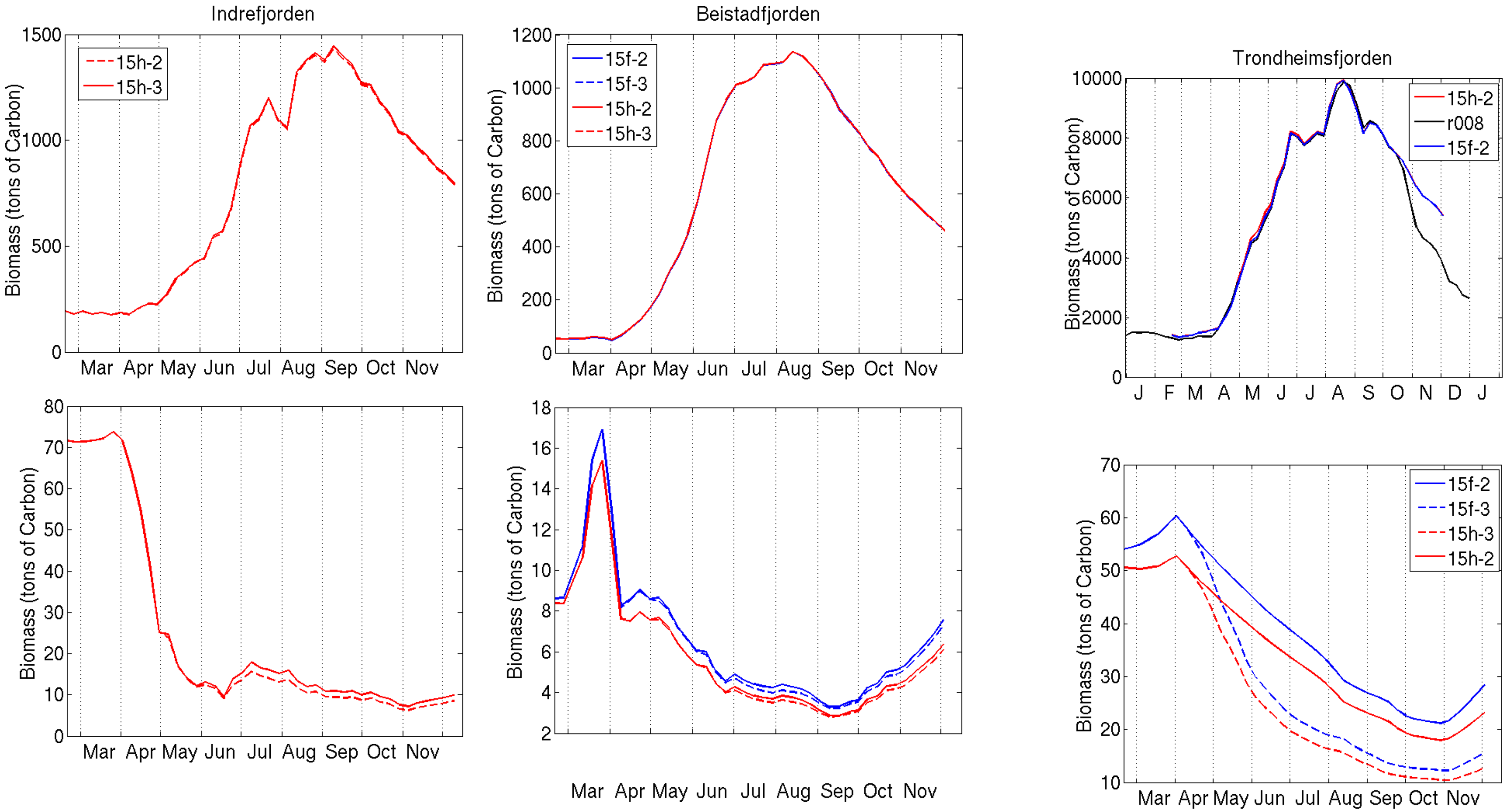
Solheim (2012)

