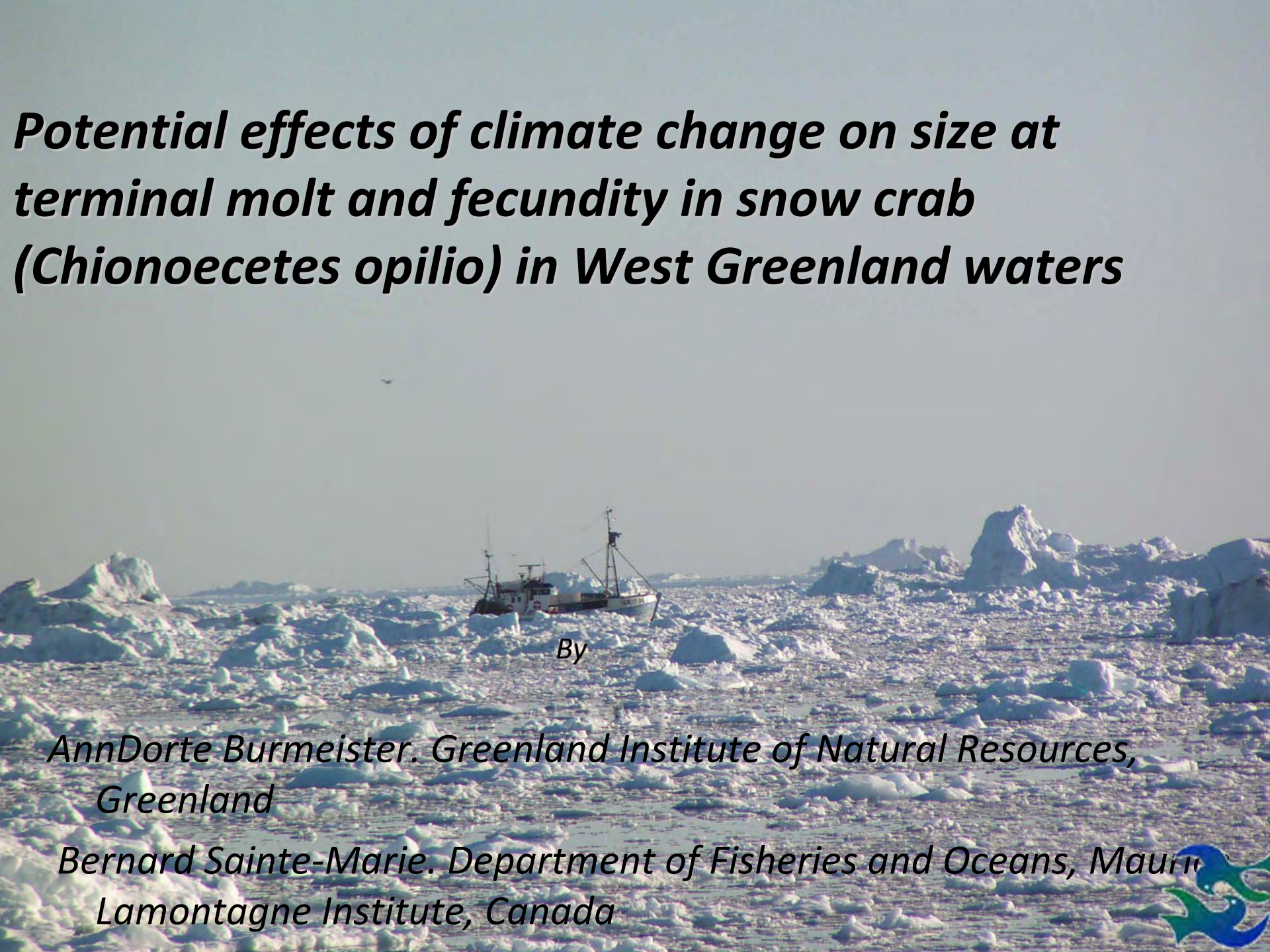
Potential effects of climate change on size at terminal molt and fecundity in snow crab (Chionoecetes opilio) in West Greenland waters



By

AnnDorte Burmeister. Greenland Institute of Natural Resources, Greenland

Bernard Sainte-Marie. Department of Fisheries and Oceans, Maurice Lamontagne Institute, Canada

Outline for the talk

- *Objective and hypothesis*
- *Sampling sites and methods*
- *Results*

-Bottom temperature

-CW in relation to temperature

-Fecundity of primi and multiparous females

- *Conclusions*
- *Impact of climatic change*

Objective

•To increase understanding of the reproductive potential of snow crab, as it relates to temperature conditions.

