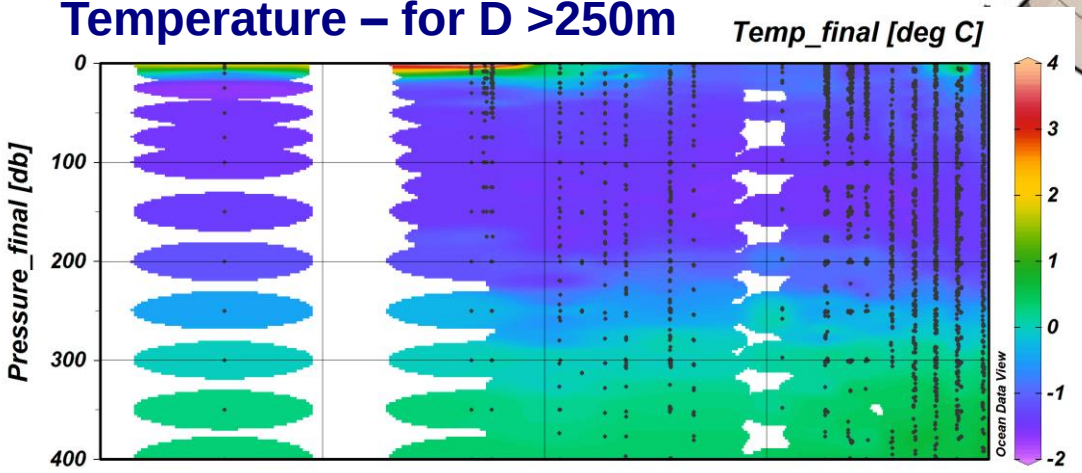
Linking climate change effects on marine ecosystems to socio-economic impacts in the Canadian Arctic
AMAP-Ocean Canada Case Study- Beaufort Sea

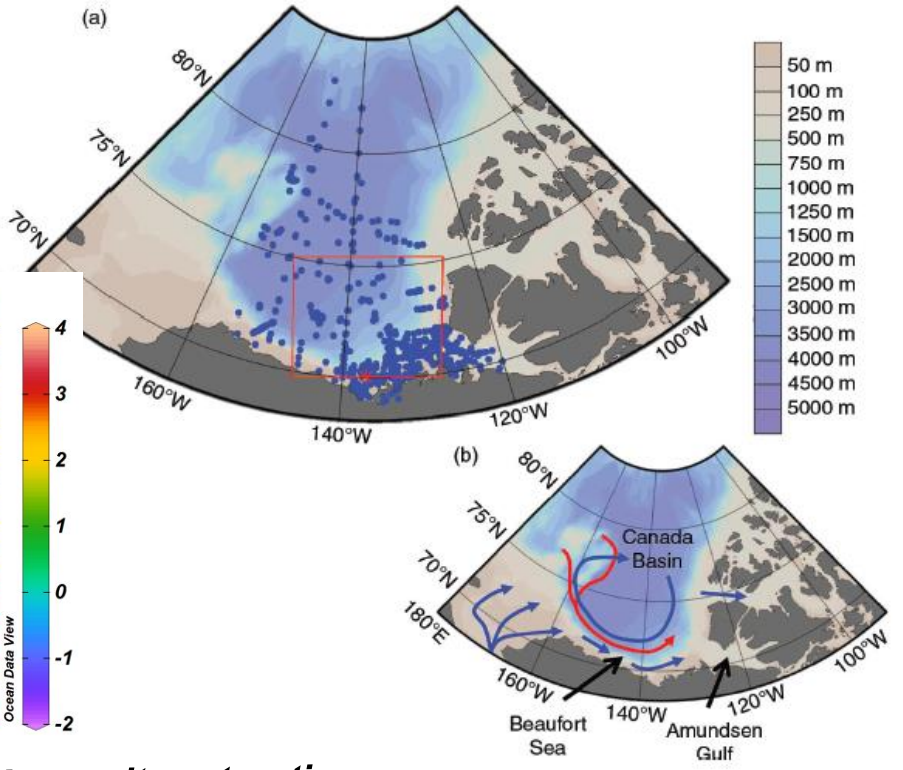
Nadja Steiner[1], Kumiko Azetsu-Scott[1], William Cheung[2], Andres-Cisneros-Montemayor[2], Helen Drost[3], Carie Hoover[4,1], Lisa Miller[1], Rashid Sumaila[2], Paul Suprenand[5], Tessa Sou[1], Travis Tai[2]

[1]Fisheries and Oceans Canada, [2]UBC Fisheries Center, [3]UBC Fish Physiology, [4]University of Manitoba,[5]Mote Marine Laboratory, Florida

