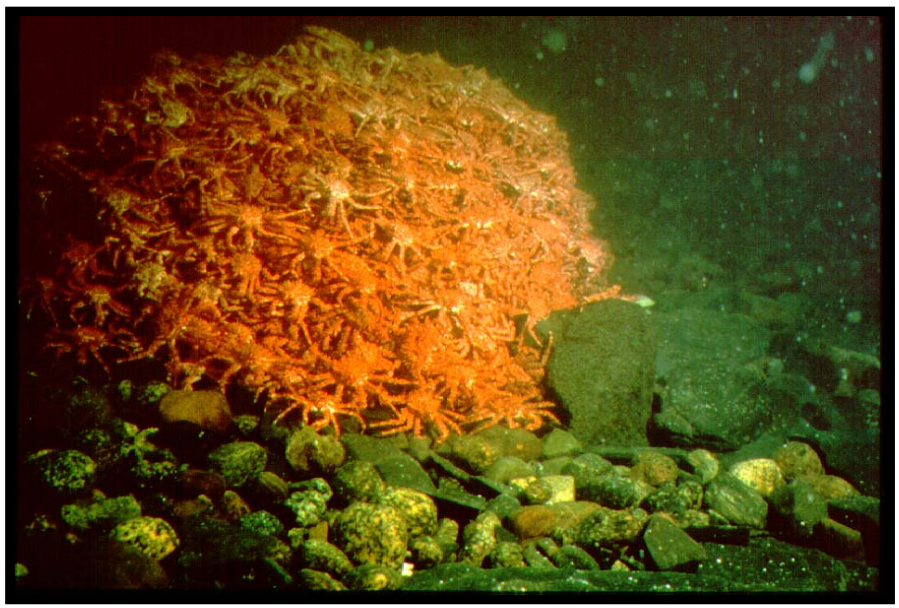
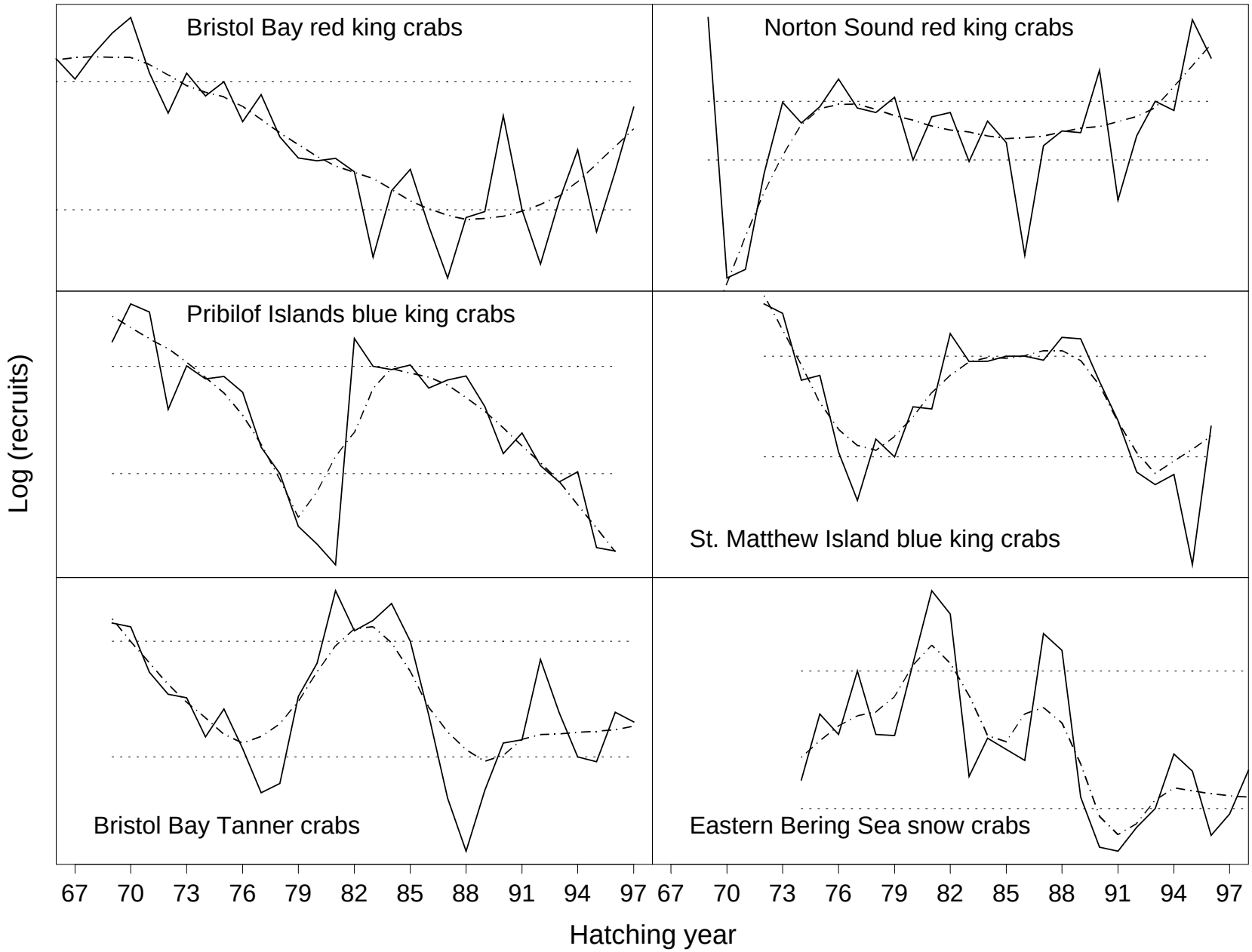
Recruitment variation of eastern Bering Sea crabs: “climate-forcing” or “top-down” effects?



Jie Zheng and Gordon Kruse
Juneau, Alaska, USA

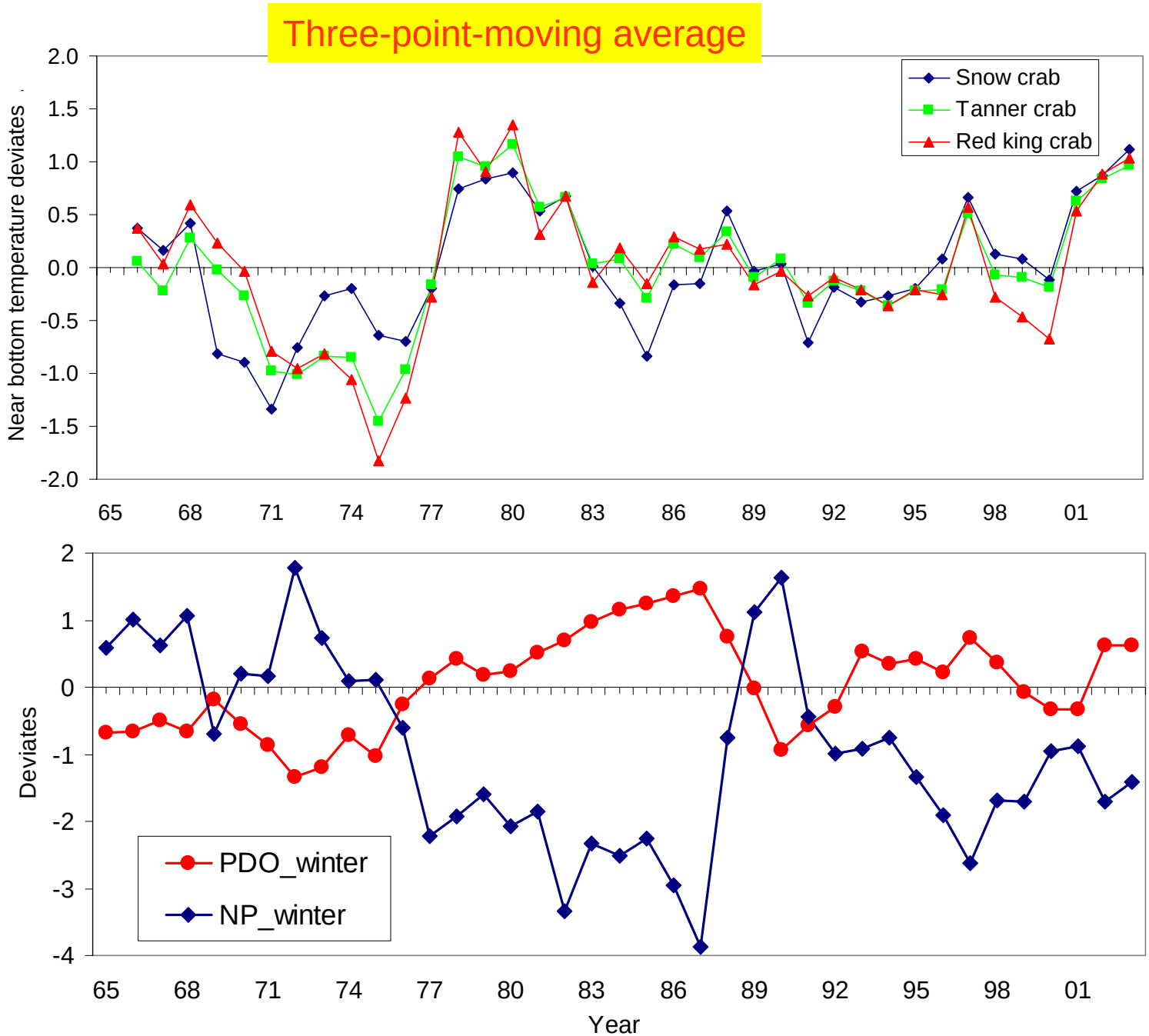
Log-transformed male recruitment indices (dashed lines are lowess lines)



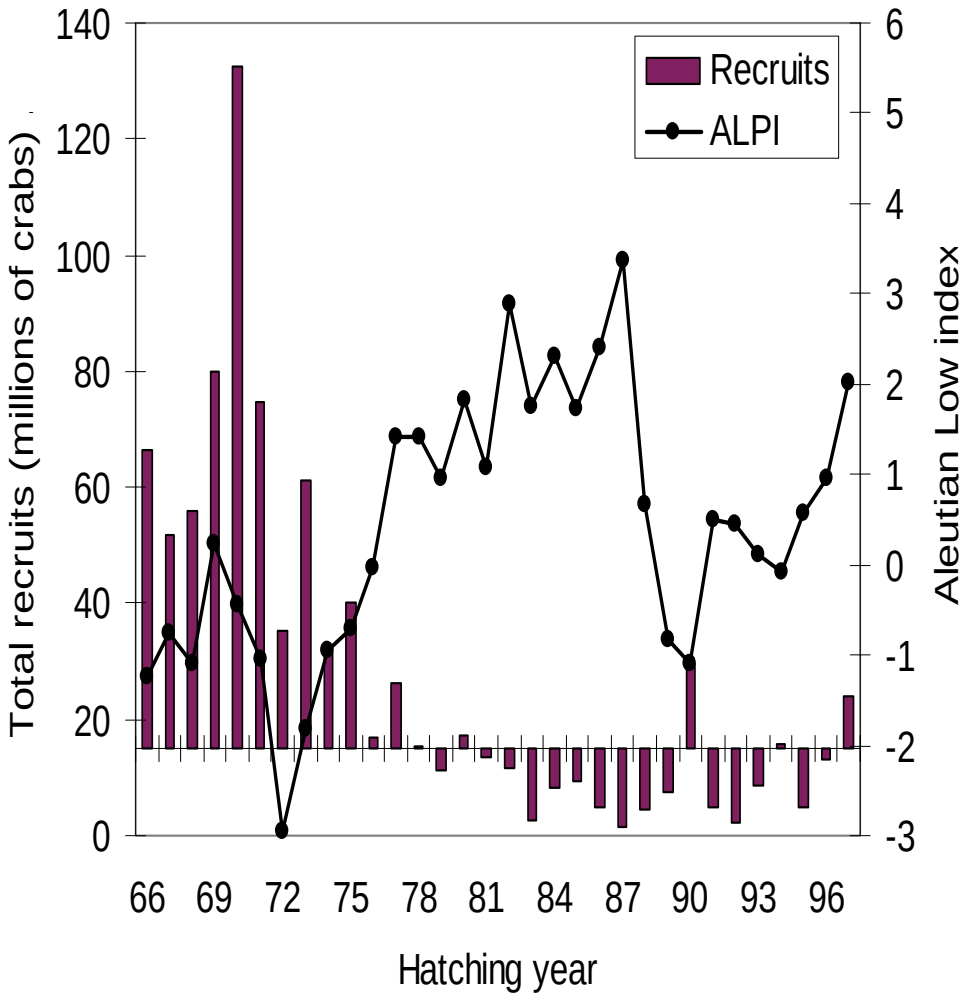
Pairwise correlation coefficients on log-transformed recruitment