Hypothesis

H_1 : Male and female size at adulthood are less in "colder" than in "warmer" waters.

H_2: Clutch fecundity is larger in "warmer" than in "colder" waters.

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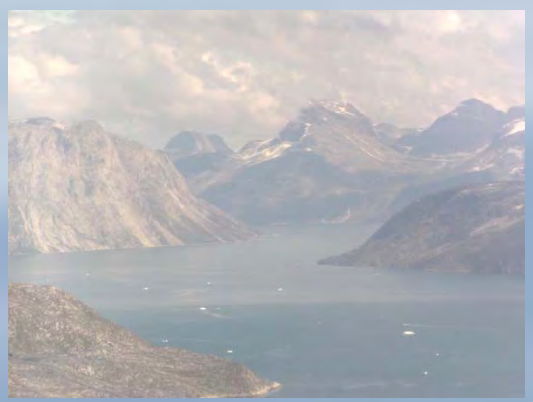
A unique coastal system in West Greenland

The Greenland coastal system of fjords and basins affords a very interesting opportunity for investigating the effect of temperature on terminal molt and fecundity in snow crab, because fjord populations are partially or completely isolated from each other and from offshore during the benthic phase by sills



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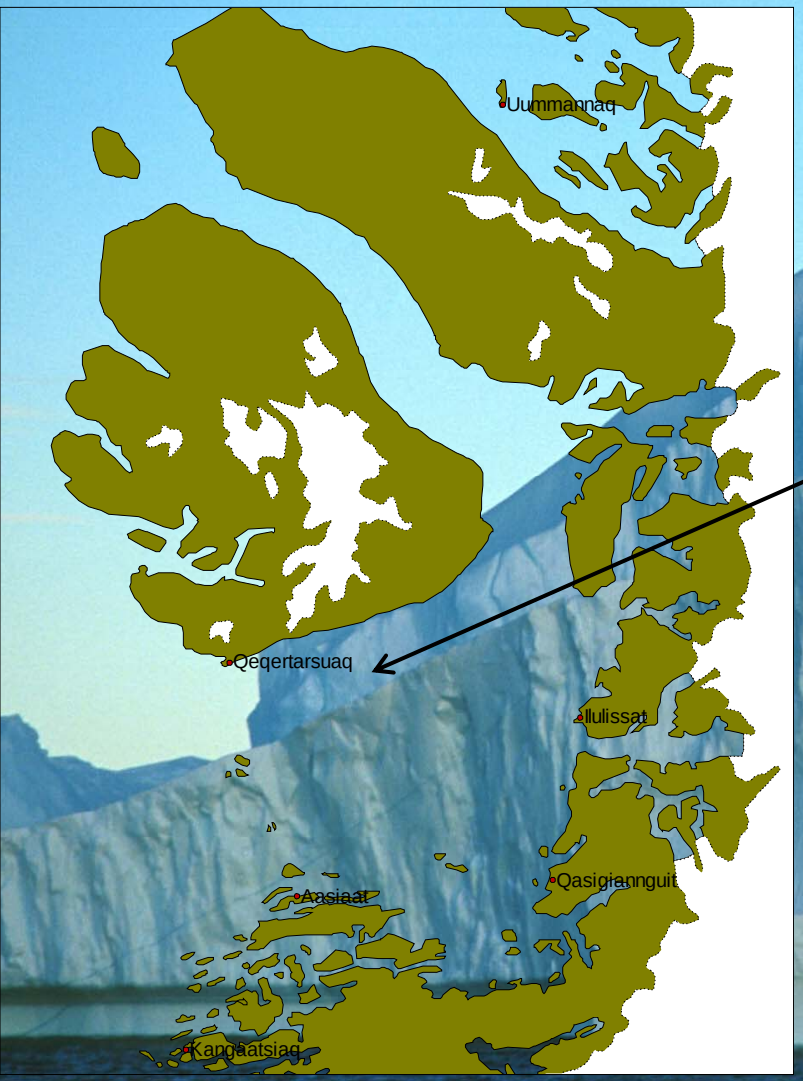
