Temporal Changes in Spatial Distribution of Bristol Bay Red King Crab in the Eastern Bering Sea and Implications for Fisheries Management

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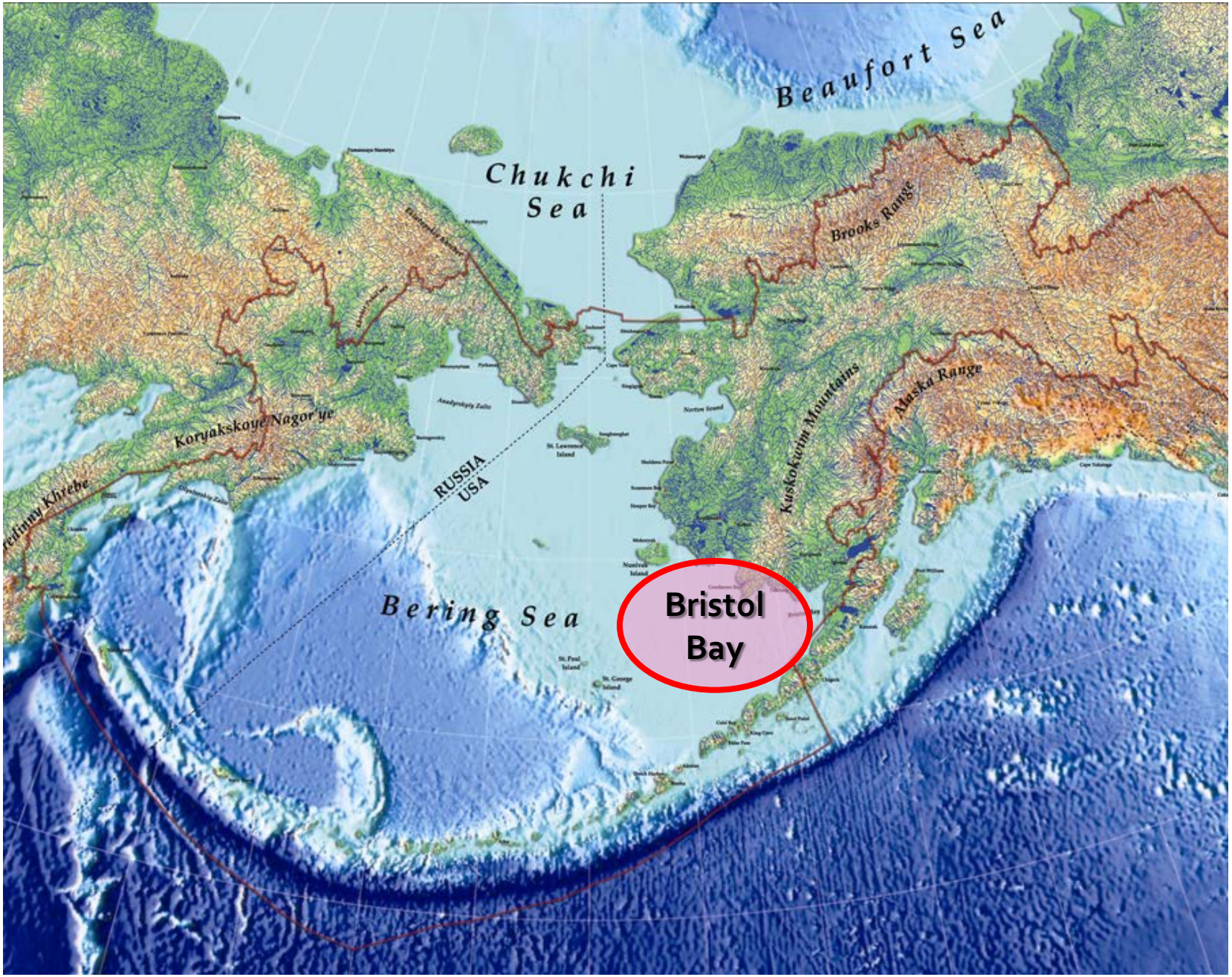
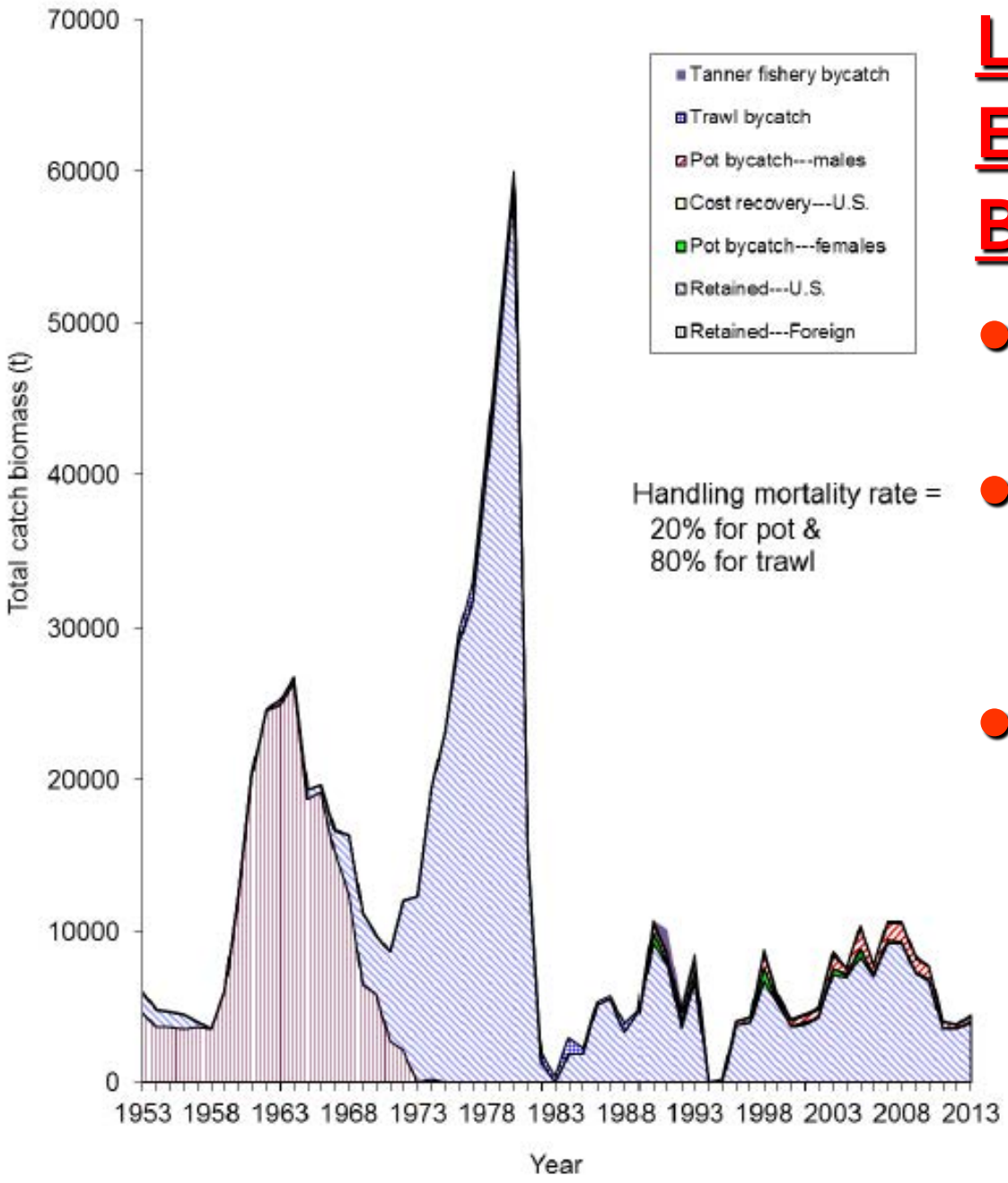
BACKGROUND


Beaufort Sea
Chukchi Sea
Brooks Range
Koryakskaye Nagor'ye
RUSSIA
USA
Kuskokwim Mountains
Alaska Range
Bering Sea
Bristol Bay