	1	2	3	4	5	6
1. Bristol Bay red king crabs		0.31	0.09	0.19	0.04	-0.01
2. Pribilof Is. blue king crabs	ns		0.67	0.14	0.09	-0.43
3. St. Mat. Is. blue king crabs	ns	*		0.19	0.23	-0.48
4. Bristol Bay Tanner crabs	ns	ns	ns		0.09	-0.16
5. EBS snow crabs	ns	ns	ns	ns		-0.05
6. Norton S. red king crabs	ns	*	*	ns	ns	

Lower triangle: ns for $p>0.05$; * for $p<0.05$


Three-point-moving average
Near bottom temperature deviates
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
65
68
71
74
77
80
83
86
89
92
95
98
01
Snow crab
Tanner crab
Red king crab
Deviates
2
1
0
-1
-2
-3
-4
PDO_winter
NP_winter
Year

Bristol Bay red king crab recruitment & Aleutian Low index



The recruitment trends of Bristol Bay red king crabs may partly relate to decadal shifts in physical oceanography:

All strong year classes occurred before 1977 when the Aleutian Low was weak.

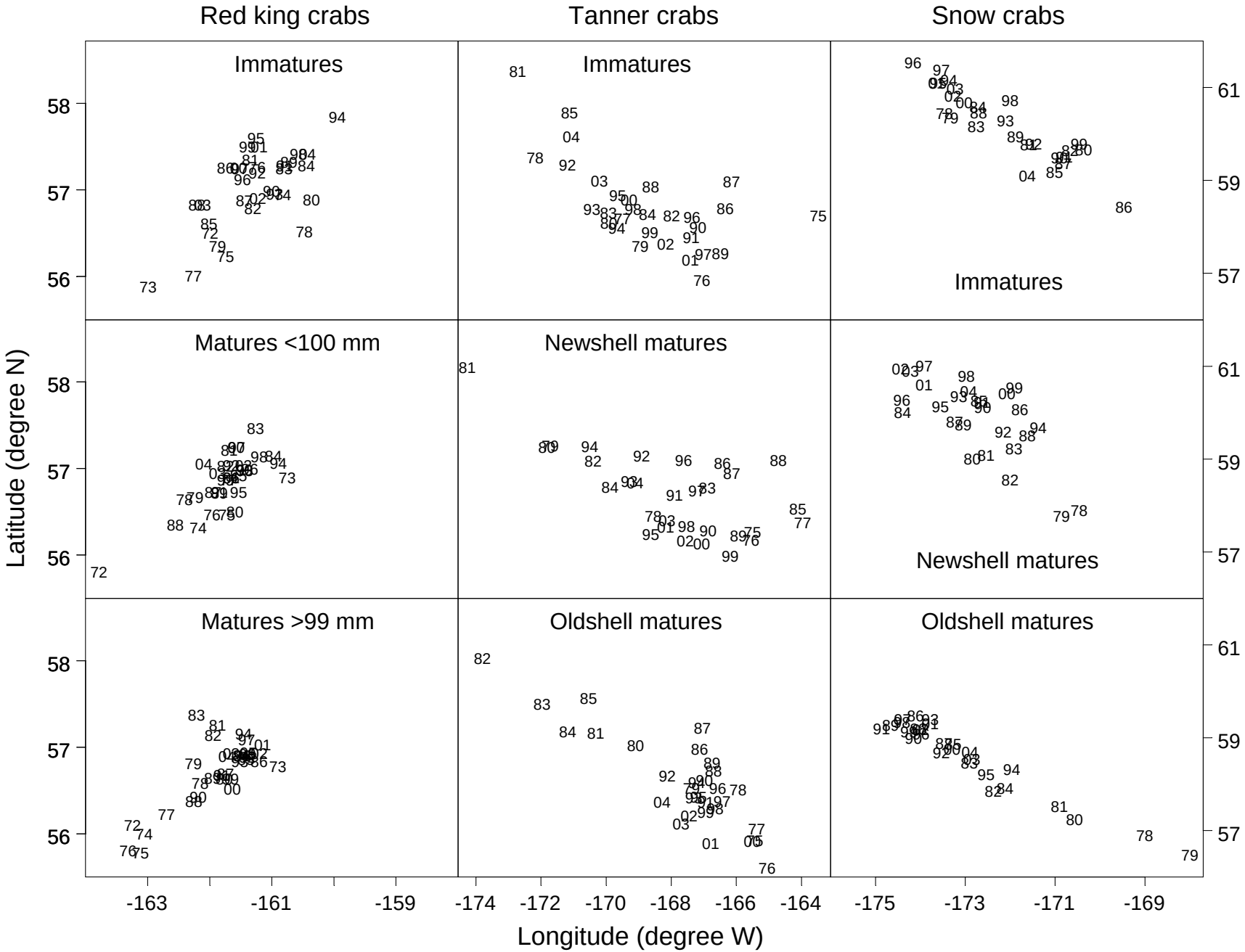
The largest year class during the last 20 years, the 1990 year class, was also coincidental with the weak Aleutian Low index during 1989-1991.

Climate forcing 1 (Zheng & Kruse 2000):

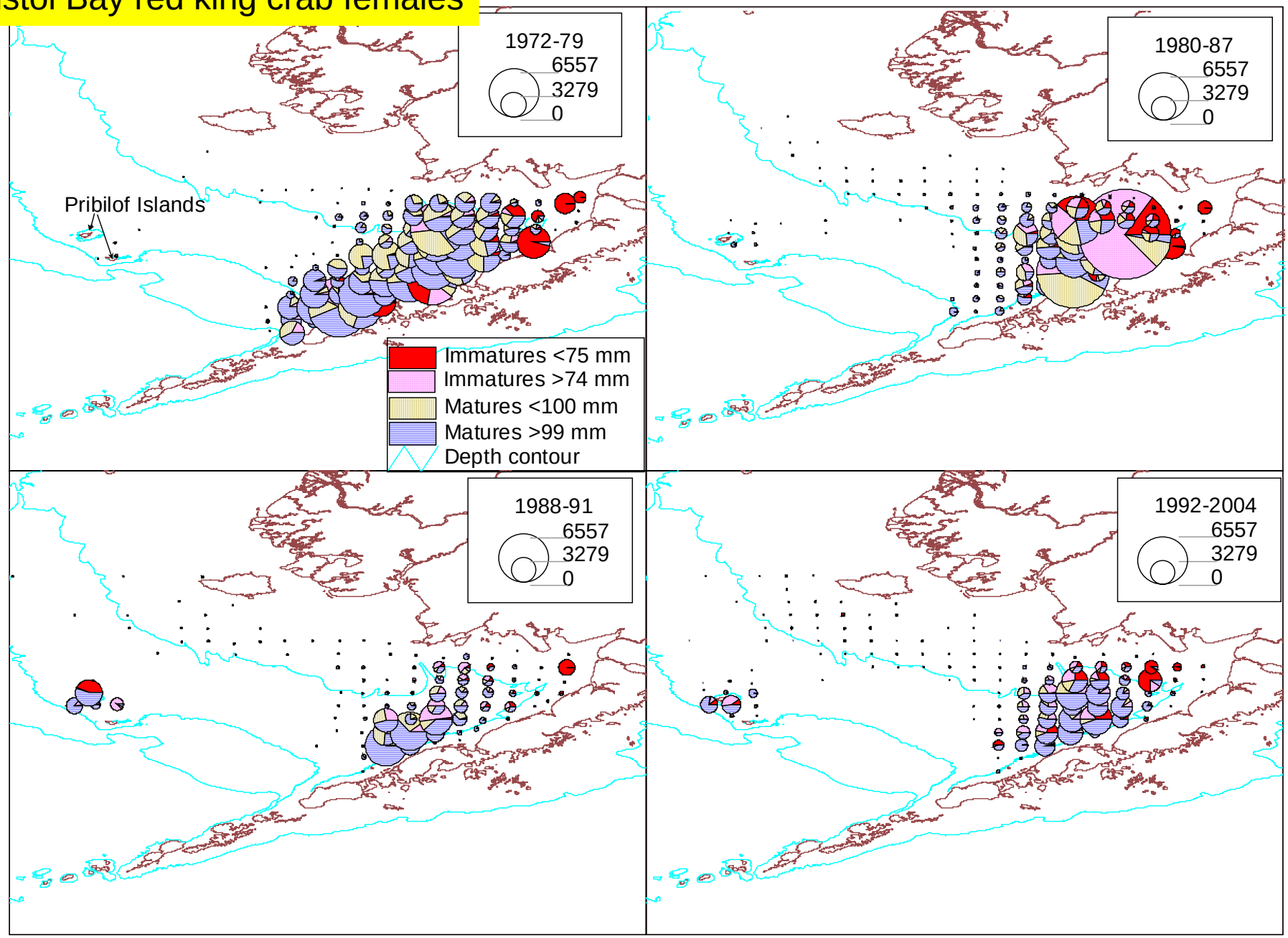
Food availability is hypothesized to be important to red king crab larvae:

Diatoms such as *Thalassiosira* are important food for first-feeding red king crab larvae and they predominate the spring bloom in years of light winds when the water column is stable. Years of strong wind mixing associated with intensified Aleutian Lows may depress red king crab larval survival and subsequent recruitment.