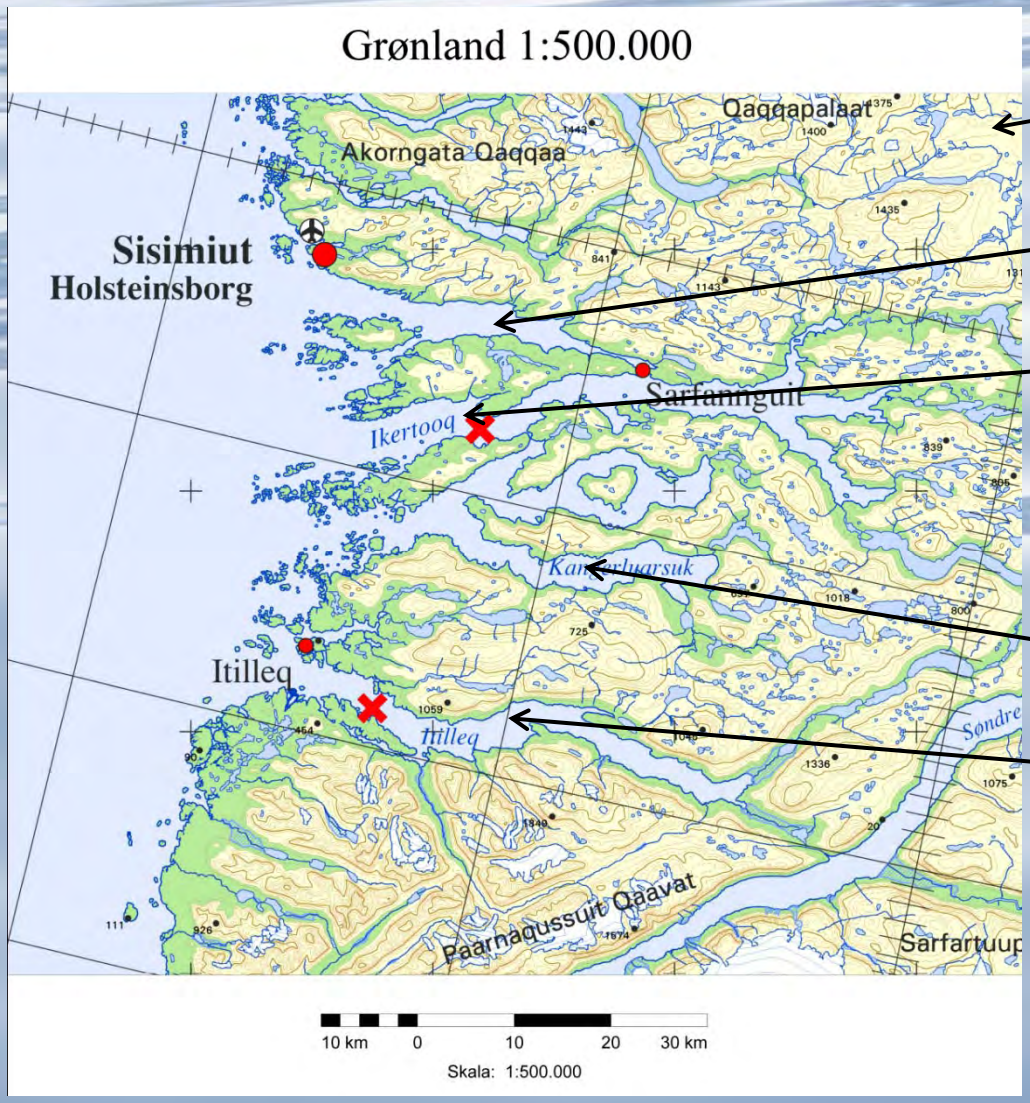
Disko Bay



- Depth range: 300 to 400 m

Sisimiut ”warm” and ”cold” fjords



Amerloq sill depth: 180 m

Ikertooq sill depth: 150 m

Depth range: 250 to 650 m

Kangerluarsuk sill depth:50 m

Itilleq sill depth: 80m

Depth range: 200 to 470 m,

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Sampling

- 2000 to 2010: Disko Bay and fjords near Sisimiut
- Gear: Traps (large and small meshed), baited with squid, soak time 24h
- Temperature recorder used to measure bottom temperature
- Measurements of 81,490 crabs: CW, CH, AW
- Subsampling of 5003 primi and multiparous females
- Determination of fecundity (clutch fecundity) and sperm load