King Crab Fishery

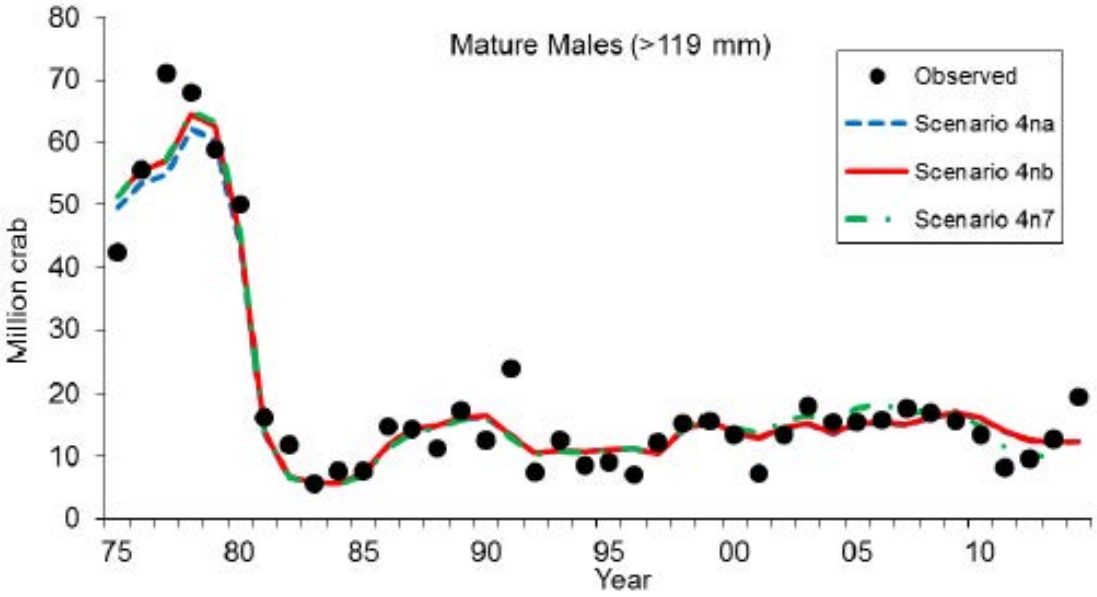
FISHERY & STOCK DYNAMICS

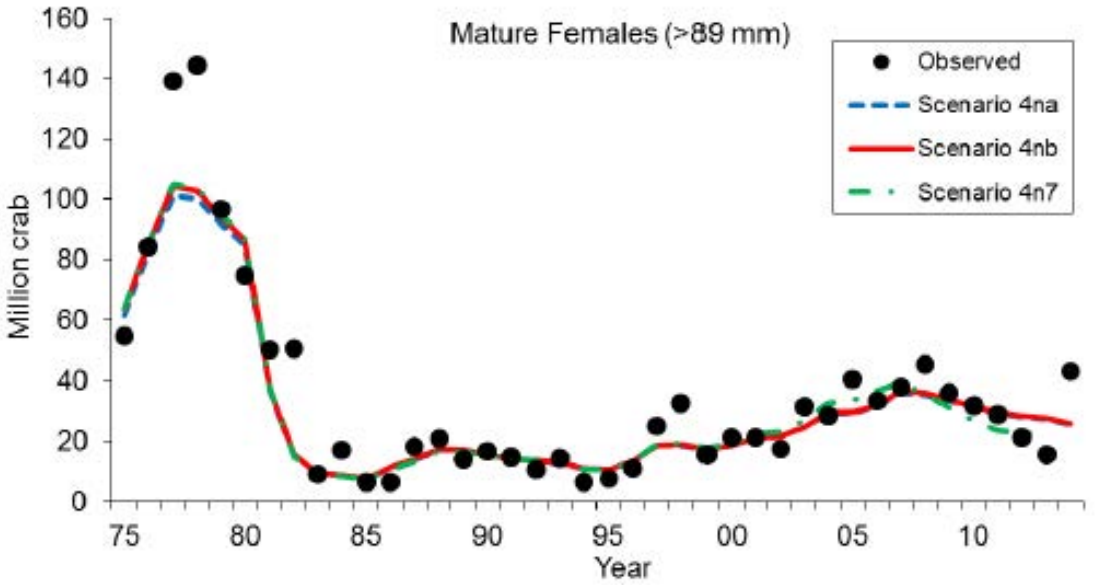


Landings and Estimated Bycatch Mortality

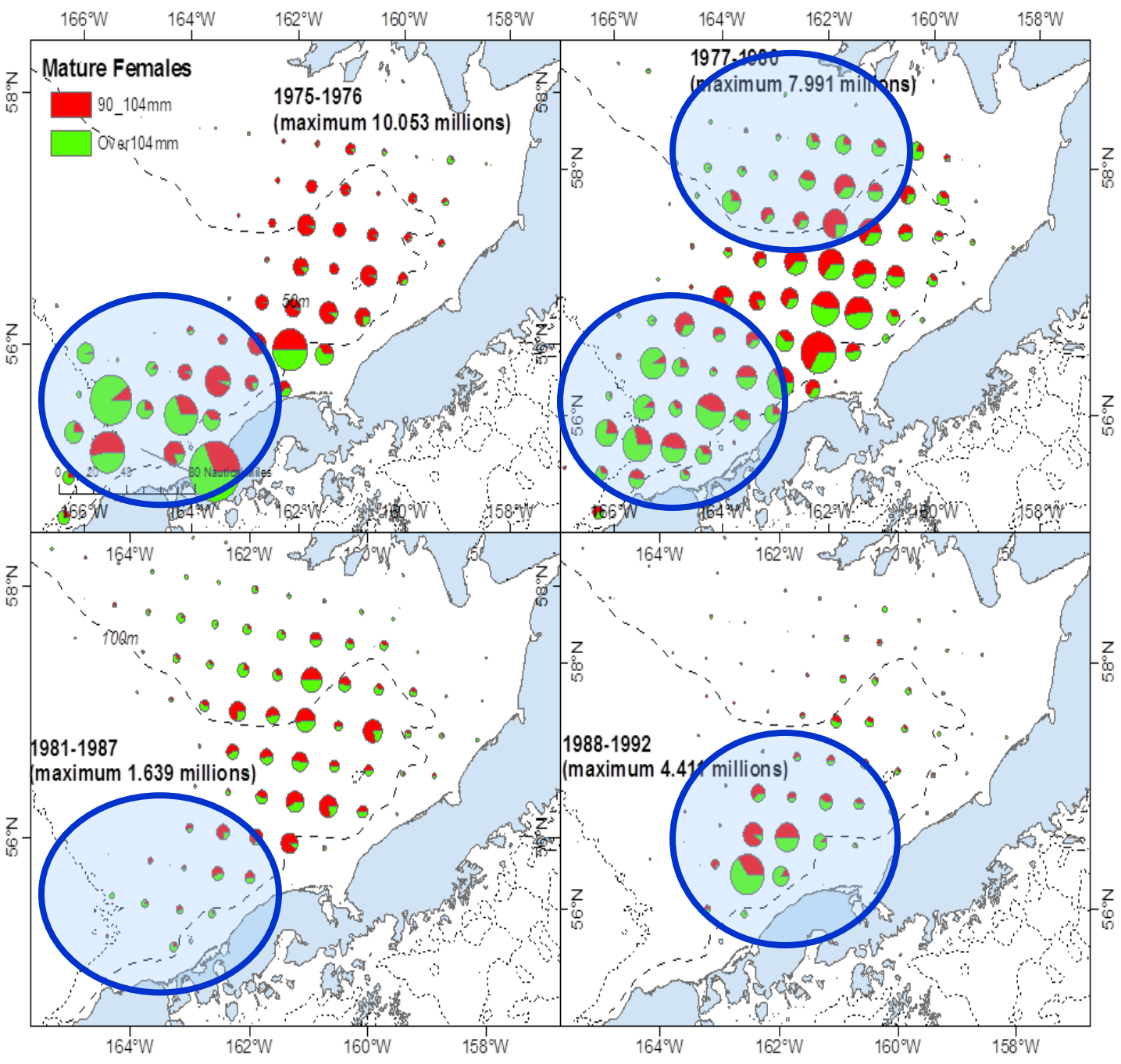
- Peak catch (1980) was 60,000 mt
- Fishery closed in 1983 and 1994 & 1995
- Bycatch mortality estimated from pot and trawl fisheries

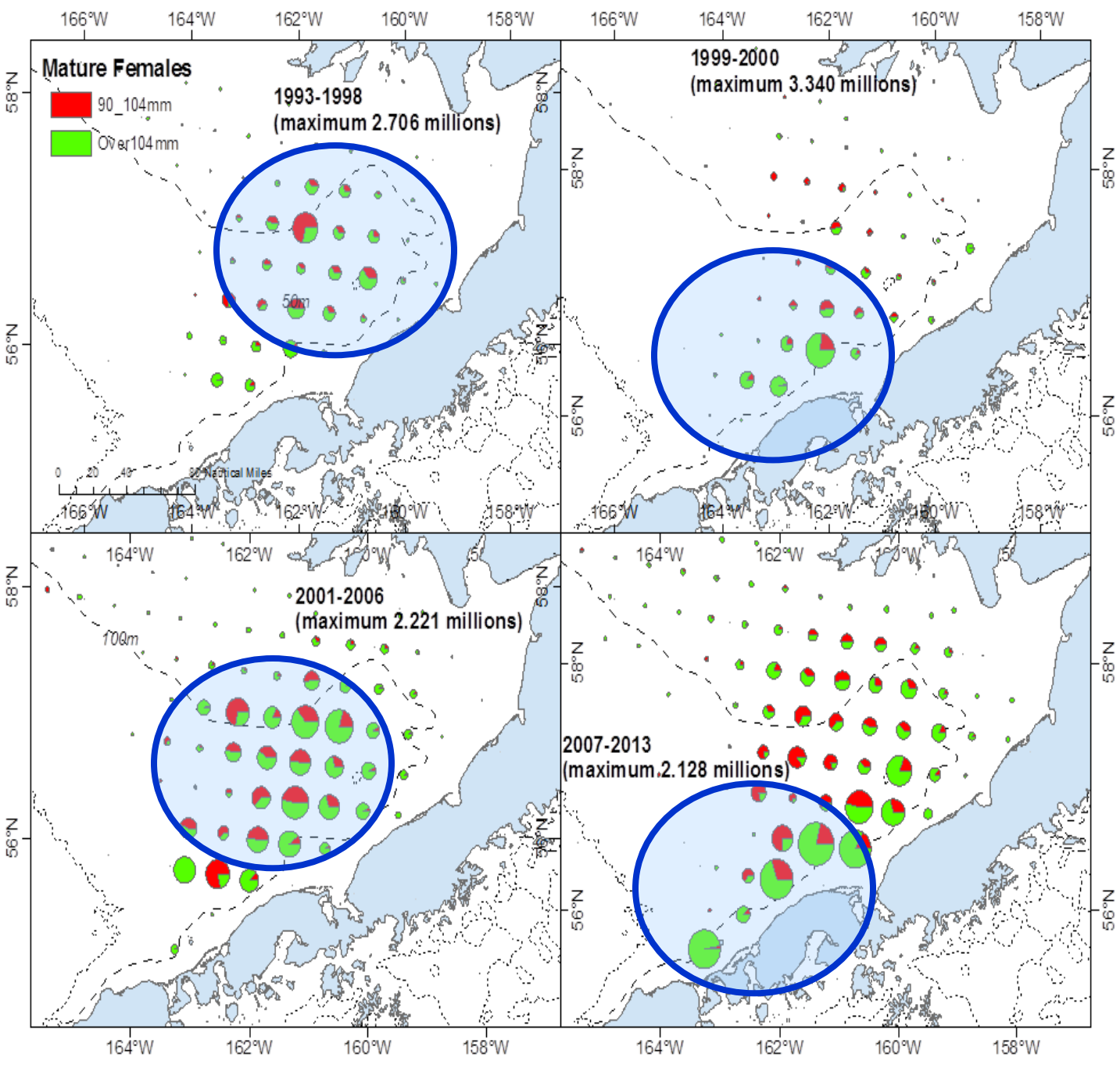
Mature Male & Female Abundance

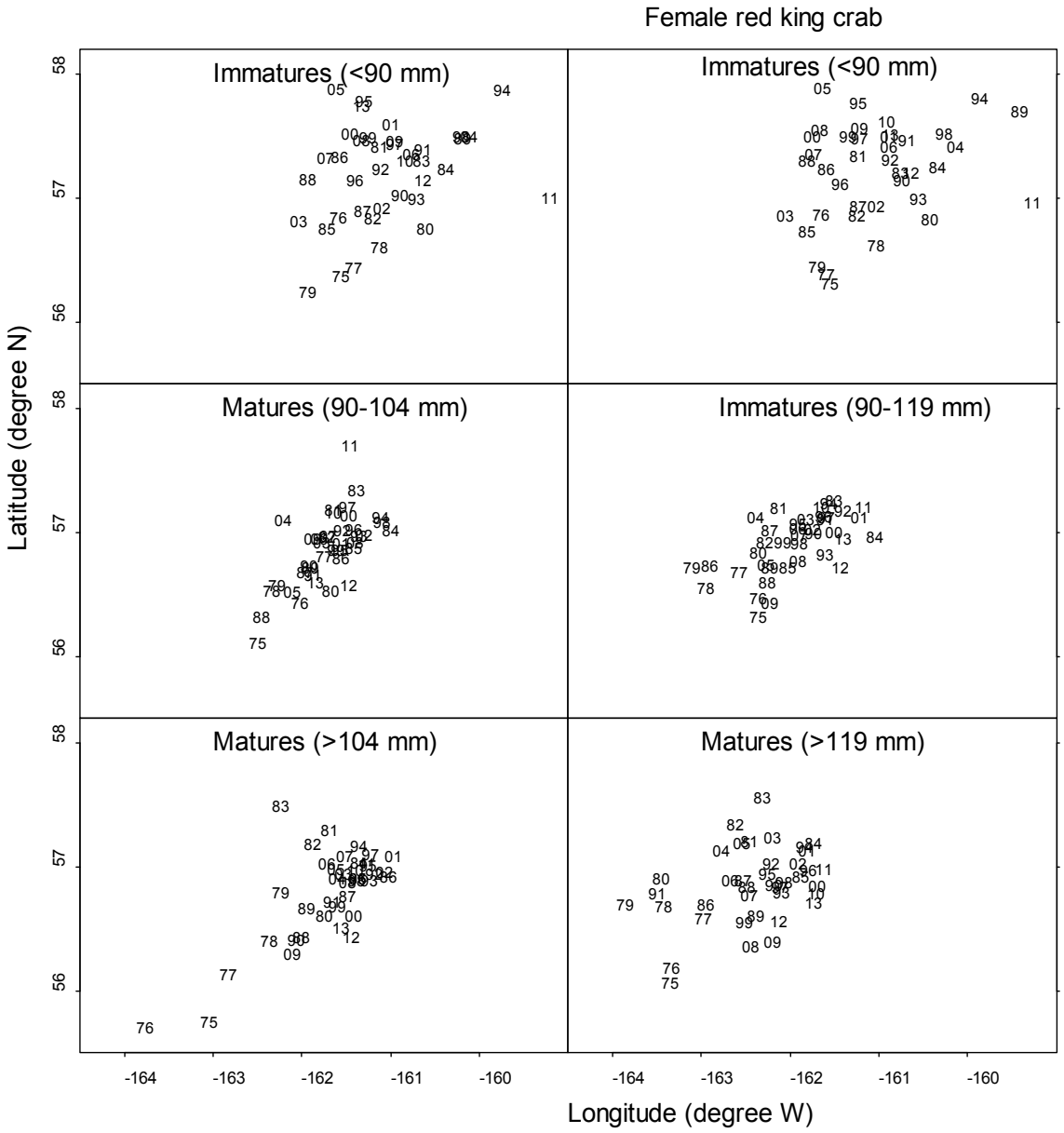




SHIFTS IN SPATIAL DISTRIBUTIONS


Mature Females
90_104mm
Over 104mm
1975-1976
(maximum 10.053 millions)
1977-1980
(maximum 7.991 millions)
1981-1987
(maximum 1.639 millions)
1988-1992
(maximum 4.41 millions)
50m
100m
166°W
164°W
162°W
160°W
158°W
58°N
56°N