Cfin r008a1 - Model domain - 2002

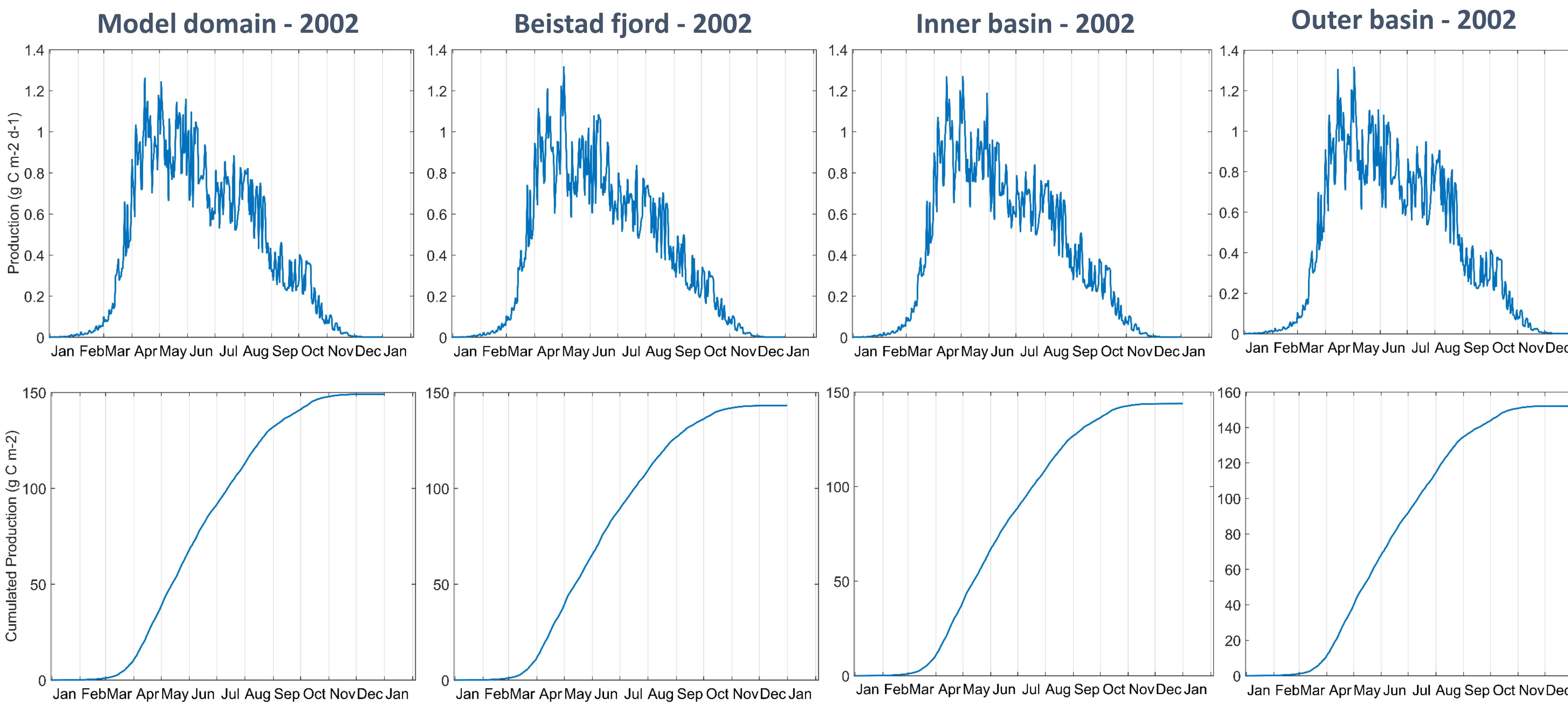




