Project information

Keywords
pelagic ecosystem sensitivity feedbacks Arctic Ocean acidification
Project title
ECOAN WP3-OA9: Investigate pelagic ecosystem sensitivity and feedbacks to Arctic ocean acidification
Year
2016
Project leader
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Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
Arctic region
Participants

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Flagship
Ocean Acidification
Funding Source

Framsenter Flagship

Summary of Results

SINMOD results

During 2015 we analysed projections from the SINMOD ocean biogeochemical model for the surface 0-50 m layer under an SRES A1B emissions scenario. Here we presented results in terms of bidecadal averages over all seasons, and this raised some questions during group meetings in regard to the biological relevance of annual average pH and saturation state. Therefore, during 2016 we repeated these analyses resolving individual seasons, but still averaging over two decades to remove interannual variability (e.g. considering averages over all summers during 2050-2070). Although the seasonality in the 0-50 m layer is significant (in general, winter sees the lowest pH / saturation state, summer sees the highest values), the climatic decreases in pH and saturation state over 50 years displayed little variation between season. For both winter and summer, the largest climatic pH decreases (>0.2 units decrease) were observed in the Arctic Basin and East Greenland Shelf, although for summer there were also comparable decreases in the northern Barents Sea and Kara Sea. For both seasons, the bidecadal mean aragonite saturation state was approaching unity by 2060 in the Arctic Basin, East Greenland Shelf, northern Barents Sea and Kara Sea.

NORWECOM.E2E results

During 2015 an RCP4.5 projection (2006-2070) with the focus on ocean acidification was performed with NORWECOM.E2E forced by a ROMS downscaling of the NORESM model. In 2016 the main activity has been on further investigations of this projection. Surface pH shows a steady decline in both the Greenland, Norwegian and Barents Seas (Figure OA9.1), with trends close to -0.003 pr. year for all three areas, which is close to previous estimates from both measurements and models (Feely et al., 2009; Olafsson et al., 2009; Skogen et al., 2014). Focusing on the CO2 uptake, the model suggests an increase in the Greenland Sea to almost 15 mmol/m2/day in 2070, and a decrease in the uptake in both the Norwegian and Barents seas. In the end of the simulation, the model indicates that the Norwegian Sea is a potential source of CO2 to the atmosphere, while the decrease in Barents Sea uptake contradicts a previous investigating with NORWECOM.E2E forced by a downscaled ROMS-GISS_AOM (Skogen et al., 2014). The latter result points on the fact that a simulation is only one realization of a possible future, and that a robust projection should be based on two or more RCMs forced by at least two GCMs (ENSEMBLES, 2009). The main benefit from using regional models is higher resolution and thus better representation of the physics in both the ocean and the atmosphere. To further investigate this, an activity to compare results from the NORESM (GCM) and NORWECOM.E2E (RCM) simulations have been initiated in

cooperation with scientists at the Bjerknes Center in Bergen. Finally, the potential changes in primary production in the Barents Sea has been studied. The main findings were that the spring bloom starts one week earlier in the end of the period and that the production season then becomes 10 days shorter. The model gives a shift in the production cycle in the northern Barents Sea, with the peak production 3 weeks earlier than in the present climate. Using Genetic Programming (Papworth et al., 2016) for analysis, the main driver for inter annual variability in the primary production in the Barents Sea is the annual upper layer (0-30m) temperature in the western Barents Sea.