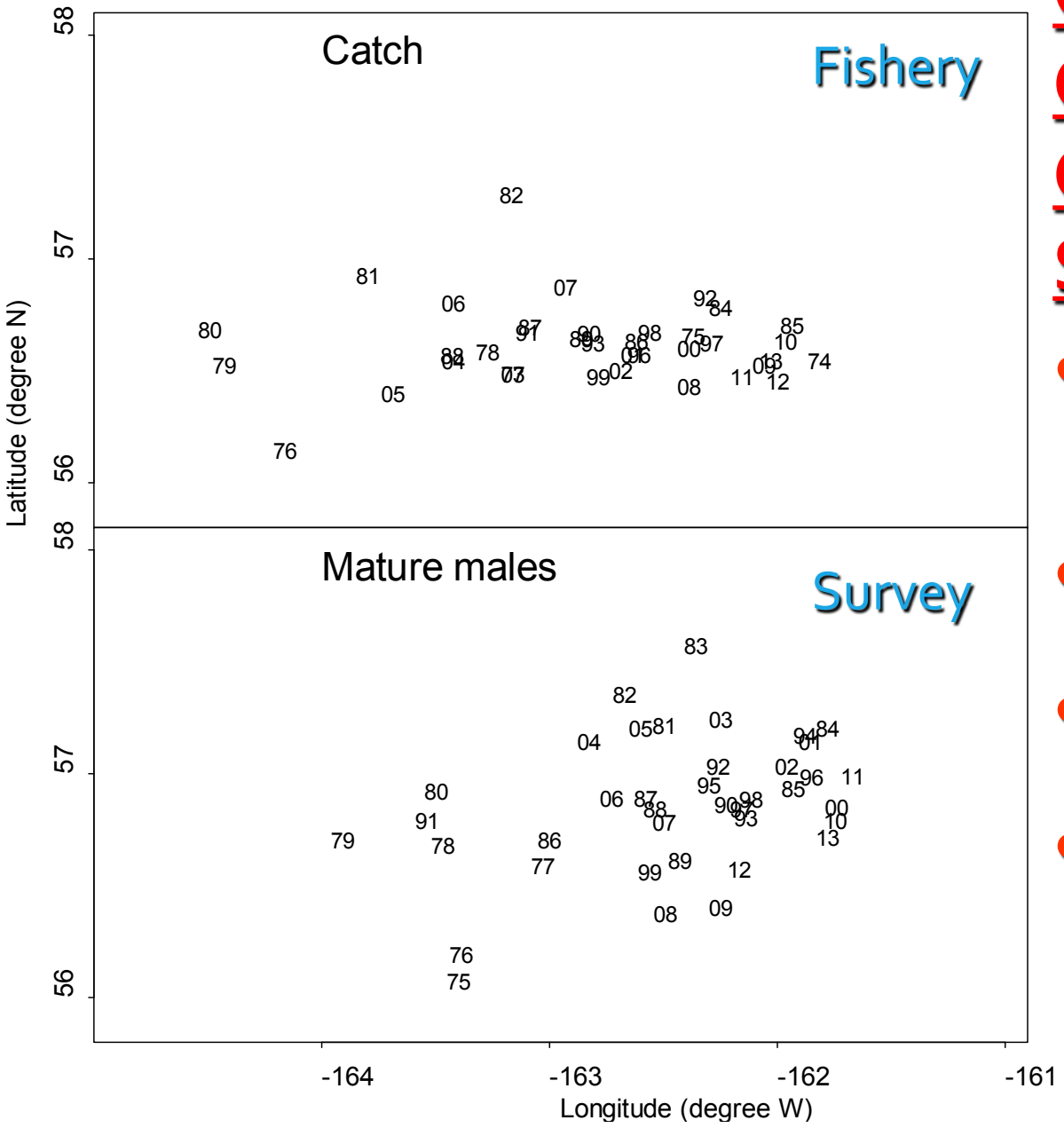

Mature Females
90_104mm
Over 104mm
1993-1998
(maximum 2.706 millions)
1999-2000
(maximum 3.340 millions)
2001-2006
(maximum 2.221 millions)
2007-2013
(maximum 2.128 millions)
50m
100m
0 20 40 80 Nautical Miles
166°W
164°W
162°W
160°W
158°W
58°N
56°N



Distribution Centroids

- Shift from SW to NE began in 1977
- Crabs first appeared in the most northern area in the early 1980s

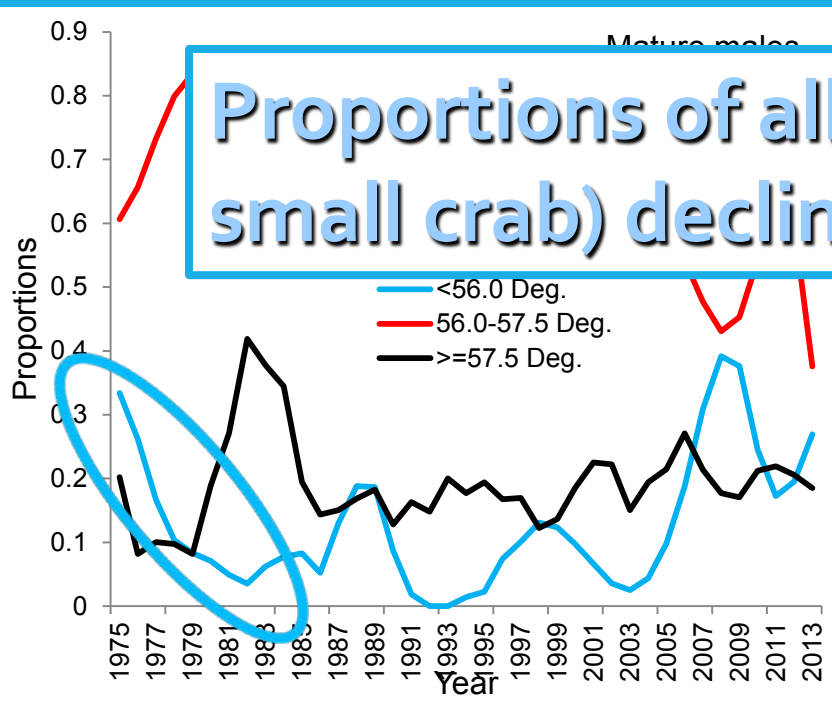
FISHING AS A CAUSE?

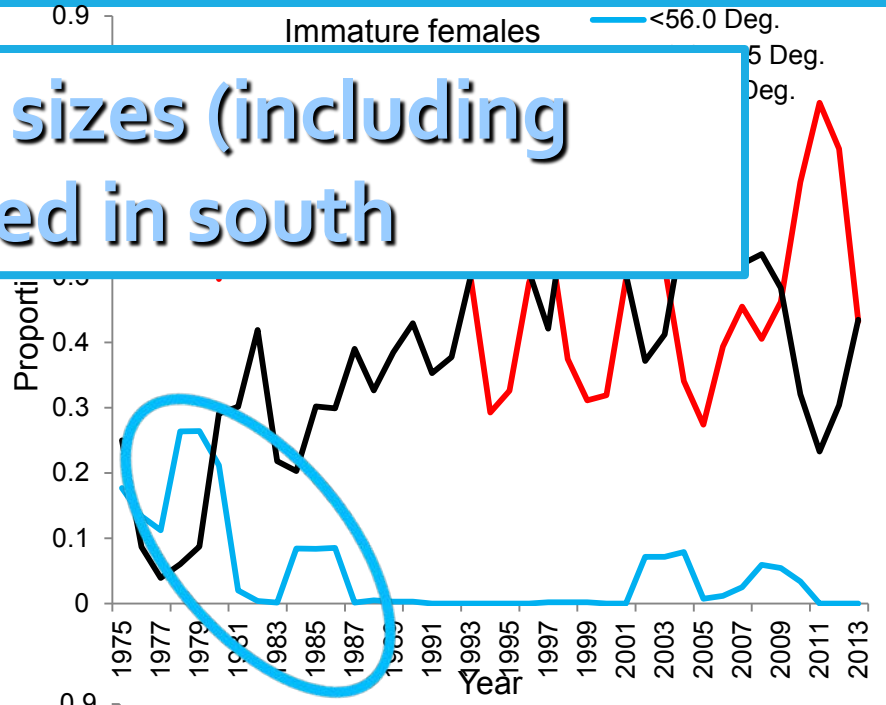


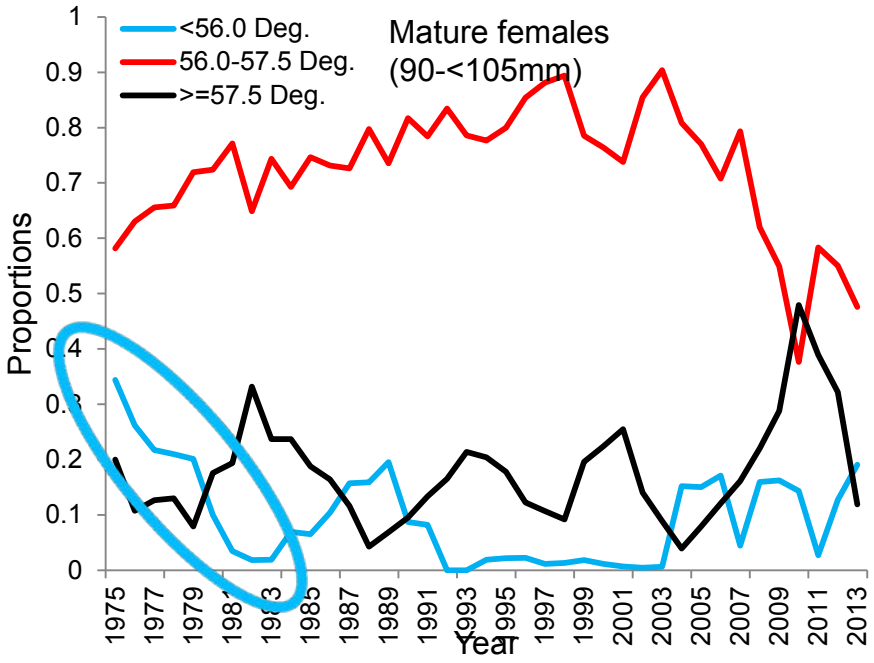
Centroids of Commercial Catch vs. Trawl Survey

