

Fluctuations in Recruitment of Snow Crab in the Eastern Bering Sea and the Role of Cod Predation

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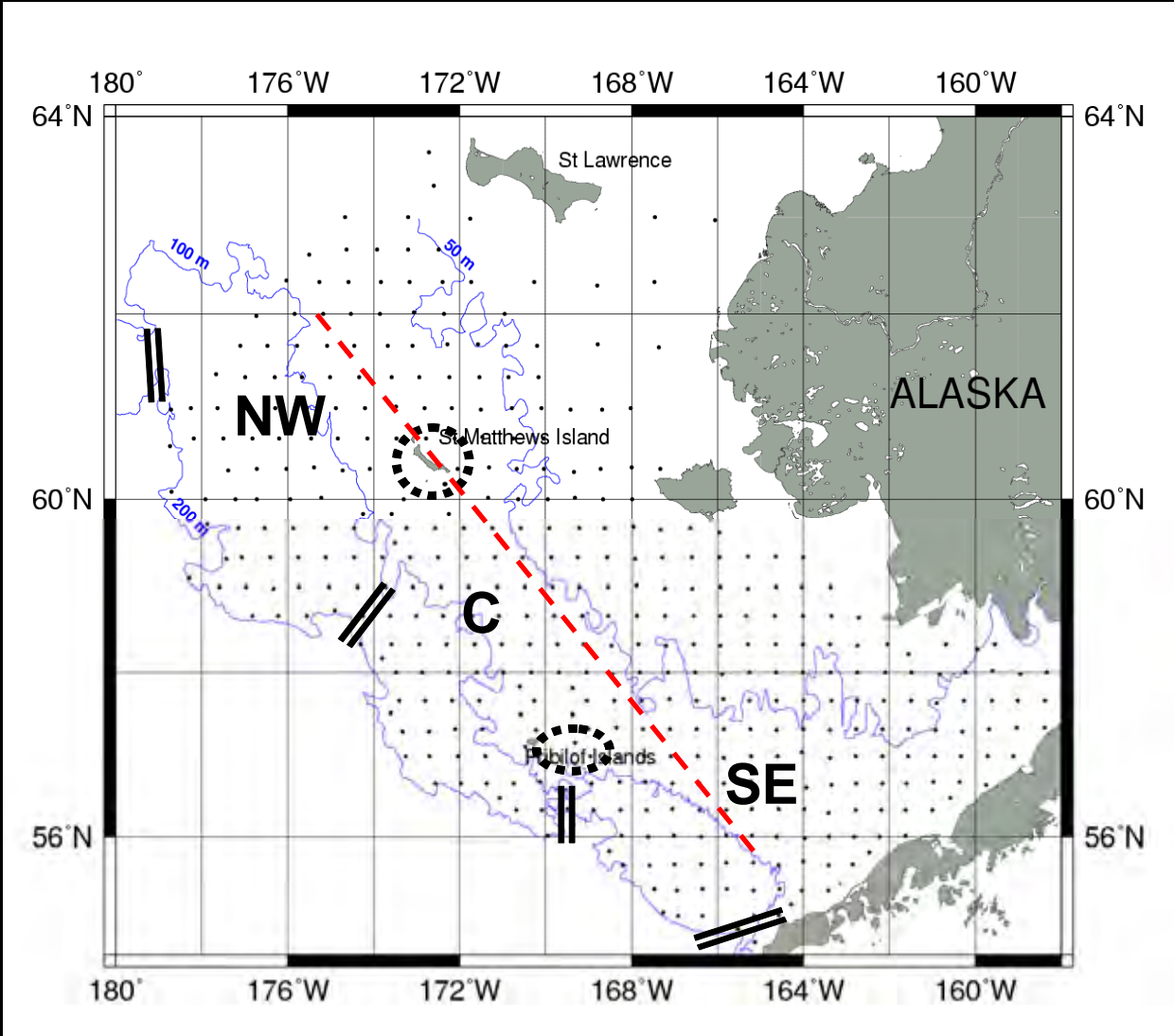
David Armstrong (UW, Seattle)



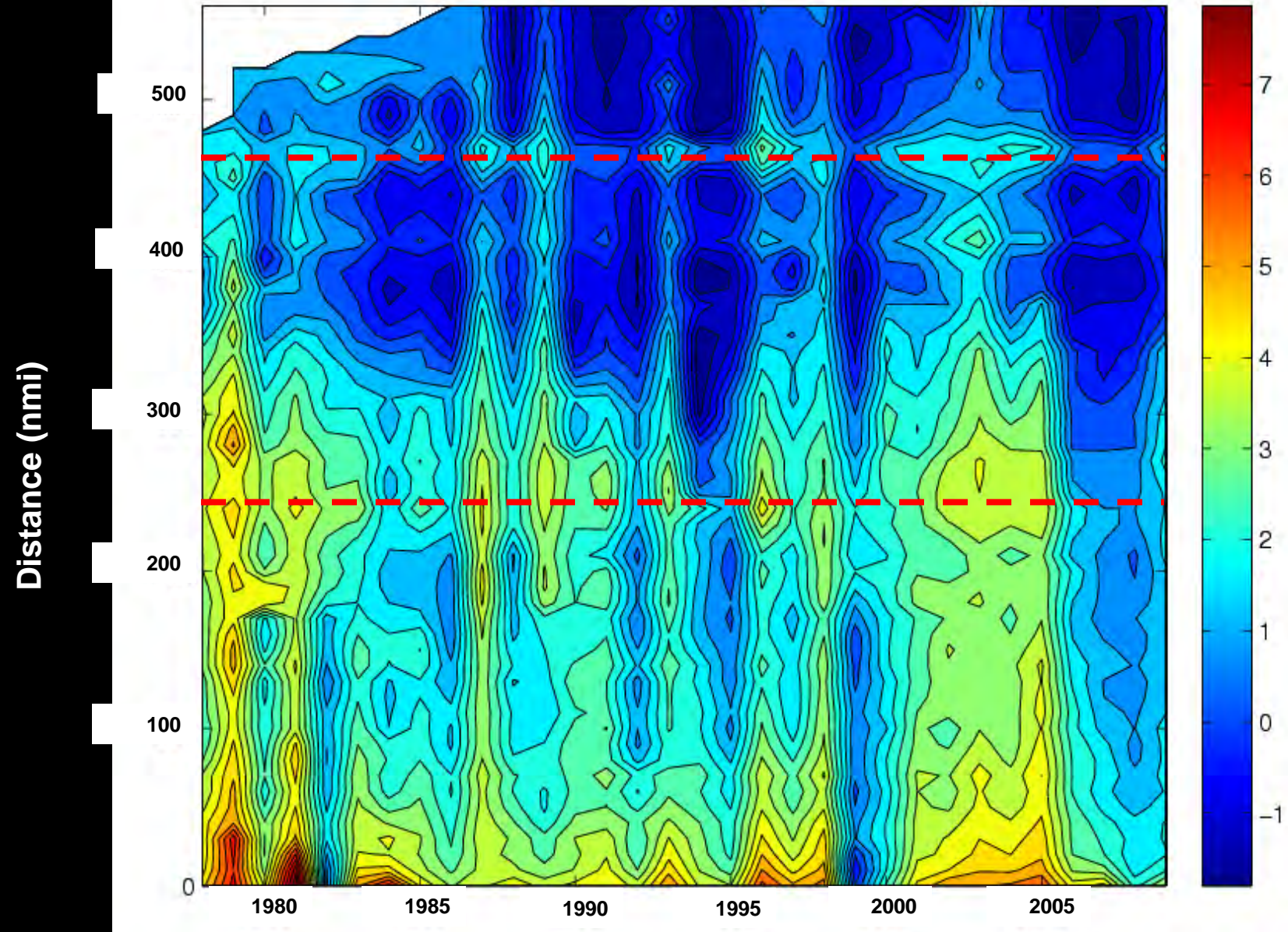


- **Strong sexual dimorphism → Male only fishery**
- **Terminal molt** **Pseudocohorts**
 Males: adolescent → adult
 Females: immature → mature
- **“Bipartite mating”**