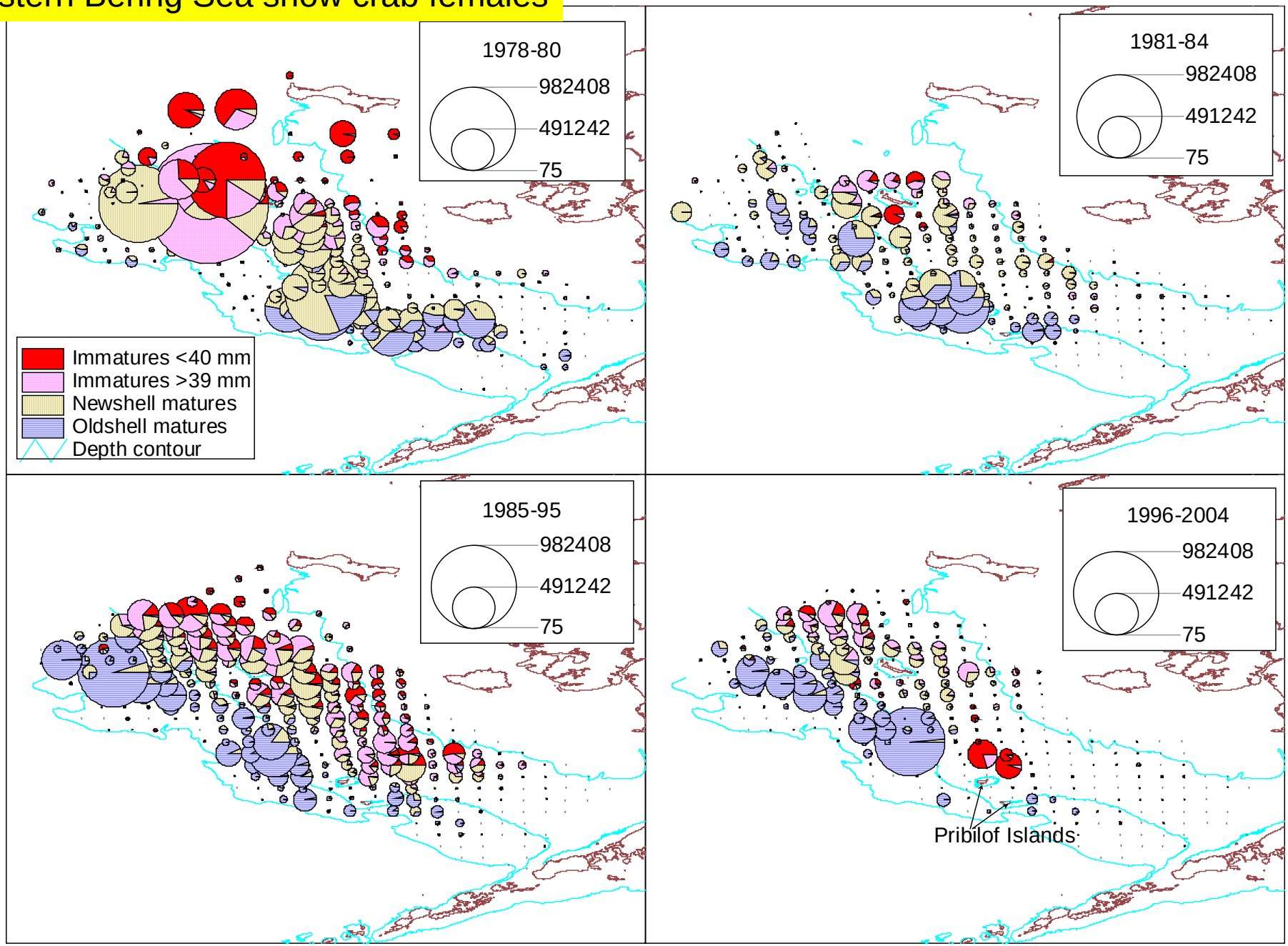
Annual centers of female crab distributions



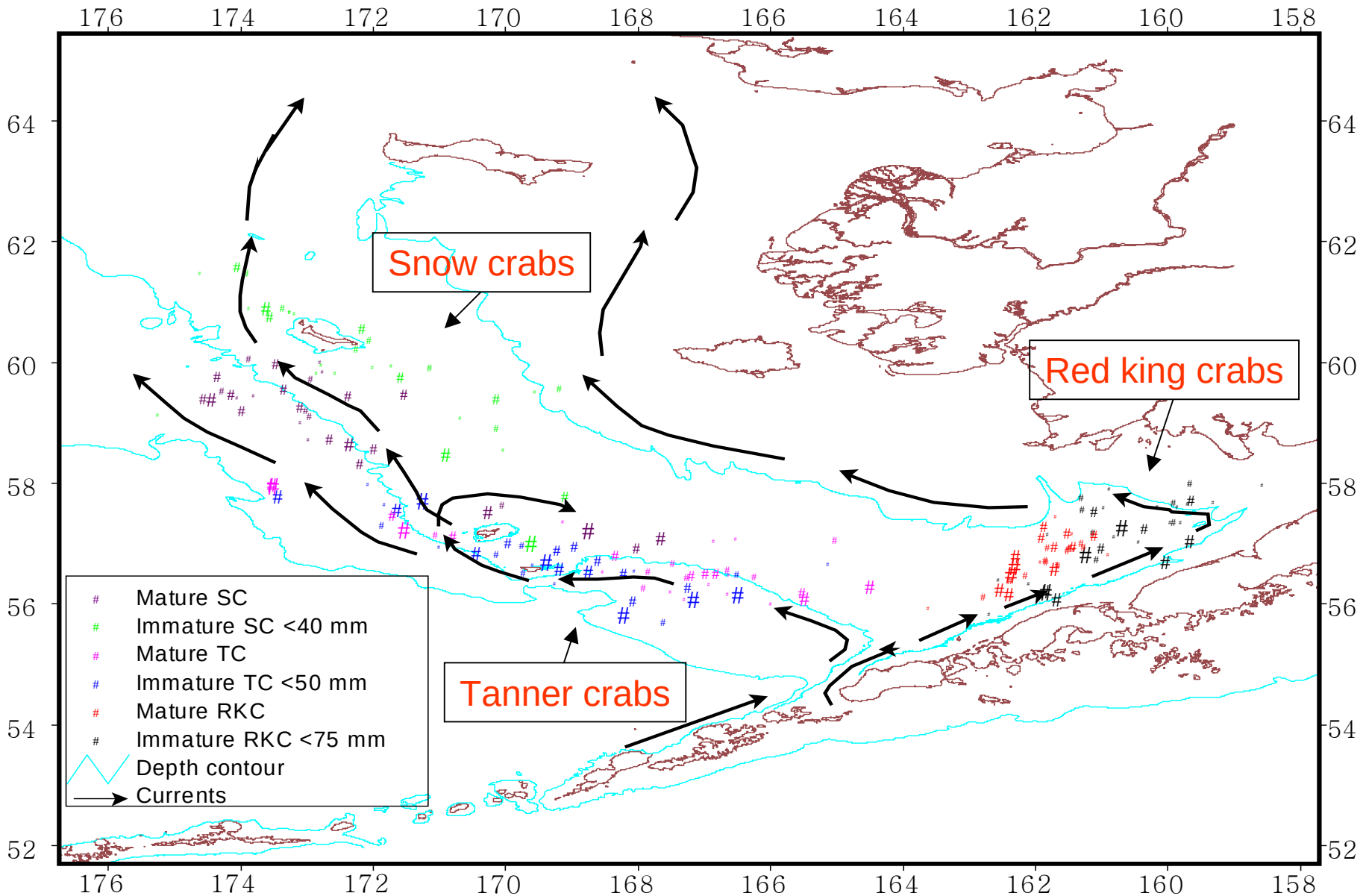
Bristol Bay red king crab females



Eastern Bering Sea snow crab females



Currents and annual distribution centers of matures and small juveniles



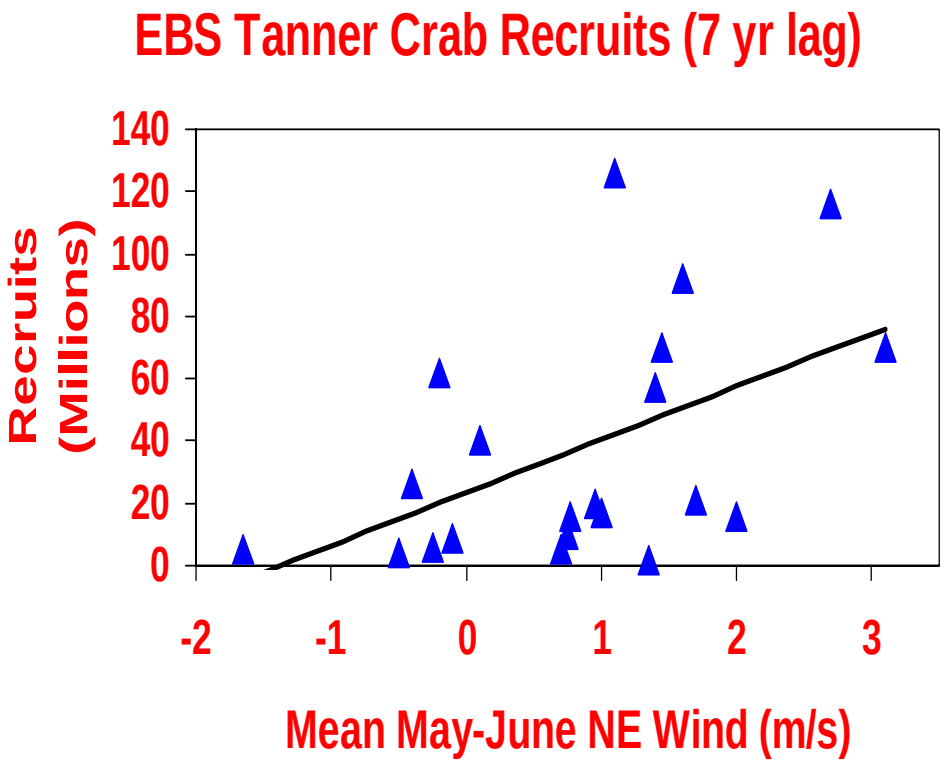
Climate forcing 2: Red king and snow crabs

- Northward shifts of spatial distributions of Bristol Bay red king crabs and eastern Bering Sea snow crabs may be related to the regime shift in 1976-77.

- The shifts of spatial distributions of mature females make it difficult to supply larvae to the southern ranges of their spatial distributions. This not only reduces the suitable habitats for juvenile crabs, but also slows juvenile growth due to relative low temperatures in the north. This will affect recruitment strength.

Climate forcing 3: Tanner crabs

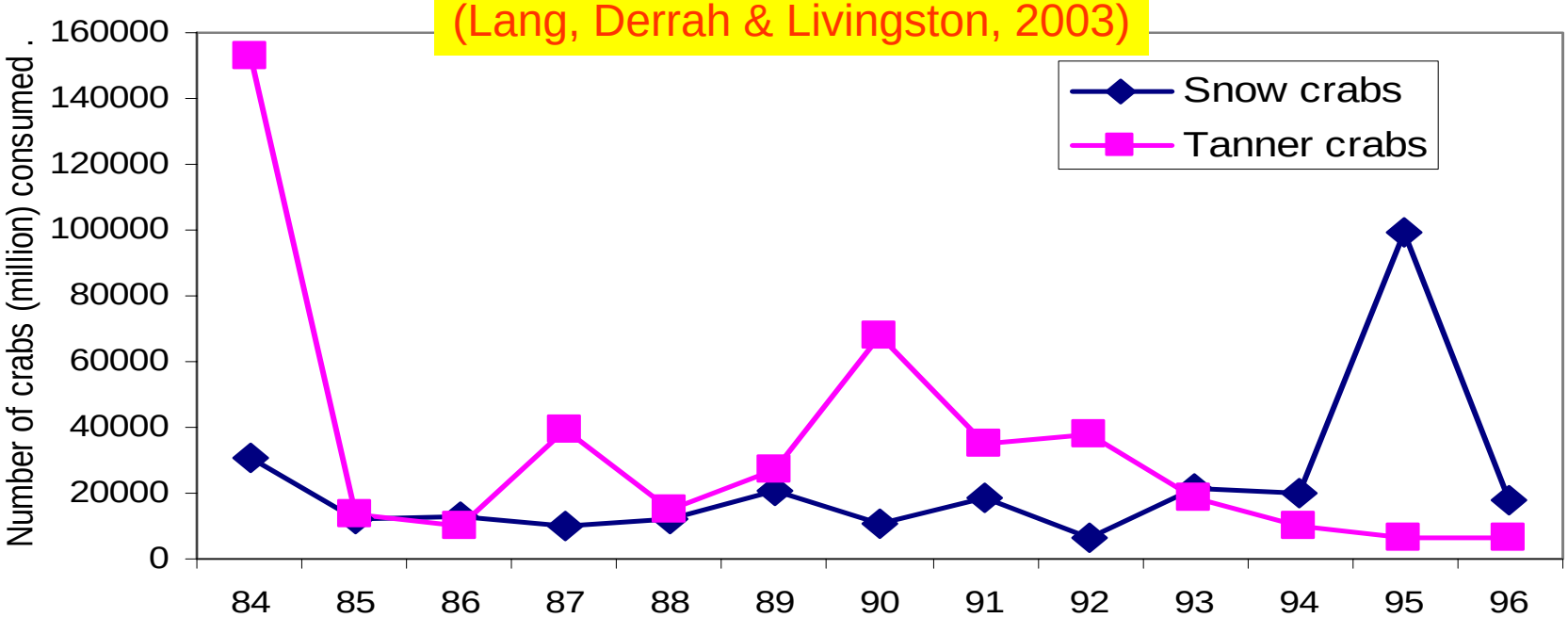
(Rosenkranz et al. 2001)