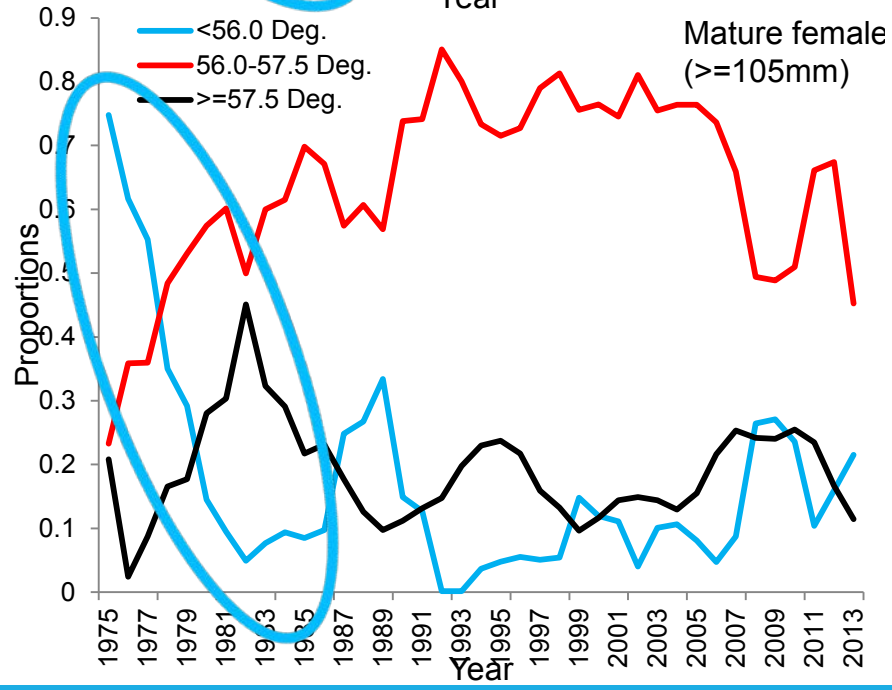
- Catches generally centered in middle Bristol Bay
- Catch in 1976 was centered to the SW
- Catches in 1979 and 1980 to west
- Catches in 1974, 1975, 1977, & 1978 overlap with subsequent years

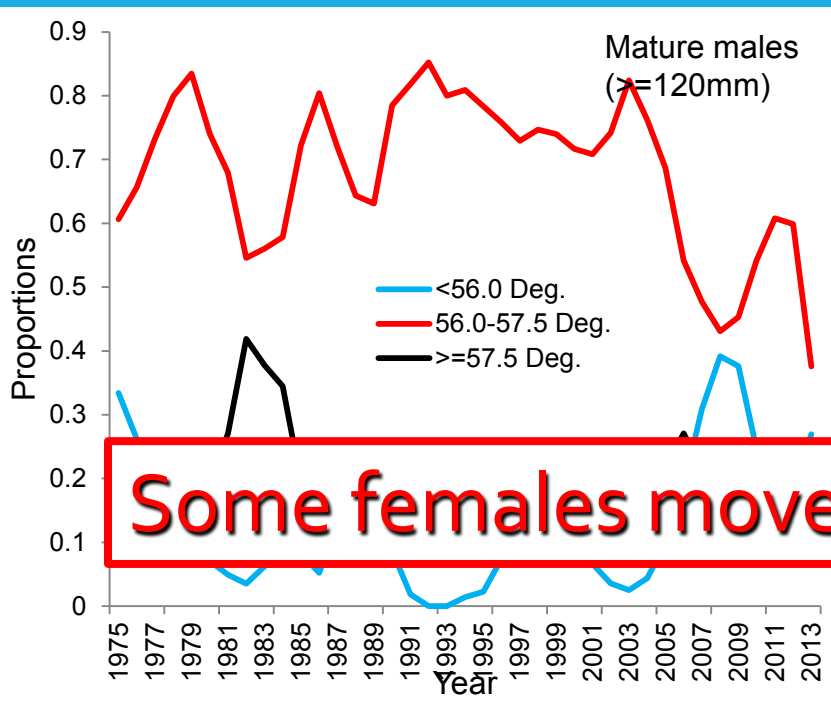
Proportions of all sizes (including small crab) declined in south