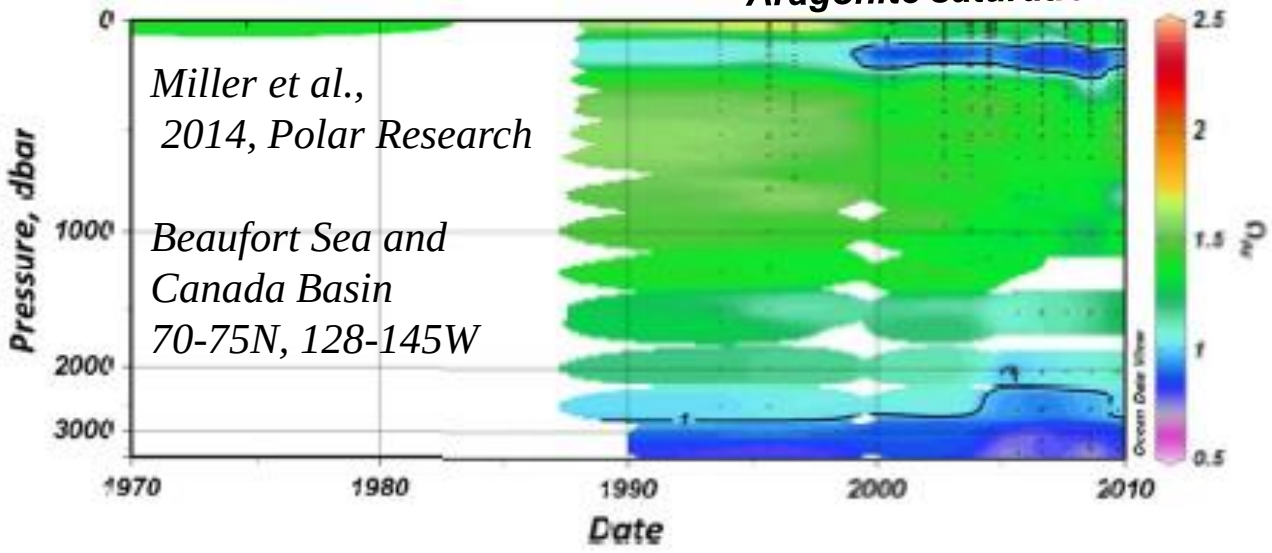
Beaufort Sea - Past Trends - L. Miller

July/August Temperature – for D >250m





Aragonite saturation

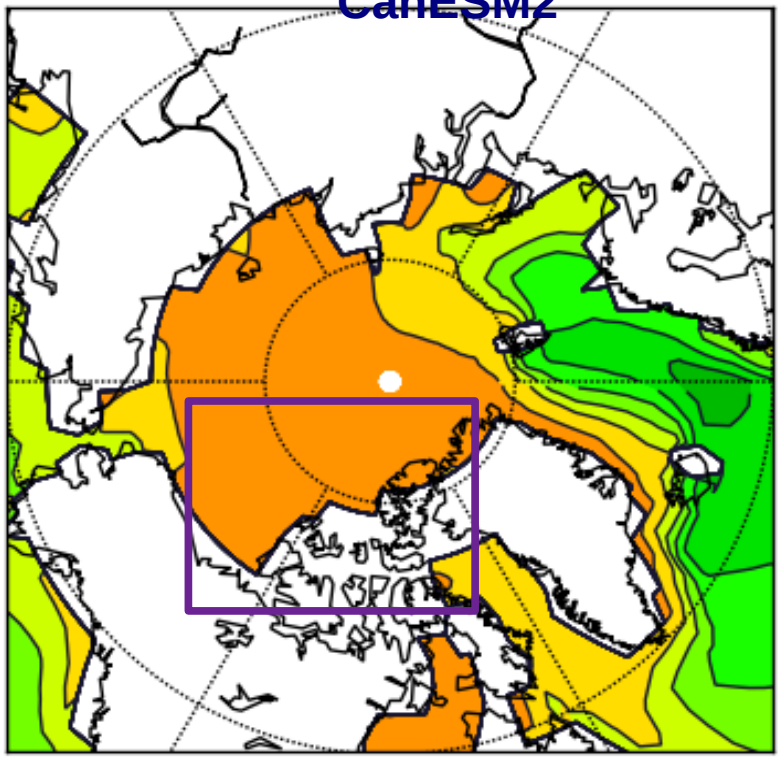


Miller et al., 2014, Polar Research

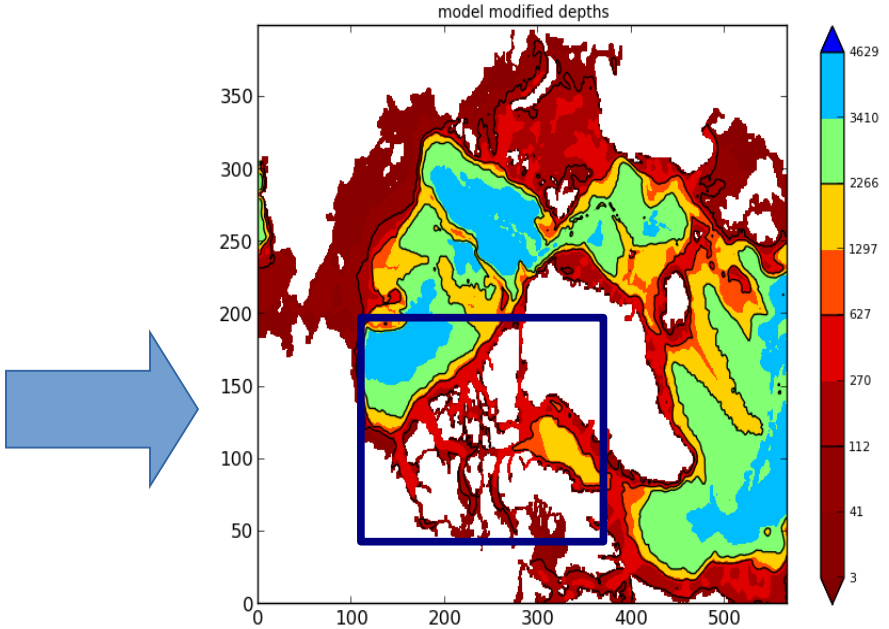
Beaufort Sea and Canada Basin 70-75N, 128-145W