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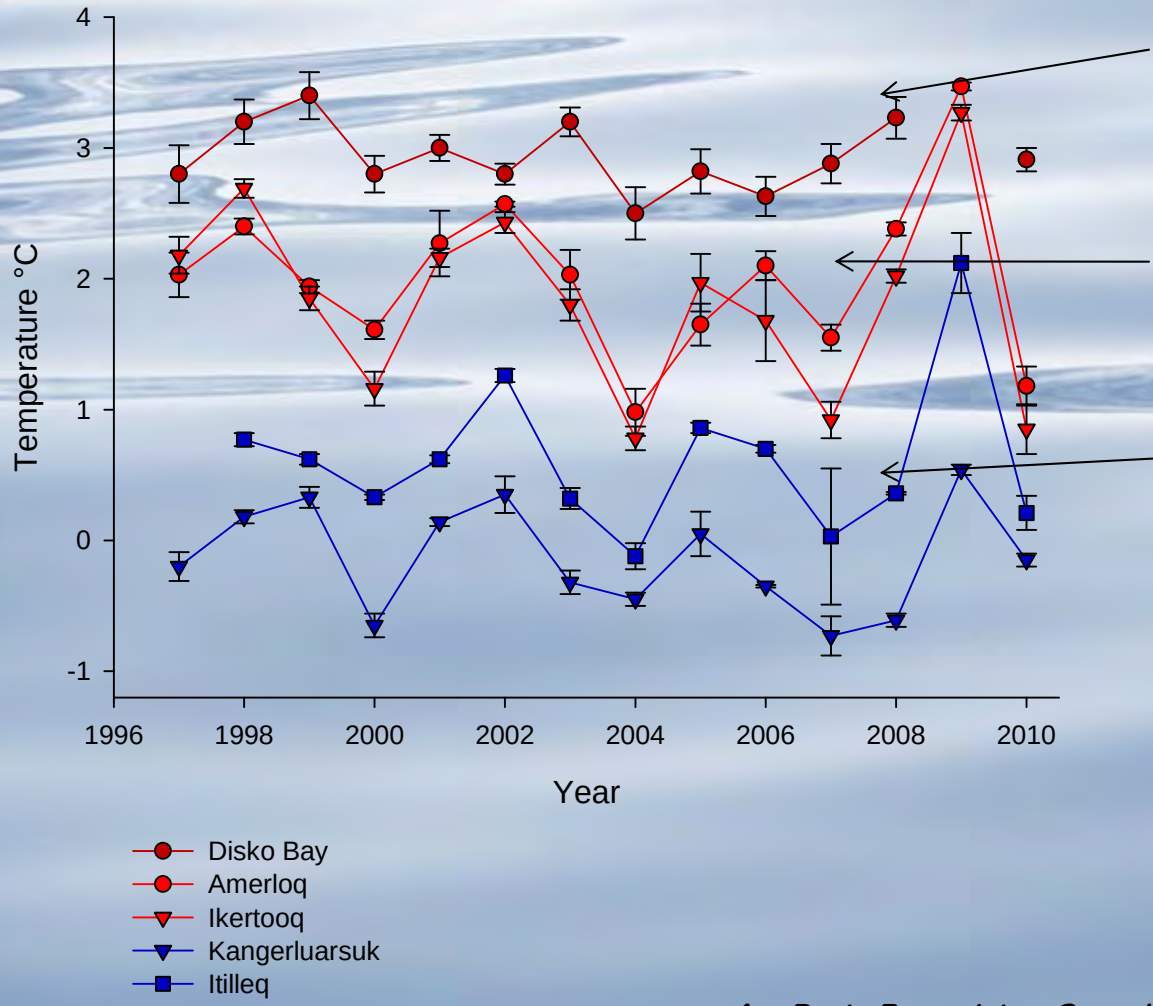
Average bottom temperature – in Disko Bay and fjords near Sisimiut, sampled during annually trap survey in June 1997 - 2010



DB: Bottom temp: 2.2 to 3.7 °C

Salinity 34.6‰

AM/IK: Bottom temp: 1-3.2 °C

Salinity: 34.3‰.

KA/IT Bottom temp:

–1.8 to 0.5°C and –0.5 to 1.3°C , respectively

Salinity: 33.5‰.