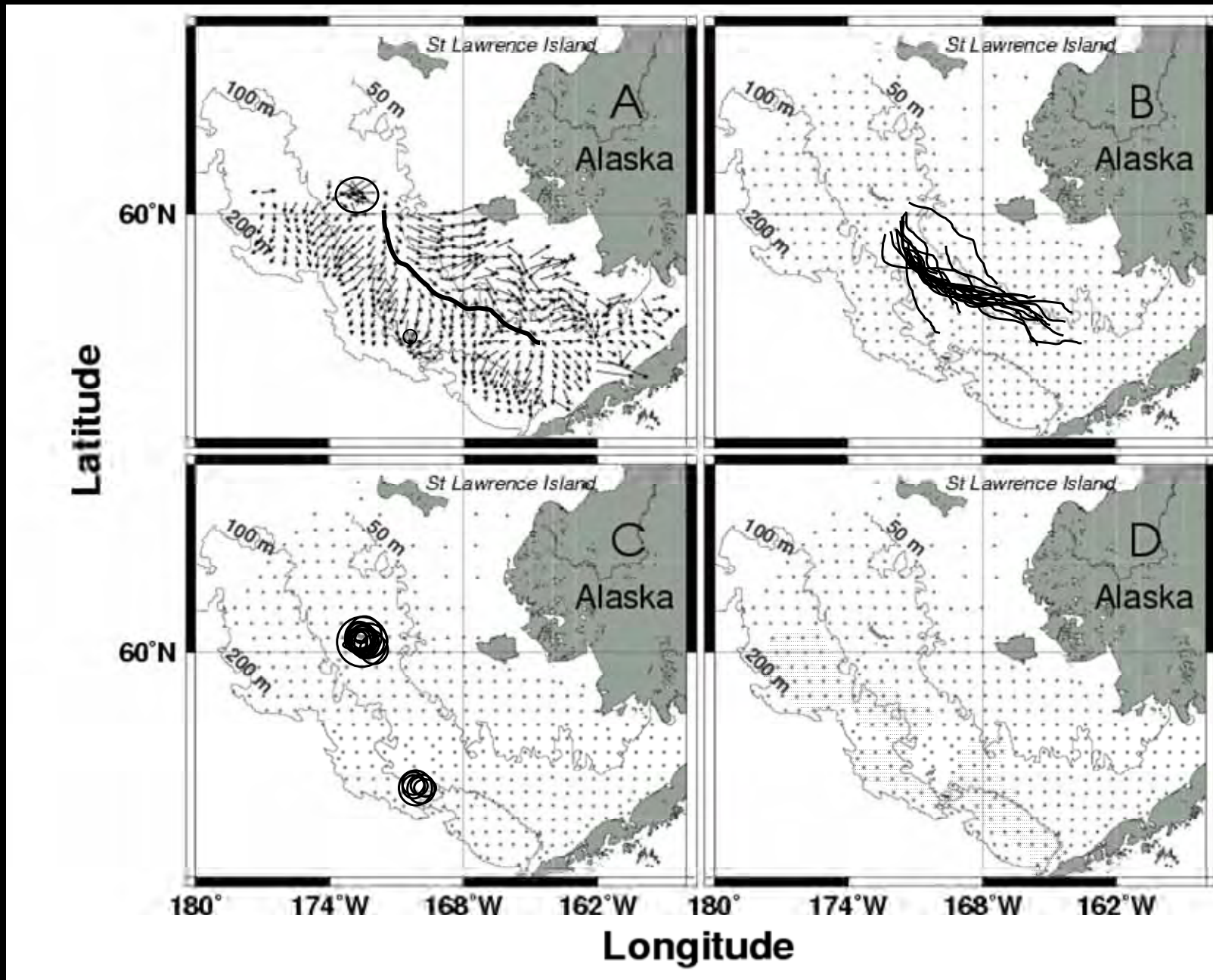
The EBS can be naturally partitioned into domains (Coastal, Middle, Outer) and sections (NW, Central, SE)

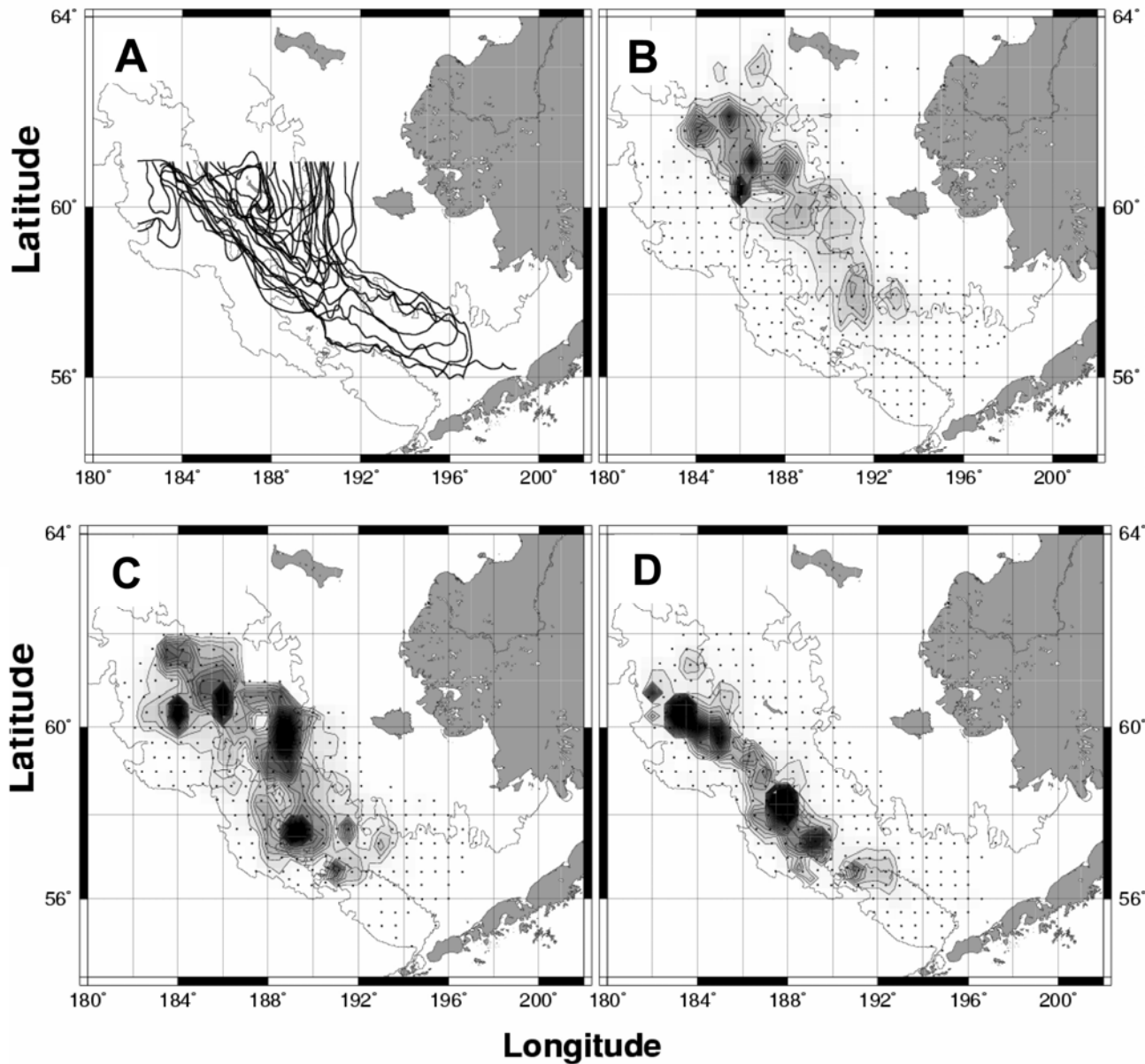


•The “Cold Pool” (NBT < 2 °C) expands and contracts from year-to-year along the main axis of the Middle Domain



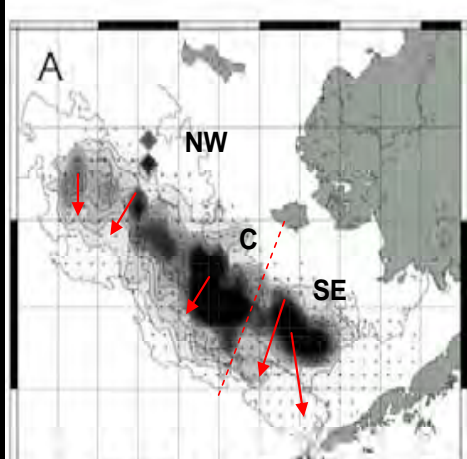
The pattern of NBT gradients is conservative



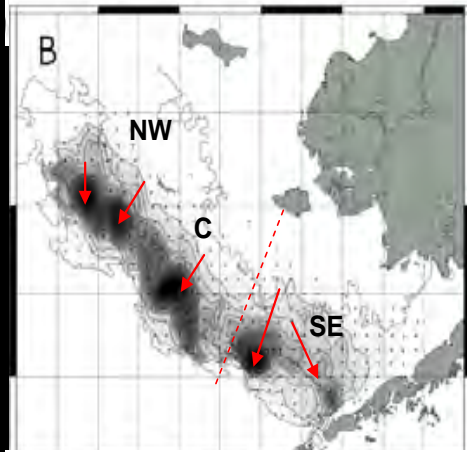


Juvenile habitat is circumscribed to the MD, where they settle, grow & recruit to the adult population (i.e., undergo terminal molt).

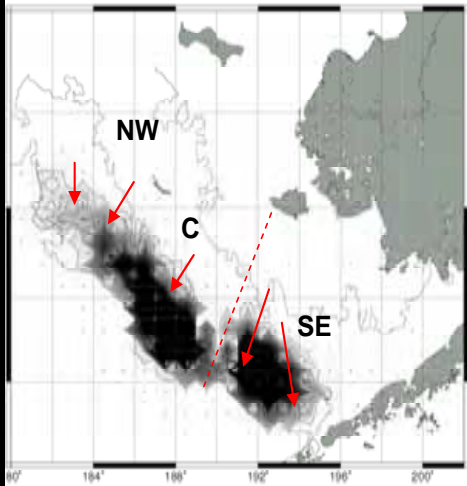
After females undergo terminal molt and mate for the first time in their life as primipara, in the MD, they migrate to the OD



Summer: males molt into the “large adult” category, mostly in the MD. Afterwards they migrate offshore during the fall becoming the “newshells” available to the winter fishery