Projection of environmental data via climate models

Canadian Earth System Model CanESM2



Canadian Arctic Ecosystem Model

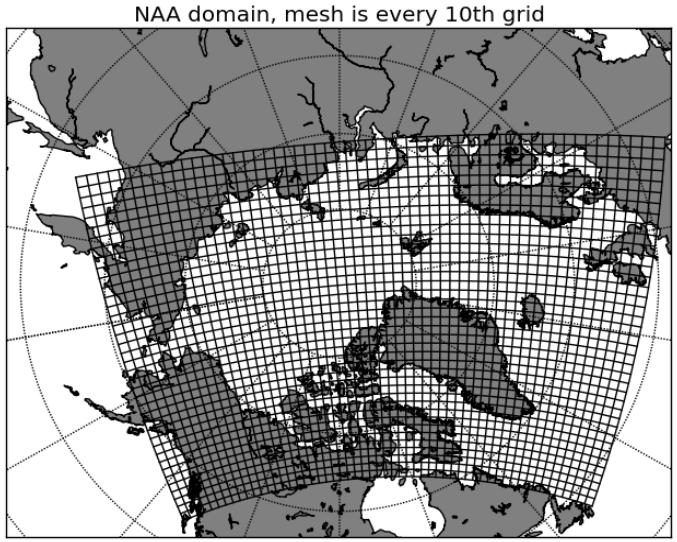


CanESM2 resolution insufficient for shelf/coastal areas

N. Steiner, T. Sou

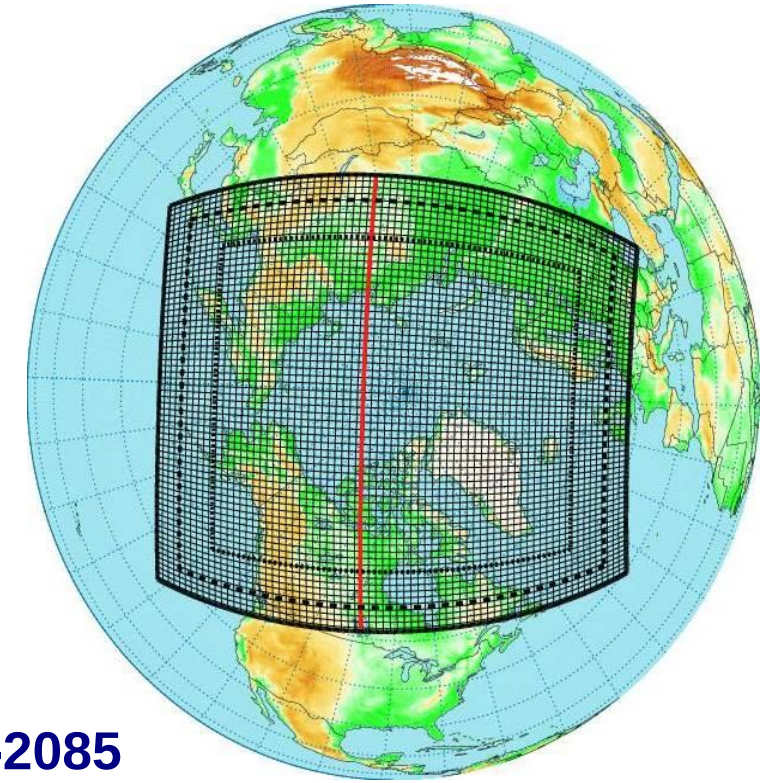
ACCASP: A higher resolution biogeochemical model for the Arctic

Physical model & configuration: NEMO-LIM2 (*Hu & Myers 2014*)
Ecosystem Models: PISCES**, CMOC,** CCCma CanOE**,**
Additionally: DMS, Sea ice ecosystem
=> development in in 1-D (ArcticNet, CCAR-NETCARE)



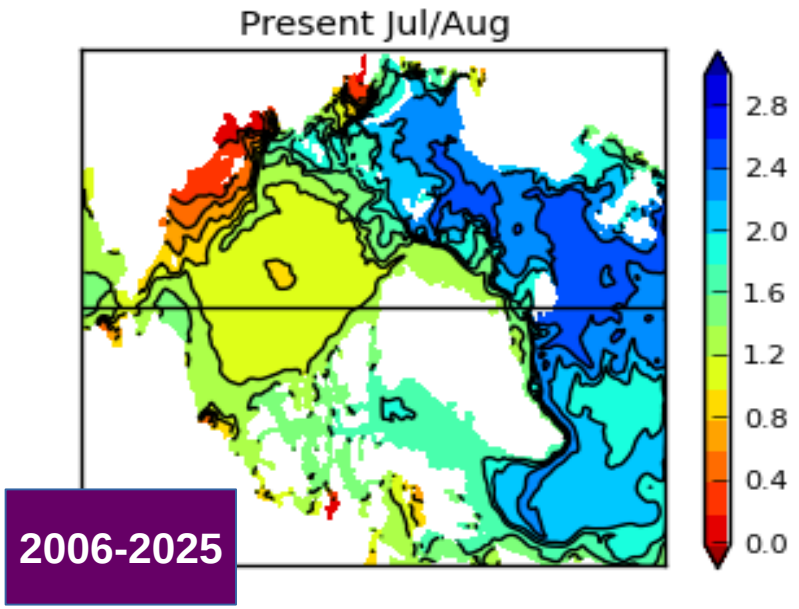
Ocean resolution: 11-15km horizontally, 6-250m vertically