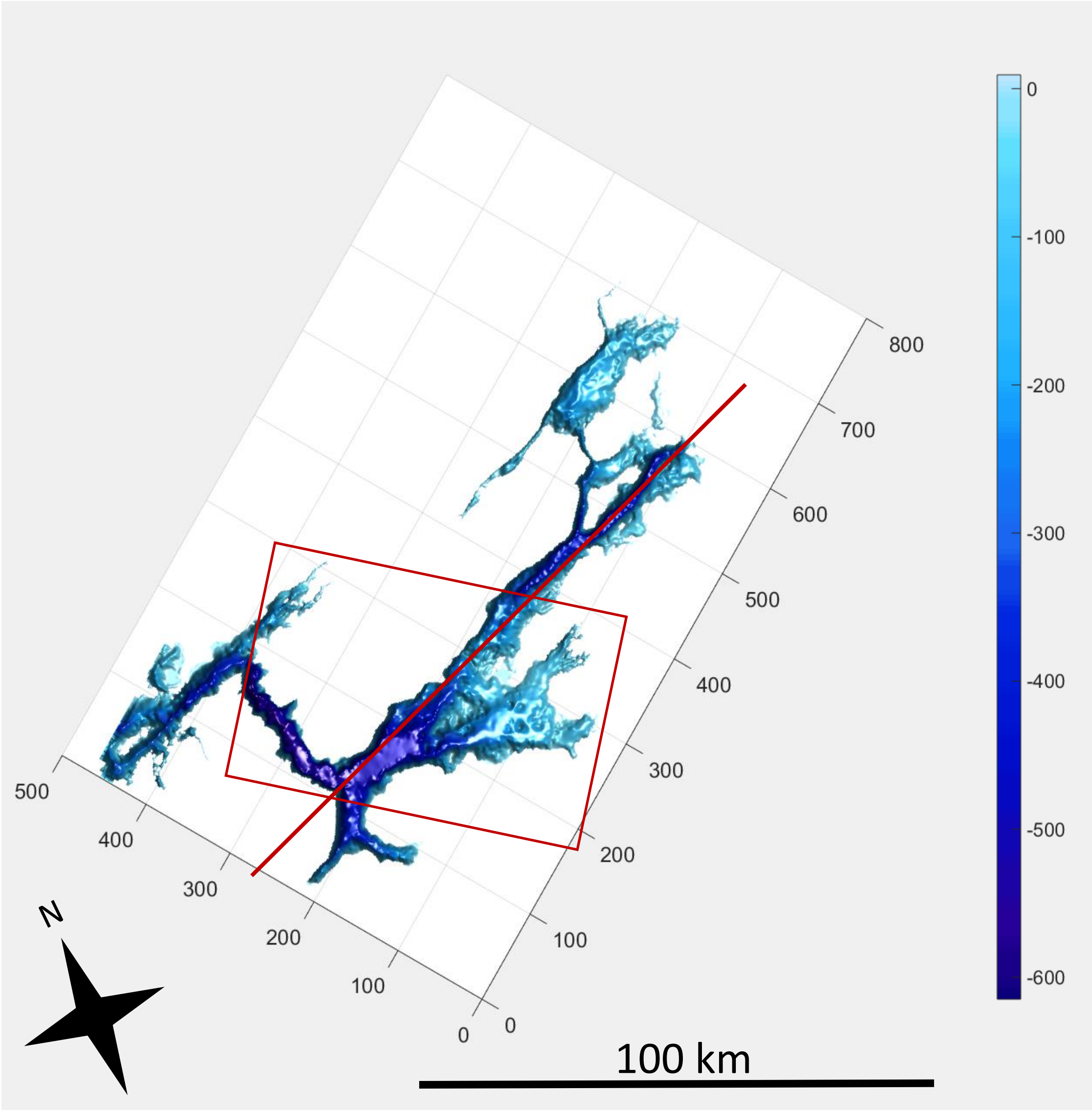
C. finmarchicus and *P. periphylla* seasonal production patterns