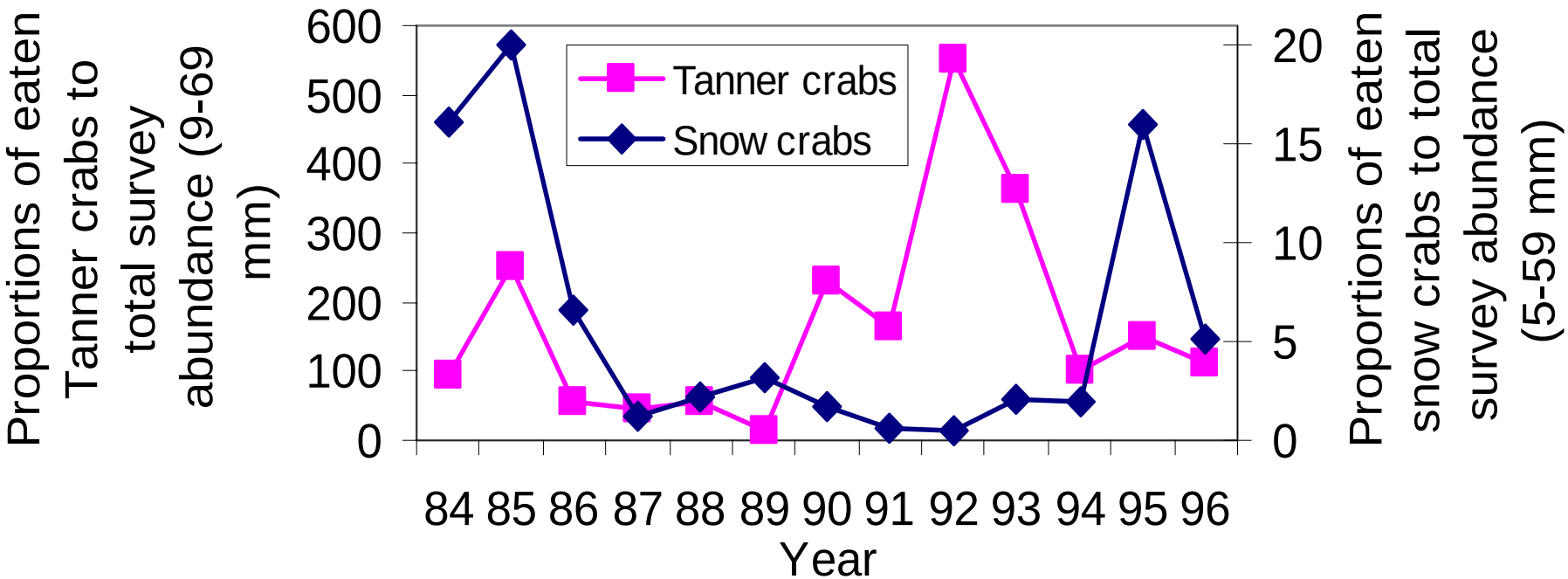


Recruitment may be enhanced by:

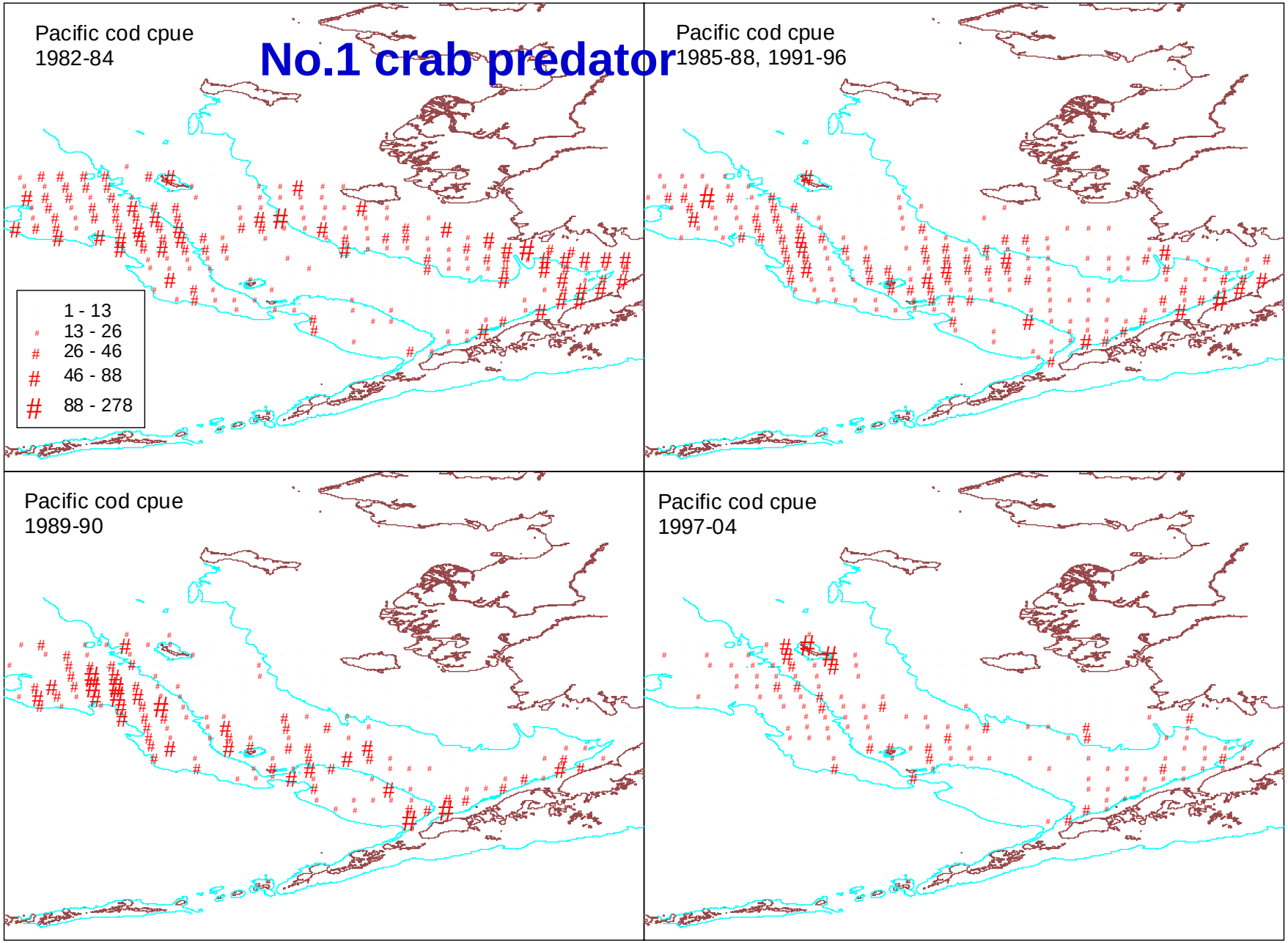
- **NE winds during larval period (advection or food)**

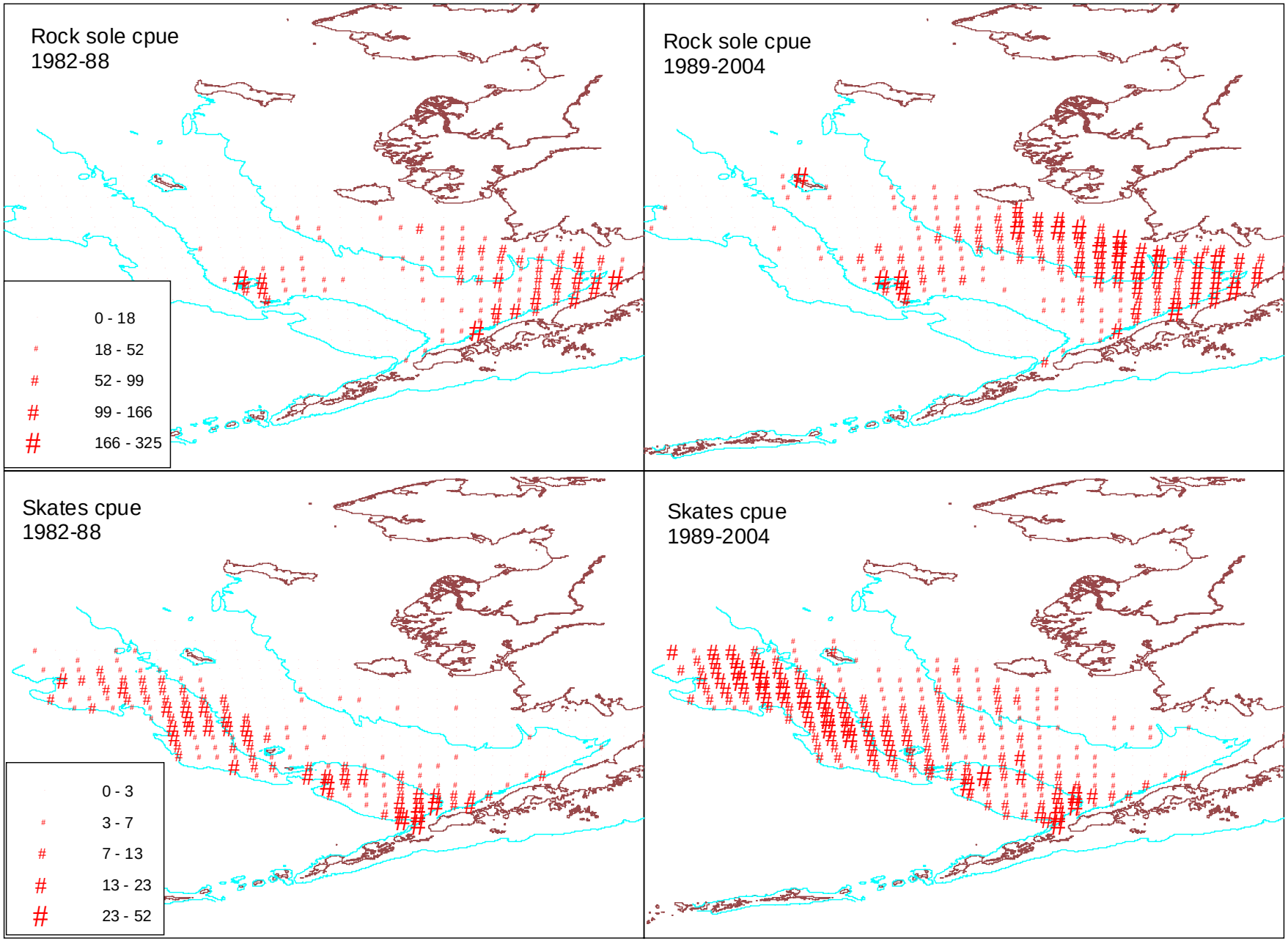
(Lang, Derrah & Livingston, 2003)