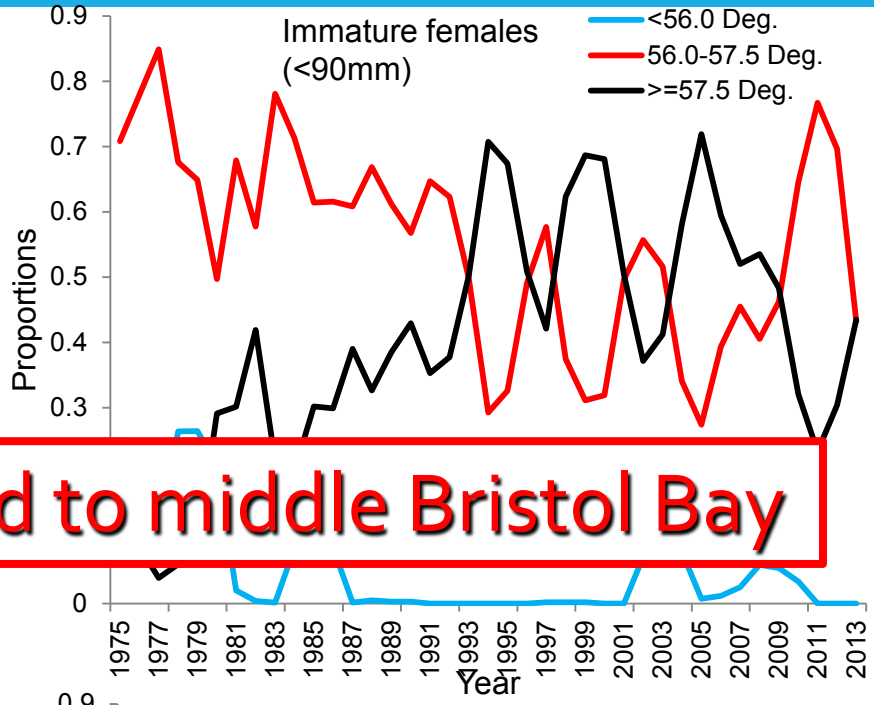




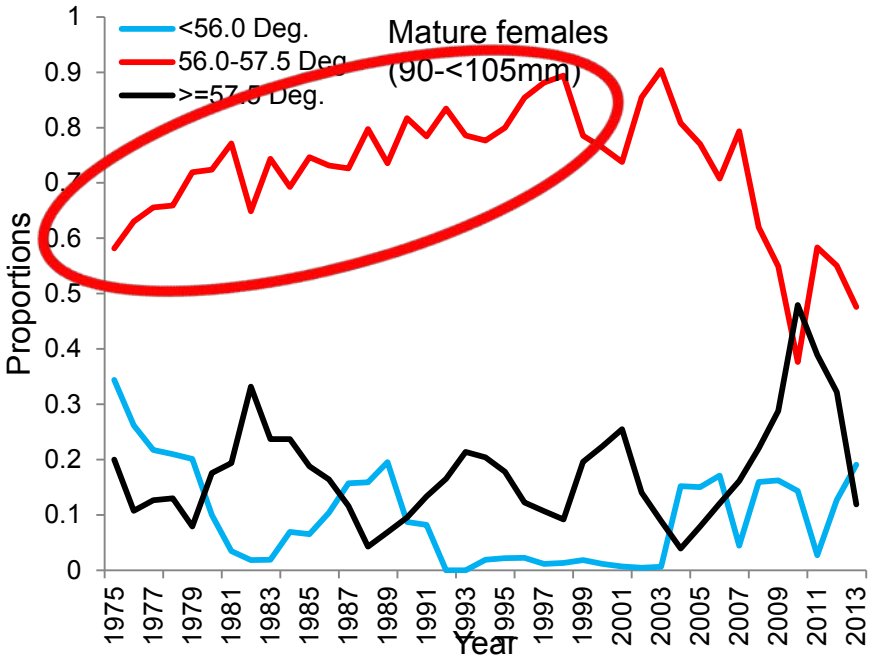


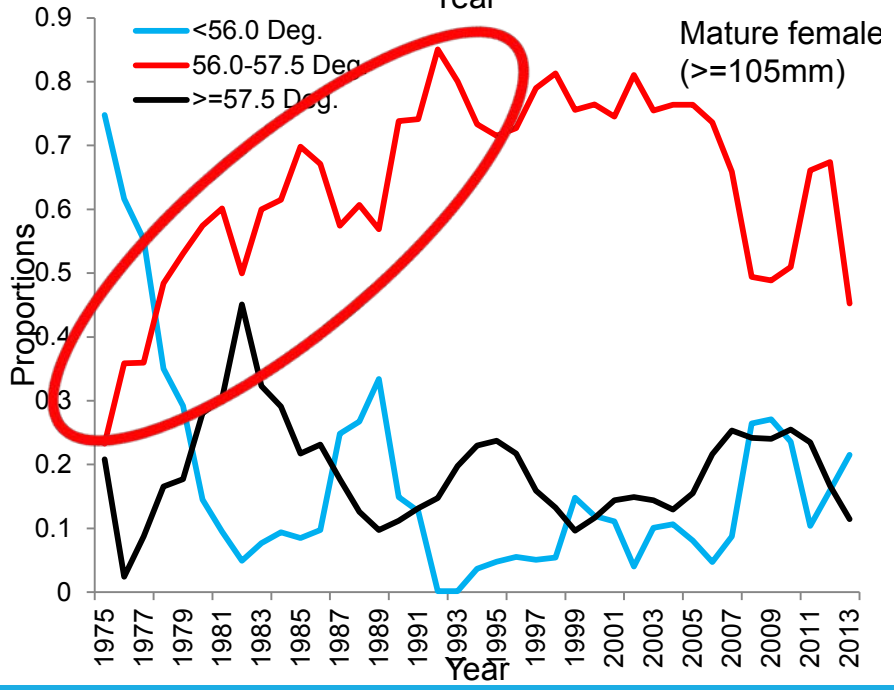


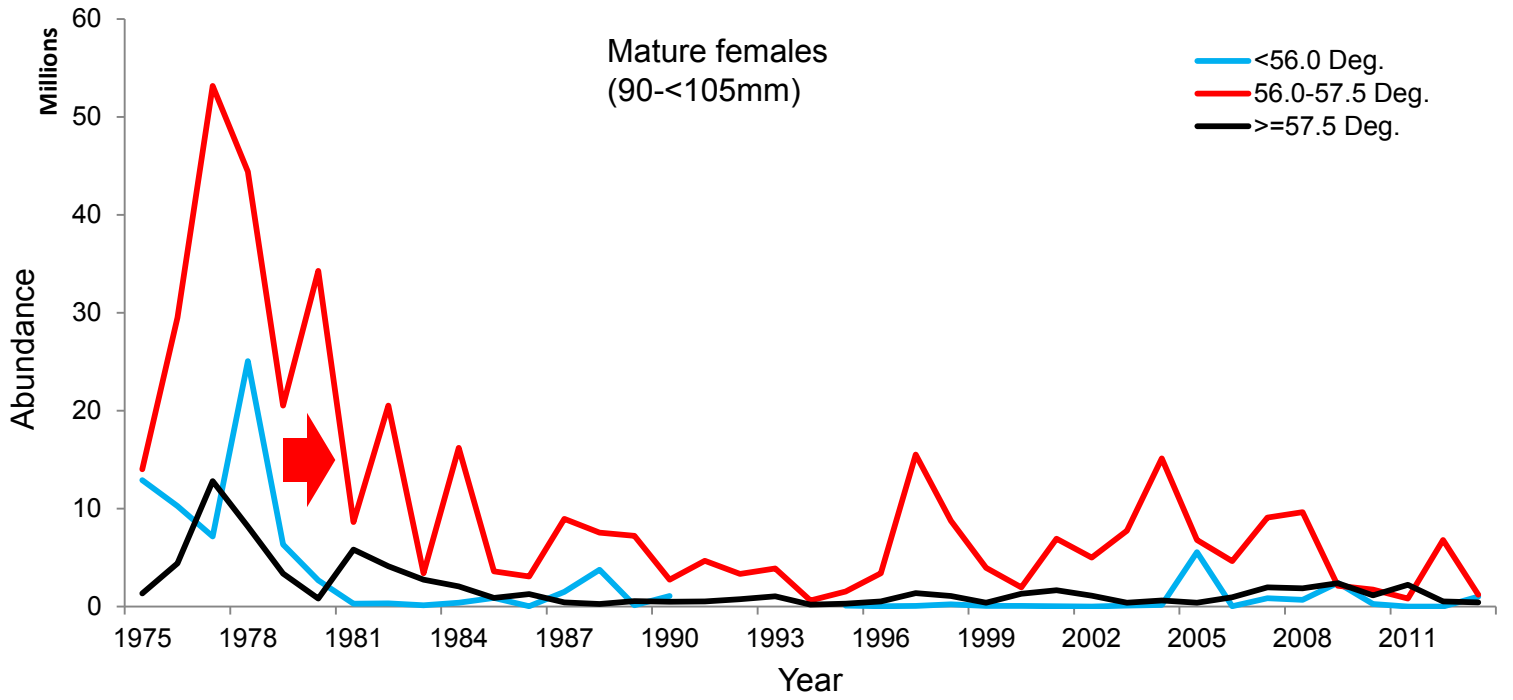


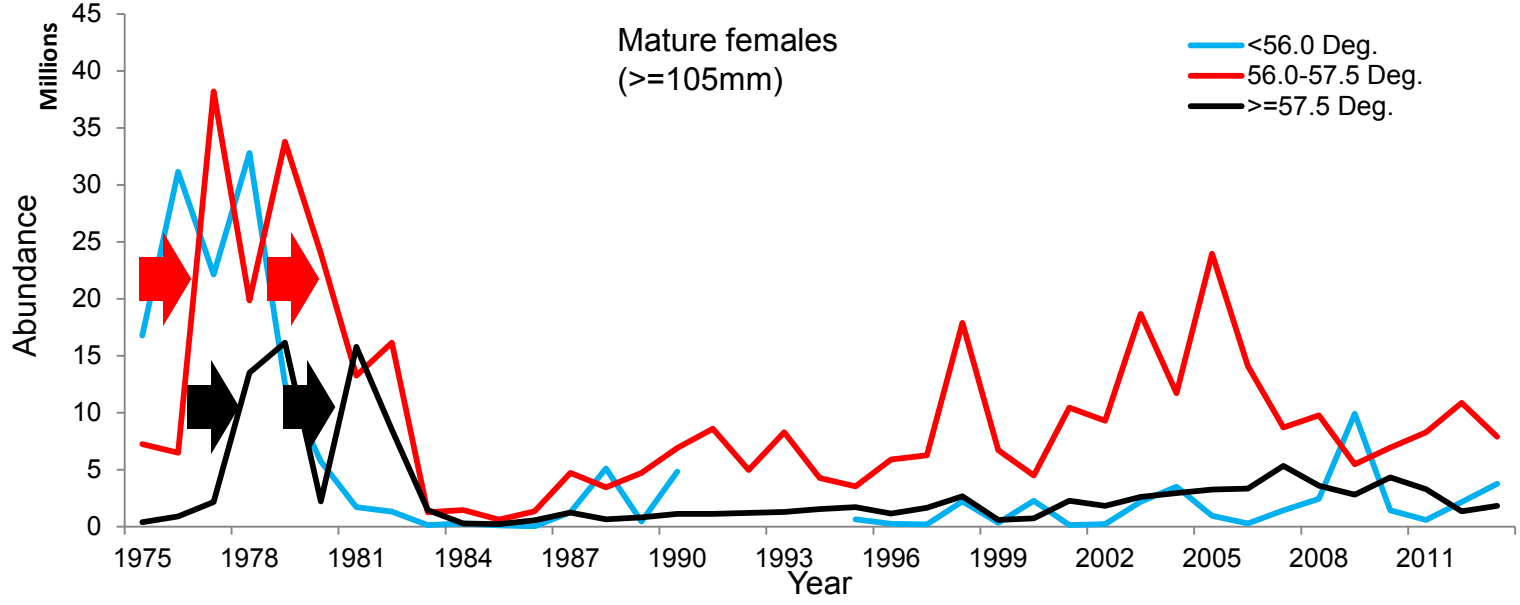


Some females moved to middle Bristol Bay

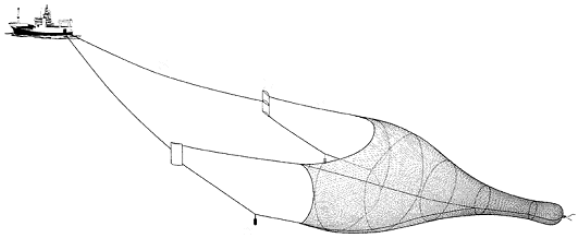


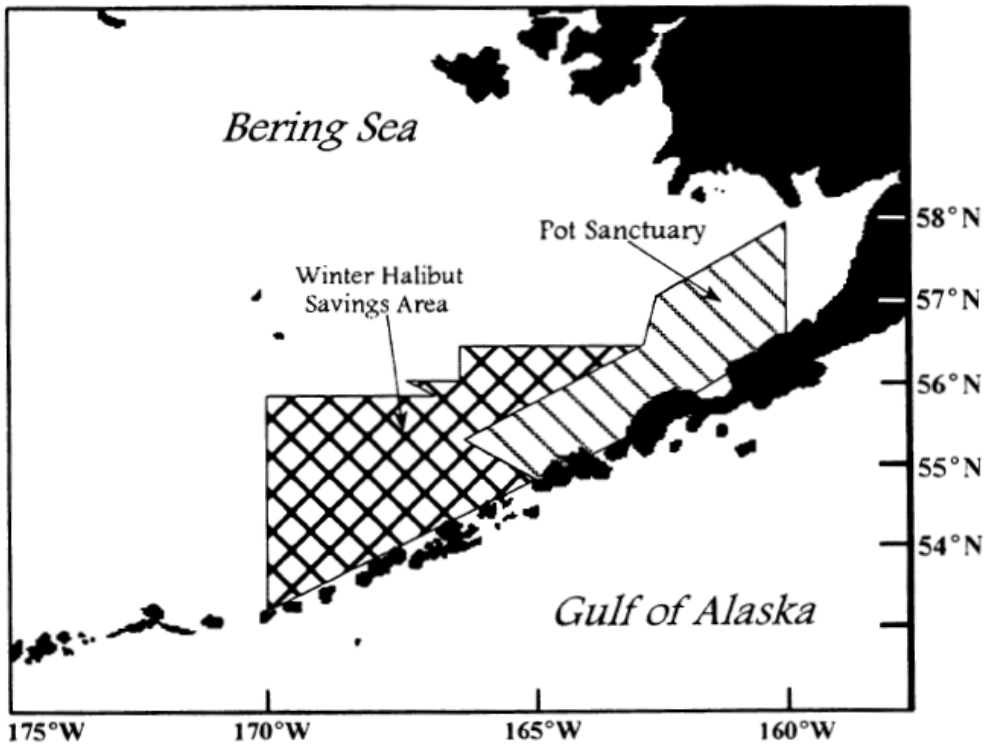



Mature females
(90-<105mm)
<56.0 Deg.
56.0-57.5 Deg.
>=57.5 Deg.
Millions
Abundance
60
50
40
30
20
10
0
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
Year

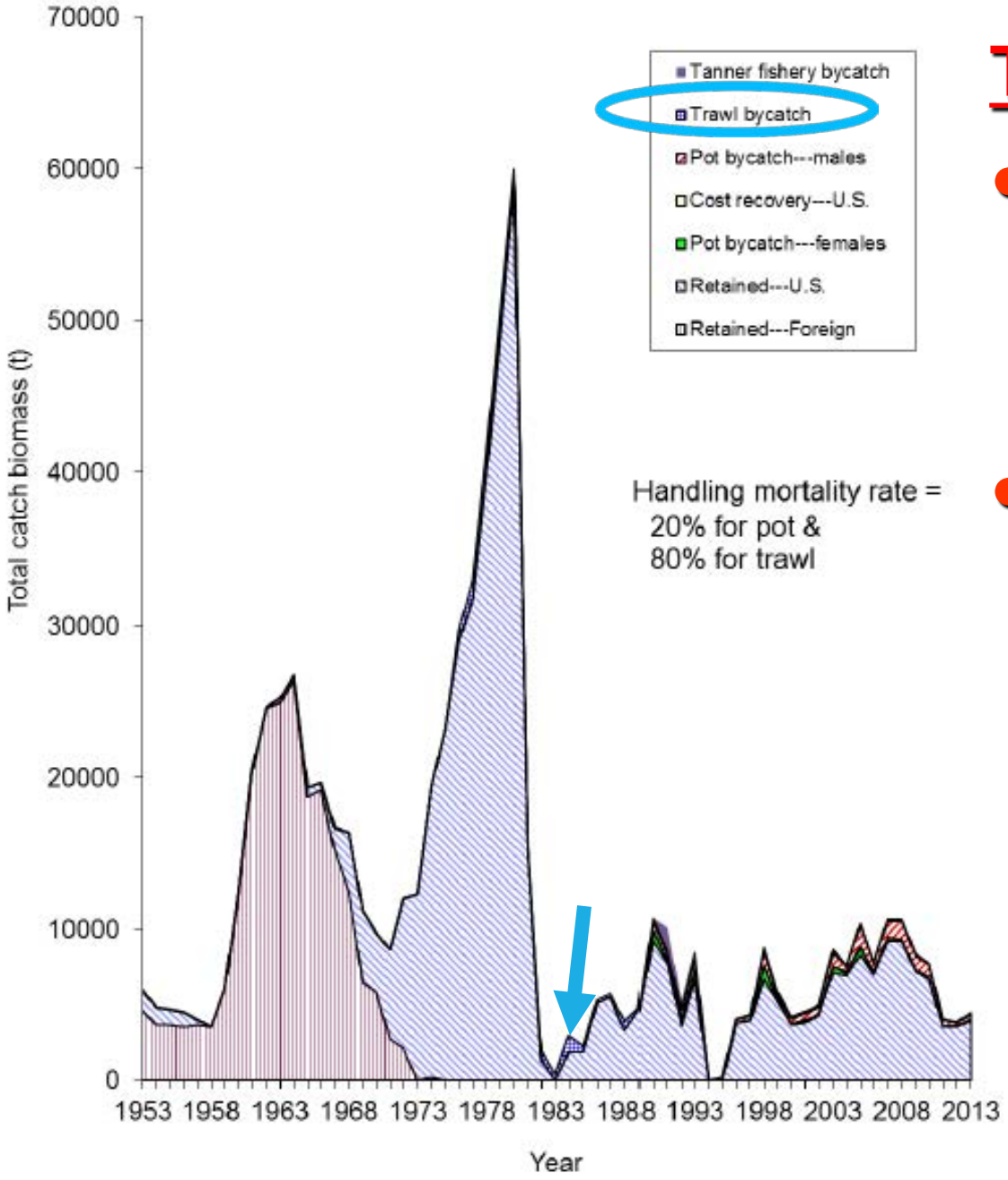

Mature females
(>=105mm)
<56.0 Deg.
56.0-57.5 Deg.
>=57.5 Deg.
Millions
Abundance
45
40
35
30
25
20
15
10
5
0
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
Year

