Effects of circulation and climate change on early life stages of Antarctic krill

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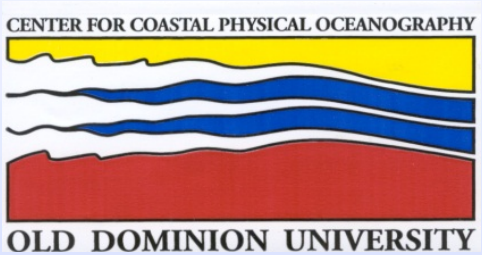


2nd International Symposium: Effects of Climate Change on the World's Oceans, May 2012, Korea

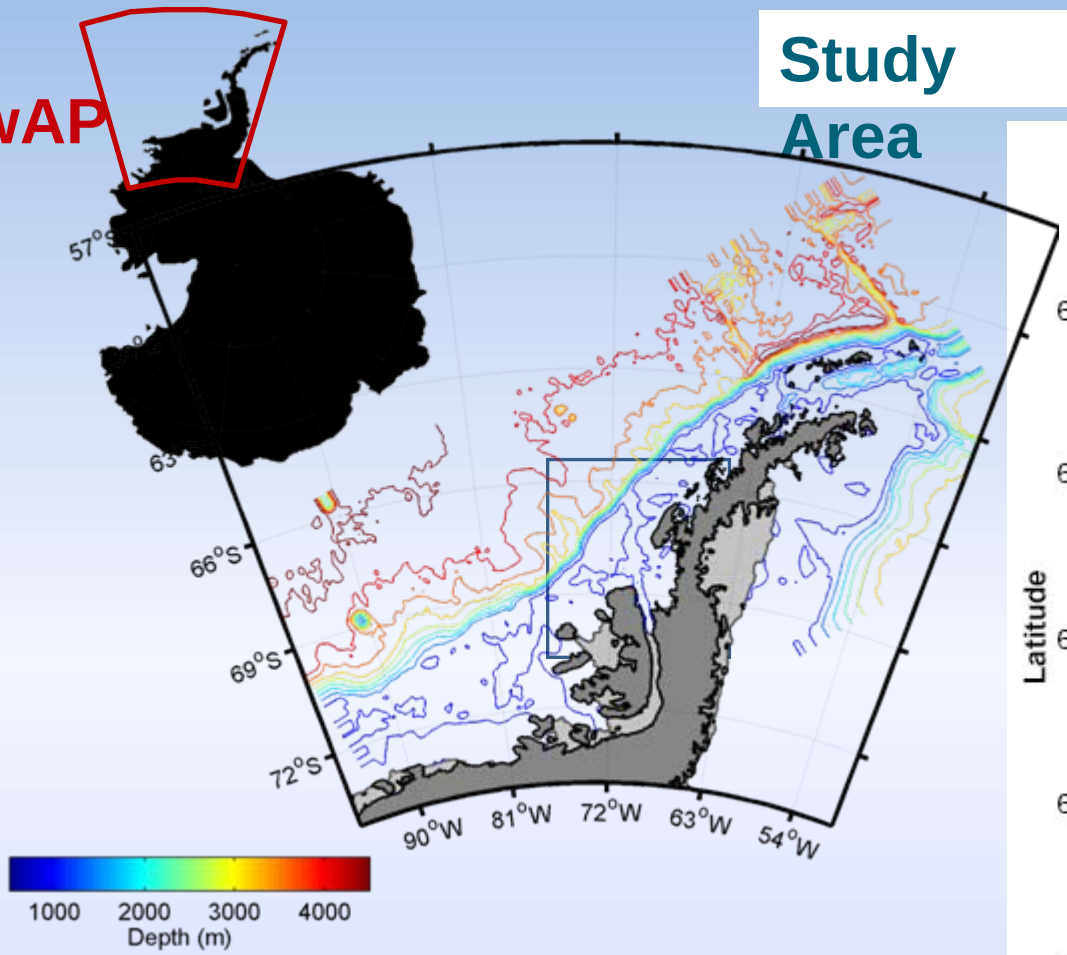
OUTLINE

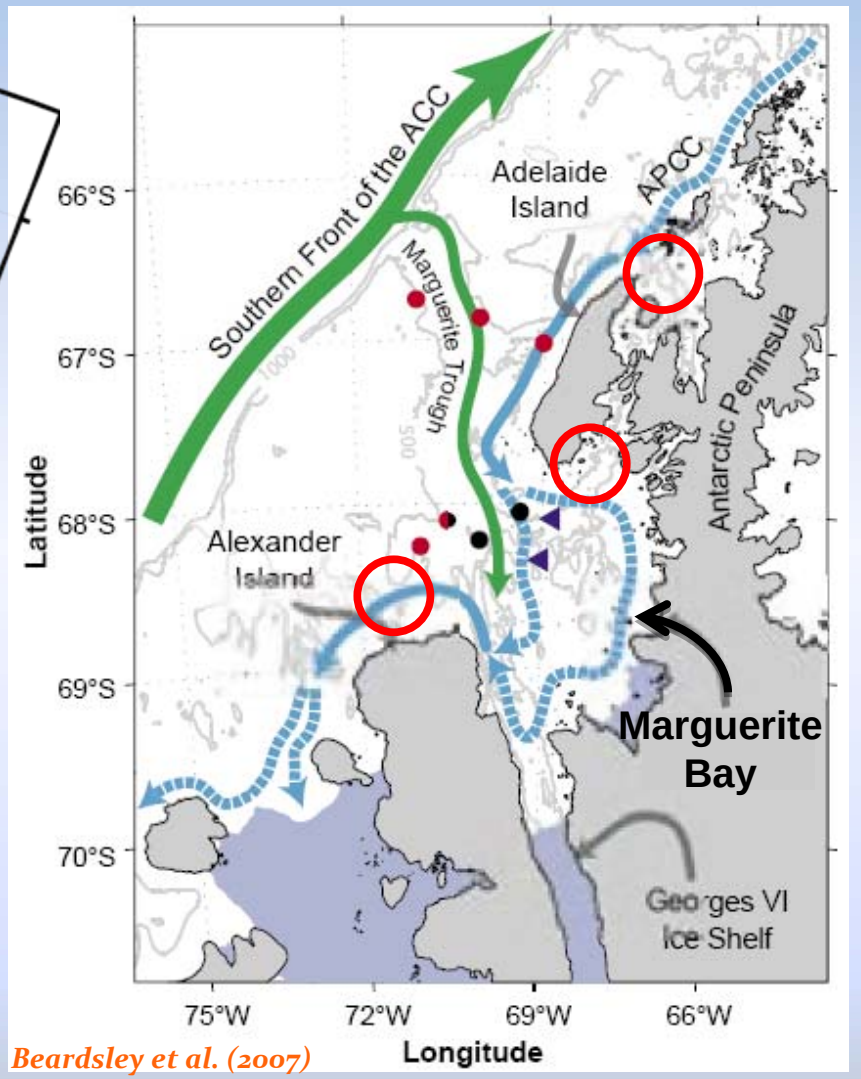
- Study area, circulation, hot spots
- Antarctic krill: early life cycle, abundance and distribution from SO GLOBEC field campaigns
- Objectives
- Models – circulation, descent-ascent of krill
- Remote and/or local reproduction of Antarctic krill
- Present and future environmental conditions
- Conclusions and Implication