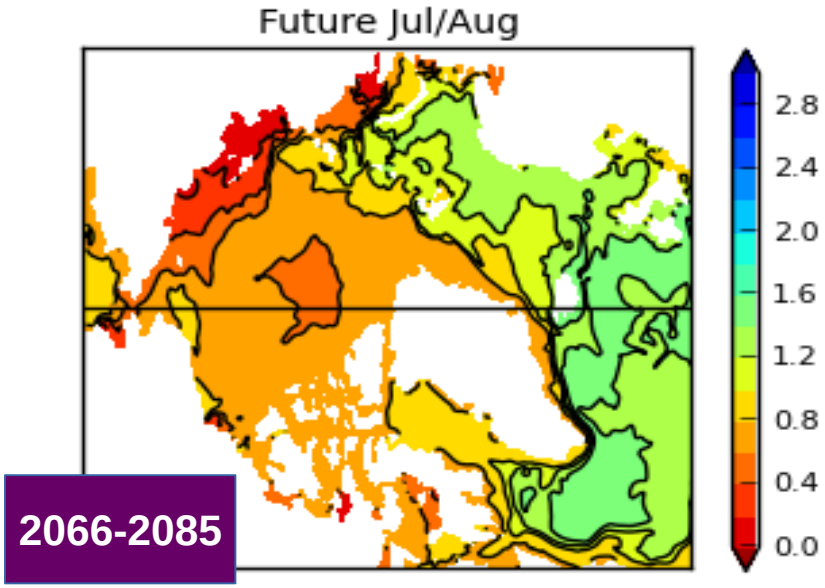
Forcing: CORDEX - Arctic domain 0.22 deg ~25km



Forcing: CanRCM4 + CanESM2,
Initialization: CanESM2 - Runs: 2006-2085

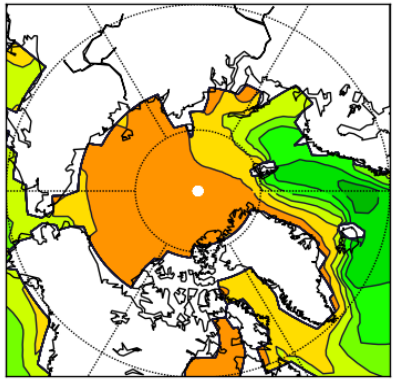
Aragonite saturation state Ωa (RCP8.5)





Regional Model

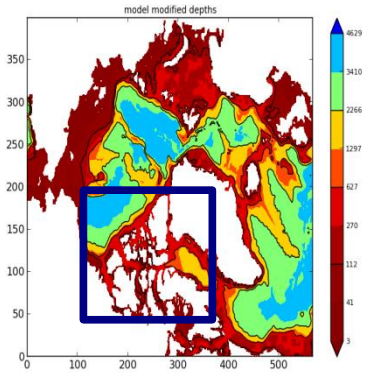
CanESM2



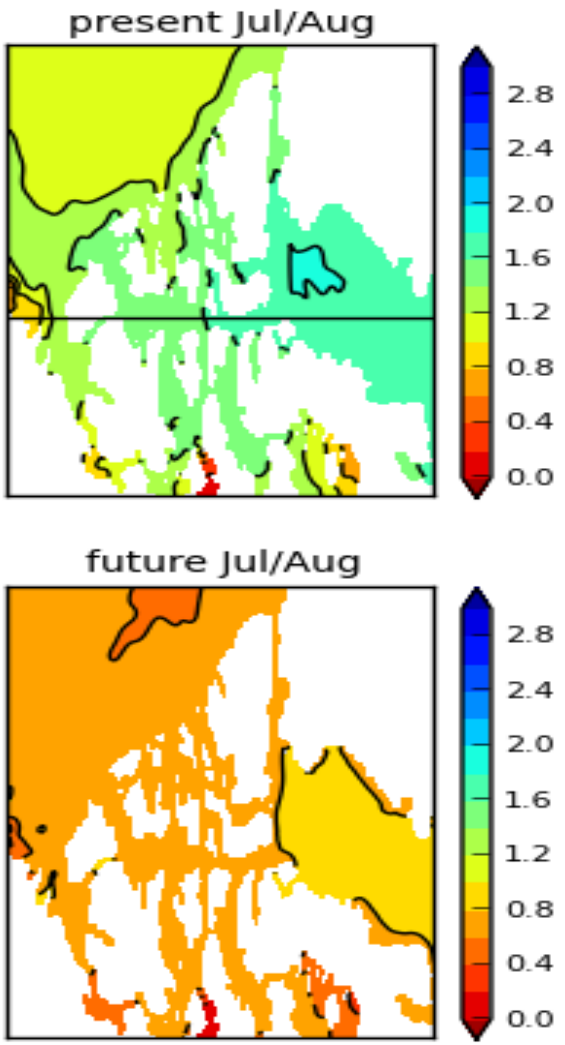
Aragonite saturation state Ωa (RCP8.5)