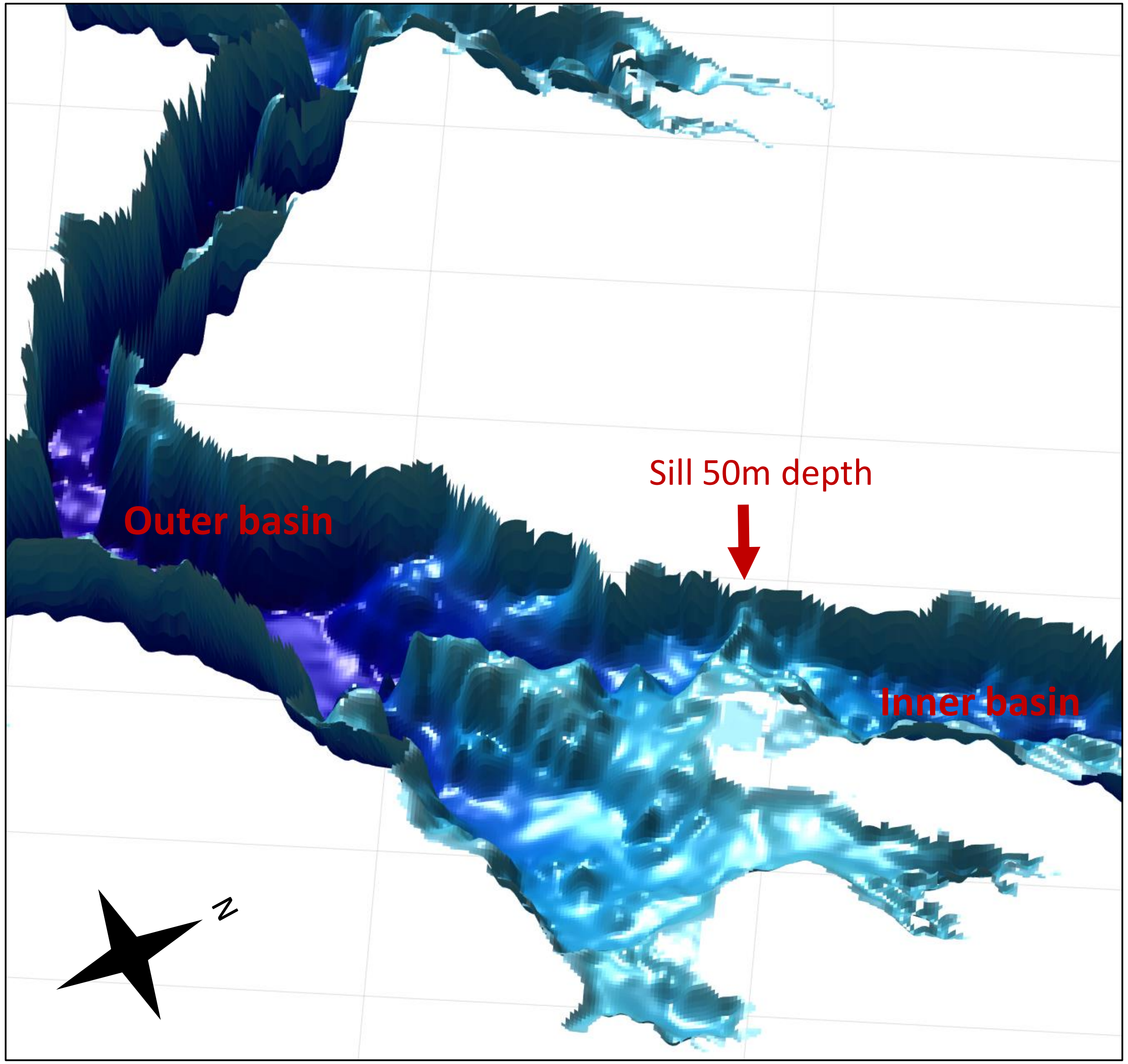


Primary production in different sub-basins

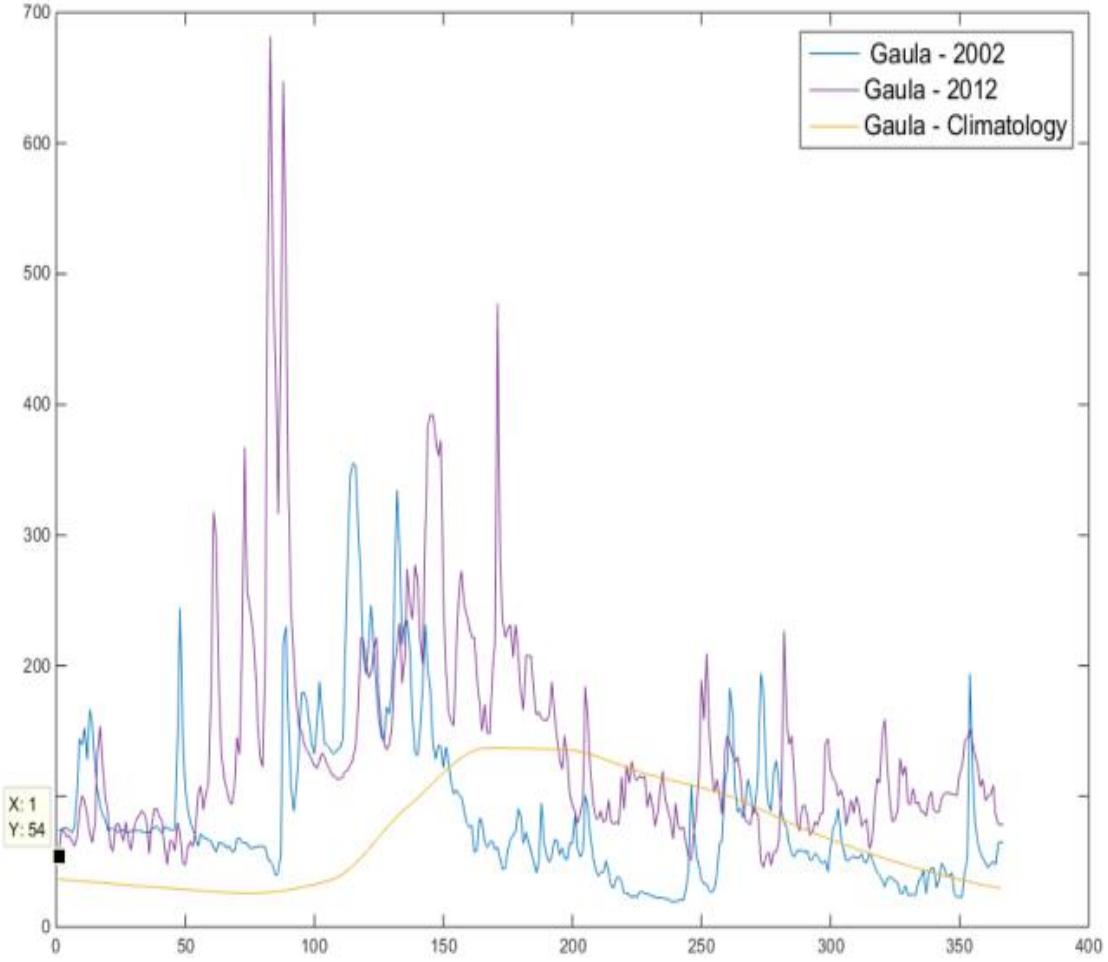