This study has been developed as part of the US SO GLOBEC program, and corresponds to the synthesis and integration phase.

wAP

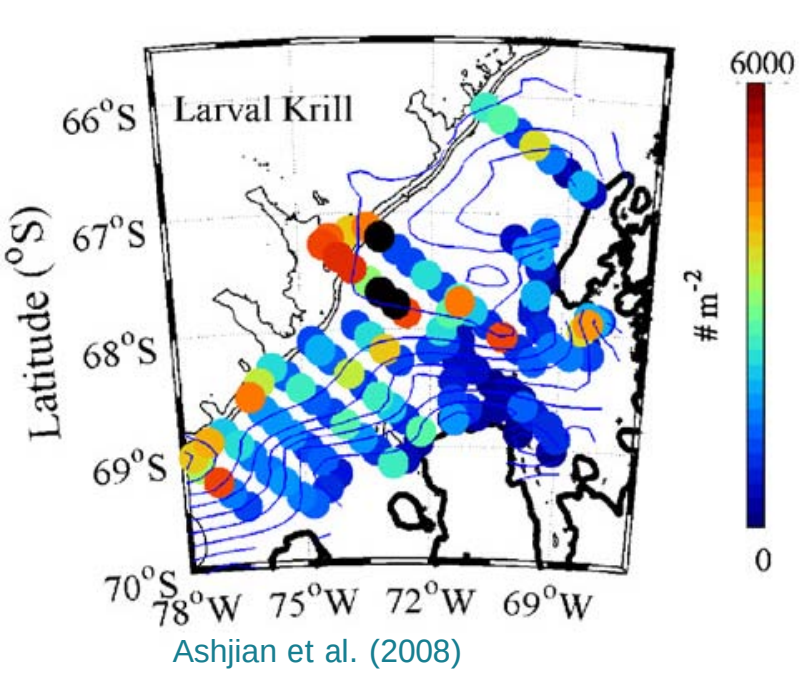
Study Area



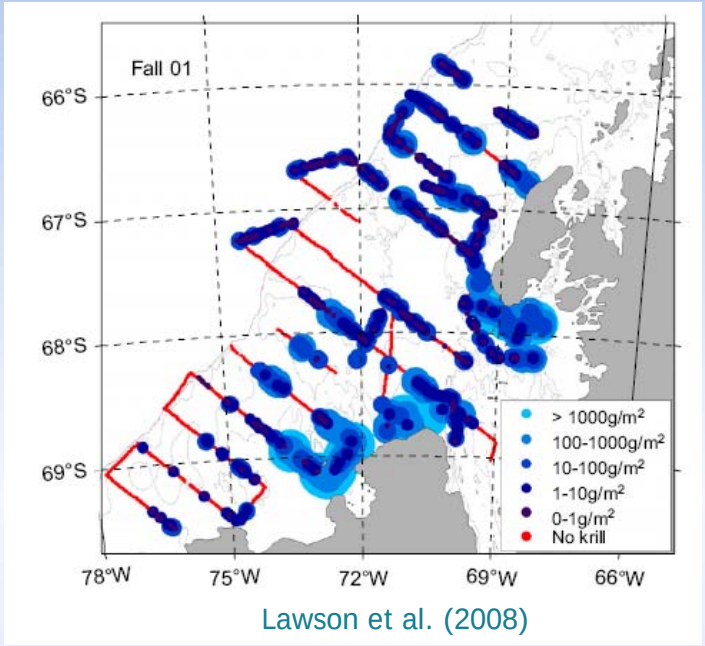


Biological hot spots (Costa et al. , 2007)

Krill abundance on the shelf



Ashjian et al. (2008)



Lawson et al. (2008)

- **Increased larval abundance at the shelf break and on the shelf.**
- **Large number of aggregations inner shelf.**
- **Ocean circulation influences connectivity of Antarctic krill populations in the wAP (remote and local effects).**
- **Krill overwinter on the shelf, timing and extension of sea ice.**

OBJECTIVES

* Evaluate remote and local connectivity of Antarctic krill populations along the wAP

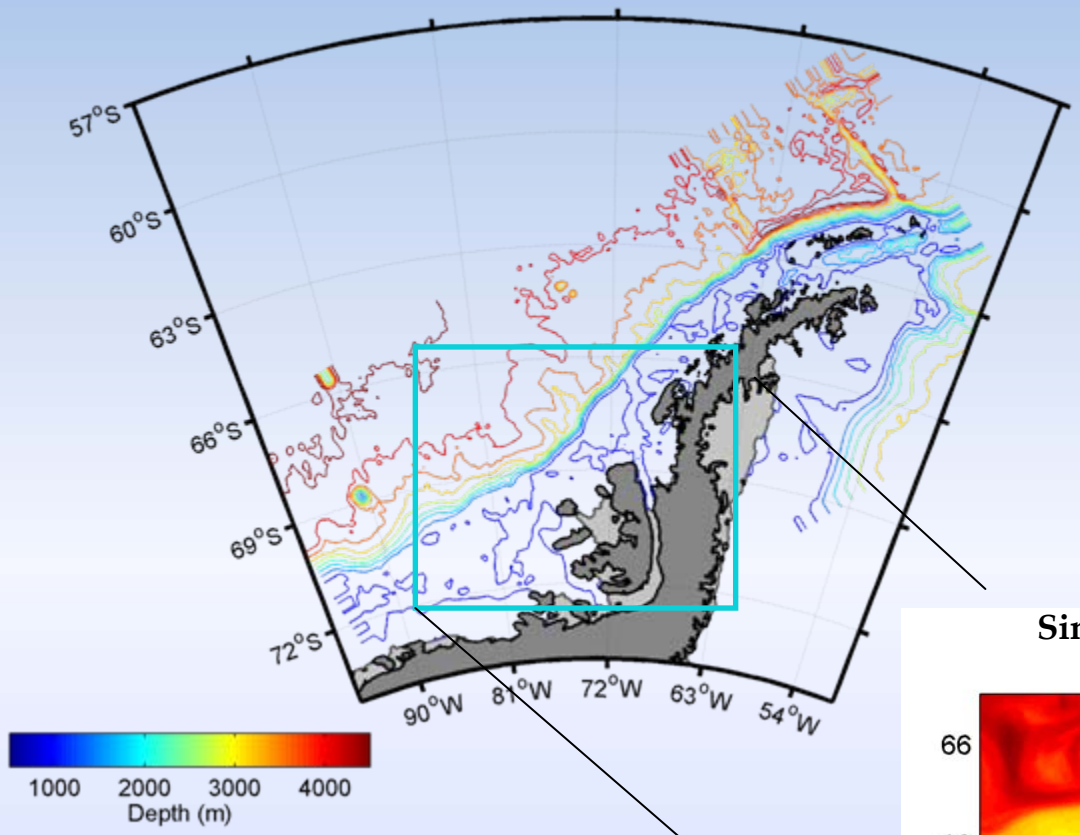
* Consider the effects of potential climate changes on the early life stages of Antarctic krill larvae along the wAP