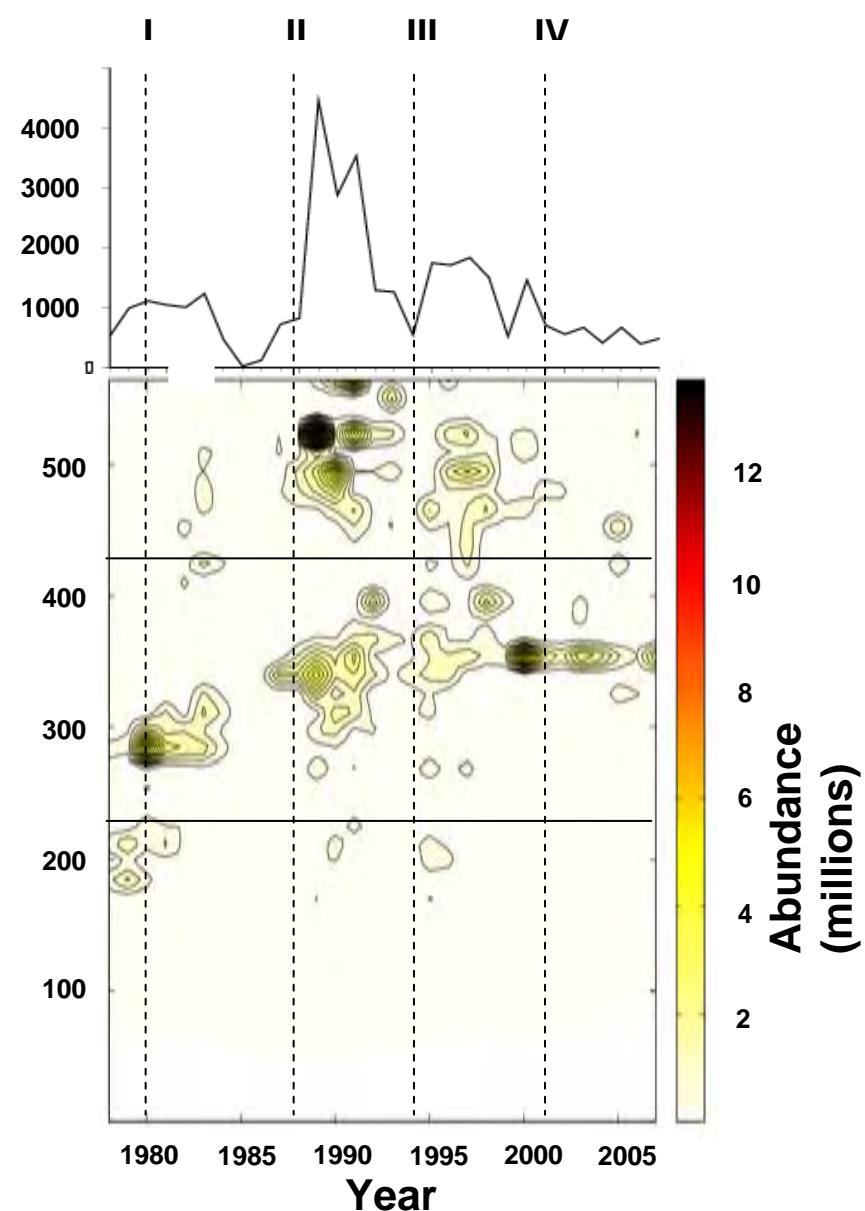
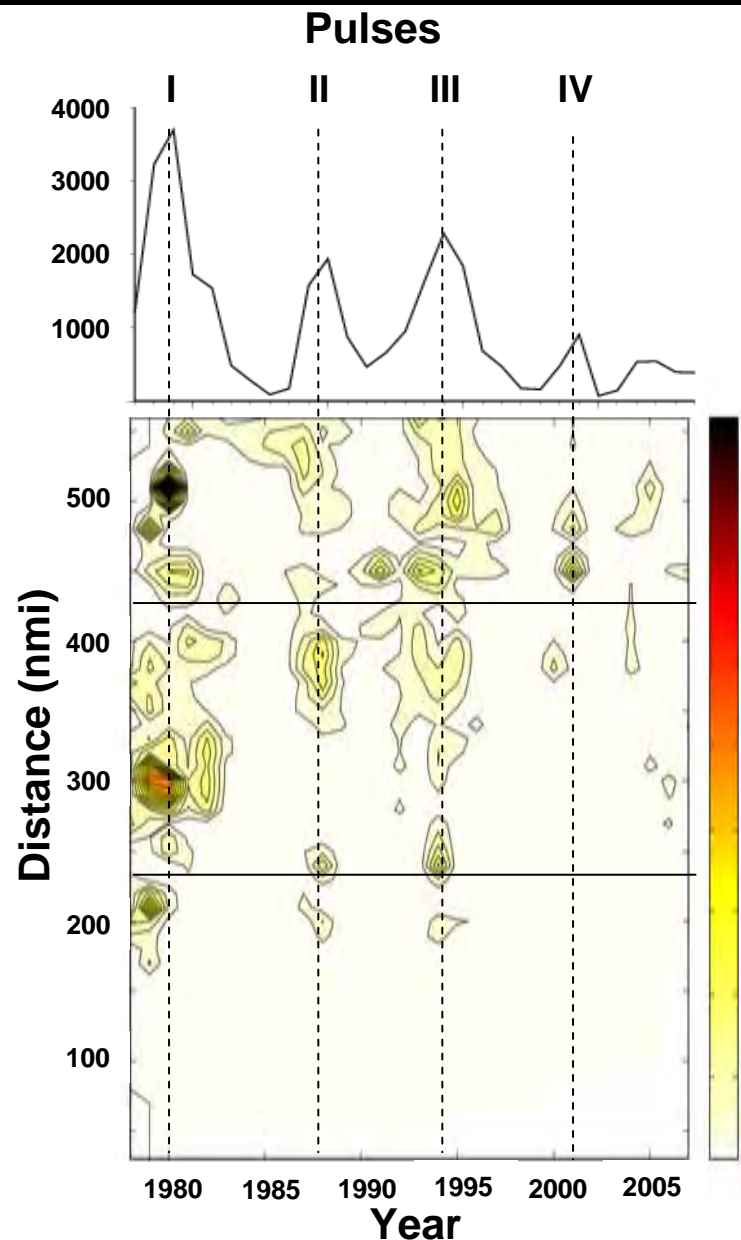
Winter: large “newshell” males targeted by the fishery in the OD, but also in the MD of the SE shelf

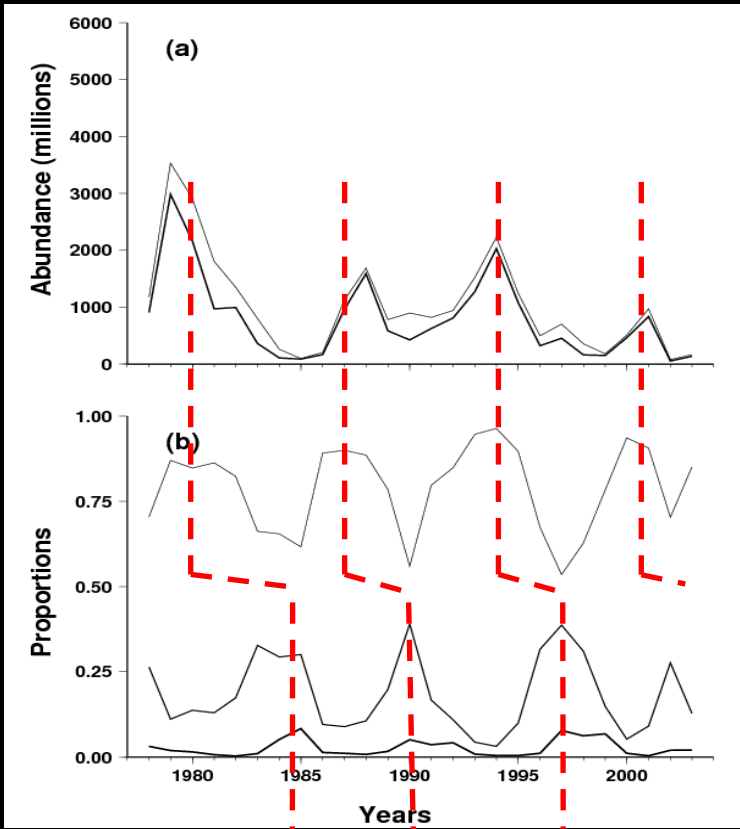


Summer: escapement (large hardshell males) observed by the survey in the same regions where the winter fishery operated. Notice that it is proportionally important in the NW, where fishing effort is relatively small

Over recent decades

- The geographic range of spawning females has contracted to the NW
- Recruitment to the mature female pool cycled regularly with a period of approximately 7 years and declining amplitude





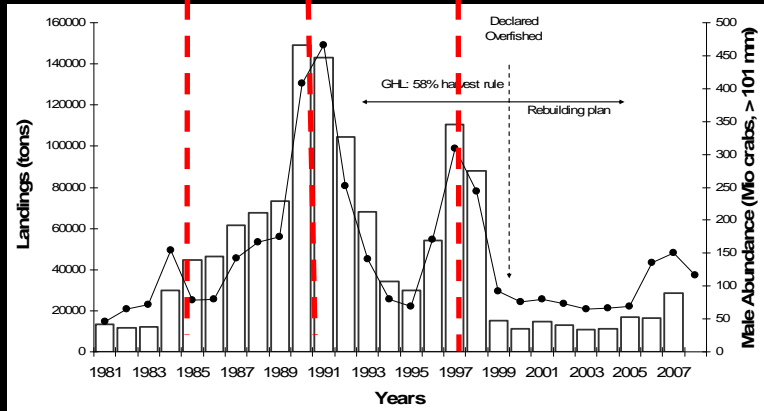
**Mature Females, Middle Domain
(Total & primipara)**

40-80 mm

**Relative abundance of
SCI2 male size groups**

80-110 mm

> 110 mm



Catch

The period of the cycle matches the average time between egg extrusion by a female and terminal molt of her female progeny

Correspondence suggests a dynamic linkage between the pulses, with each one in the sequence becoming the parental stock for the subsequent