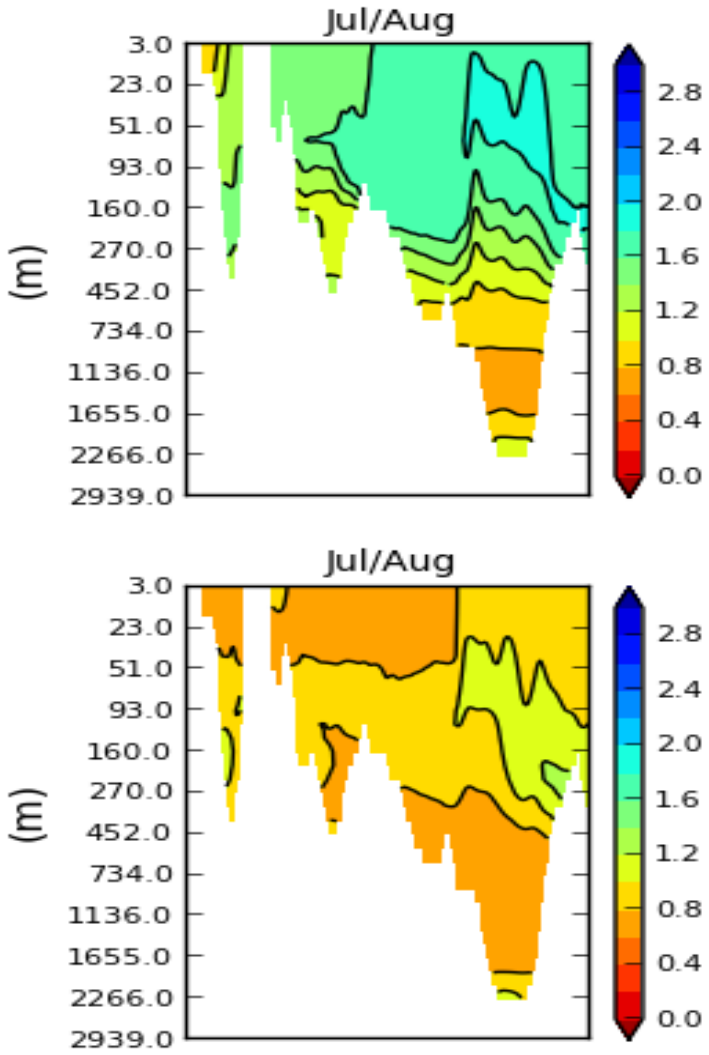
Regional Model

2006-2025



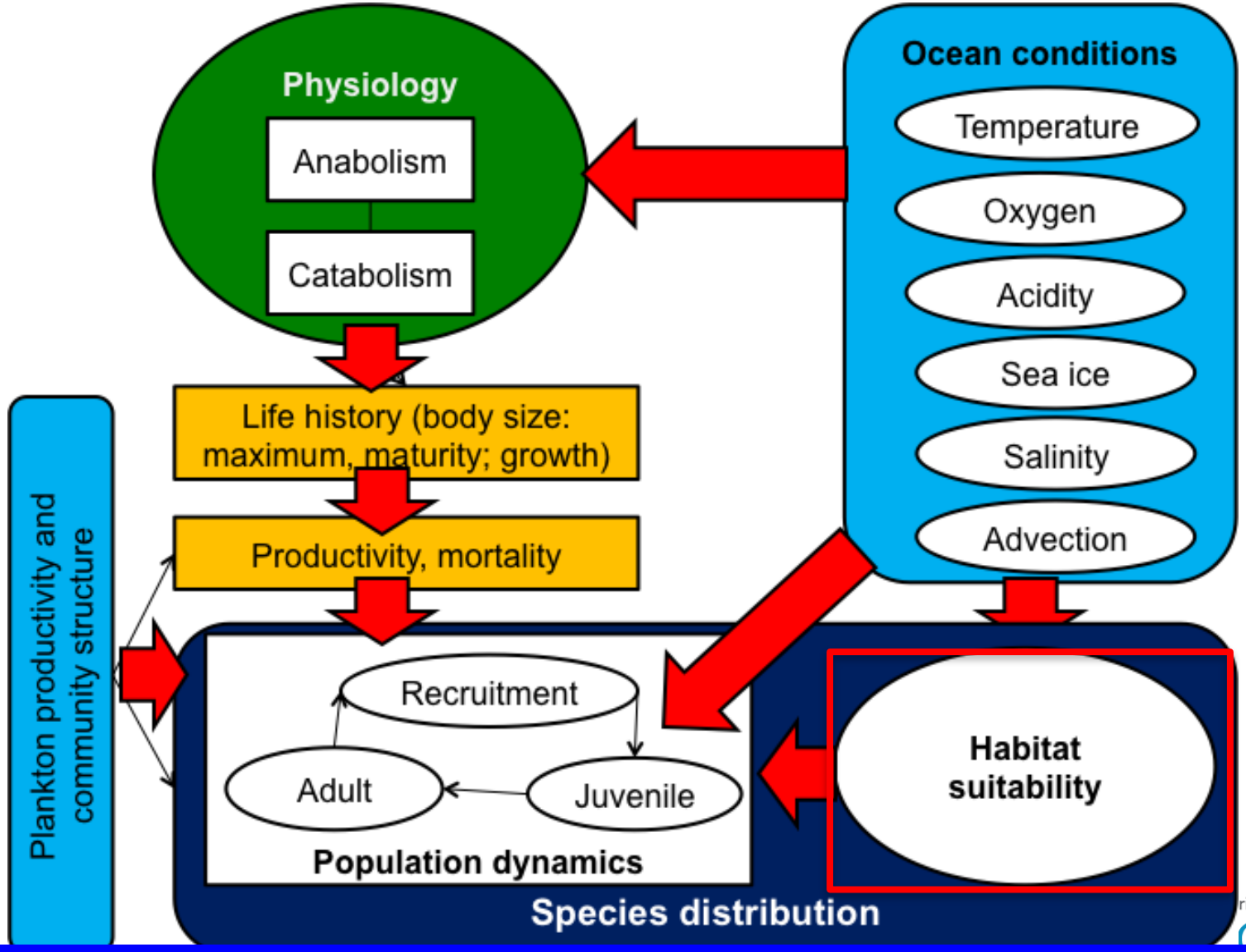
2066-2085





Courtesy T. Sou

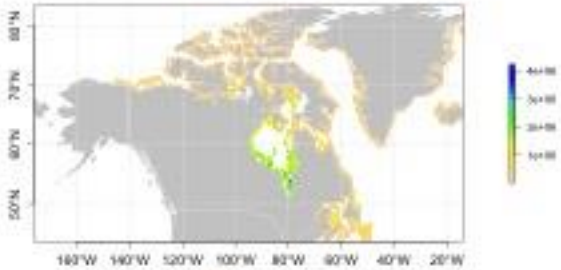
Dynamic Bioclimate Envelope Model

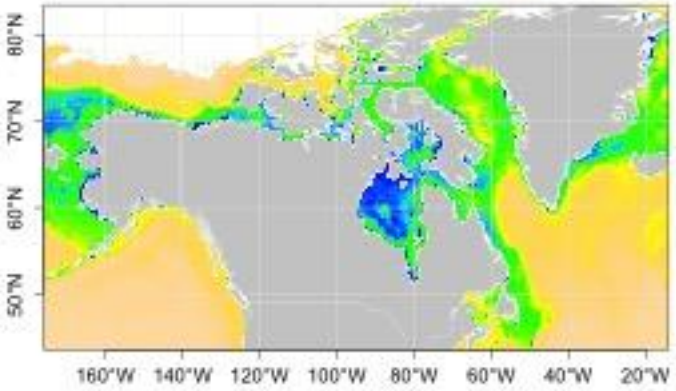


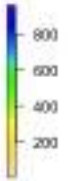
Source: Cheung et al. (2008, 2011, 2013)