Approach

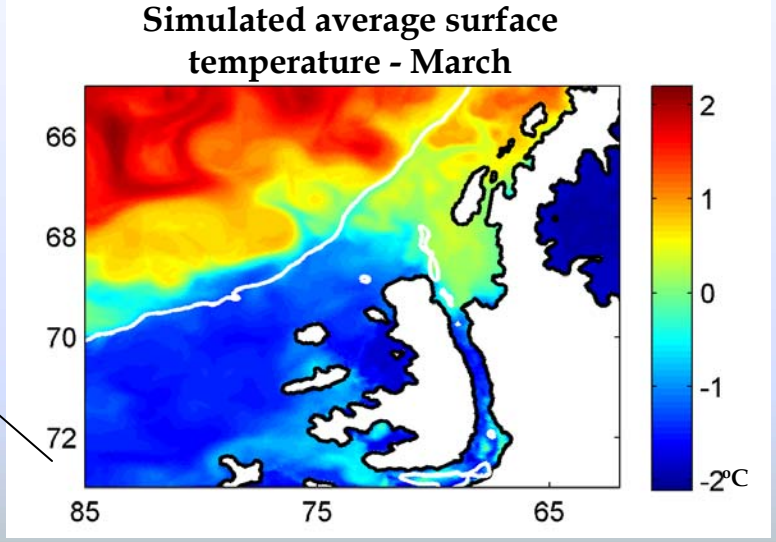
- ROMS-based circulation model and Lagrangian particle simulations

- Model of descent-ascent cycle of the embryos and early larval stages of Antarctic krill,

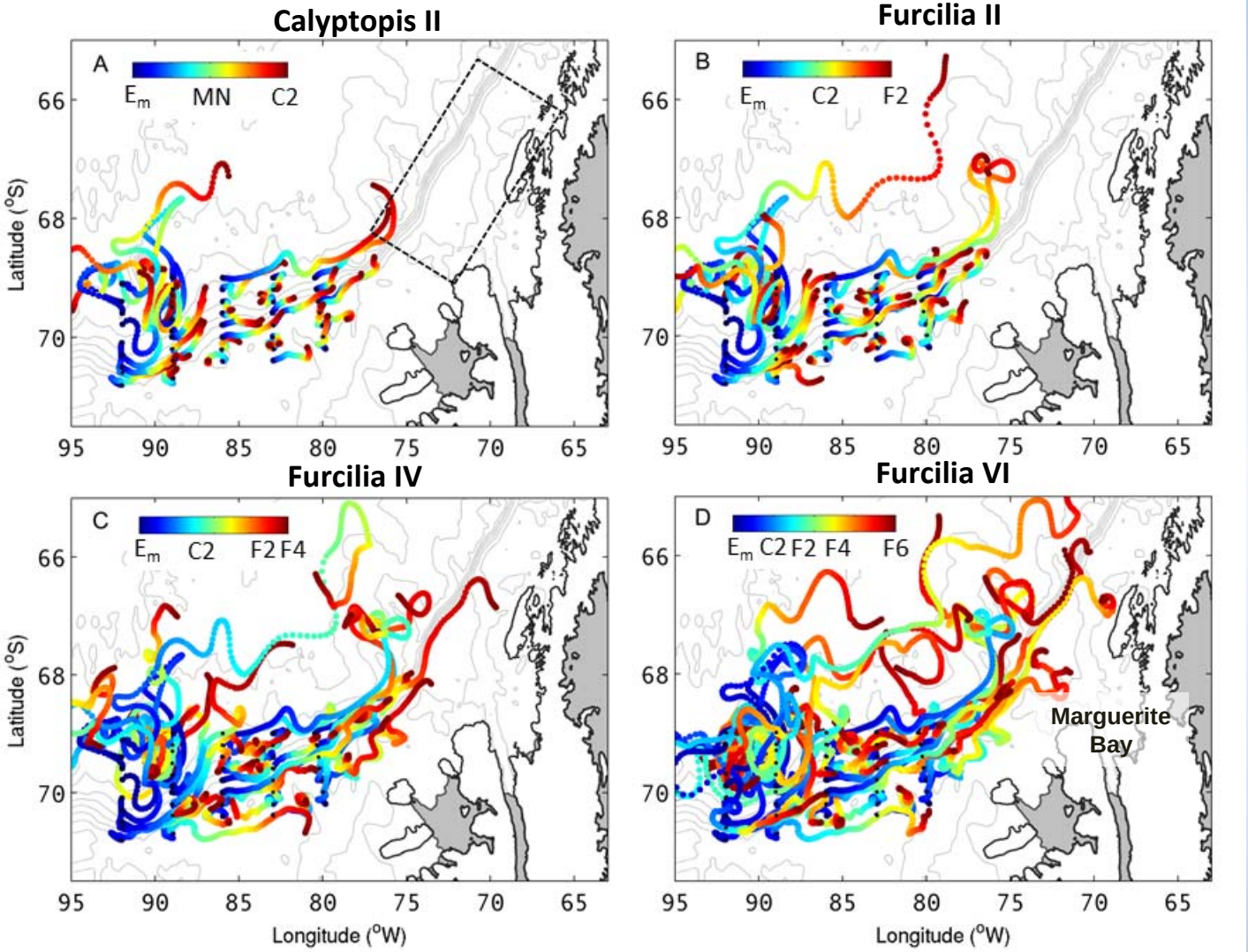
Ocean circulation model



- ROMS – wAP (Dinniman et al., 2011)
- Particle tracking simulations
- Temperature and density fields provided environmental inputs to the embryo-larva model