Year

x

$x+1$

$x+2$

$x+3$

$x+4$

$x+5$

$x+6$

$x+7$

$x+8$

$x+9$

Progenie from an annual brood

Progenie from a biennial brood

Pseudocohort x

Year-class $x+1$

Year-class $x+2$

VIII

Pseudocohort $x+6$

IX

Pseudocohort $x+7$

VIII

X

Pseudocohort $x+8$

IX

XI

Pseudocohort $x+9$

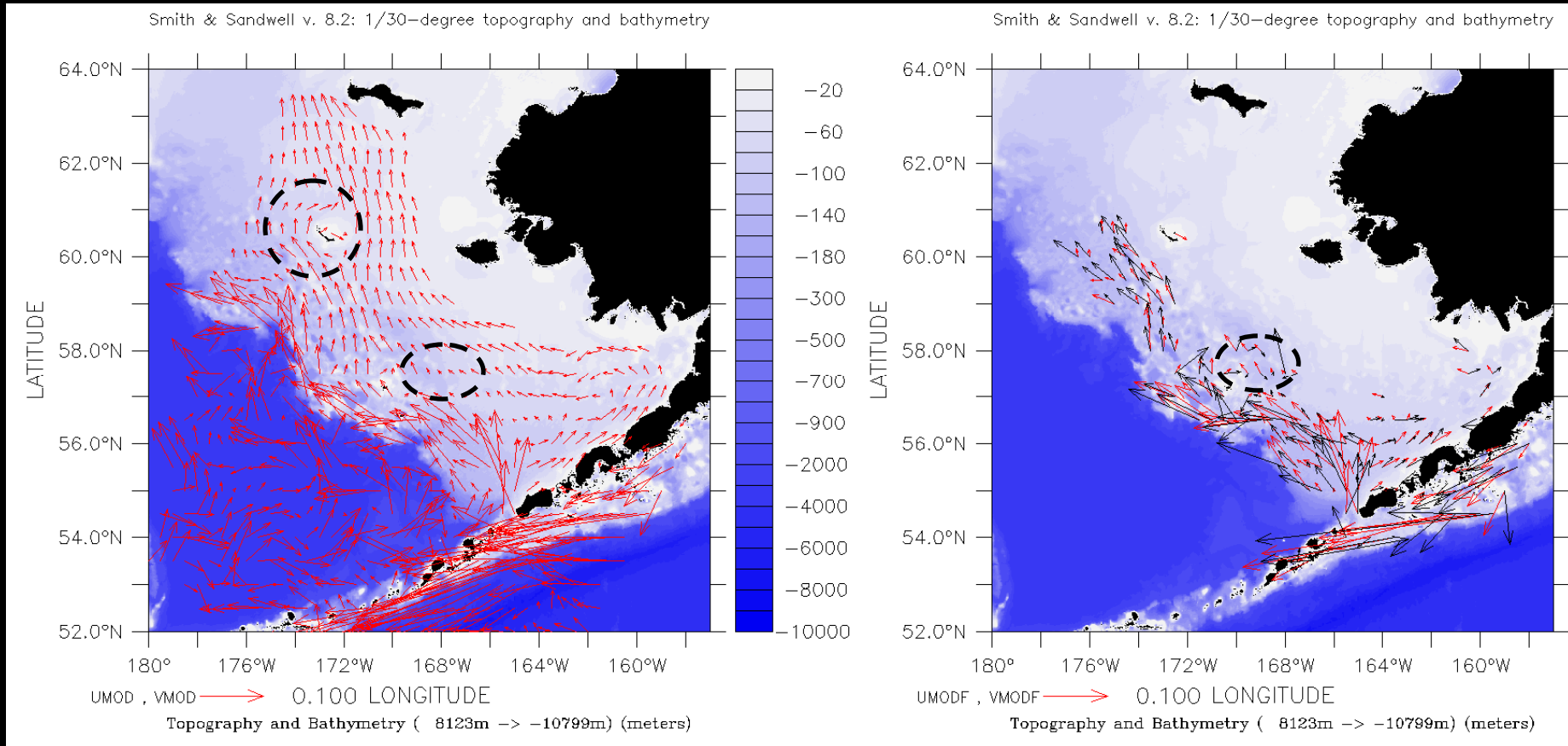
X

XI

Pseudocohort $x+10$

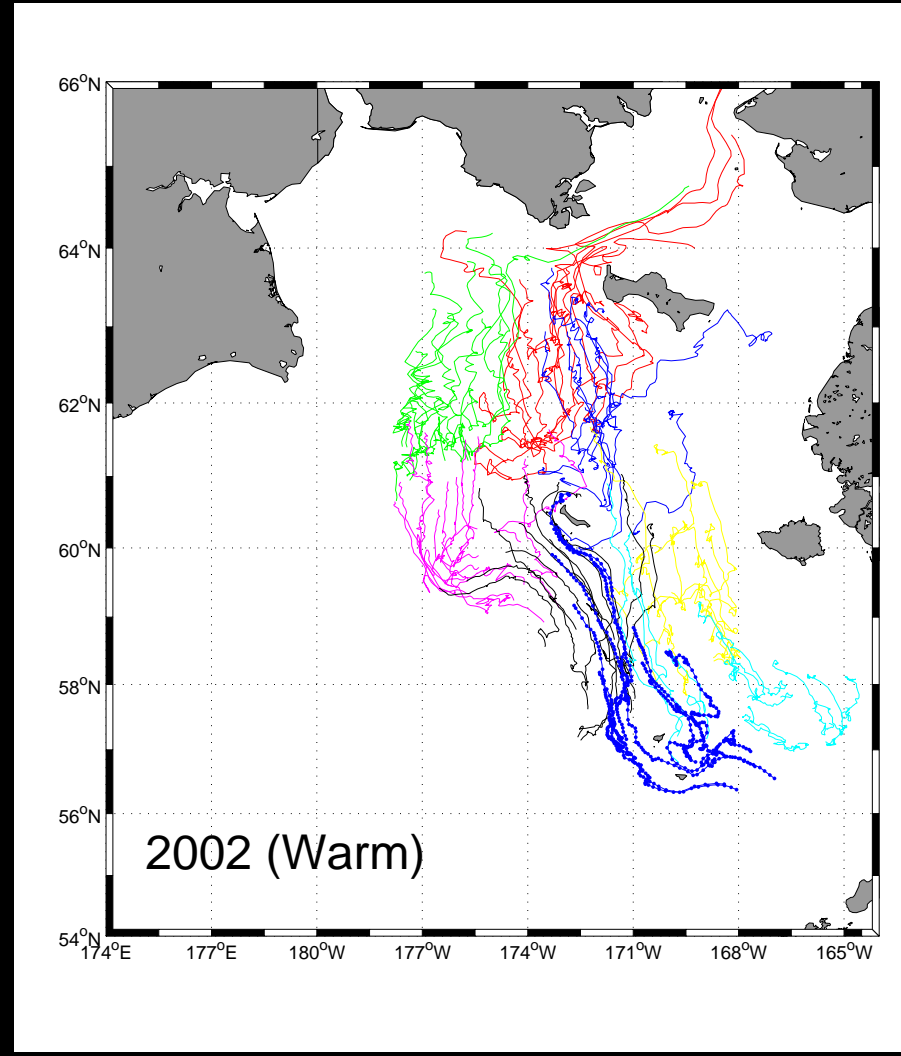
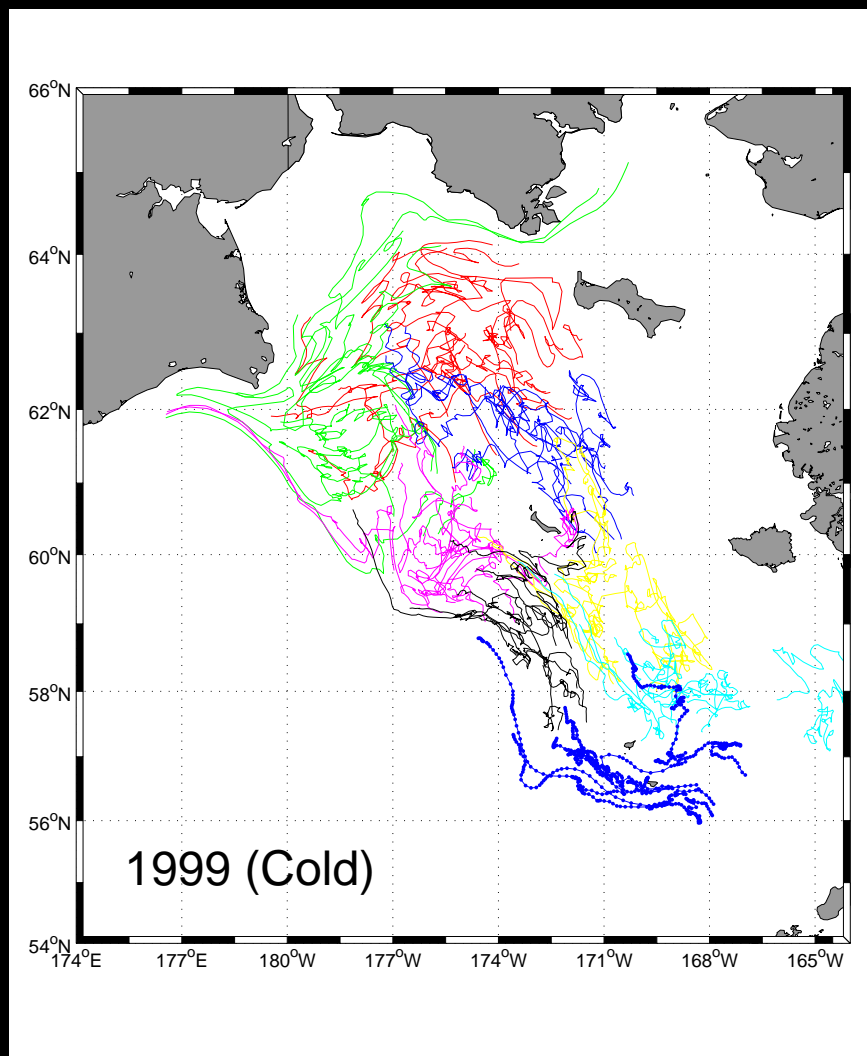
- Brooding, hatching, pelagic larval life and settlement
- - - - - Growth
- Growth and terminal molt
- VIII-XI: mature instars