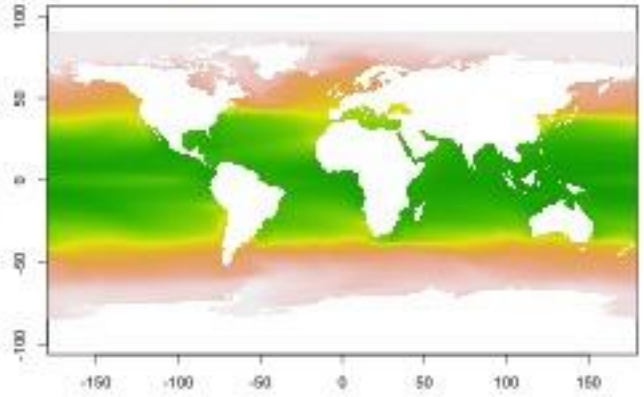
Arctic char – *Salvelinus alpinus*

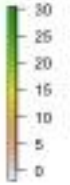
Current SDM with 0.5x0.5 grid











Habitat suitability using MAXENT with 0.25x0.25 grid

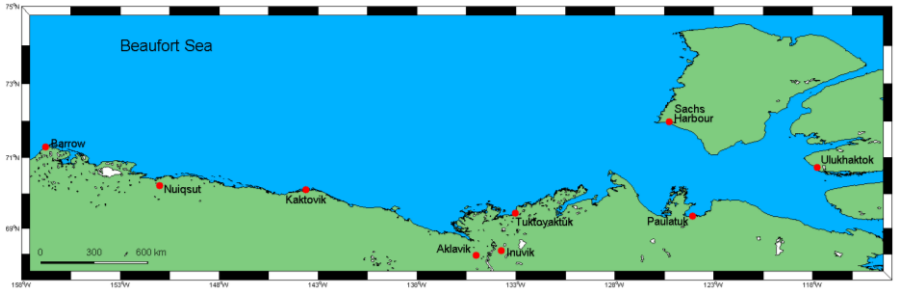
Primary productivity

Use habitat suitability and PP of each cell to characterize abundance

Ecosystem Models (Ecopath/Ecosim)

– C. Hoover, P. Suprenand

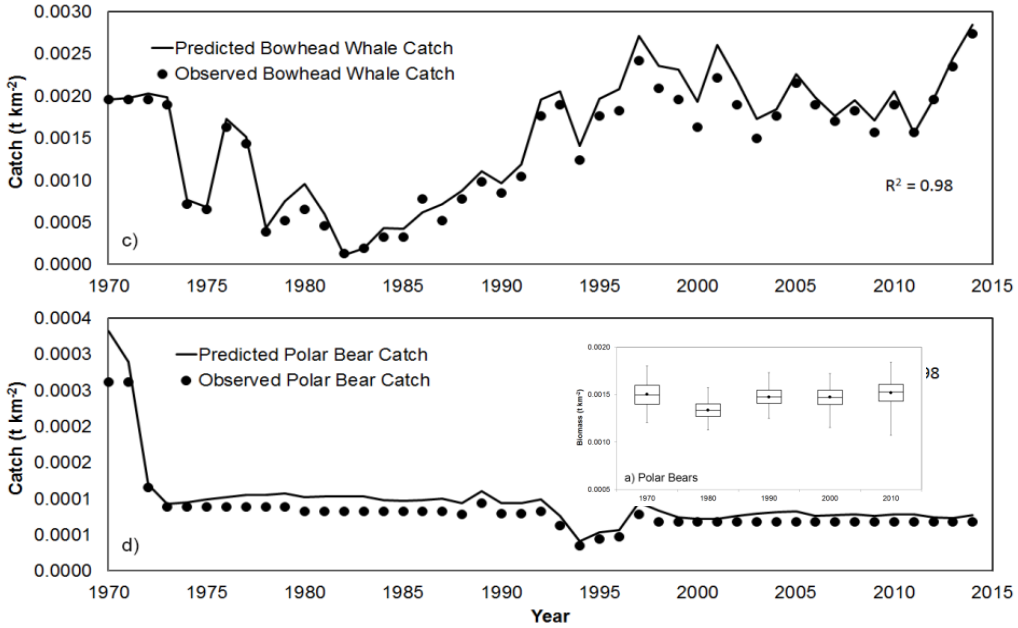
- Beaufort Sea 1:
  - Canadian Beaufort Shelf
  - 1970-2012
  - Temporal
  - Aggregate catches (fish, mammals)