Connectivity - Bellingshausen Sea inputs



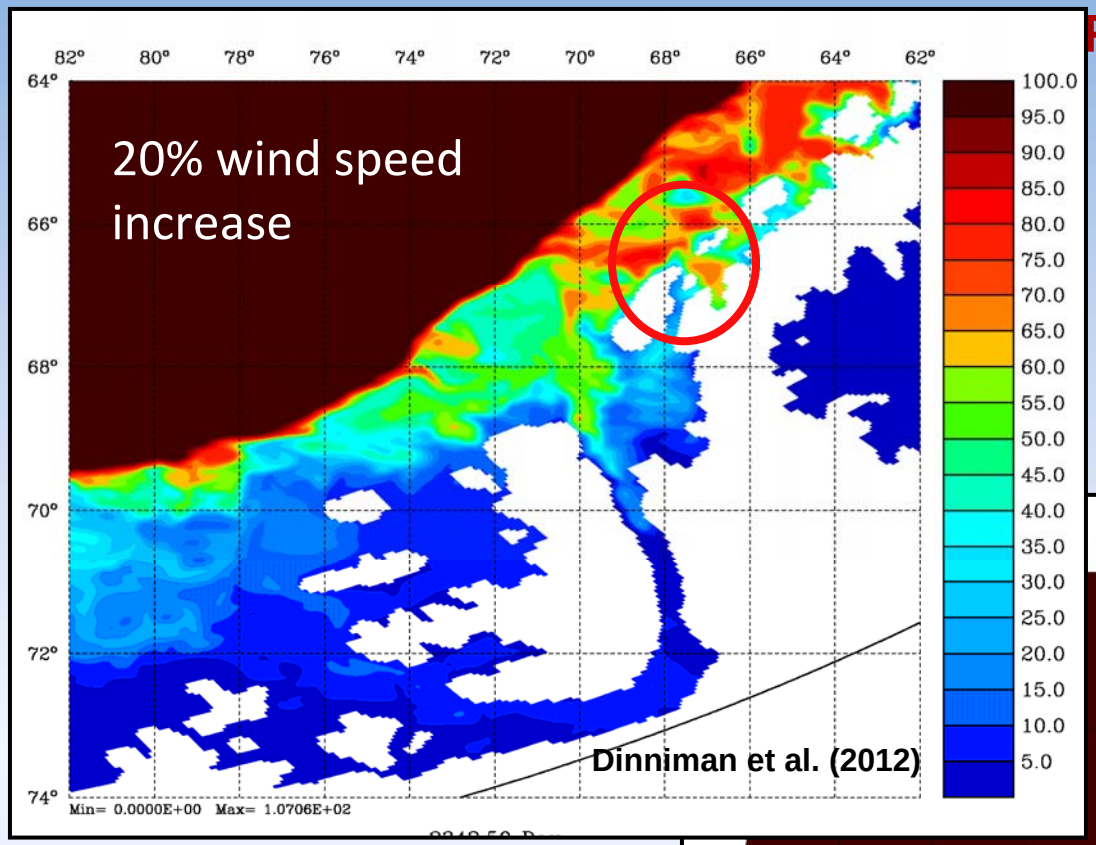
Development Times (days)
C2 => 44-60
F2 => 70-105
F3 => 85-120
F6 => 124-258

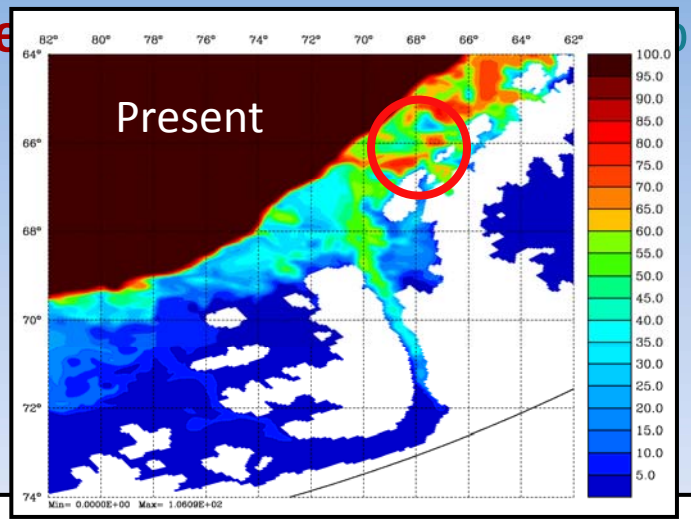
Connectivity – Local retention and export

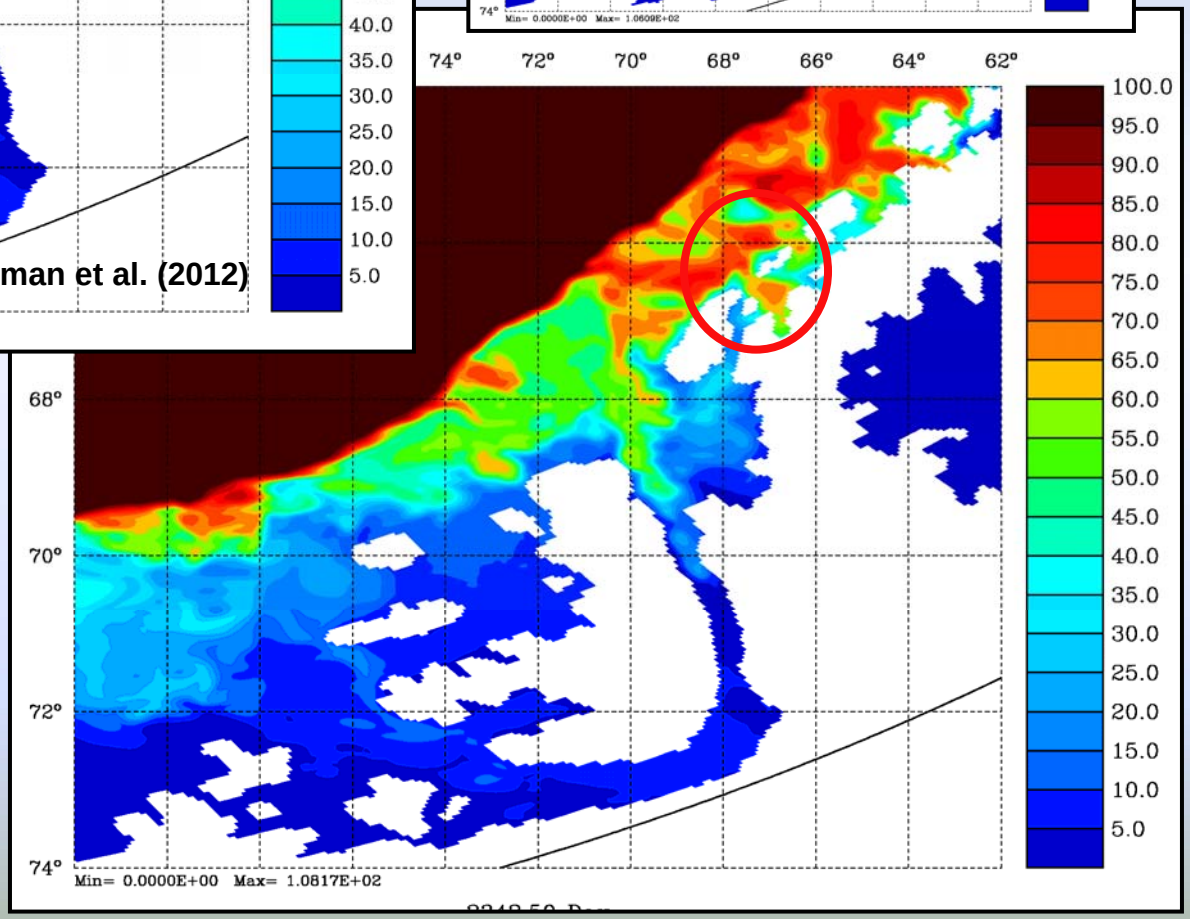
Larval stage	Time (days)	South	Central	North
C2	50	0.0%	0.5%	0.0%
F2 and F3	90	1.4%	4.3%	7.7%
F6	180	13.0%	19.2%	26.0%