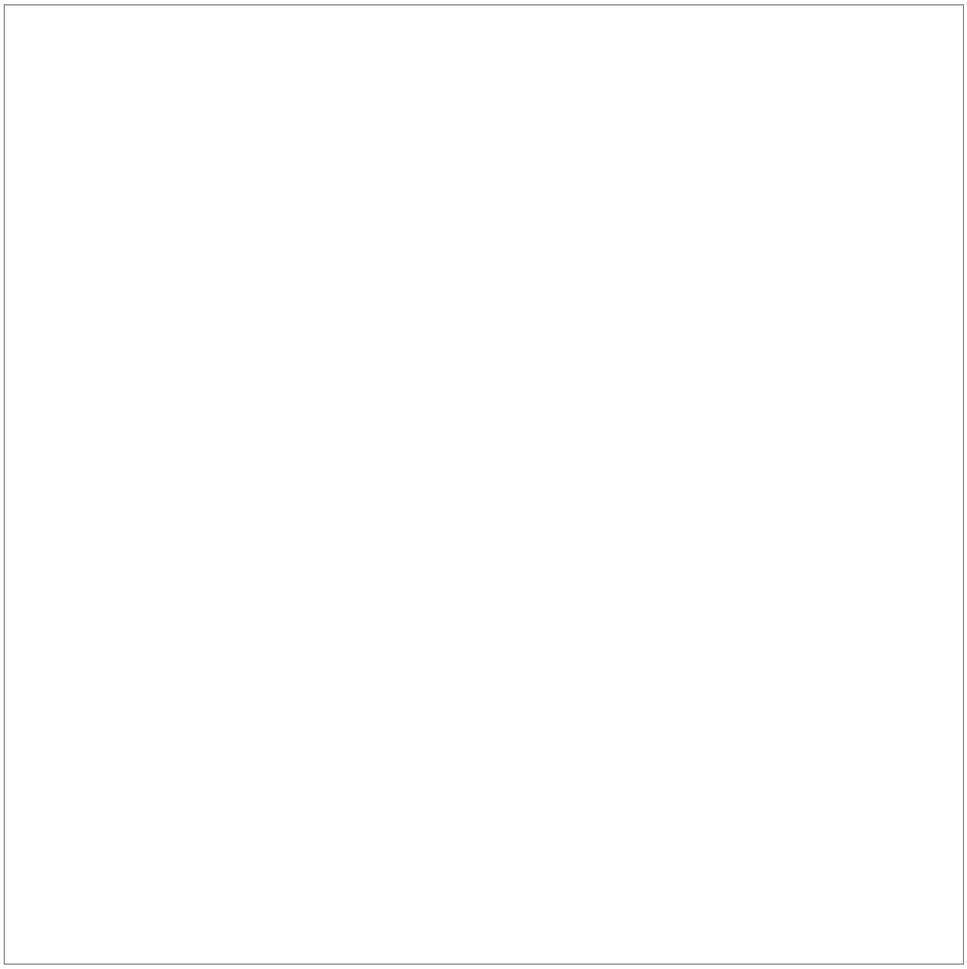

Figure OA9.1: Surface pH in the Barents, Greenland and Norwegian seas from the NORWECOM.E2E model.

NoBa results

Following a workshop held in Tromsø in November, 2015, we agreed upon a set of scenarios to be run with the NoBa model, suggesting changes in growth rate, consumption rate, nutritional content and change in non-predator mortality as a function of different pH levels. The model was run for two periods; historical: 1981-2001 and climate change: 2046-2065. These two periods are chosen due to available physical forcing from the ROMS model, as NoBa requires daily input of salinity, temperature and currents. The change in biomass was calculated over each simulation period (1981-2001 and 2046-2065), and compared to the average biomass of the historical period (1981-2001).

For the cod, capelin and haddock, the results were as following:

	NCO		CAP		HAD	
Simulation	Cs1	Cs2	Cs1	Cs2	Cs1	Cs2

1	0.1	4.1	-4.4	-16.0	-28.7	6.8
2	8.4	10.3	6.8	-1.7	42.1	130.3
3	0.3	1.5	-11.2	-15.1	90.9	41.4
4	0.2	2.4	-3.0	-13.4	-22.4	-10.2
5	6.4	5.5	22.3	-7.5	92.9	104.0
6	8.1	10.4	7.3	0.3	43.8	210.7
7	-0.2	1.1	-11.3	-13.5	91.0	37.6
8	6.6	5.7	21.8	-9.4	93.5	77.5
9	7.4	10.1	6.8	-0.5	36.2	158.1
10	6.5	7.0	22.7	-7.5	102.7	43.0
11	7.4	10.0	7.9	-2.7	30.7	132.4
12	6.6	6.7	22.7	-7.7	99.7	55.3
13	-0.6	1.3	-7.3	-15.6	57.5	-38.4
14	-0.2	1.6	-7.9	-16.9	59.1	-27.2
15	-0.7	2.3	-1.4	-10.4	-15.5	-29.4

Where we see enourmous variability in the haddock stock, compared to the capelin and cod. For the capelin in particular, it is interesting to see that for all but one run, the stock experiences a negative biomass change for the climate change scenario, whereas for the historical runs, there is a mix between positive and negative responses to the changes in mesozooplankton parameters. The cod is from earlier sensitivity studies shown to be a stable stock, where it's position as a top predator in the foodweb and a generalist has a buffering effect on the stock response to parameter changes. The capelin is more vulnerable to changes in the lower trophic level, being a planktivore fish. The strong responses in haddock need to be further investigated.

The fishing pattern will cause large differences between the two runs, and the fishing patterns which should be used in climate change scenarios requires further discussions. Keeping these at the current levels seemed to us at this time the most sensible.

It seems like cod will be rather robust to changes in zooplankton levels and parameters, whereas other species (e.g. haddock and herring) are more vulnerable to a negative development. In saithe, there seems to be a positive response to the parameter changes for a larger fraction of the simulations.

References

ENSEMBLES, 2009. RCM-specificweights based on their ability to simulate the present climate calibrated for the ERA40-based simulations. ENSEMBLES (http://ensembles-eu.metoffice.com) Project report D3.2.2 to the EU. 66pp.+2app.).

Feely, R., Doney, S., Cooley, S.R., 2009. Ocean acidification. present conditions and future changes in a high CO2 world. Oceanography 22 (4), 36–47.

Olafsson, J., Olafsdottir, S., Benoit-Cattin, A., Danielsen, M., Arnarson, T., Takahashi, T., 2009. Rate of Iceland Sea acidification from time series measurements. Biogeosciences 6, 2661–2668.

Papworth, D.J., Marni, S. and Conversi, A. (2016). A Novel, Unbiased Analysis Approach for Investigating Population Dynamics: A Case Study on Calanus finmarchicus and Its Decline in the North Sea. PLoS ONE 11(7): e0158230. doi:10.1371/journal.pone.0158230

Skogen, M.D., et al. (2014) Modelling ocean acidification in the Nordic and Barents Seas in present and future climate. Journal of Marine Systems. doi: 10.1016/j.jmarsys.2013.10.005.

For the Management

The project has progressed as planned in the proposal and all milestones and deliverables have been met.

Published Results/Planned Publications

A peer-review paper on the SINMOD projections is planned for 2017.

Communicated Results

SINMOD and NORWECOM projections were presented to the ECOAN group during the annual meeting in October.

Interdisciplinary Cooperation

This project has demanded collaboration between biogeochemical modellers (SINMOD, NORWECOM), ecosystem modellers (NoBa), the socioeconomic modellers in ECOAN-WP4 as well as the observationalists in ECOAN-WP1 and ECOAN-WP2.

Could results from the project be subject for any commercial utilization

No

Conclusions

The project has progressed in line with the proposal, and is providing important insights into projected climate change, acidification, and possible ecosystem responses. Interdisciplinary collaborations with other workpackages have been established and utilized.