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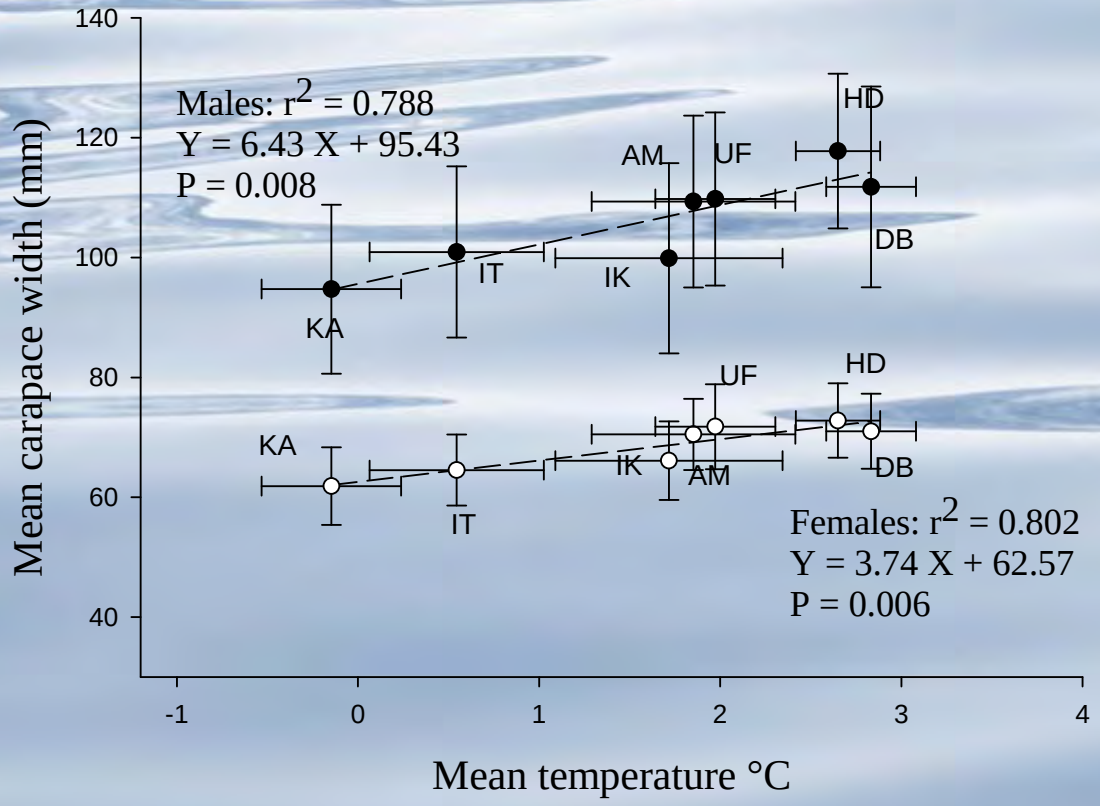
Does carapace width change with temperature?



Burmeister and Sainte-Marie (2010), Polar Biology 33, 775-788

- Significant pattern of increasing adult size with increasing temperature in both sexes

- Mean CW:

KA: ♂ 94.7 mm ♀ 61.9 mm

HD: ♂ 117.8 mm ♀ 72.8 mm

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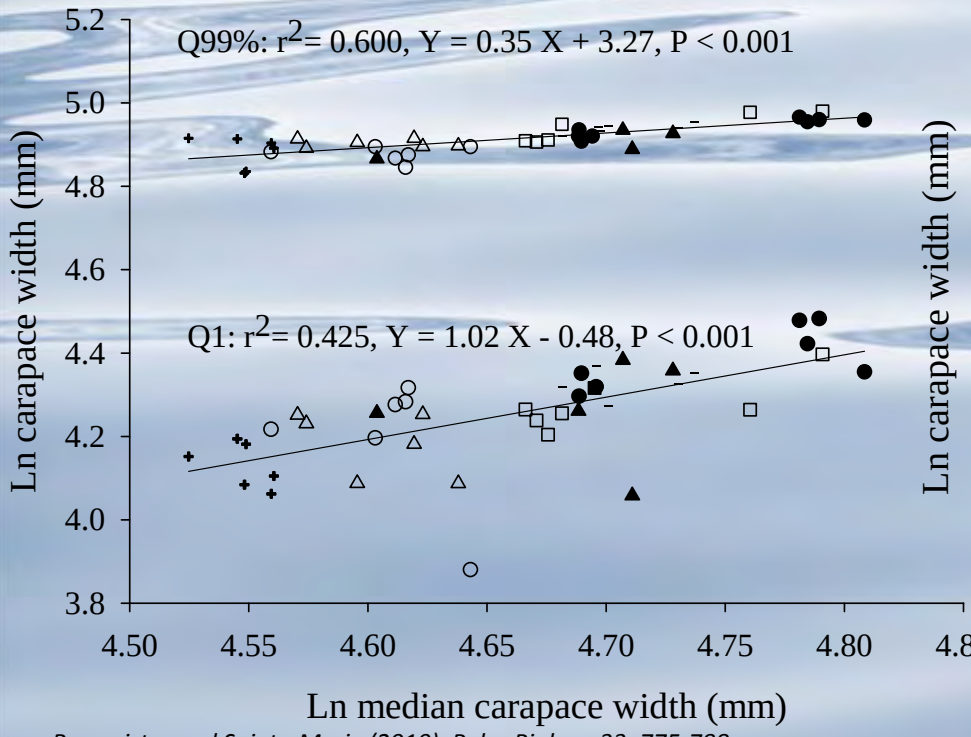
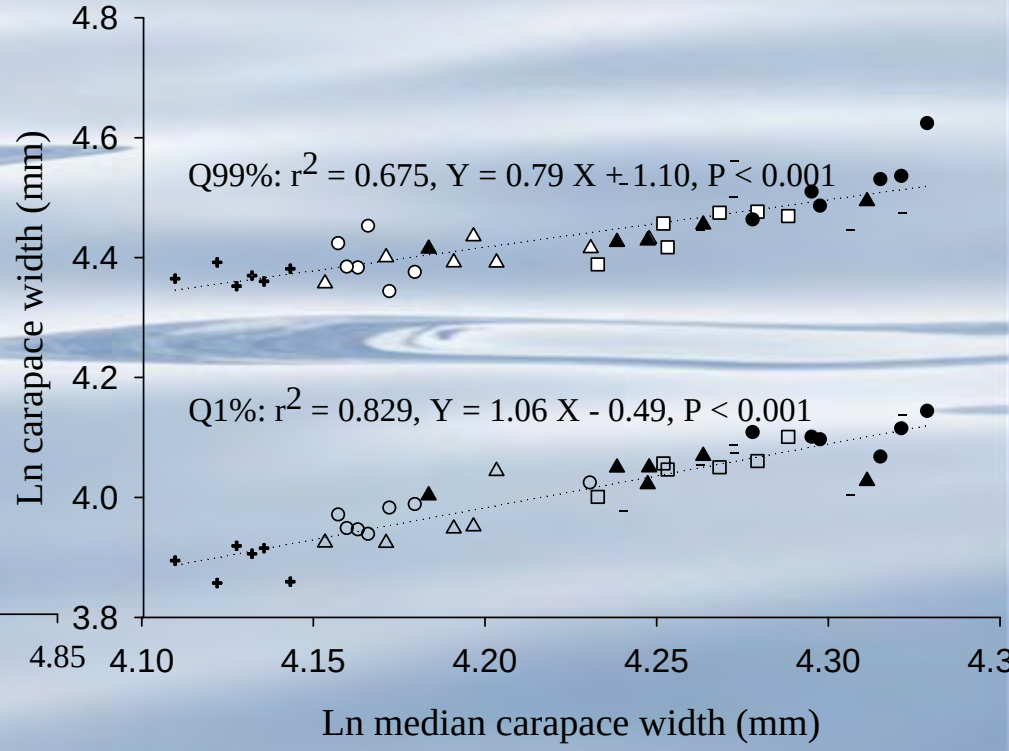
Is the rate of change equal for minimum and maximum size between sexes?

Adult males



Adult females



Burmeister and Sainte-Marie (2010), Polar Biology 33, 775-788

- Isometric relationships for Q1% on median CW
- Q99% not isometric and different between sexes, fishery removals

What is the proximate mechanism of changing size?