Climate Change Effects

- Effects of increased and decreased wind strength and increased transport of Antarctic Circumpolar Current on CDW intrusions onto the WAP shelf
- Modified wind scenarios represent regional effects - positive Southern Annular Mode gives stronger westerlies
- Change in ACC transport represents large-scale circulation effects - global thermohaline circulation

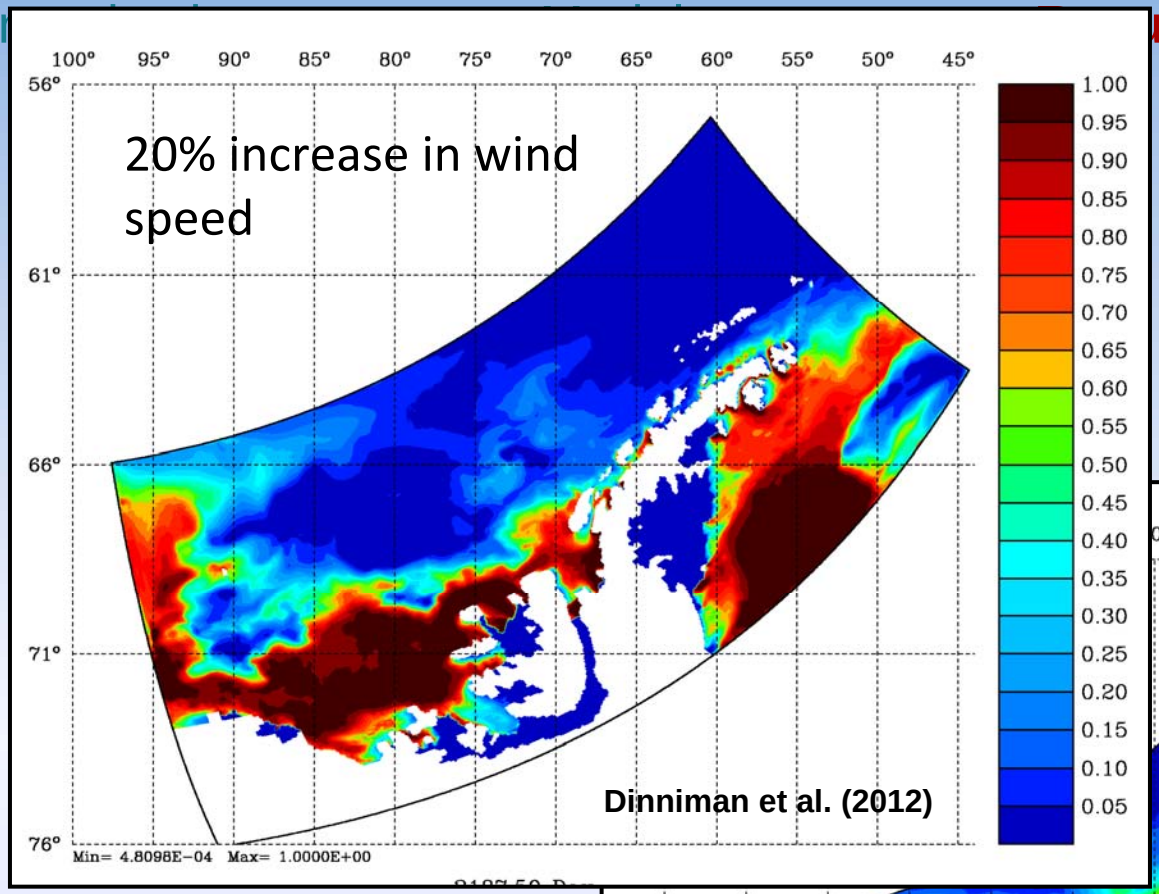


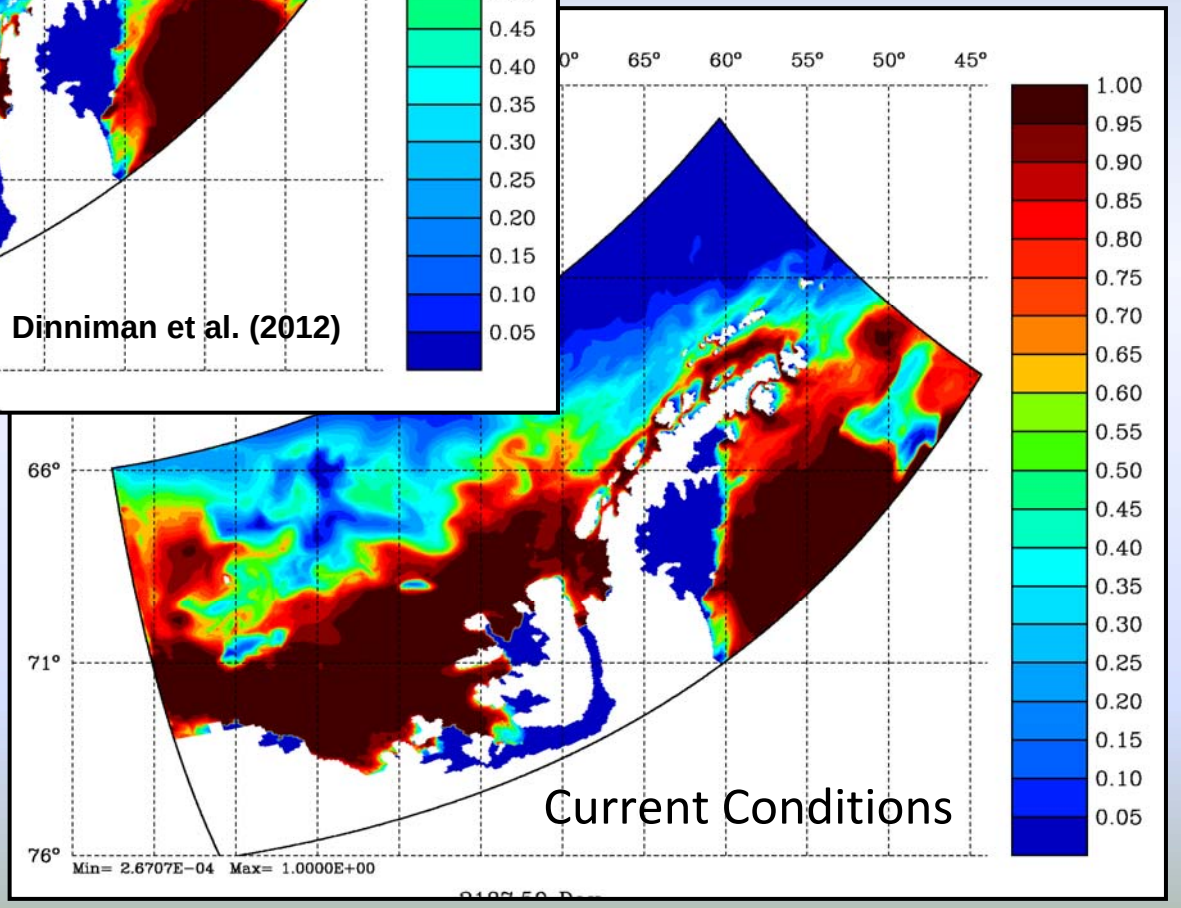




20% increase in wind speed and increase in ACC transport