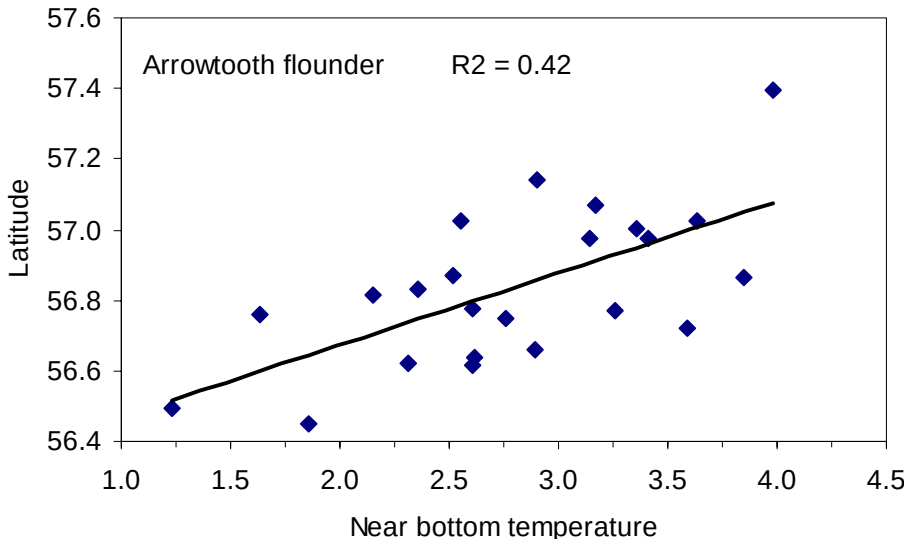


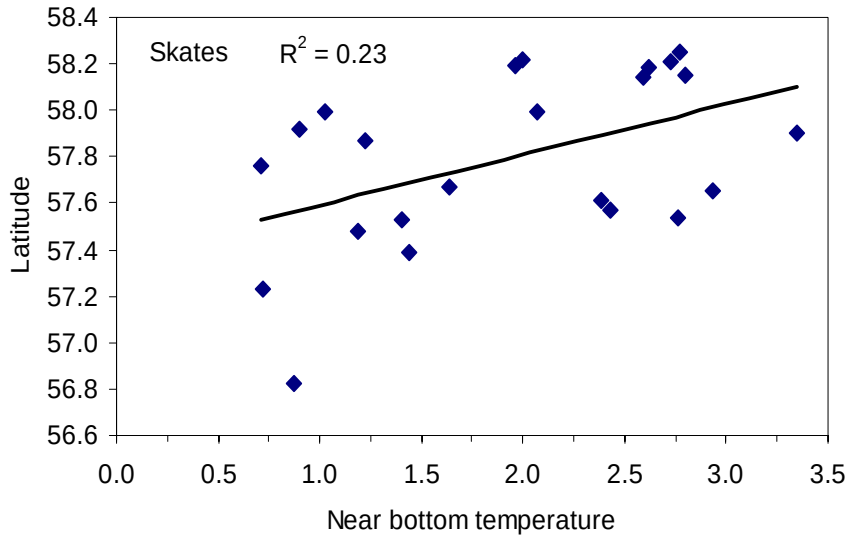
No.1 crab predator

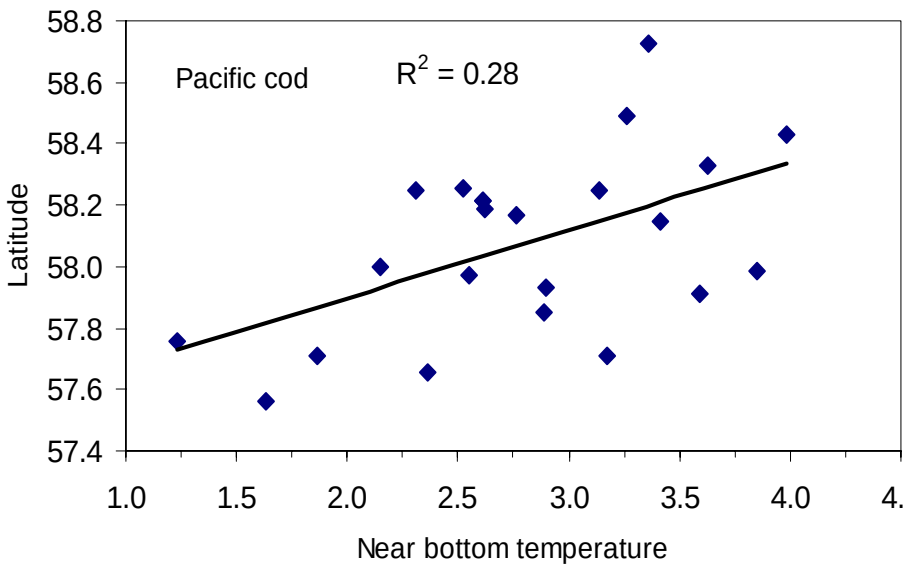


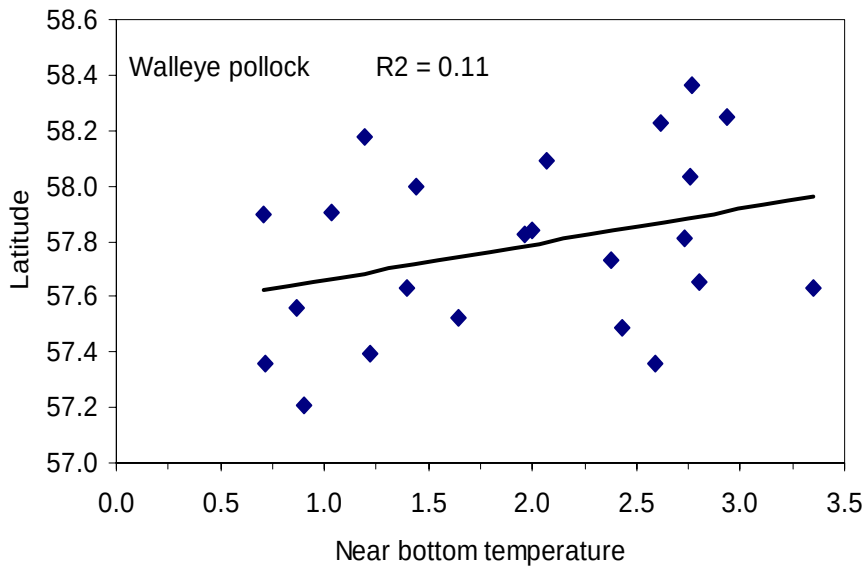

Rock sole cpue
1982-88
0 - 18
18 - 52
52 - 99
99 - 166
166 - 325
Rock sole cpue
1989-2004
Skates cpue
1982-88
0 - 3
3 - 7
7 - 13
13 - 23
23 - 52
Skates cpue
1989-2004