The Trondheim fjord





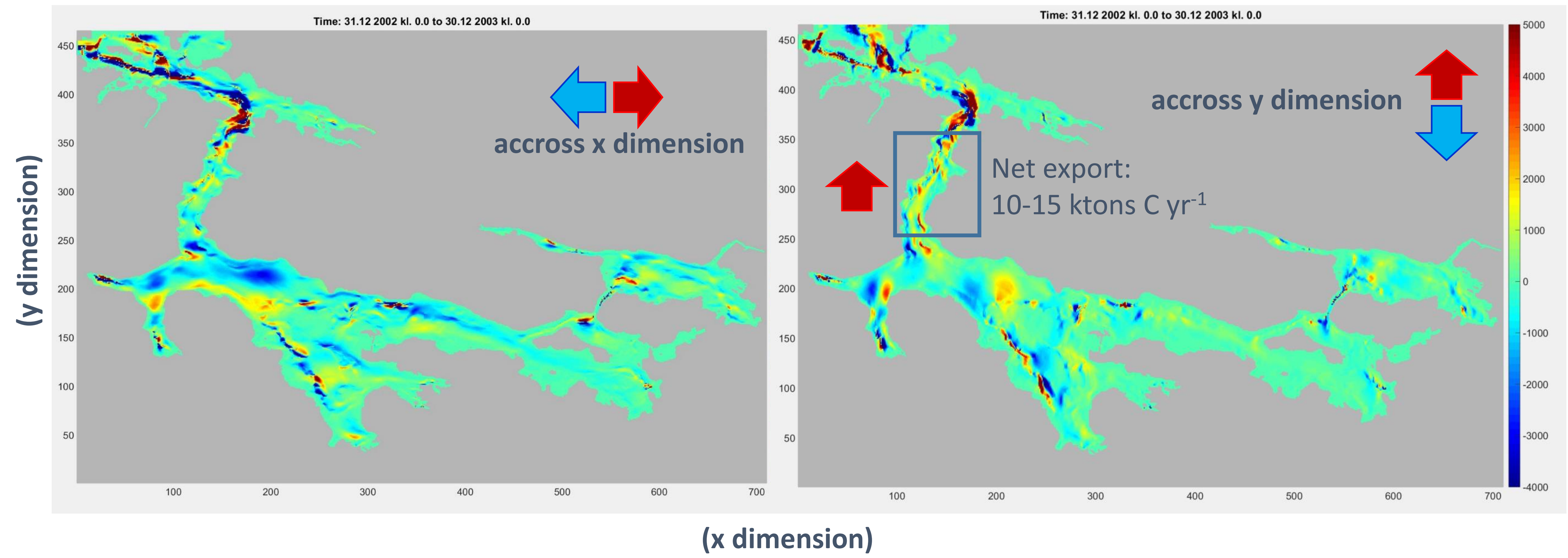
(add skarnsundet!)