Winter sea ice distribution





One-dimensional temperature-dependent model

Krill egg descent

Sinking rate

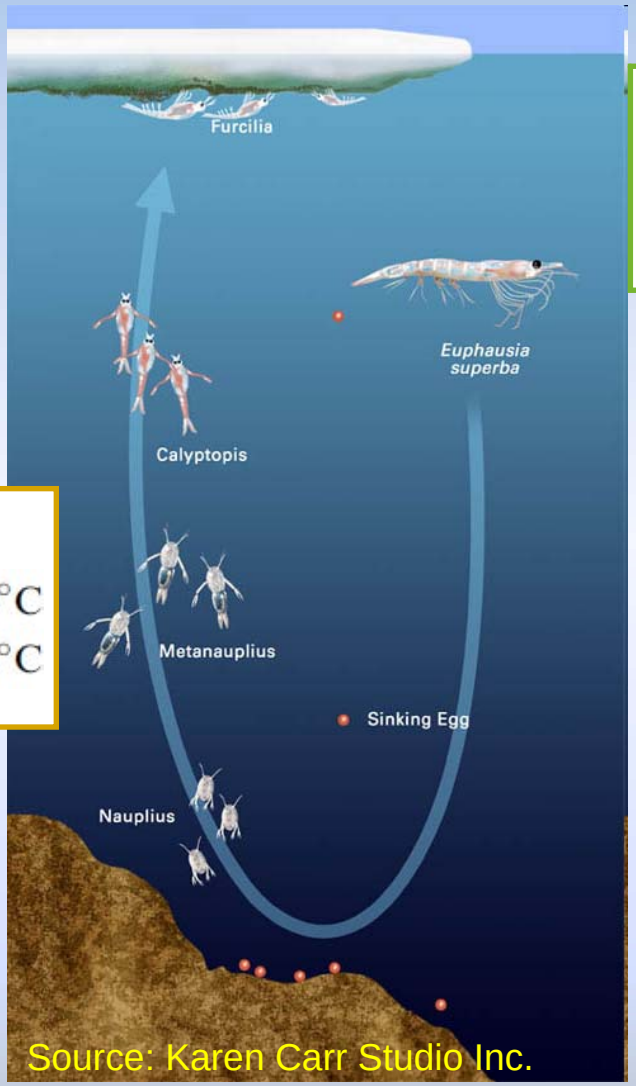
$$S = \frac{\mathrm{Dm}^2}{18v} g \left(\frac{\rho_e}{\rho_w} - 1 \right) \qquad \rho_e = \frac{6 W_i}{\pi \, \mathrm{Dm}^3}$$

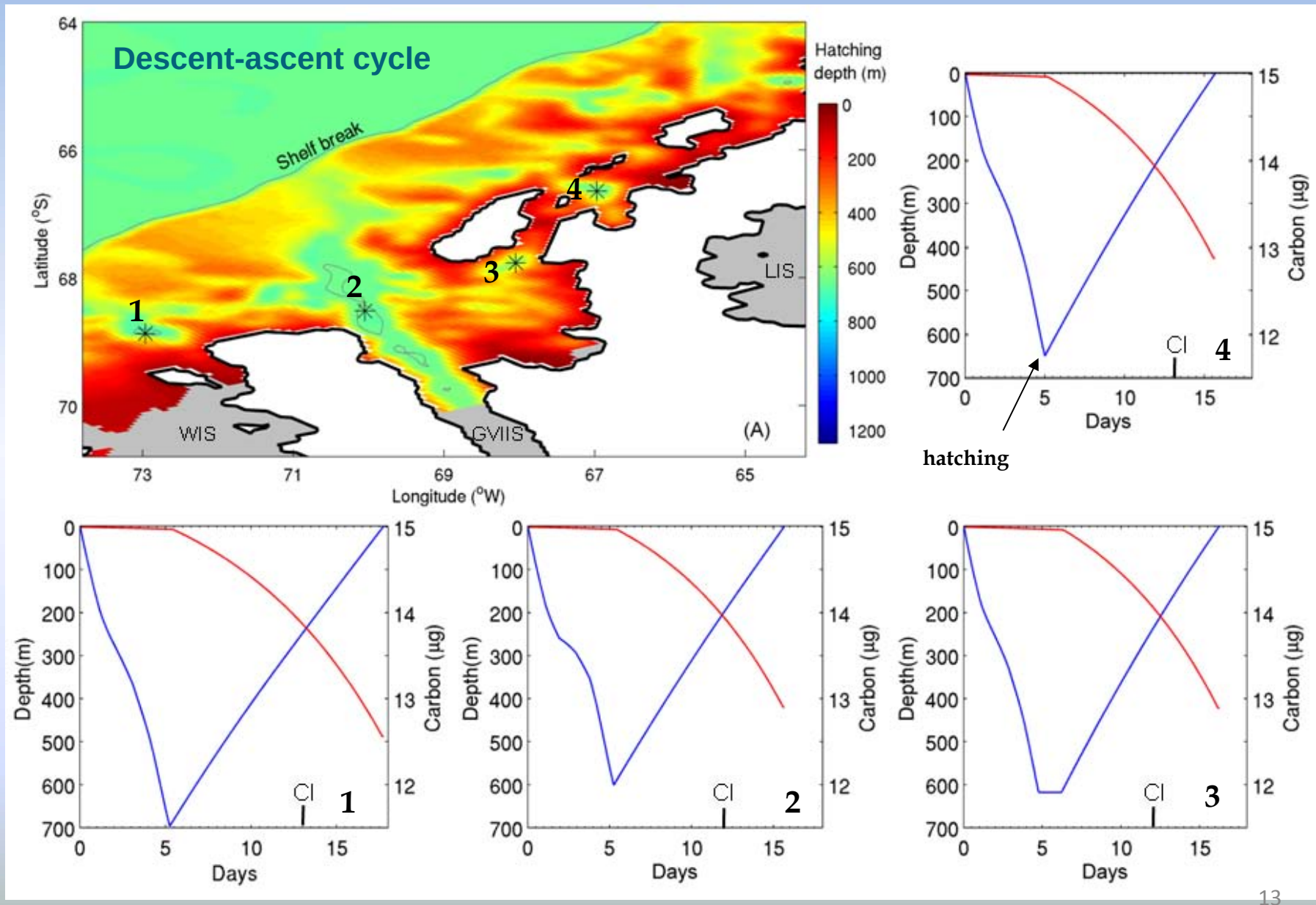
Dm : diameter of embryo
v : kinematic viscosity (1.787×10^{-6} m^2 s)
ρ_e : density of embryo
ρ_w : density of water
W : wet weight of embryo
g : gravitational acceleration