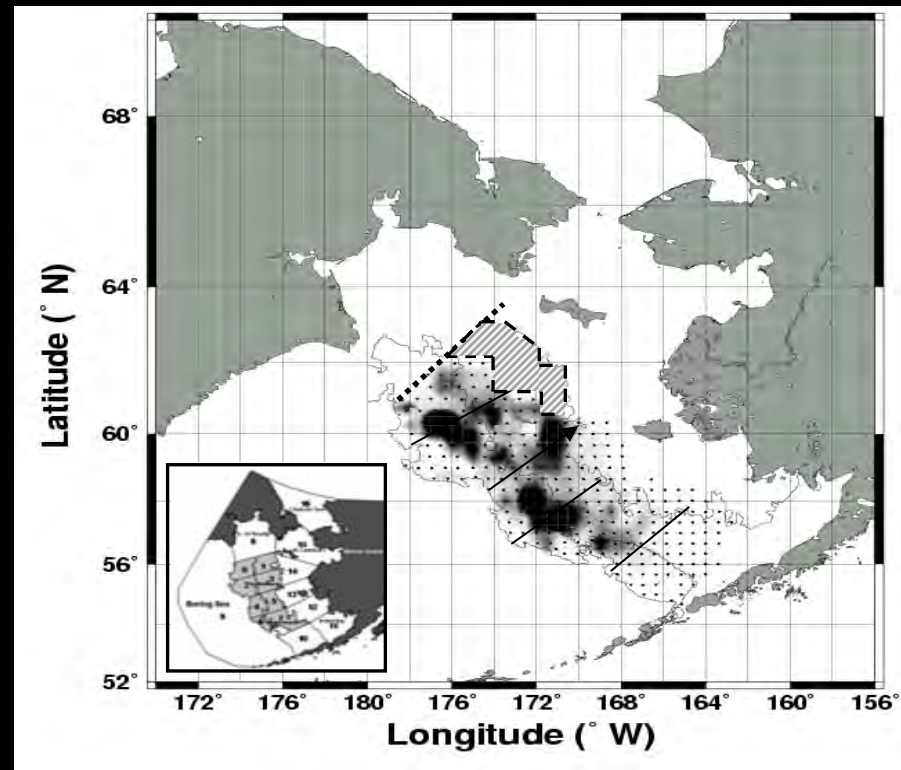
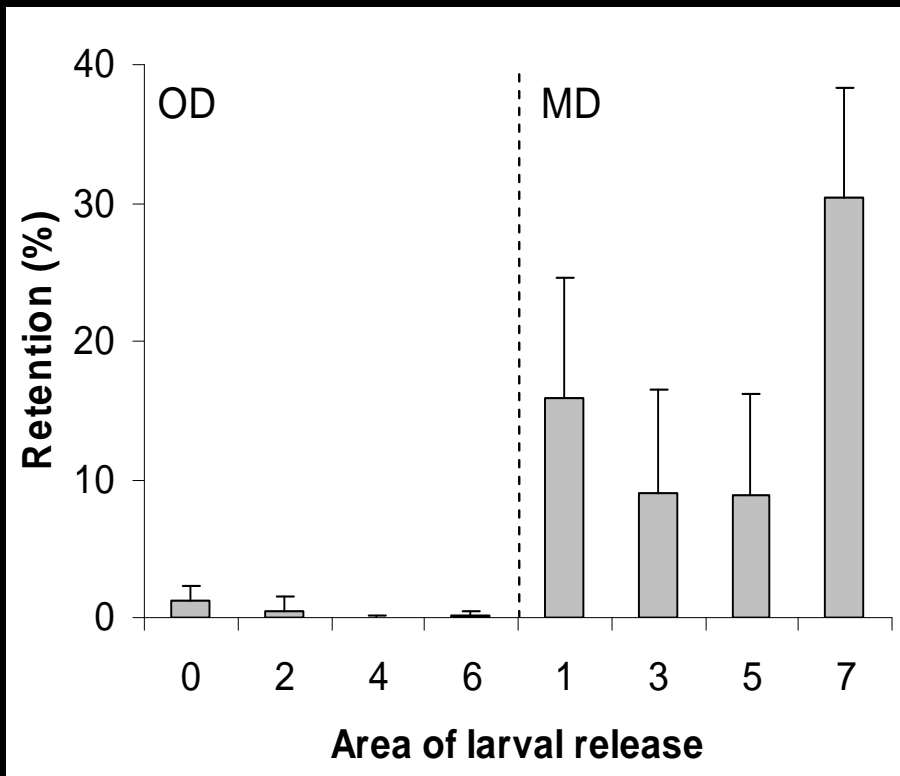
Predominant direction of currents is from SE to NW



Once the reproductive stock contracts to the north, re-expansion to the south tracking year-to-year fluctuations in NBT is made difficult because of the northward direction of residual currents.

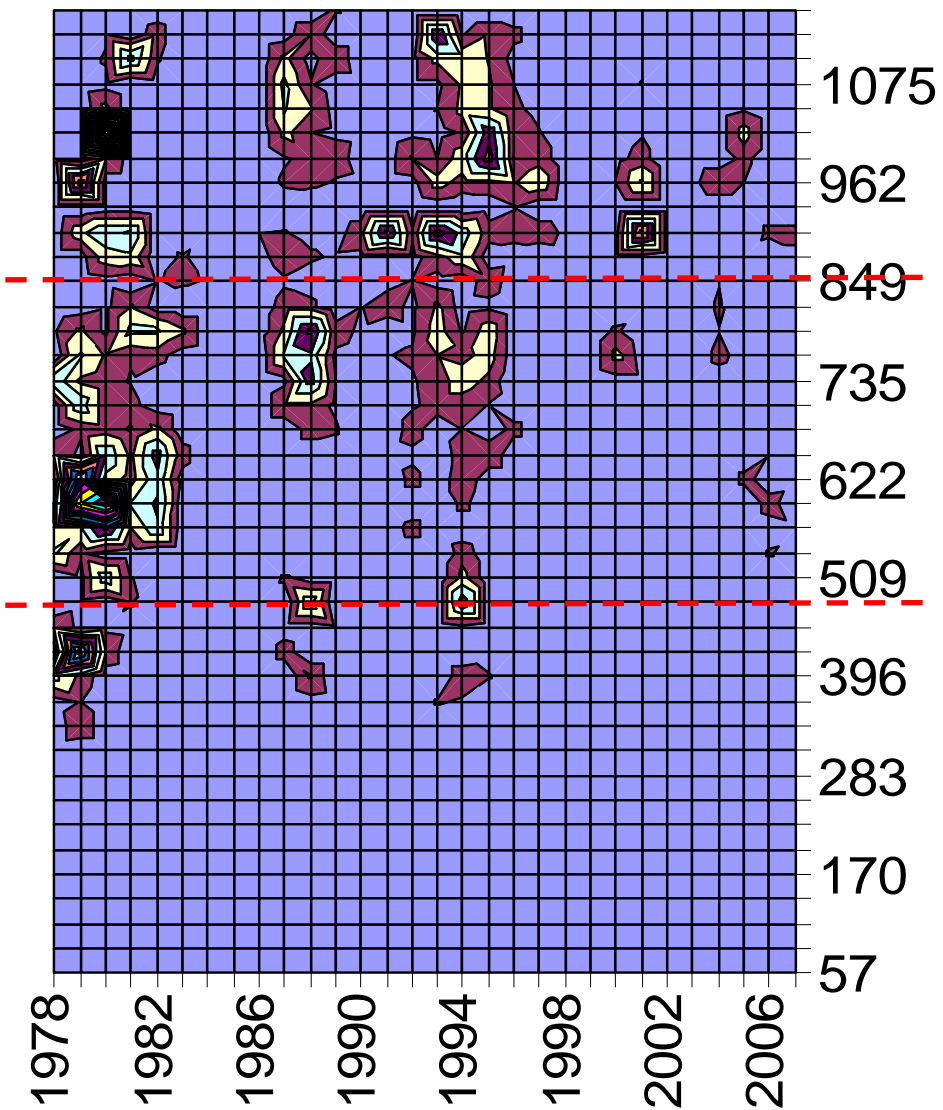
Larval trajectories simulated with coupled bio-physical model