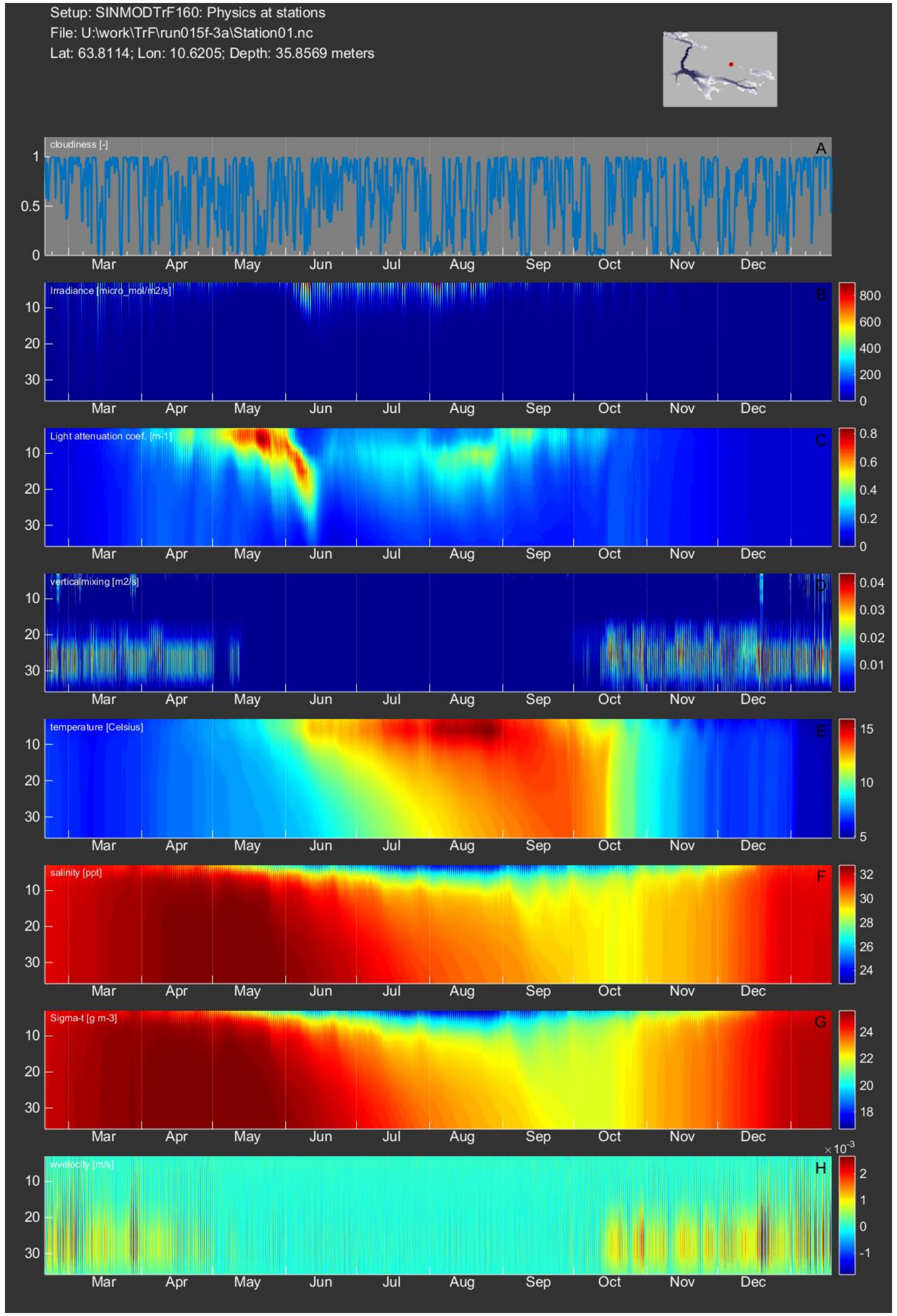
Gaula - 2002
Gaula - 2012
Gaula - Climatology
X: 1
Y: 54
0
100
200
300
400
500
600
700
0
50
100
150
200
250
300
350
400