Instar		DB		KA	
Preadult females	%	Mean CW	%	Mean CW	T-test
VI			16.7	22.9	
VII			4.7	27.5	
VIII	2.8	32.7	15.3	34.8	ns
IX	11.3	42.5	22.1	42.6	ns
X	30.2	51.8	31.0	50.2	*P<0.05*
XI	50.6	61.0	9.2	56.4	*ns*
XII	5.1	68.5	1.0	66.0	ns

DB: $\chi 2$= 14.81, P=1.00, df=64
KA: $\chi 2$= 16.58, P= 1.00, df=57

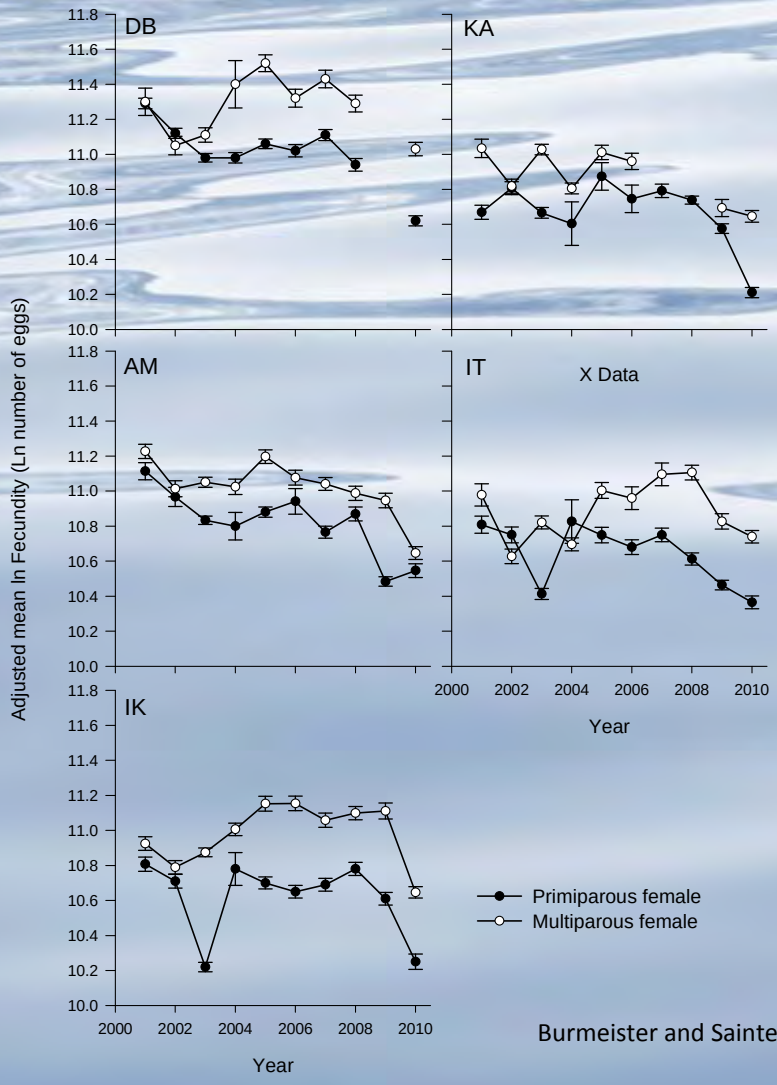
Instar		DB		KA	
Adult females	%	Mean CW	%	Mean CW	T-test
X			7.0	52.6	
XI	5.2	60.8	67.5	60.9	*ns*
XII	52.3	68.4	22.3	69.2	*ns*
XIII	35.3	75.0	2.4	76.1	*ns*
XIV	6.1	81.8	0.4	81.5	*ns*
XV	1.2	88.6			

DB: $\chi 2$= 14.81, P=1.00, df=64
KA: $\chi 2$= 16.58, P= 1.00, df=57

- KA ”cold site”: 87.6% reached adulthood at instar XI and XII
- DB ”warm site”: 89.8% reached adulthood at instar XII and XIII
- A shift to a higher instar number with increasing temperature (preadult females were of equal or larger size at the cold site compared to the warm site)

Burmeister and Sainte-Marie (2010), Polar Biology 33, 775-788

Interannual variability in fecundity



Burmeister and Sainte-Marie, in prep.