Trawl Protections





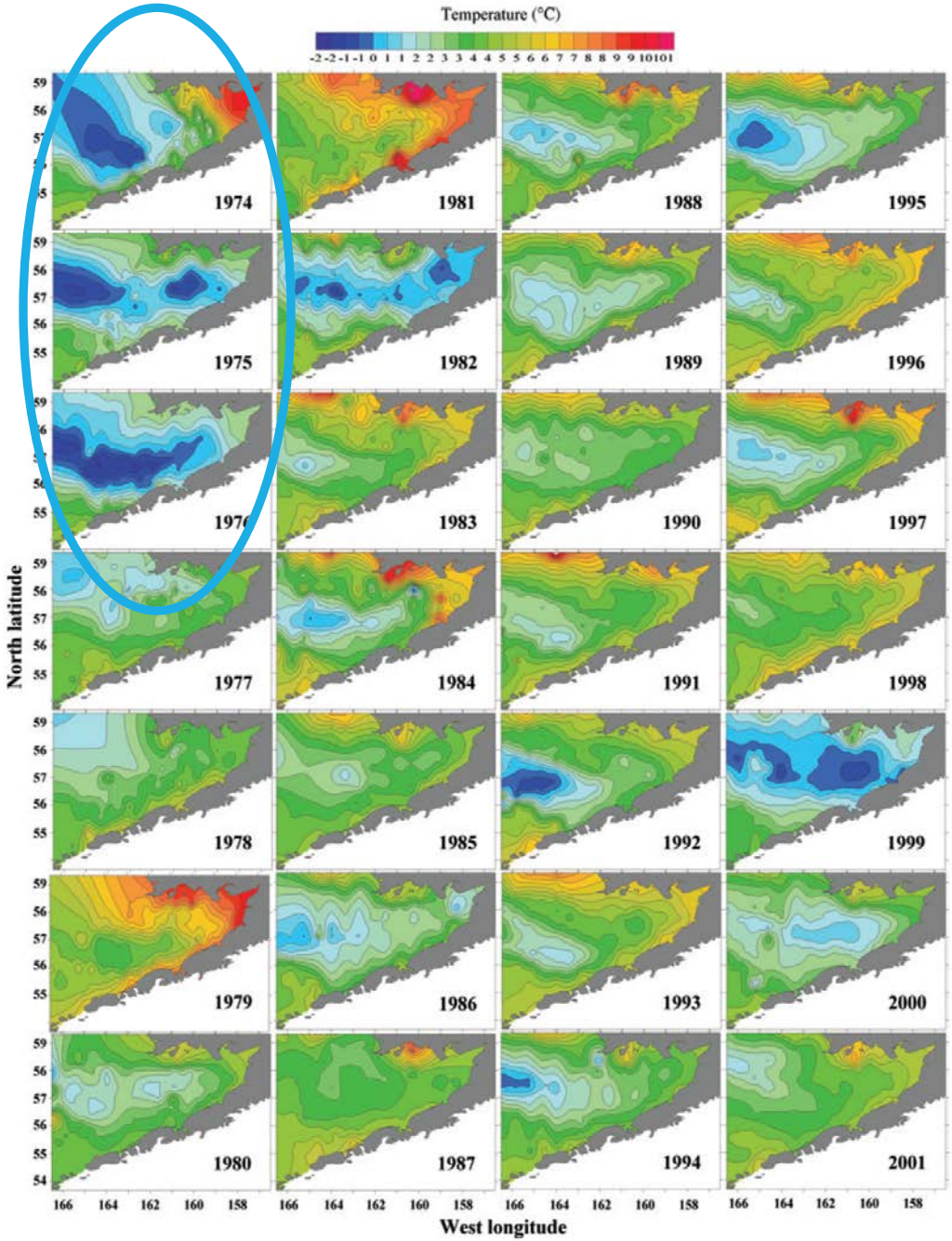
- 1959 – trawling banned in pot sanctuary
- 1975 – trawling banned in halibut savings area during December – March
- 1984 – year-round trawling allowed in pot sanctuary & experimental trawling allowed in savings area
- Protections relaxed after shift in distribution occurred



Trawl Bycatch

- Estimated trawl bycatch is a small fraction of total catch
- However, cannot rule out unobserved trawl bycatch in the early 1980s

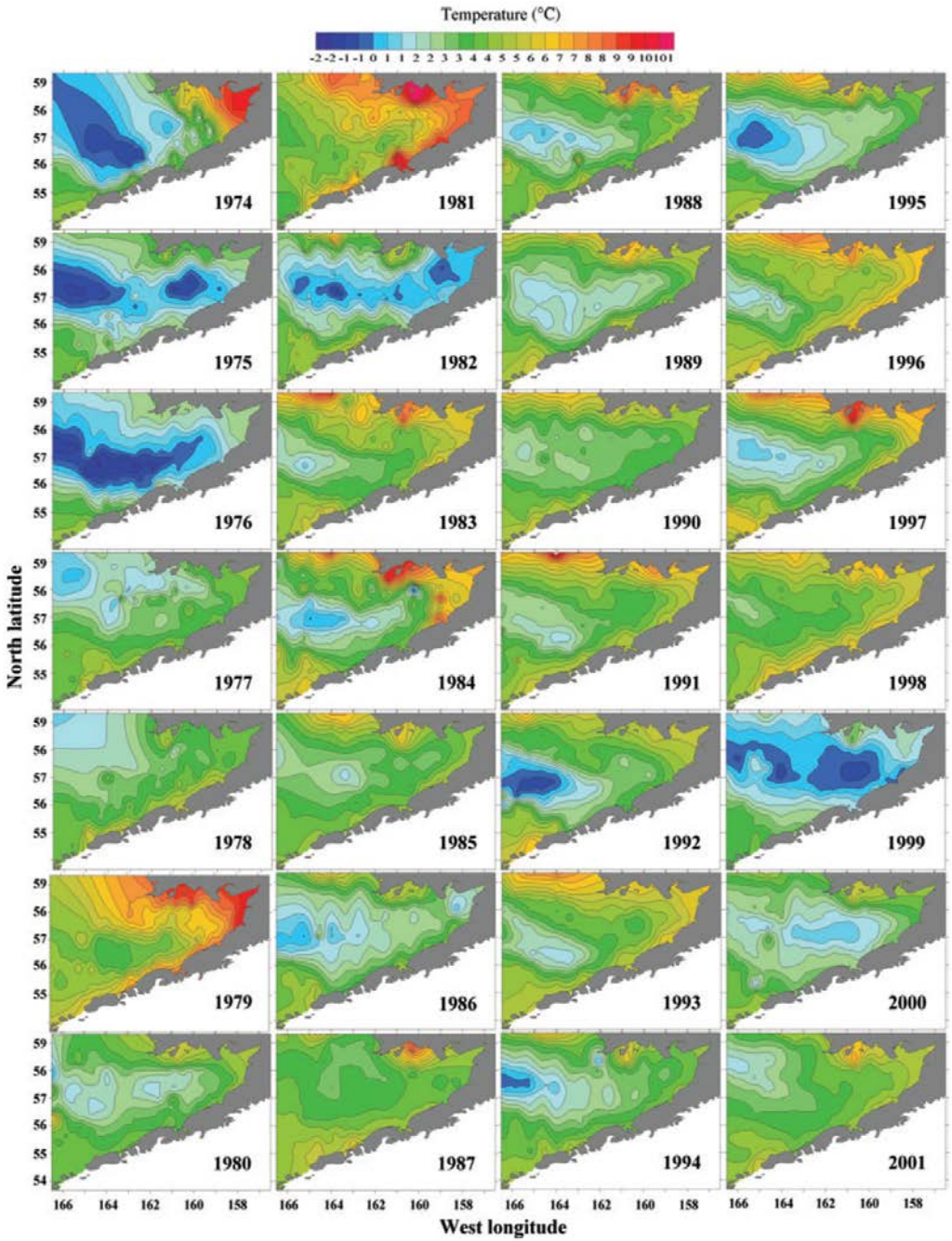
CLIMATE VARIABILITY AS A CAUSE?



Summer Bottom Temperature

- Variable cold pool on continental shelf
- Cold bottom temperatures in Bristol Bay before 1977

Loher & Armstrong (2005)