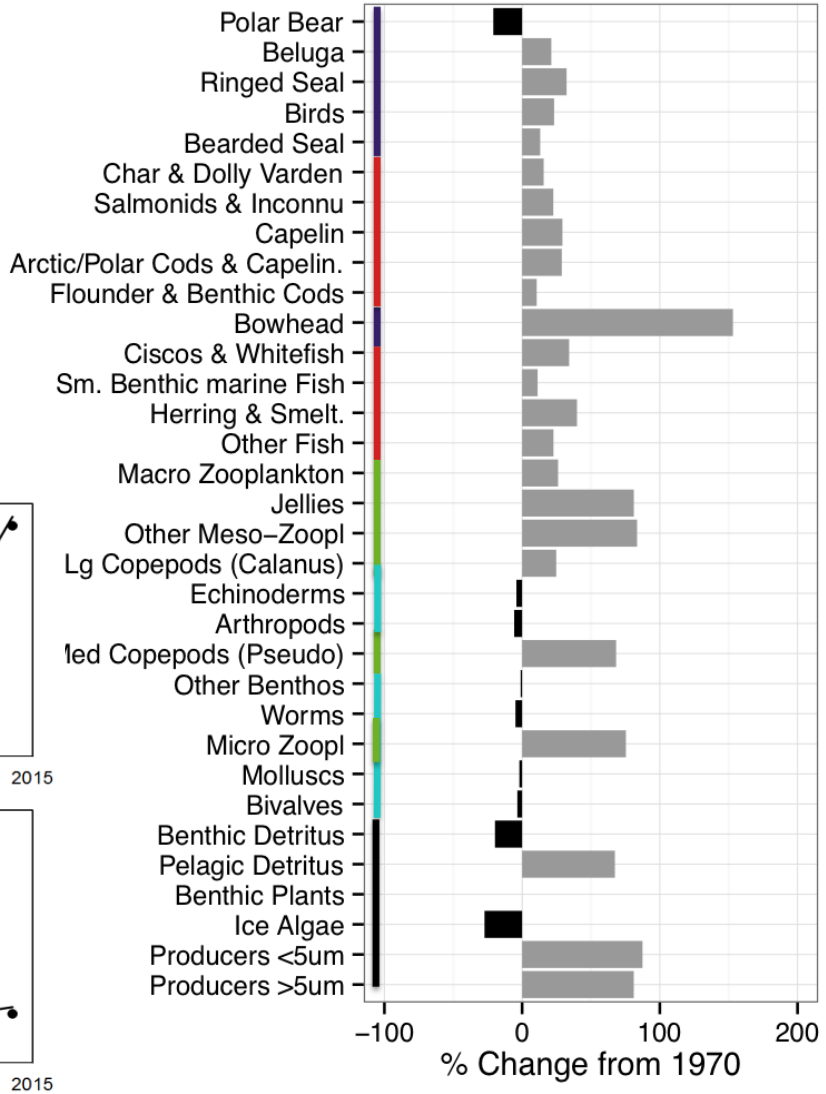


- Beaufort Sea 2:
  - US & Canada (expanded BS1)
  - 1970-2014
  - Dynamic Spatial-Temporal
  - Catches and effort by Community, mammal/fish, and subsistence use area

Historical Changes

- Verified with Catch & Abundance data
- Sensitivity Analysis performed on temporal Abundance data