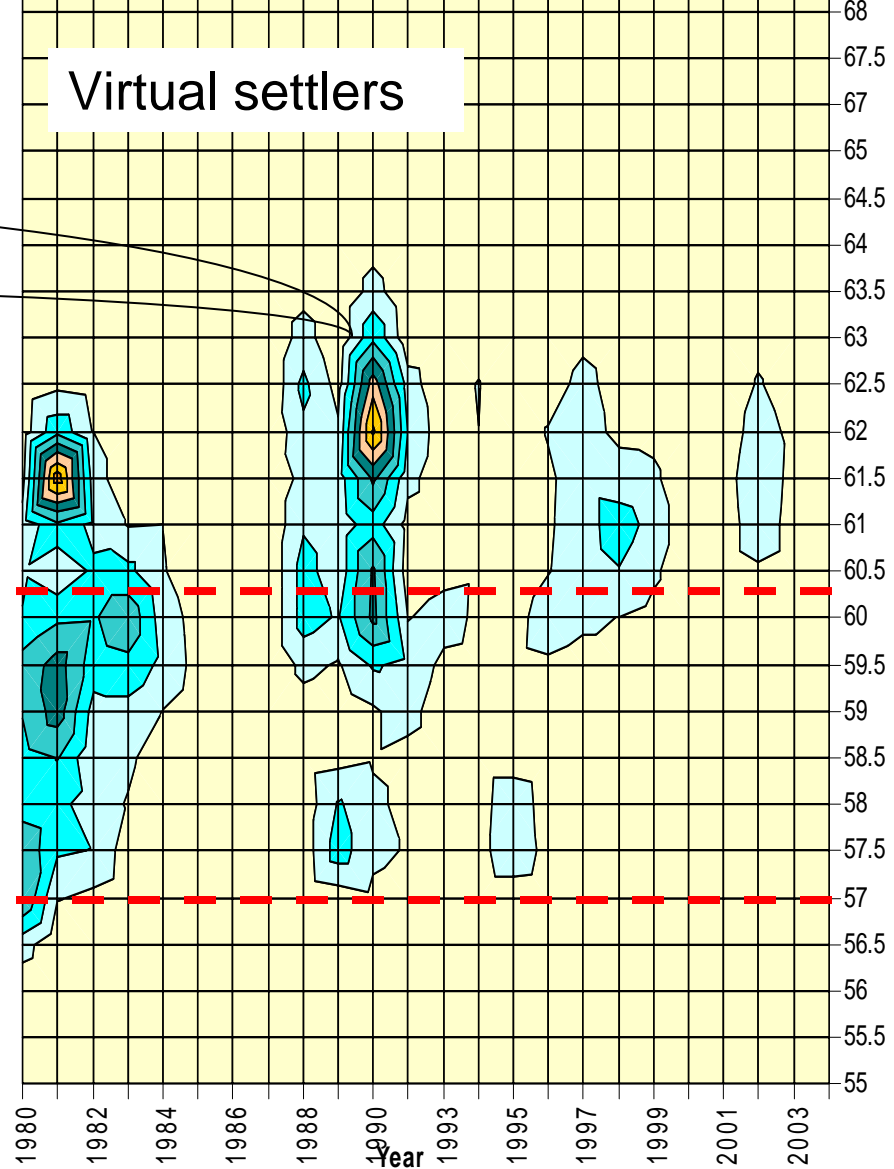


Negligible retention of virtual larvae released in the outer domain
Consistent retention of virtual larvae in the middle domain, particularly east of the Pribilof Islands

Primipara



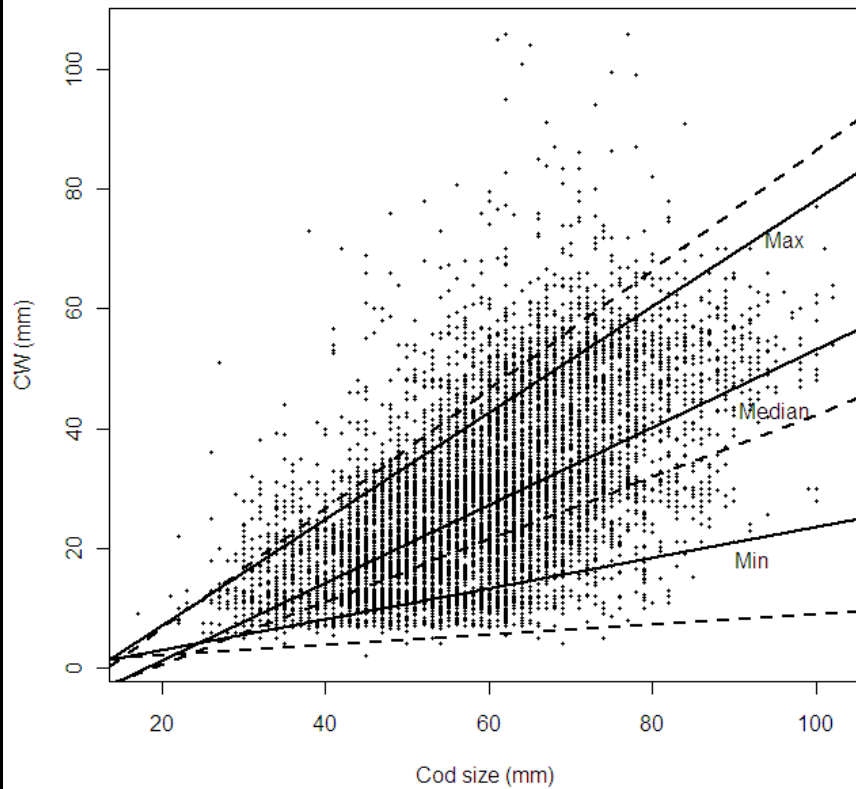
Virtual settlers



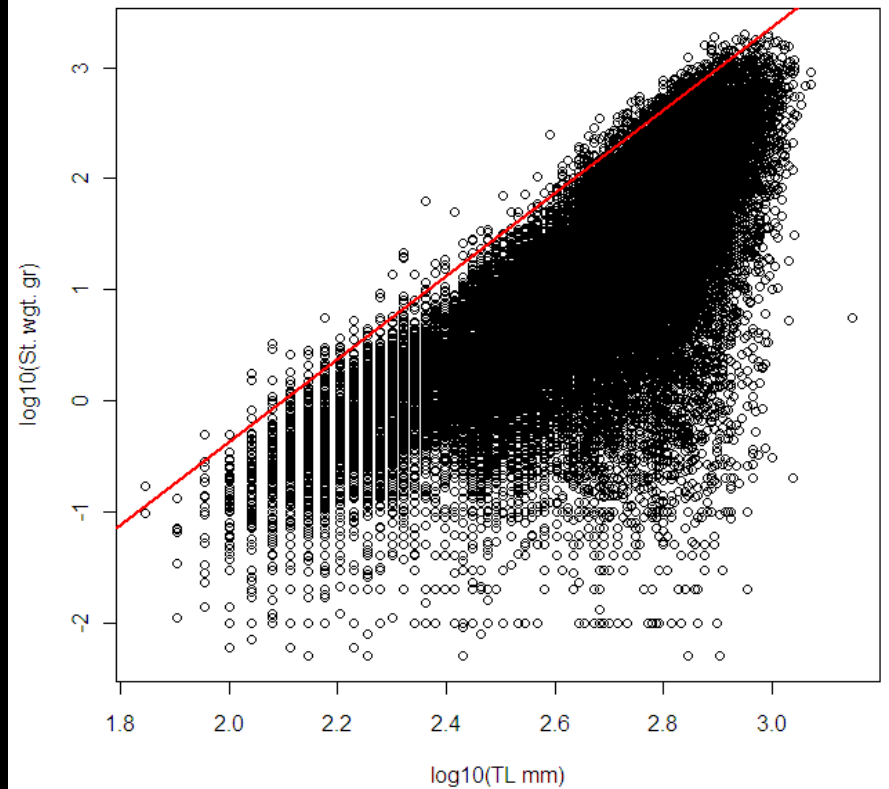
What role for cod predation?