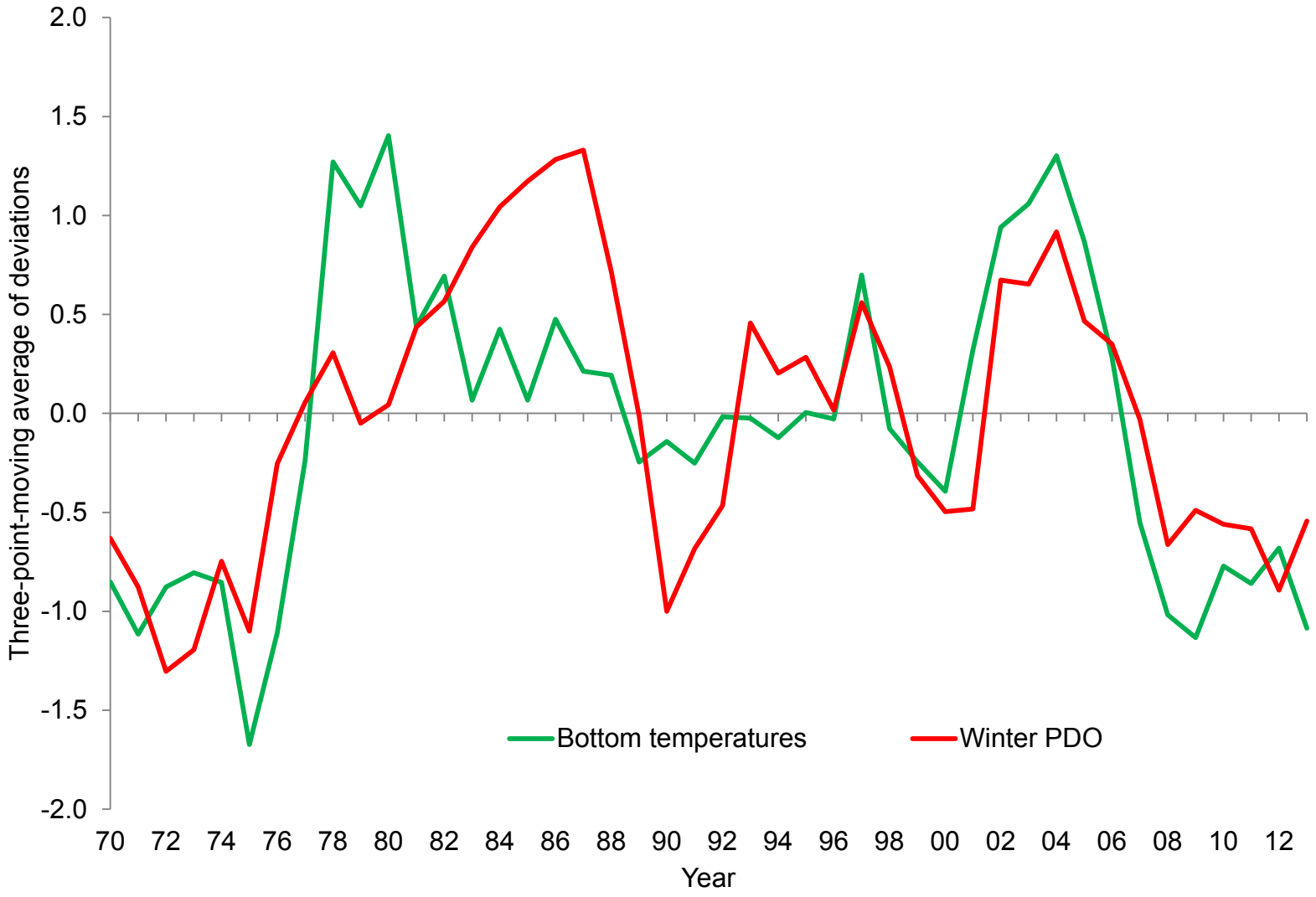


Summer Bottom Temperature

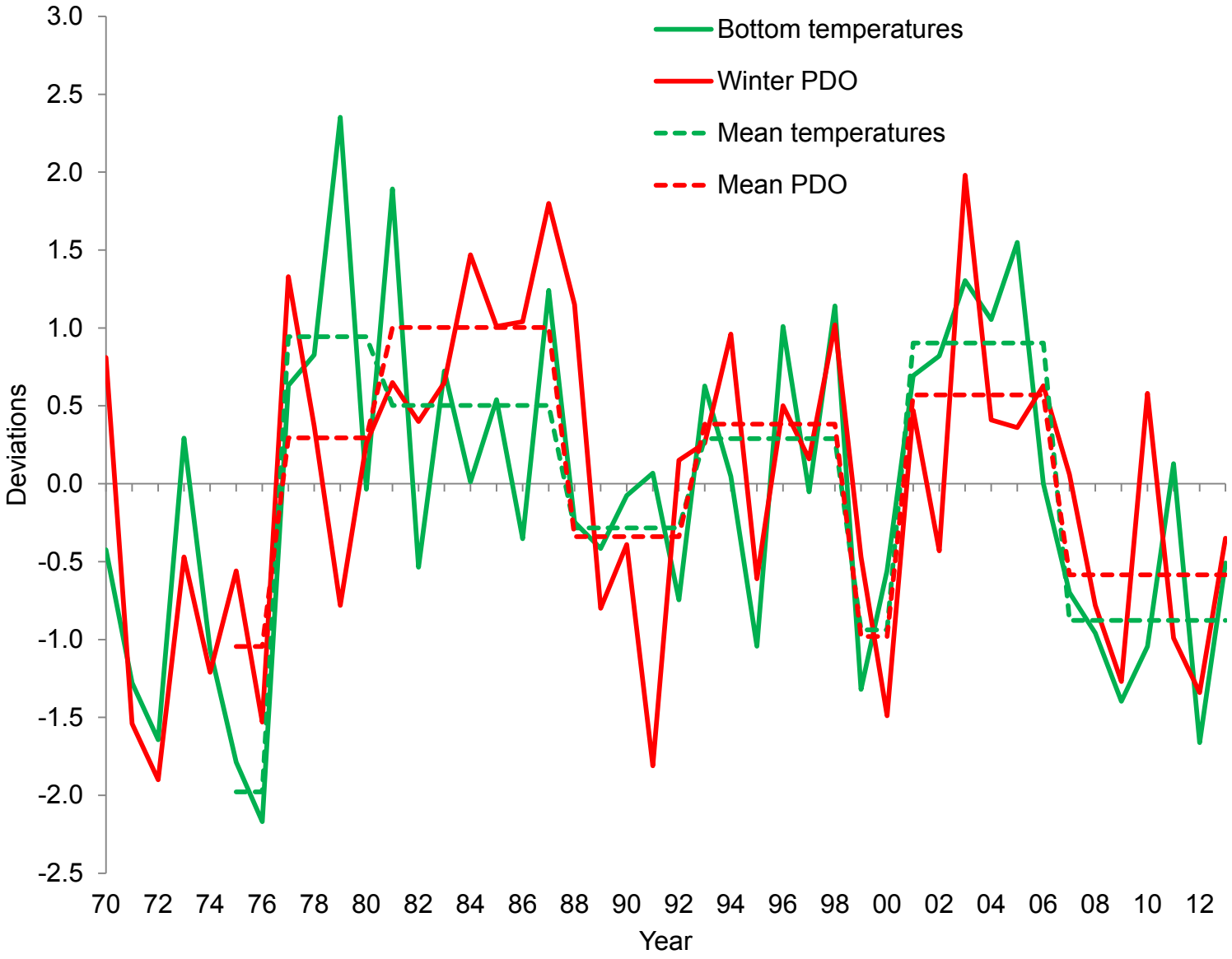
- Variable cold pool on continental shelf
- Cold bottom temperatures in Bristol Bay before 1977
- Warming evident starting in 1977
- Note some cooling during late 1980s & early 1990s and 1999 & 2000

Loher & Armstrong (2005)