Krill larvae ascent

Ascent rate

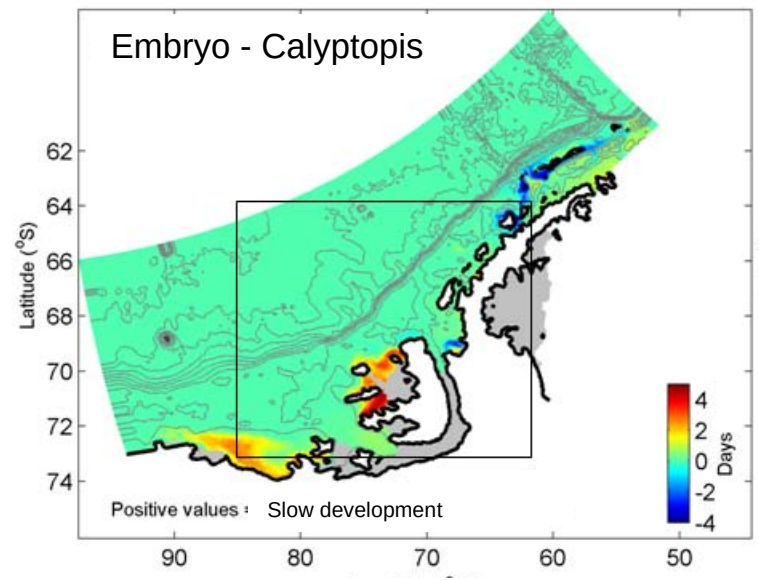
$$A = -(0.011T + 0.208)P_s, \quad T < 0^\circ\mathrm{C}$$
$$A = -(0.043T + 0.208)P_s, \quad T \geqslant 0^\circ\mathrm{C}$$

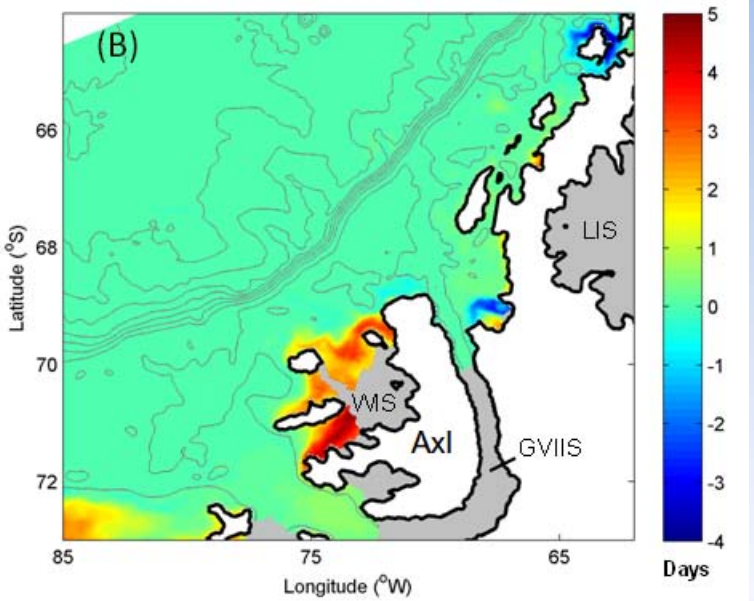



Descent-ascent cycle
Shelf break
Hatching depth (m)
0
200
400
600
800
1000
1200
Latitude (°S)
64
66
68
70
Longitude (°W)
73
71
69
67
65
WIS
GVIIS
LIS
(A)
1
2
3
4
Depth(m)
Carbon (µg)
Days
CI
hatching

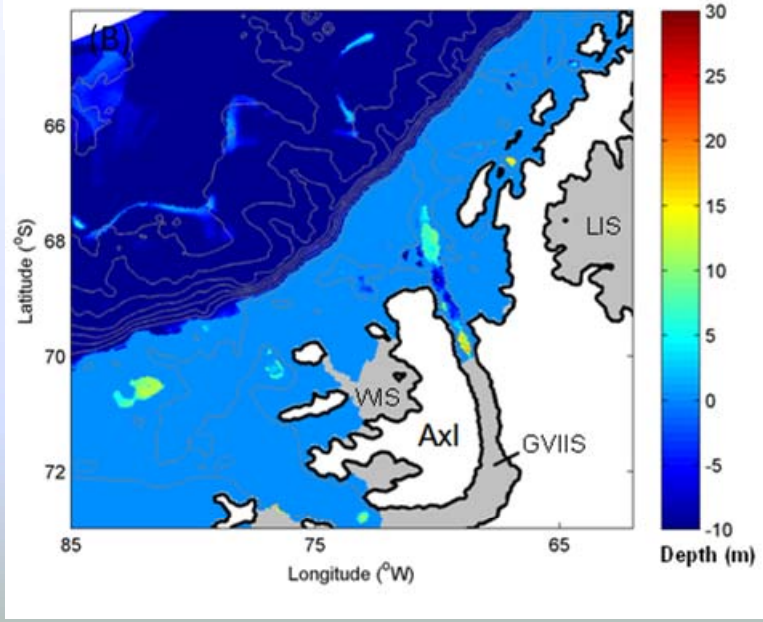
Effects of projected environmental conditions