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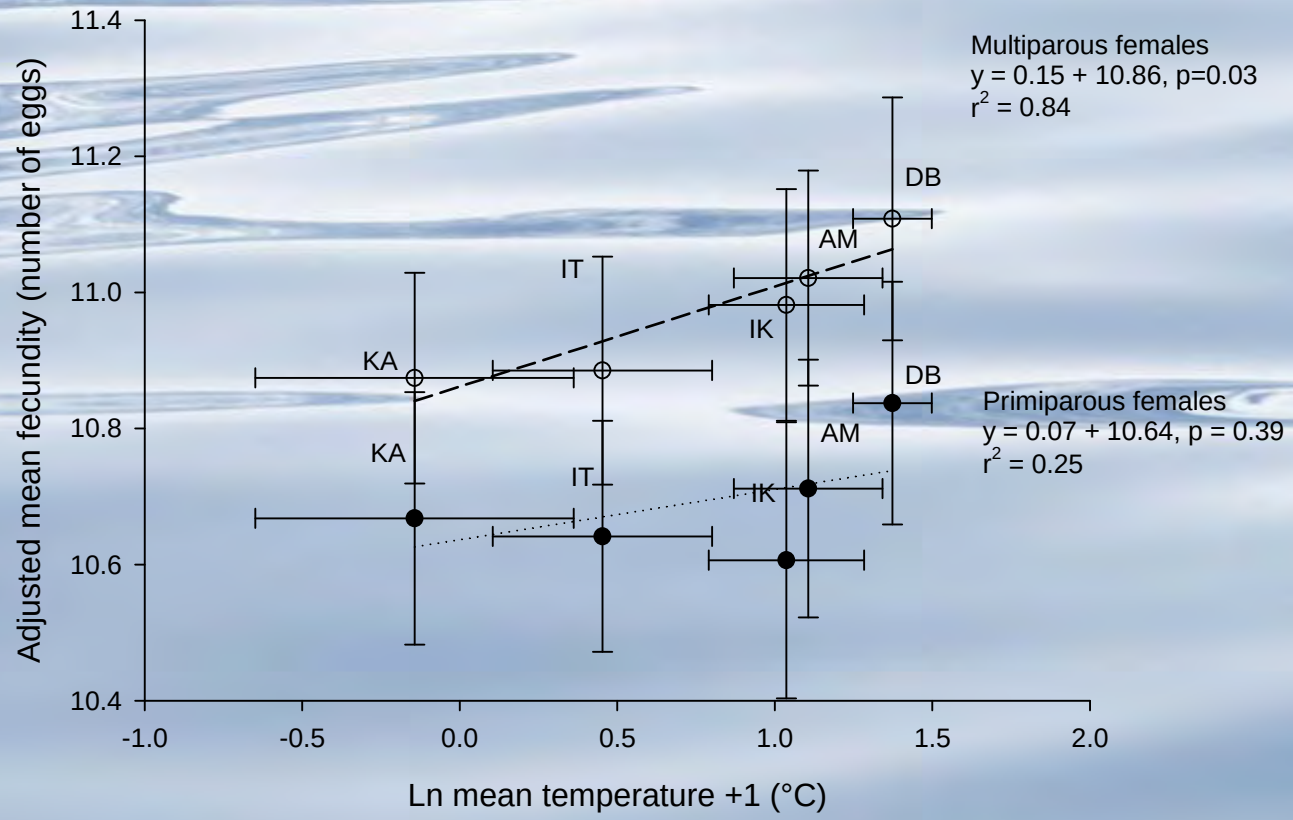
Fecundity adjusted to overall mean CW of primi- and multiparous females



Multiparous females
$y = 0.15 + 10.86$, $p=0.03$
$r^2 = 0.84$

Primiparous females
$y = 0.07 + 10.64$, $p = 0.39$
$r^2 = 0.25$

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Ultimate mechanisms for changing size

•Shift toward higher instars in warmer waters is not an immediate effect of temperature operating on pre-terminal-molt females and males

•It is likely that males and females are conditioned for maturity at lower or higher instars in the early phase of their life – as hypothesized by Sainte-Marie and Gilbert (1998) and Orensanz et al. (2007)

•It is postulated that females are able to achieve more molts in “warm” than in “cold” environments before the onset of pre-puberty. The resulting size advantage at the pre-puberty molts carries over to terminal molt because development time is fixed (Alunno-Bruscia and Sainte-Marie (1998).

•Assumptions: 1) molt increment is temperature-dependent, 2) intermolt period decreases with increasing temperature during the immature phase, 3 there exists an age-related trigger for pre-puberty and terminal molts (Orensanz et al. 2007)

Possible impact of climate change

- per capita fecundity increasing with increasing temperature

- proportion of adult males that become vulnerable to the fishery under a fixed minimum legal size limit increases with temperature

Acknowledgments

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- Thank you, for your attention!
- Questions?