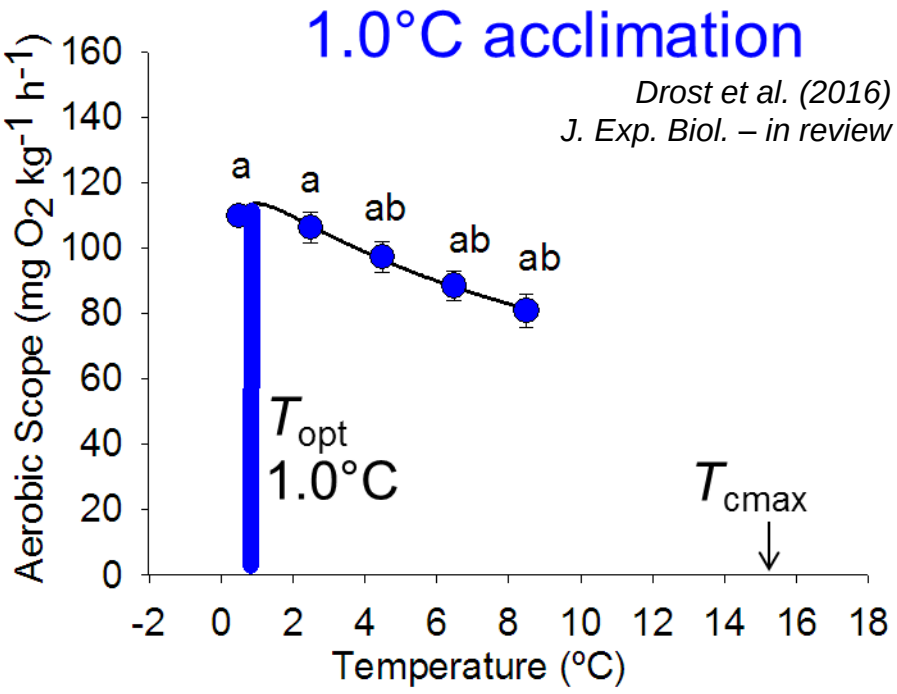


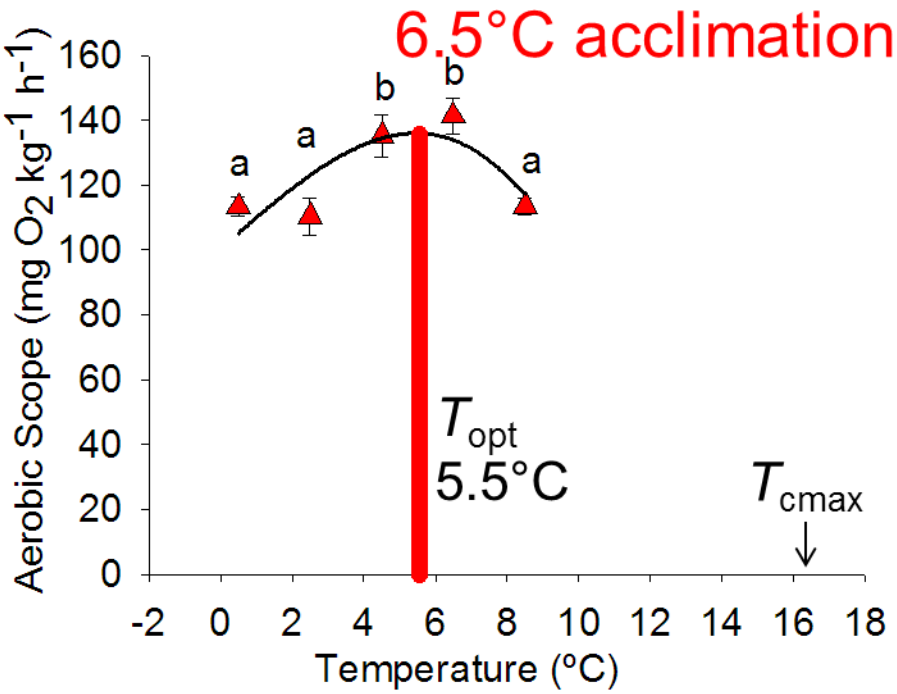


Physiological responses in fish (H. Drost)

Some fish species can compensate for increases in temperature (phenotypic plasticity), potentially making them more resilient to global warming *(Seebacher et al., 2015)*. E.g., the key food web species Arctic cod (*Boreogadus saida*) can:

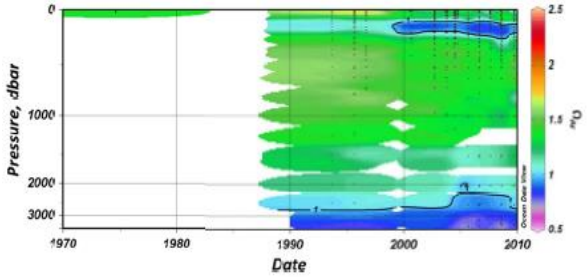
- Increase their aerobic scope (capacity to supply O_2 for activity) by 4.5˚ C when acclimated from 1.0 to 6.5˚ C water temperature
- Increase their tolerance to lethal temperatures (T_{cmax}) by 2.3˚ C from 14.9˚ C to 17.1˚ C over that same temperature range.



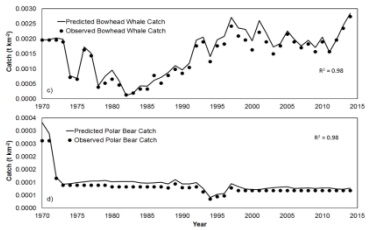


"Reducing model uncertainty is an urgent matter, but it will require a better understanding of phenotypic plasticity and genotypic diversity within a species" *Farrell & Franklin (2016), Science*

Past Trends

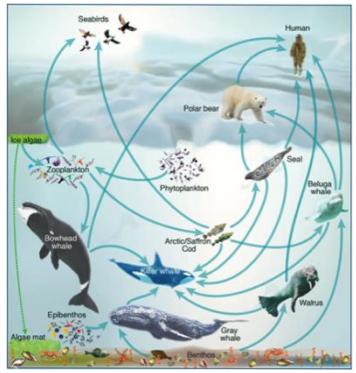


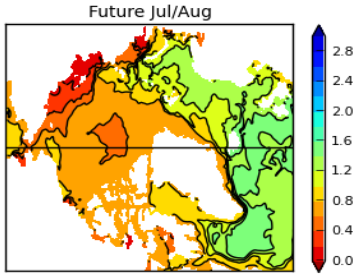
Current fishery-economic activities

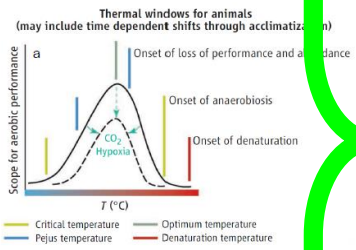


non-spatial tropho-dynamic ecosystem models (Ecopath/Ecosim)

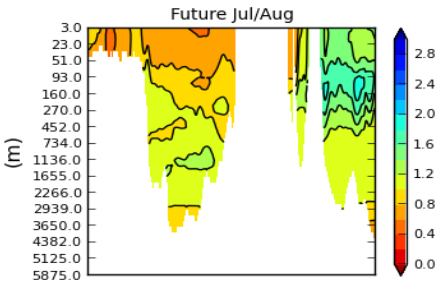
Economic models => Socio-Economic Responses



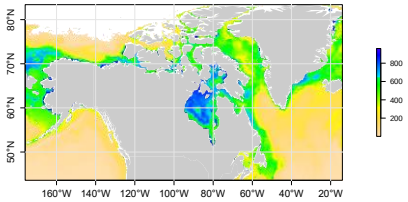




Physiological responses to multiple stressors in marine species



Future projections (Regional and Global Climate Models)



Species distribution - habitat suitability models

Goal: Link climate change projections of Canadian Arctic waters to effects on marine species and socio-economic impacts on people.

Summary

Goal: Link climate change projections of Canadian Arctic waters to effects on marine species and socio-economic impacts on people.

*** Develop and run a regional Arctic climate model for 2006-2085**
*** Feed model output to species distribution/habitat suitability and higher trophic level Ecosim/ecopath models**
*** Include physiological responses and thresholds in marine species**
*** Assess socio-economic impact via economic models and current fishery-economic activities.**

Initial case study in the Beaufort Sea as part of Ocean Canada & AMAP with focus on acidification impacts.
(Within DFO additional -funding request from IGS for 2016/2017)