Near bottom temperatures vs. GF distribution centers

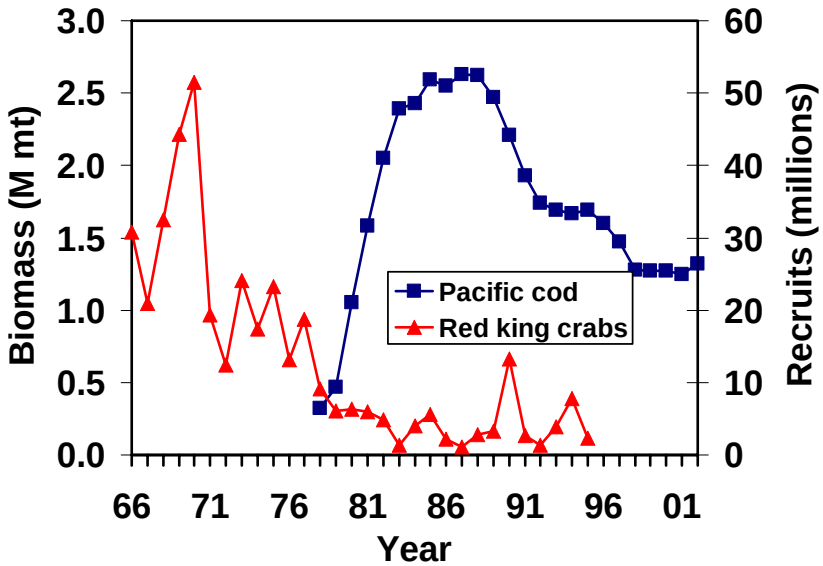


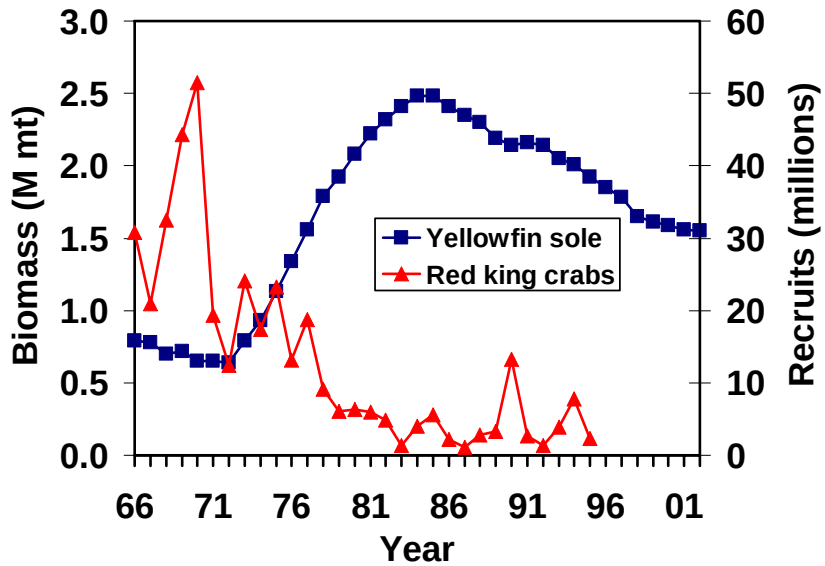


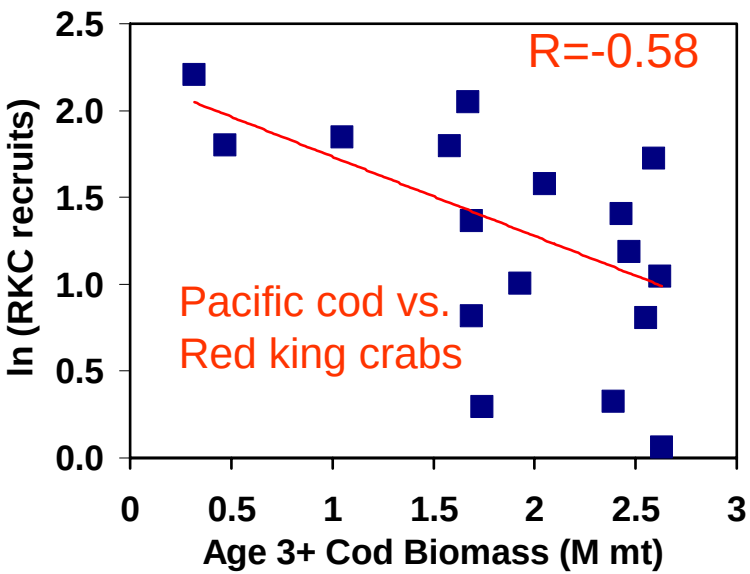


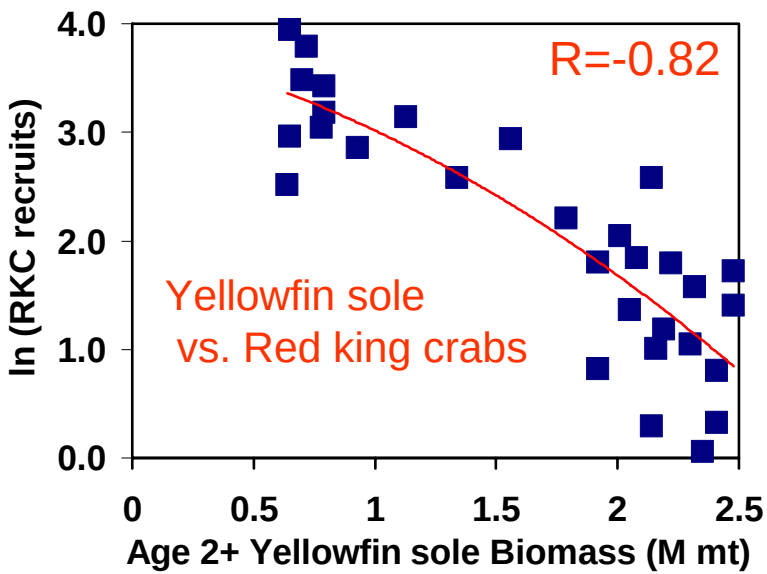


Predation Hypothesis: Bbay red king crabs









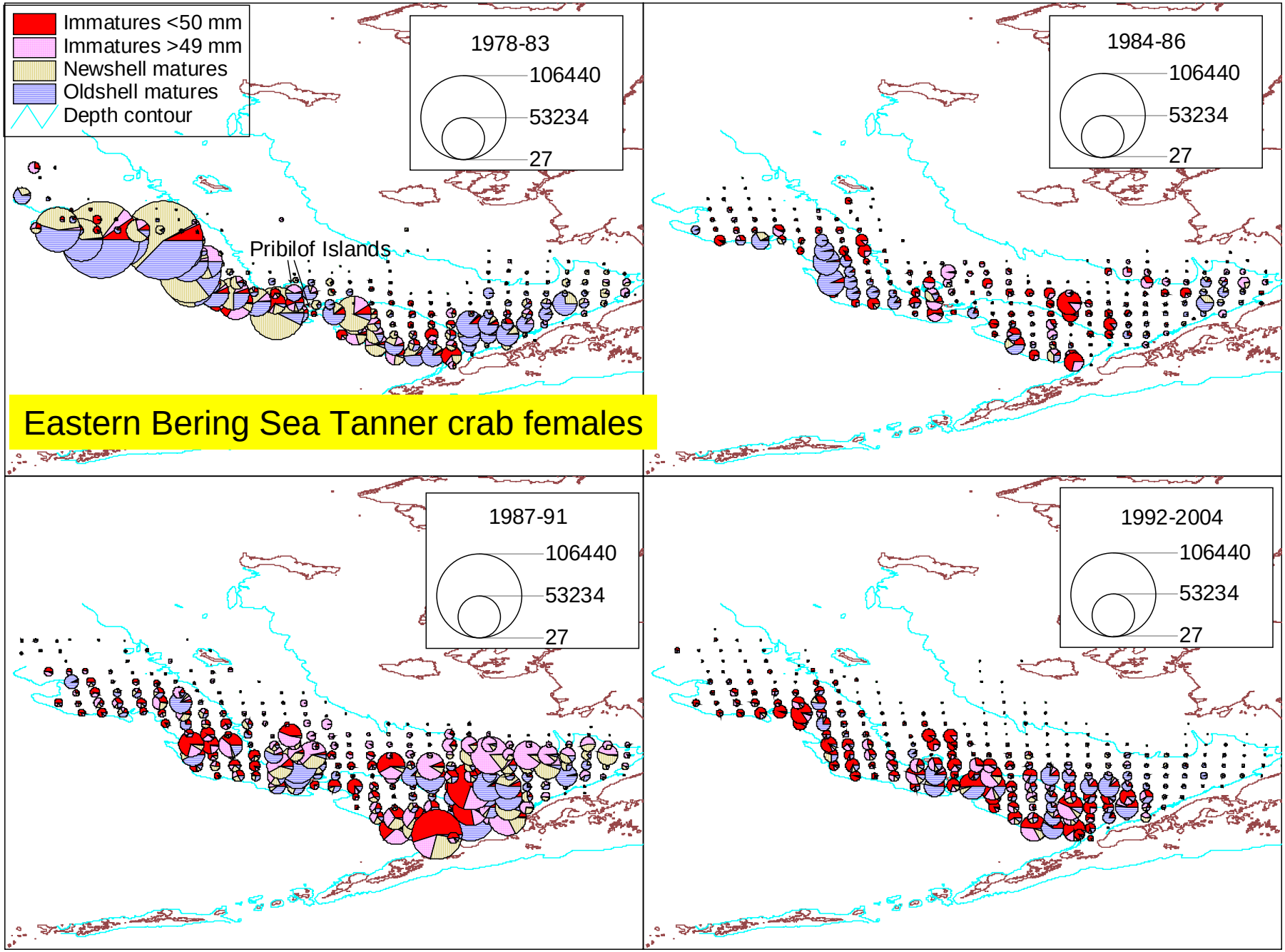
Support for top-down control

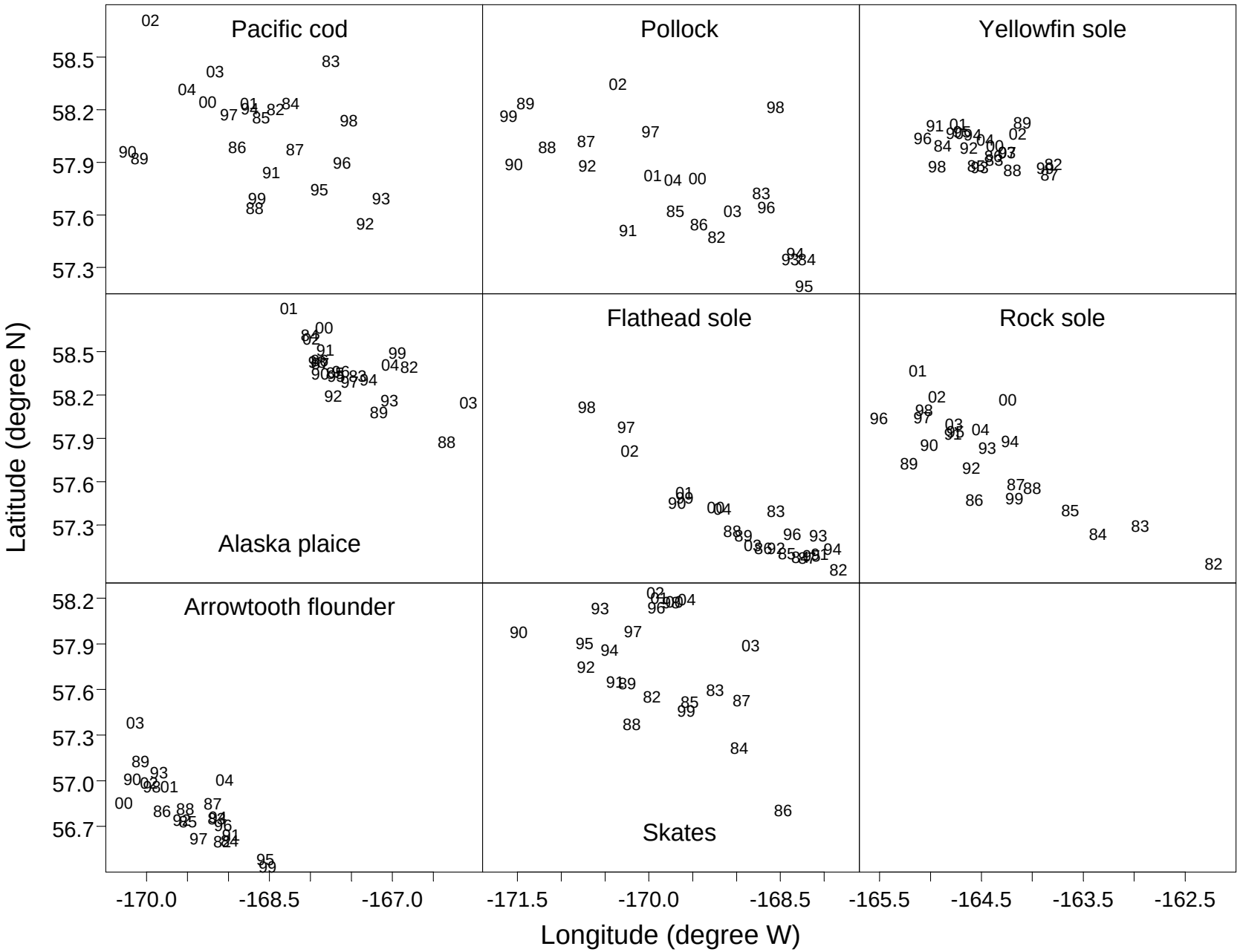
- Crab cohorts in late 1960s are all strong for 6 stocks when groundfish are low
- Statistically significant relationships between Bristol Bay red king crab recruits and Pacific cod biomass and yellowfin sole biomass.
- Large amounts of Tanner and snow crabs were consumed by groundfish
- Even though main predator (Pcod) biomass was very high in early 1980s, they mainly occurred in shallow waters <50 m in Bristol Bay area and in deep waters >100 m in northwest, spatially mismatch with juvenile snow and Tanner crabs. Both crab stocks had strong cohorts during early 1980s.
- Strong snow crab cohorts in 1987 and 1988 may also benefit from mainly deep water distribution of Pacific cod in 1989 and 1990.
- Shifts of Pacific cod to the north and expansion of rock sole in recent years may continue to depress snow and St. Matthew blue king crab recruitment.
- Distribution of Tanner crab and Pribilof Islands blue king crab overlap with many groundfish stocks. Both stocks may need good environmental conditions to overcome predation for good recruitment.

Summary

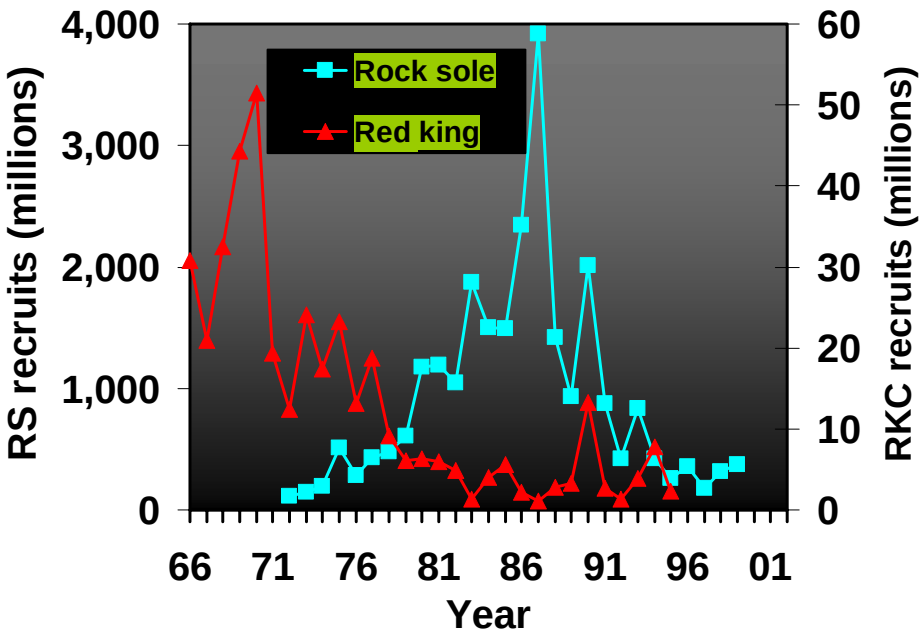
- ***Recruitment = f(spawning biomass, fishing effects, larval survival, and juvenile cannibalism & predation). No one factor alone can consistently explain crab recruitment variation.***
- ***Three climate forcing hypotheses focus on larval survival.***
- ***Groundfish predation may play a very big role for crab recruitment success. But spatial dynamics of groundfish and crabs over time make it difficult to relate crab recruitment strength to total groundfish biomass.***

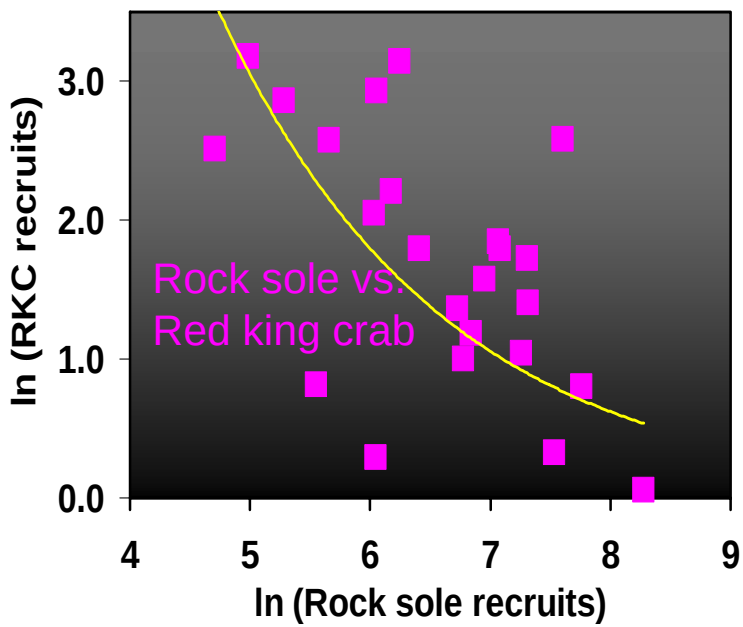

Thank You!