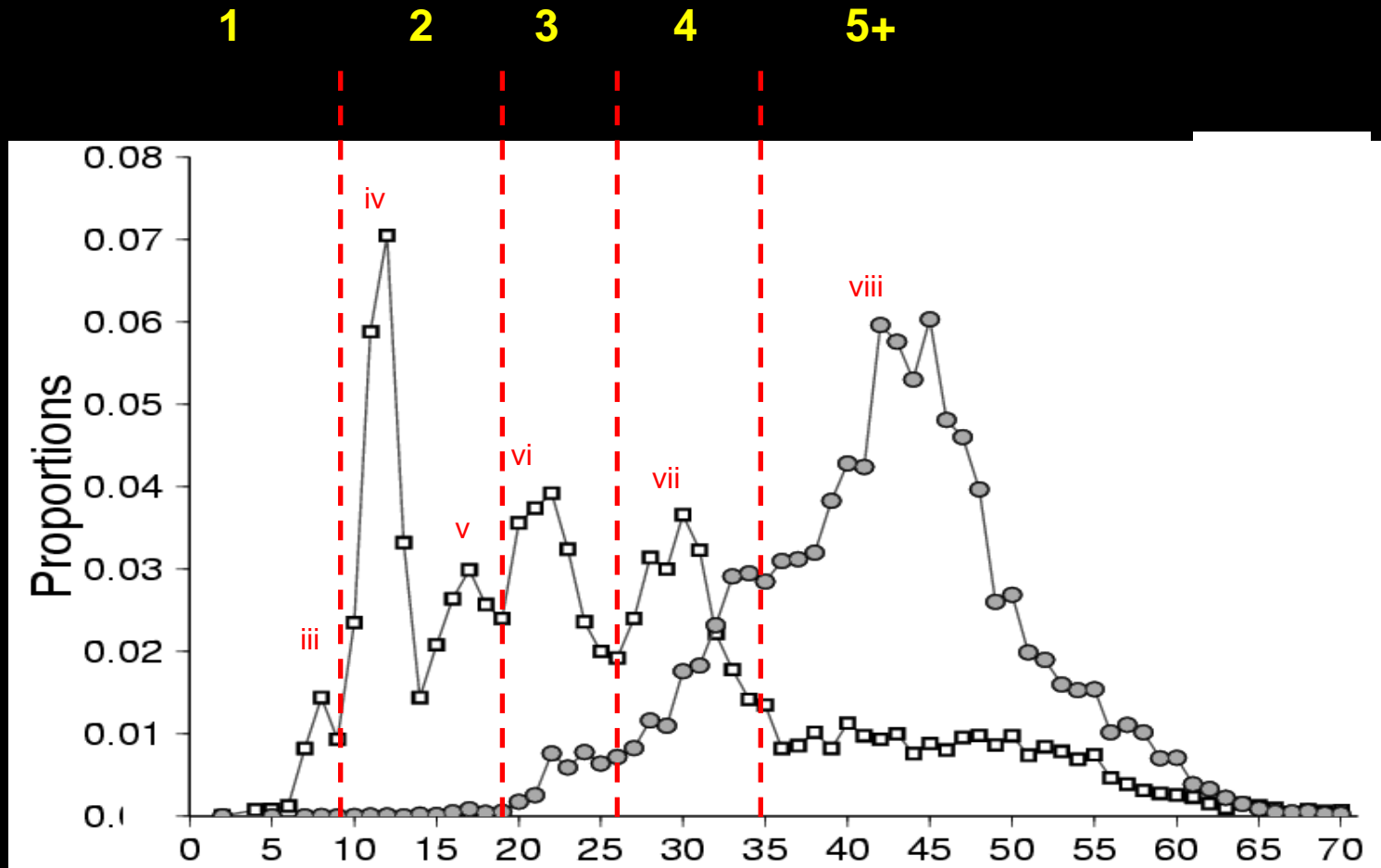
prey (crab) vs. predator (cod) size



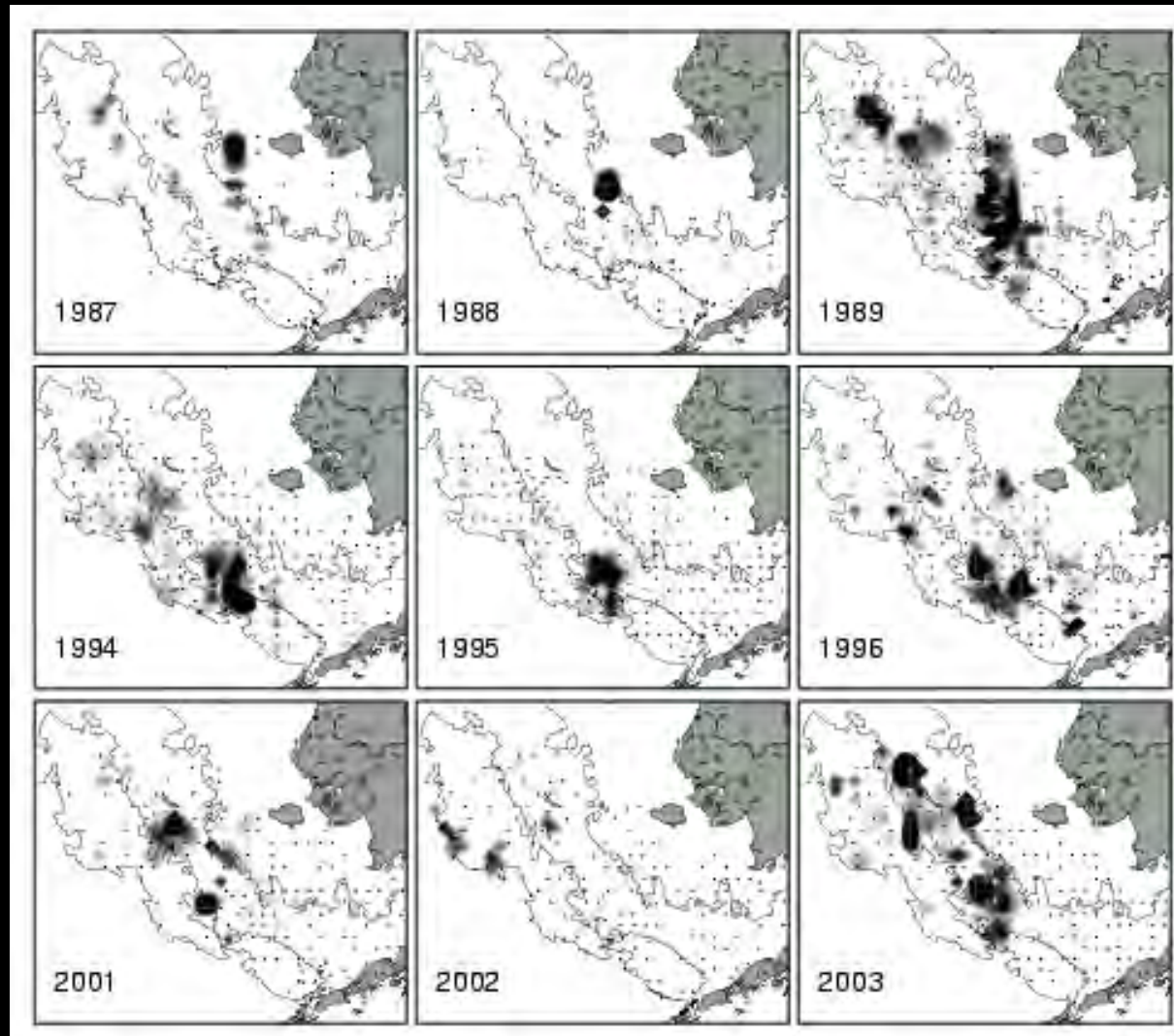
predator (cod) stomach fullness



Cod preys on Instars iv-vii, settled 1-4 years earlier

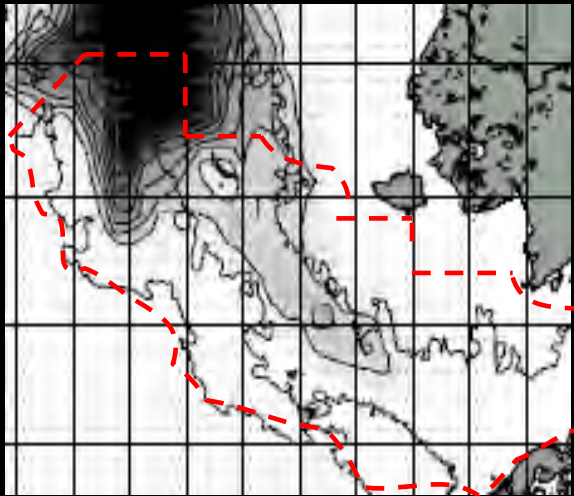


Pseudochort strength is established early in life history, before immature females become vulnerable to cod predation

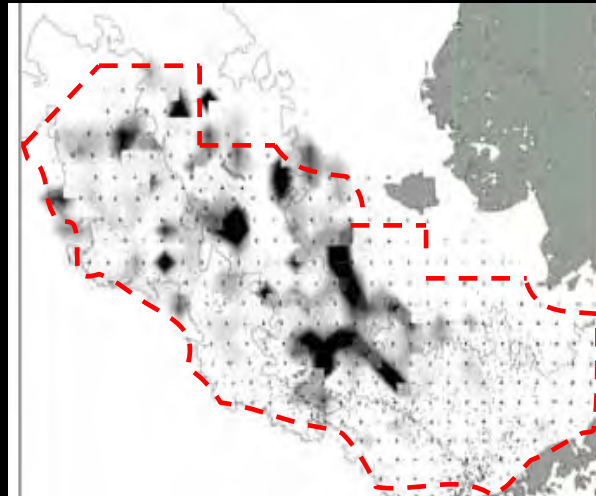


Geographic spread of immature females in cod stomachs during the summers contracted one year after pulse core years, and expanded abruptly one year later. As the geographic spread of immature crab found in cod stomachs expanded, there was an increase in the relative significance of Instar iv, which became overwhelmingly dominant three years after pulse core years. Cod predation tracks the cycle of recruitment in time and space and may contribute to the environmental ratchet effect, but does not appear to control the cyclic pattern of recruitment

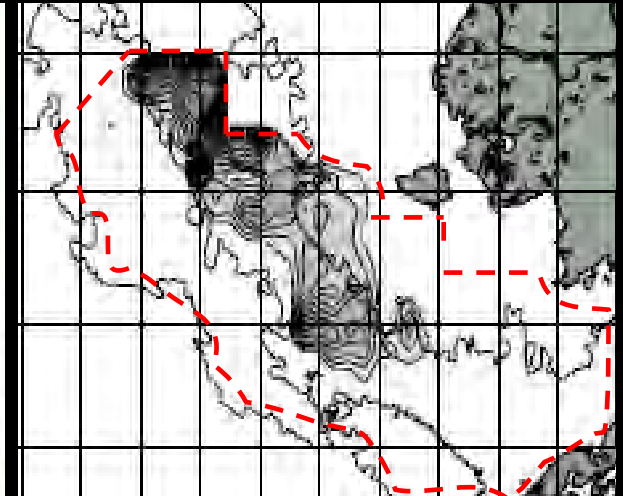
Virtual settlers



**Av. crabs per
cod stomach**

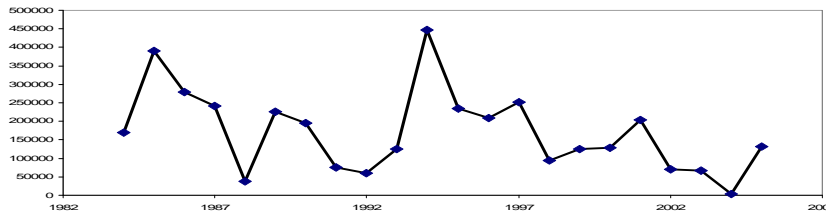


**Immature females,
CPUE (NMFS survey)**

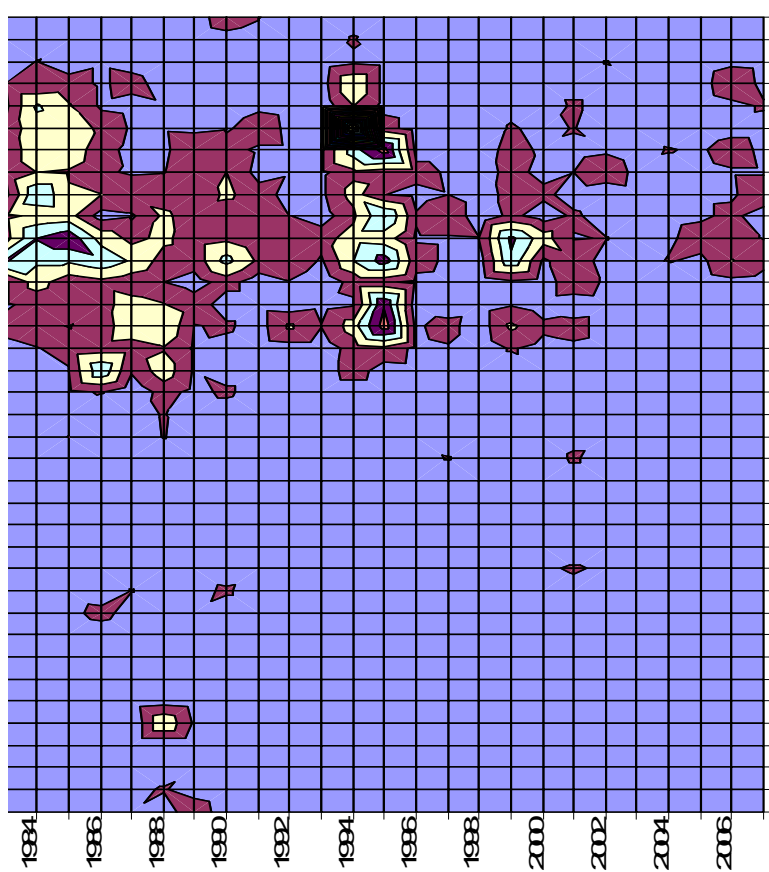


**After contraction of the stock to the north, cod predation on juveniles
constrains the geographic range of immature females**