Krill development (days) difference

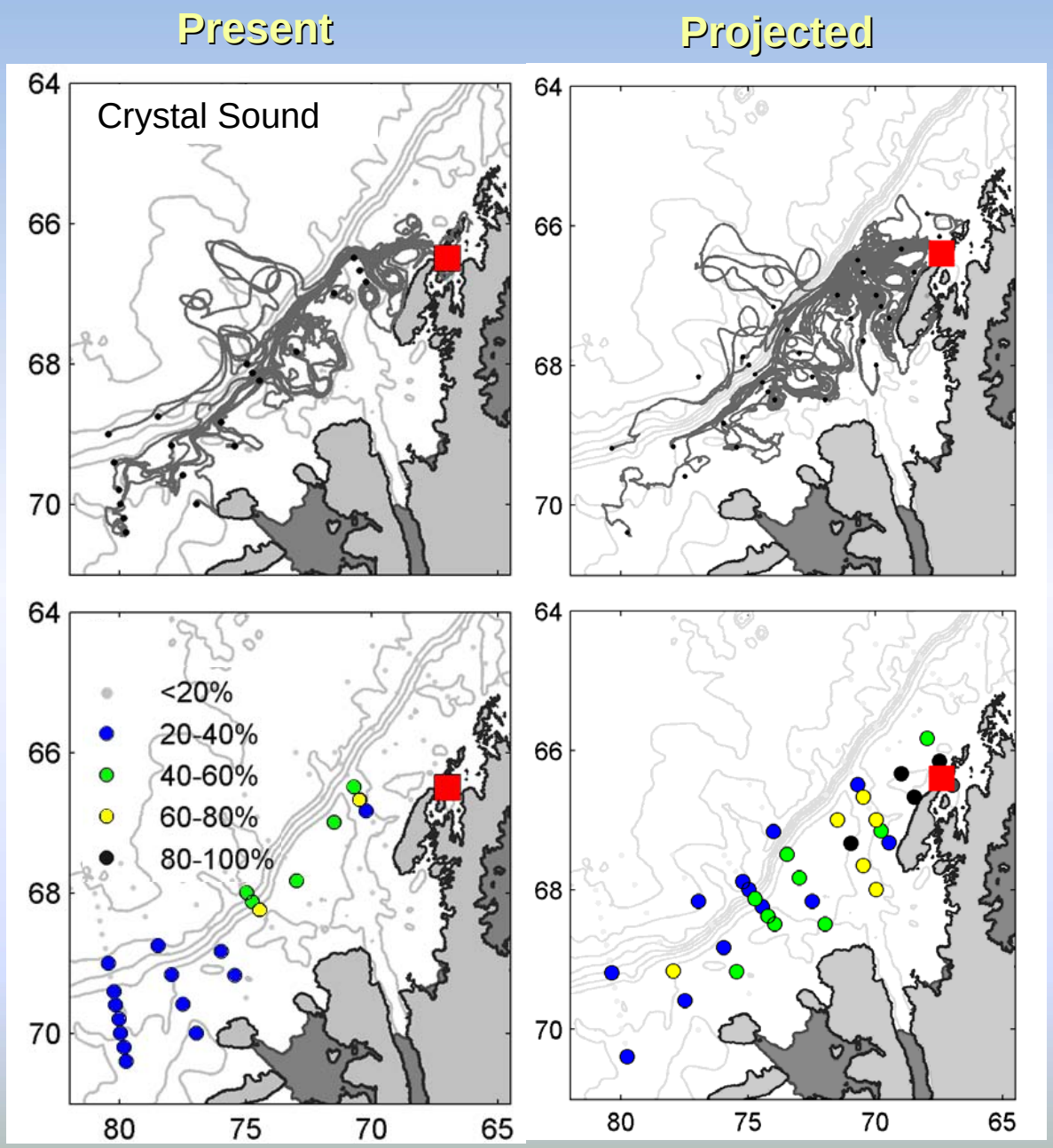




Hatching depth (m) difference



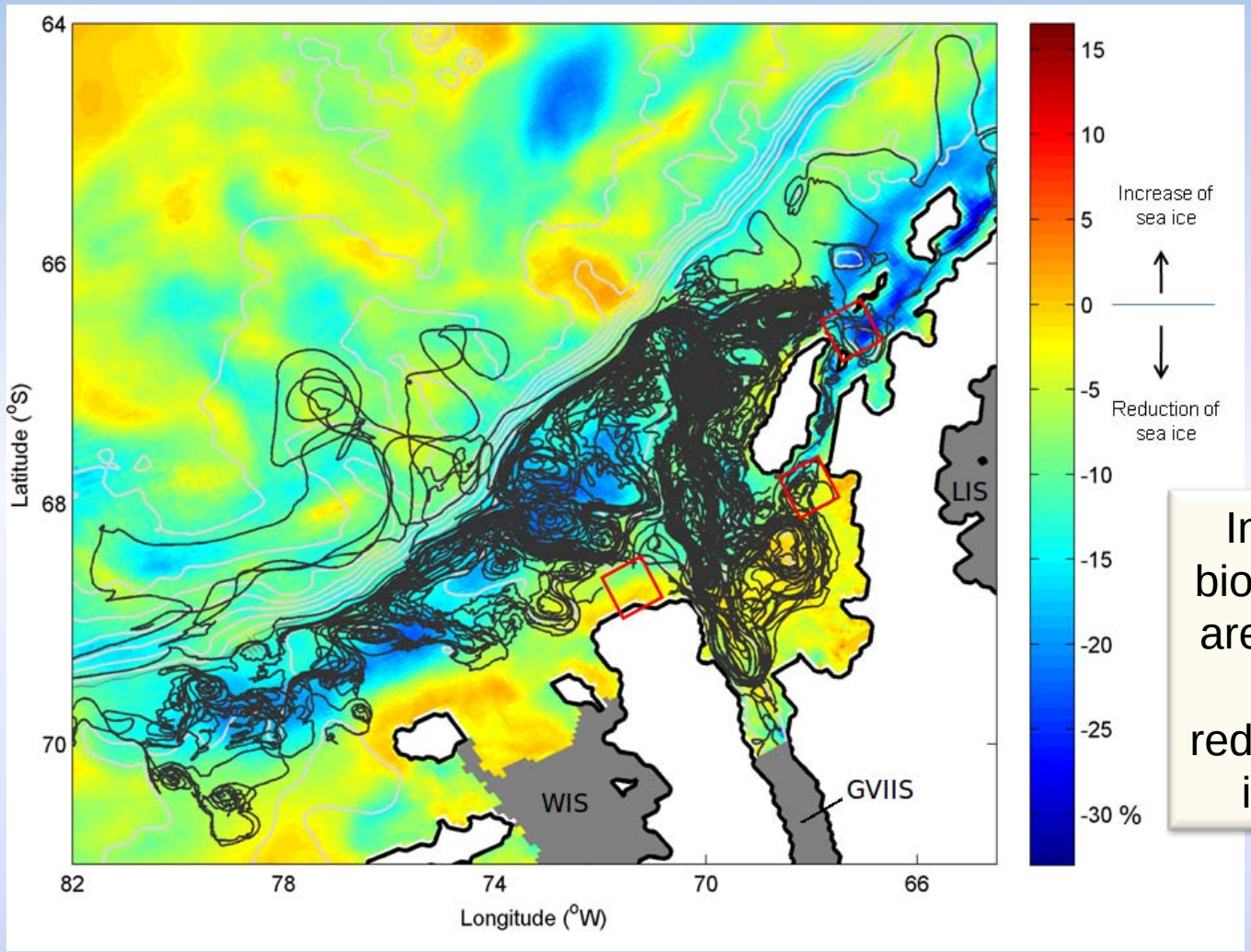
Development time from embryo to calyptopis and hatching depth are not strongly affected by increases in the CDW transported to the shelf



- Input sources to hot spots are similar but expanded at future conditions

- Increased transport to biological hot spots from all input sources

Difference in sea ice and inputs to hot spots



Input sources to biological hot spots are coincident with the largest reduction in the sea ice distribution

Dinniman et al. (2012) shows winter sea ice reduction

Conclusions

- Antarctic krill along wAP are connected via local and remote pathways.

- Projected changes in circulation have little effect on the descent-ascent cycle.

- The changes in circulation enhance advection of particles to wAP continental shelf and to the biological hot spots. Positive effect.

- Source regions for particles the wAP are shelf areas with the largest reduction in sea ice. Negative effect


Thank you
Questions?
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