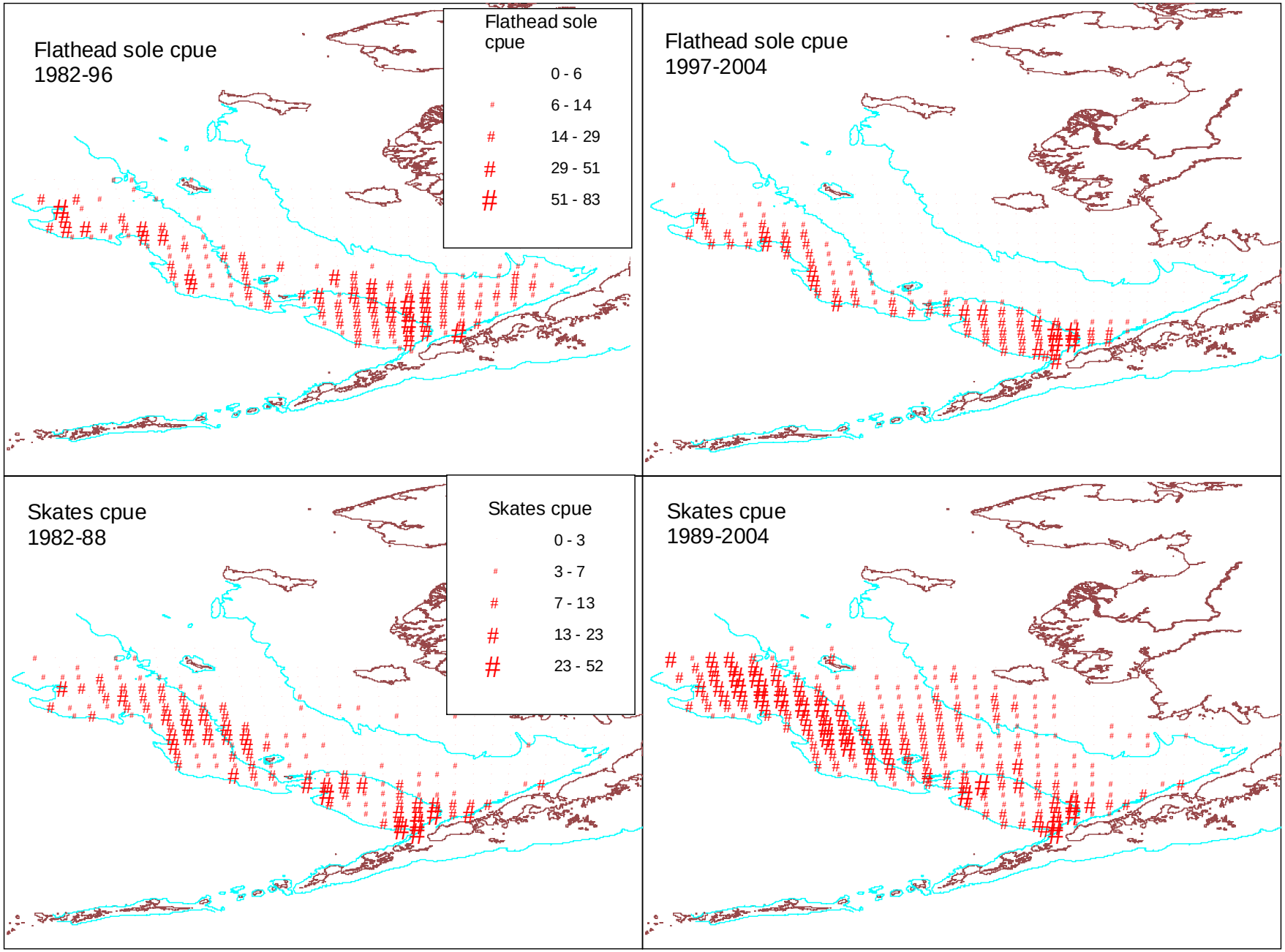

Immatures <50 mm
Immatures >49 mm
Newshell matures
Oldshell matures
Depth contour
1978-83
106440
53234
27
Pribilof Islands
1984-86
106440
53234
27
Eastern Bering Sea Tanner crab females
1987-91
106440
53234
27
1992-2004
106440
53234
27

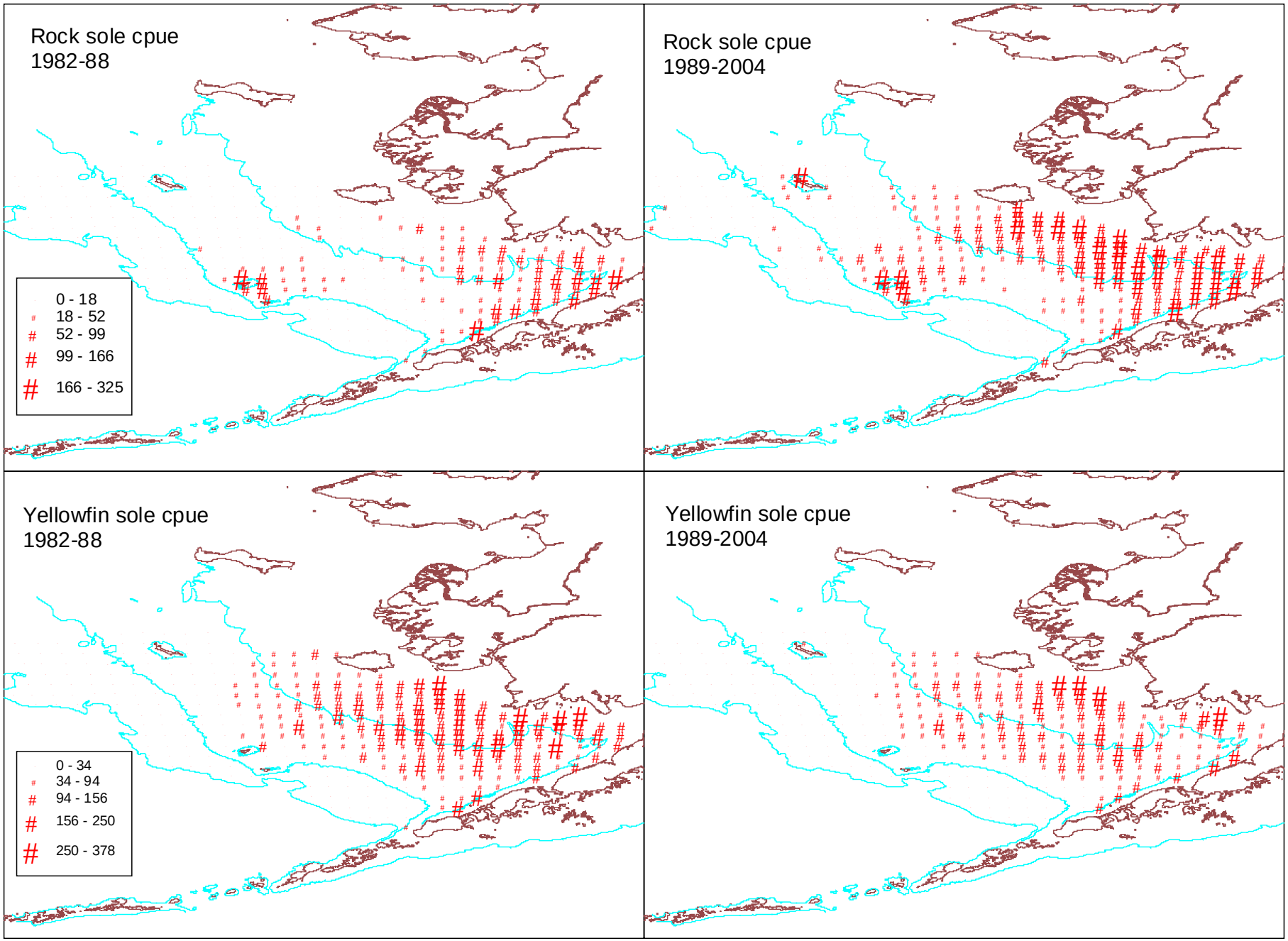

Pacific cod
Pollock
Yellowfin sole
Alaska plaice
Flathead sole
Rock sole
Arrowtooth flounder
Skates
Latitude (degree N)
Longitude (degree W)
58.5
58.2
57.9
57.6
57.3
57.0
56.7
-170.0
-168.5
-167.0
-171.5
-170.0
-168.5
-165.5
-164.5
-163.5
-162.5