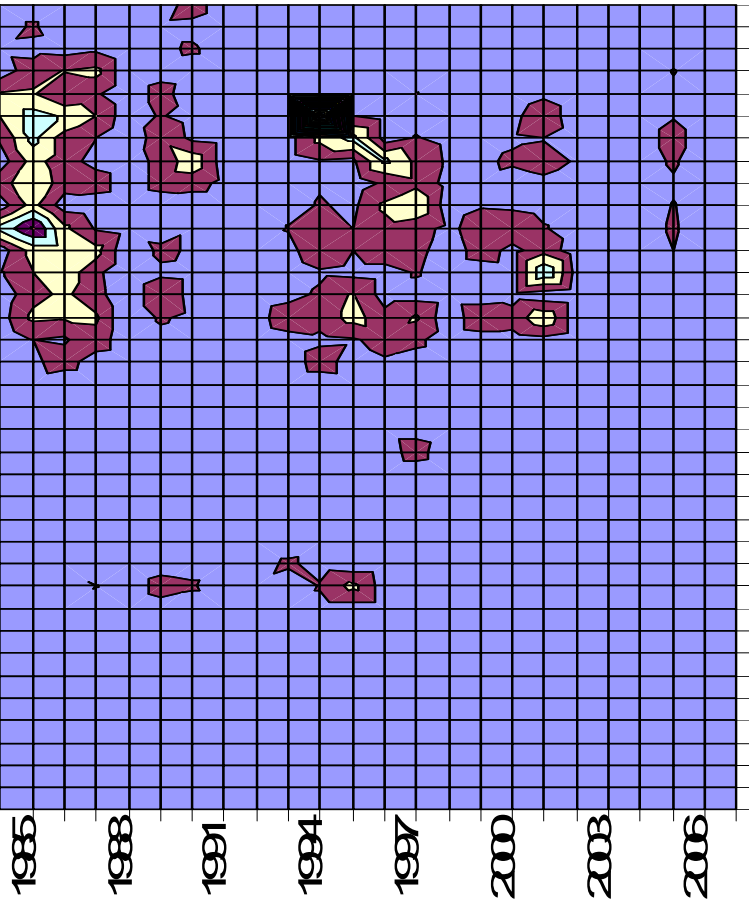
Outer Domain



NW



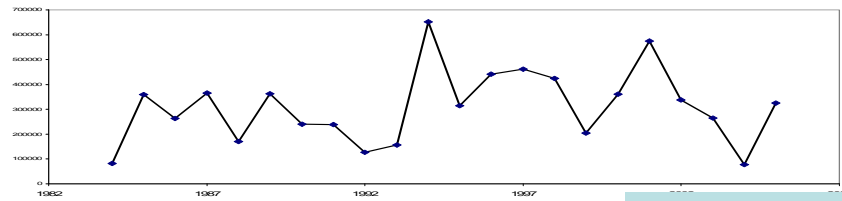
Cod CPUE (NMFS survey)



Crab consumption (summer)

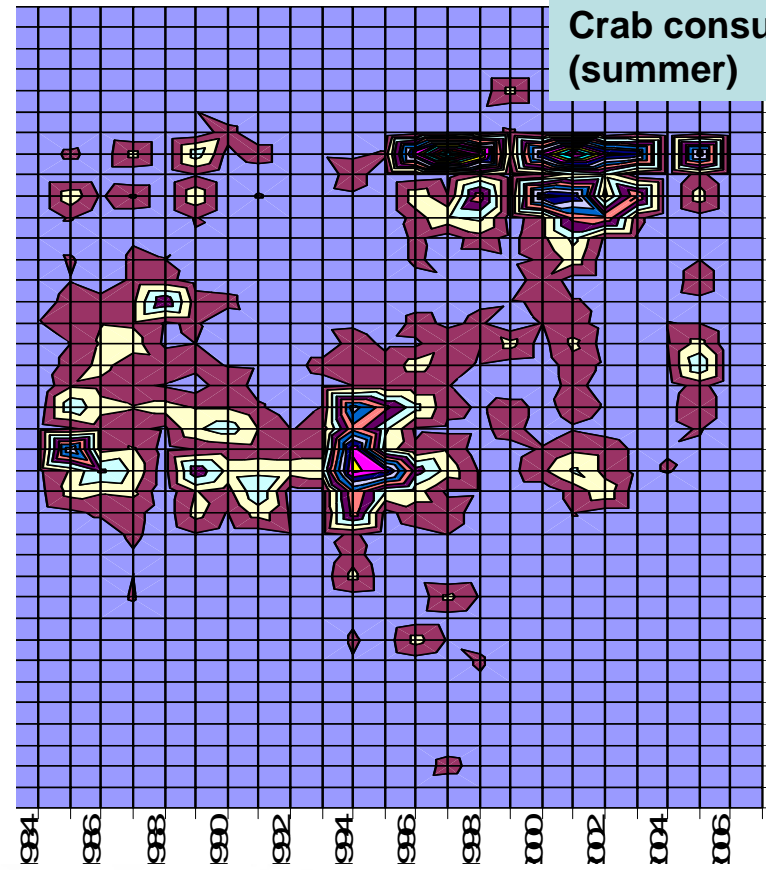
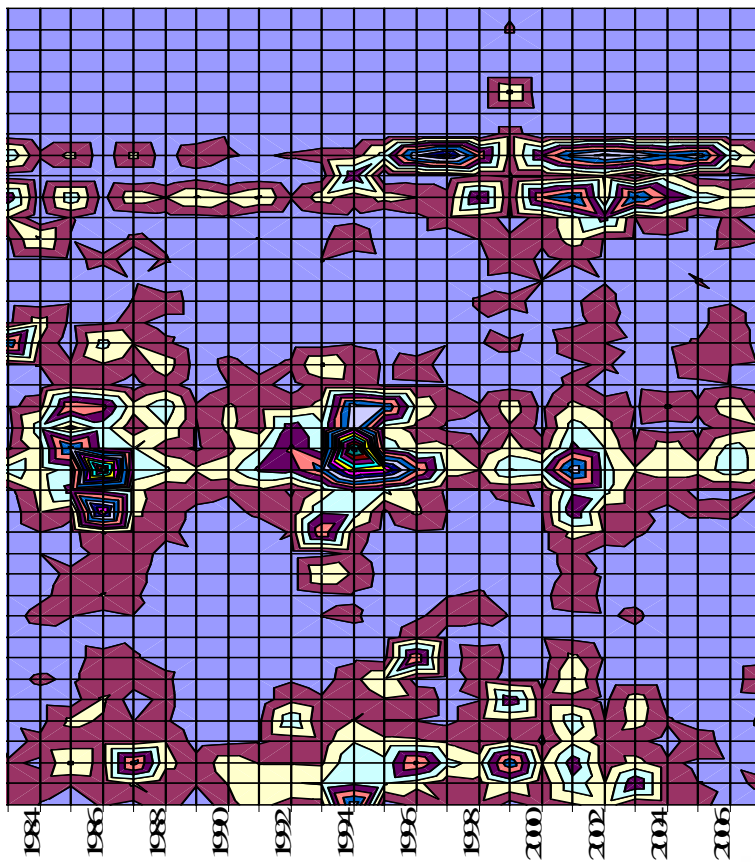
SE

Middle Domain



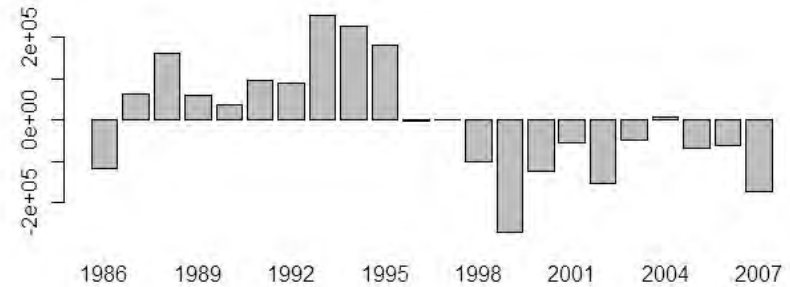
NW

Crab consumption (summer)



SE

Cod CPUE (NMFS survey)



PUZZLING BUT PLAUSIBLE IMPLICATIONS

Snow crab from the EBS may be a contingently quasi-semelparous population, the primipara being the primary contributors to stock renewal; cyclical recruitment could be driven by serial linkage of pulses of primipara abundance

- **Climate:** the cycle could have been initiated by a climatic perturbation, but fluctuations in abundance do not appear to be driven by climatic forcing
- **Predation:** cod predation appears to constrain the geographic range of the stock, but does not appear to drive its fluctuations in abundance
- **Fishing:** the fishery depends on a segment of the stock (large adult males) whose contribution to renewal of the stock may be marginal.