Transport of *C. finmarchicus*

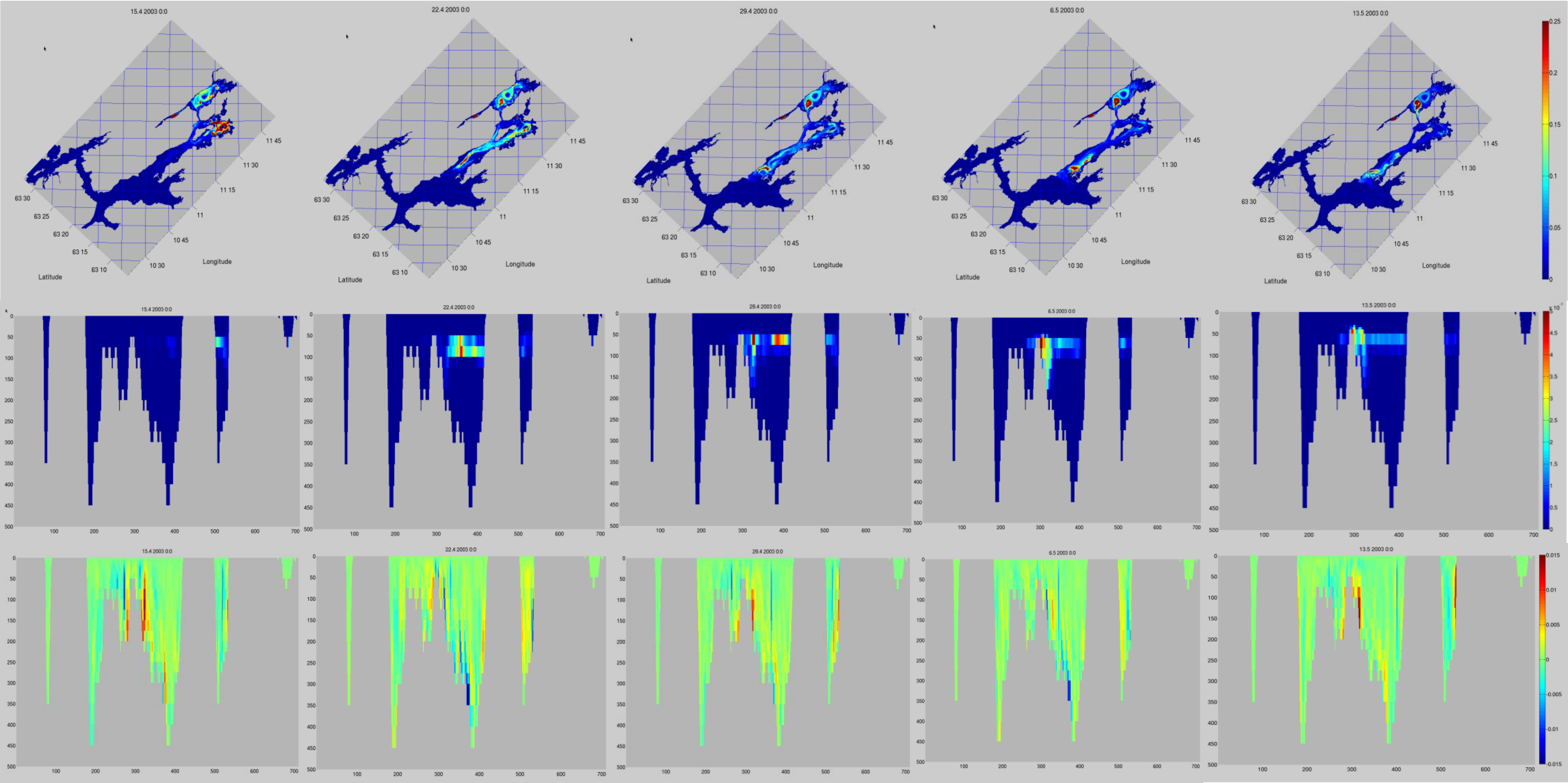
Vertically integrated biomass flux (tons of carbon km^{-1} yr^{-1})



Local time series (2002)



Biomass distributions: bathymetry and



Biomass distributions: hydrographical parameters