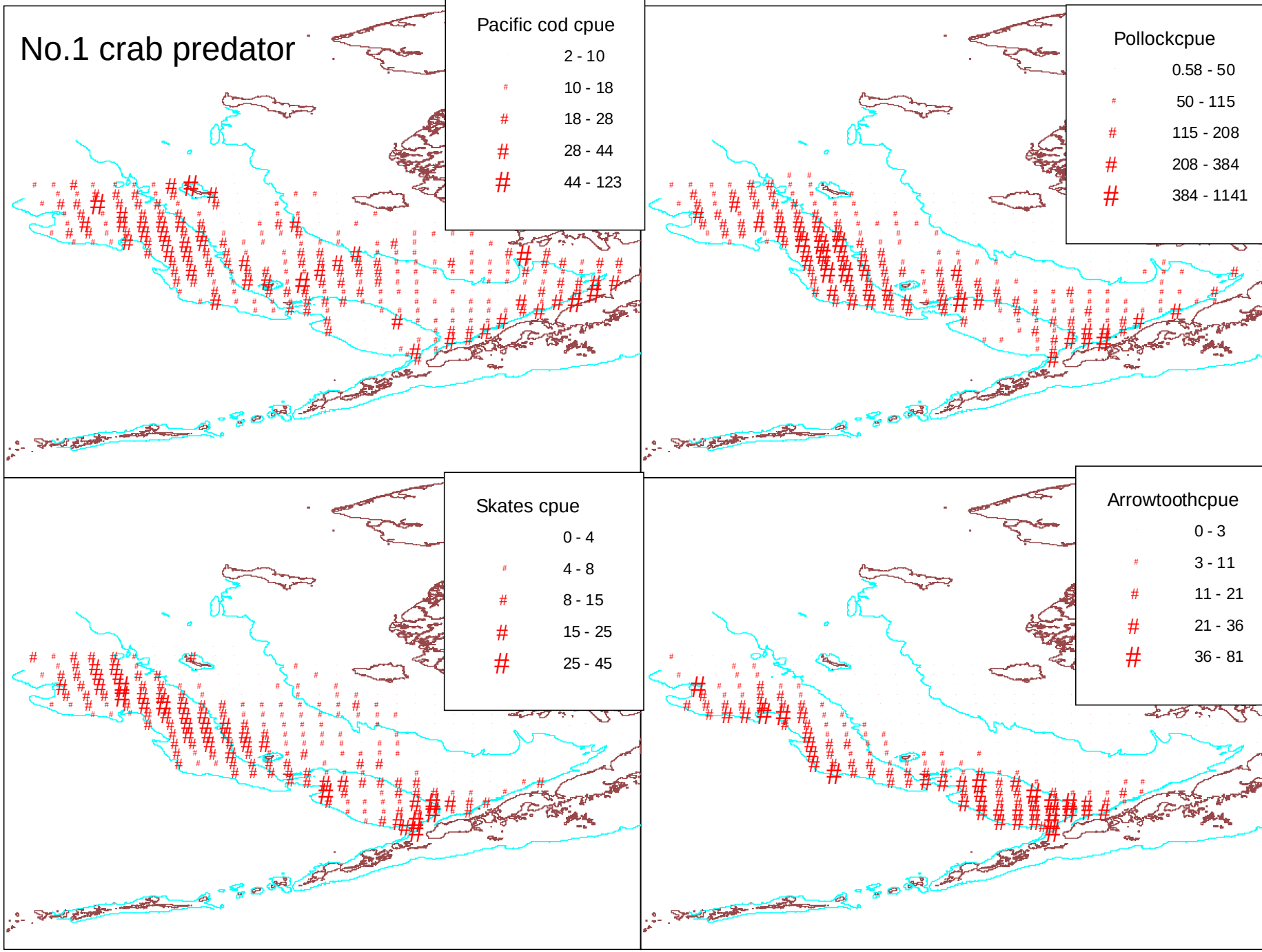
Common Forcing Hypothesis

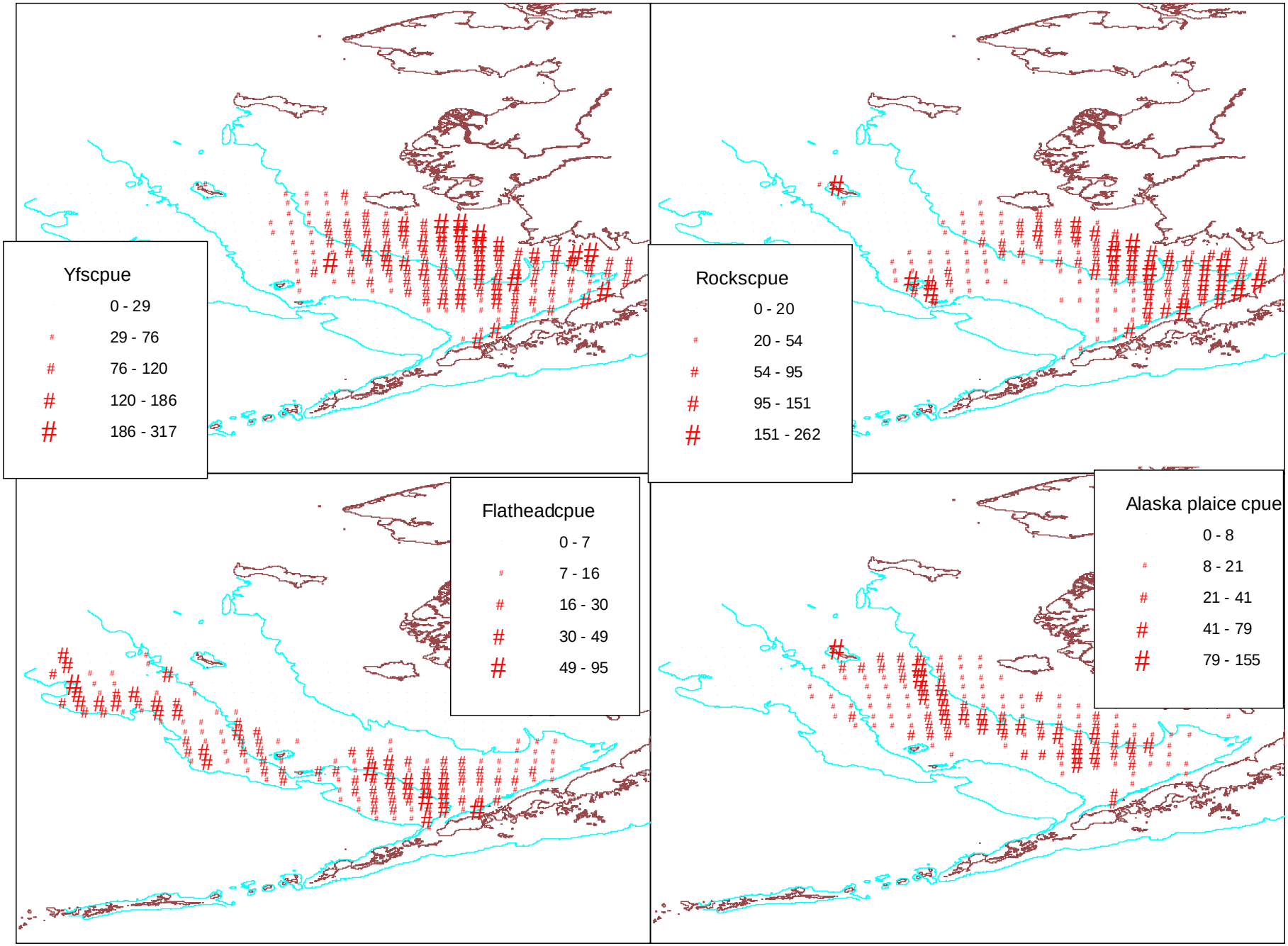


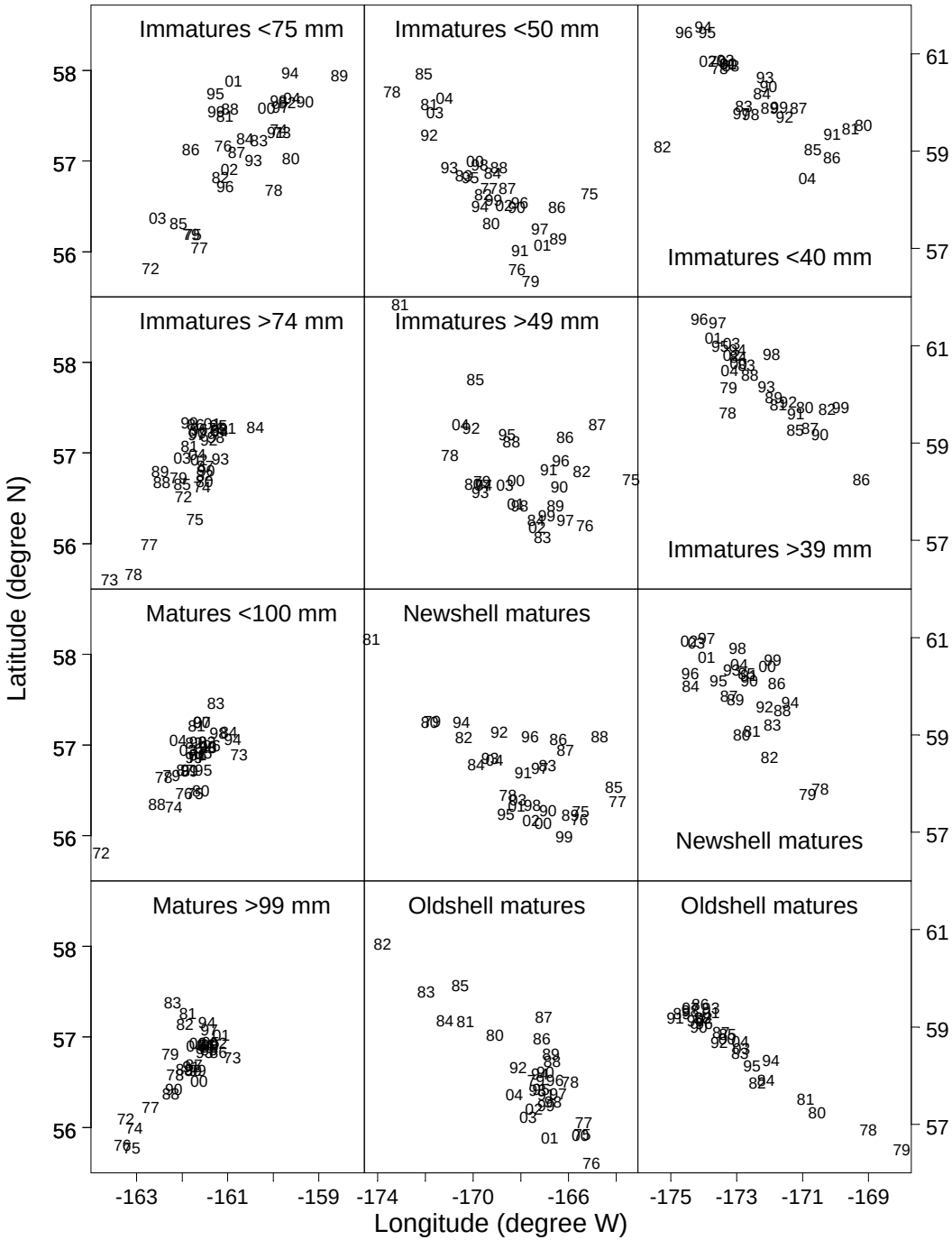



Flathead sole cpue
1982-96
Flathead sole cpue
0 - 6
6 - 14
14 - 29
29 - 51
51 - 83
Flathead sole cpue
1997-2004
Skates cpue
1982-88
Skates cpue
0 - 3
3 - 7
7 - 13
13 - 23
23 - 52
Skates cpue
1989-2004


Rock sole cpue
1982-88
0 - 18
18 - 52
52 - 99
99 - 166
166 - 325
Rock sole cpue
1989-2004
Yellowfin sole cpue
1982-88
0 - 34
34 - 94
94 - 156
156 - 250
250 - 378
Yellowfin sole cpue
1989-2004


No.1 crab predator
Pacific cod cpue
2 - 10
10 - 18
18 - 28
28 - 44
44 - 123
Pollockcpue
0.58 - 50
50 - 115
115 - 208
208 - 384
384 - 1141
Skates cpue
0 - 4
4 - 8
8 - 15
15 - 25
25 - 45
Arrowtoothcpue
0 - 3
3 - 11
11 - 21
21 - 36
36 - 81


Yfscpue
0 - 29
29 - 76
76 - 120
120 - 186
186 - 317
Rockscpue
0 - 20
20 - 54
54 - 95
95 - 151
151 - 262
Flatheadcpue
0 - 7
7 - 16
16 - 30
30 - 49
49 - 95
Alaska plaice cpue
0 - 8
8 - 21
21 - 41
41 - 79
79 - 155


Immatures <75 mm
Immatures <50 mm
Immatures <40 mm
Immatures >74 mm
Immatures >49 mm
Immatures >39 mm
Matures <100 mm
Newshell matures
Newshell matures
Matures >99 mm
Oldshell matures
Oldshell matures
Latitude (degree N)
Longitude (degree W)
58
57
56
61
59
57
-163
-161
-159
-174
-170
-166
-175
-173
-171
-169