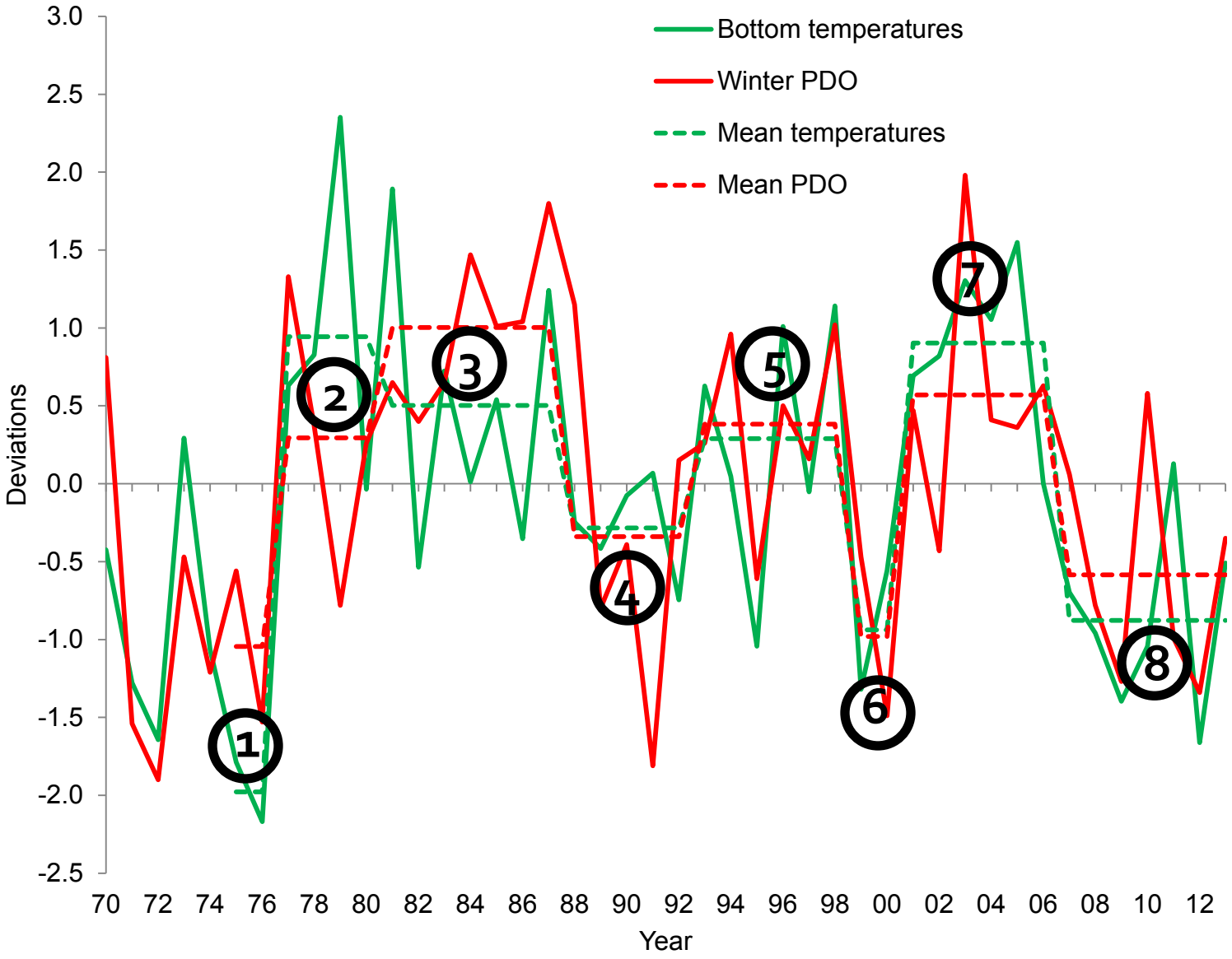
Covariation in Bottom Temperature & PDO

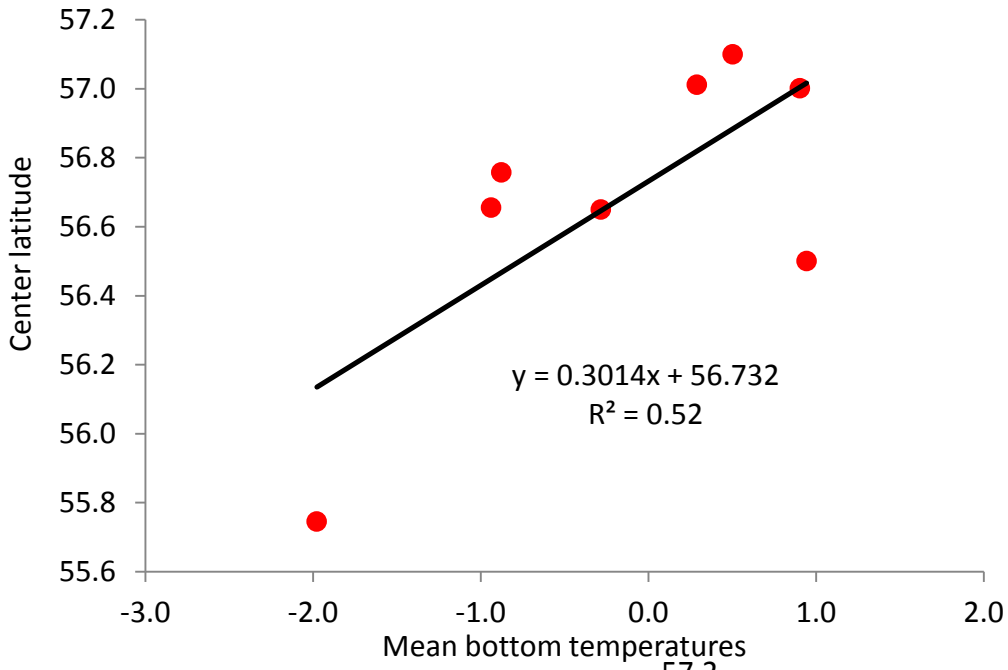


Eight Averaging Periods

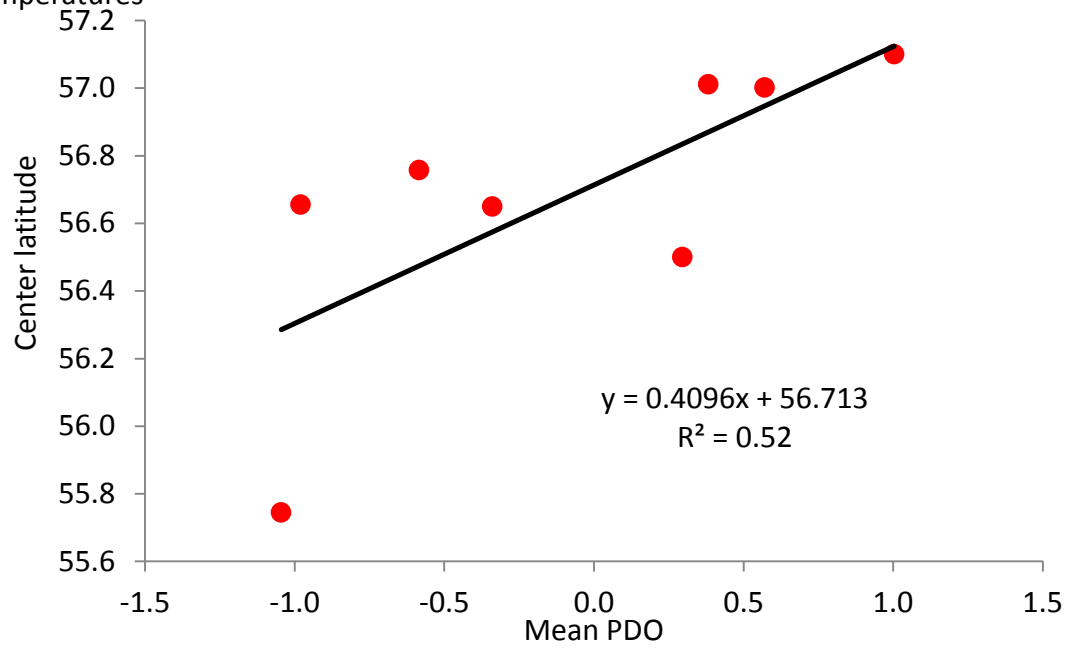


Eight Averaging Periods

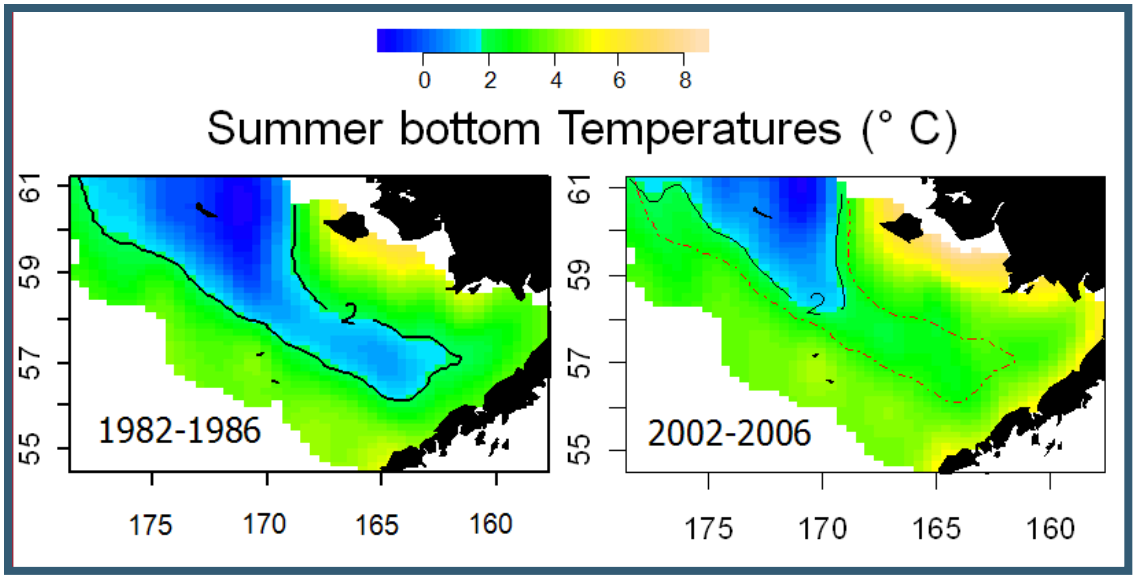


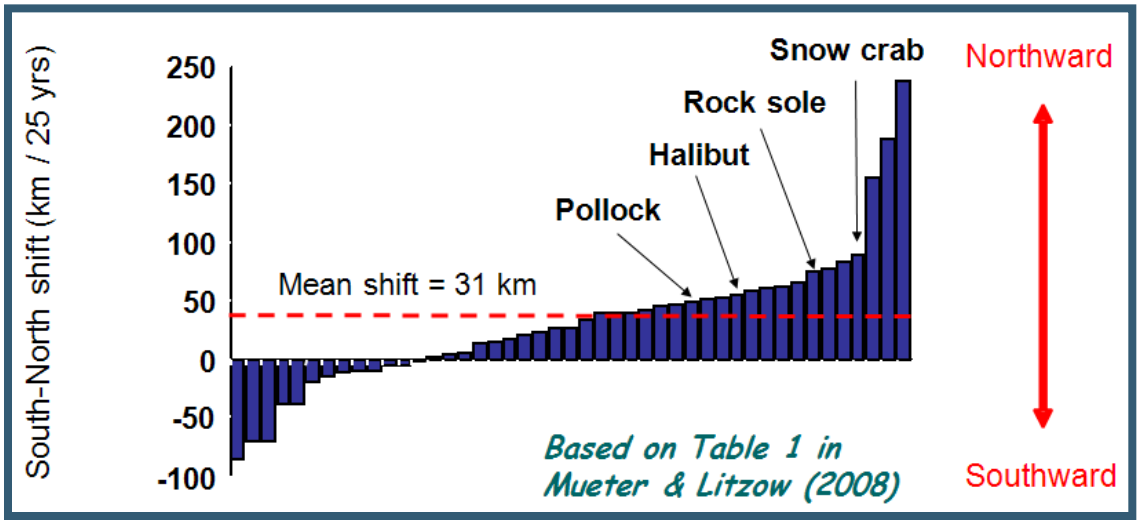


Mean temperature or PDO accounts for 52% of variability in latitude of large mature female centroids



Shift in Benthic Community & Cold Pool





- Southern edge of cold pool retreated 230 km north
- Northward shift in benthic community
- Sea ice explains 57% of variability in snow crab catch
- King crab sensitive to sea ice cover

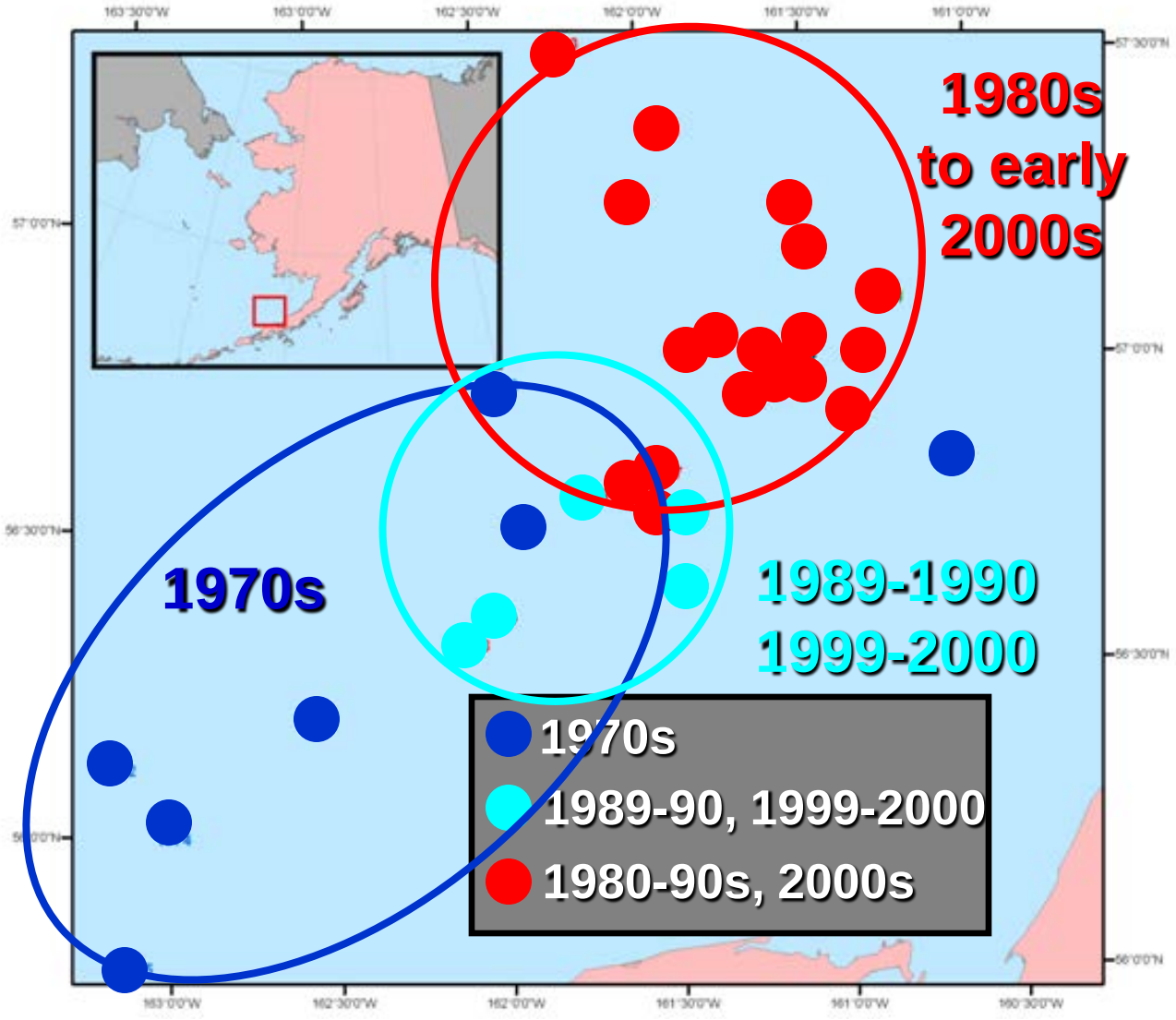
Mueter & Litzow (2008)

CONCLUSIONS AND IMPLICATIONS

Conclusions

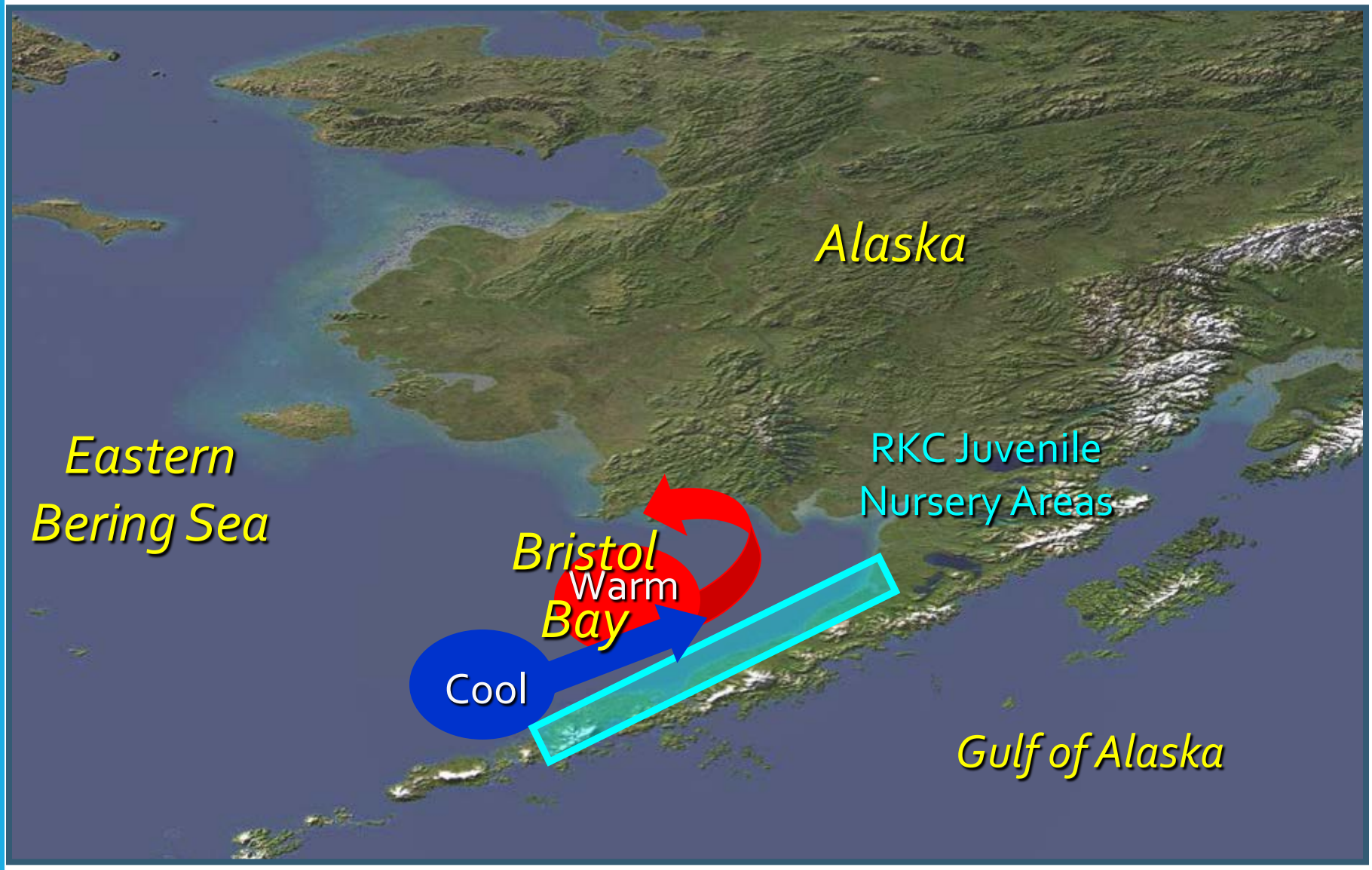
- Evidence does not appear to support fishing as a main cause:
  - Directed fishing was concentrated in the middle Bristol Bay
  - Shift began in late 1970s while trawl closures were in place
  - Proportions for all size groups declined in the southern area in late 1970s, including immature crab with low catchability by commercial gears
  - Data indicate that some mature females shifted from the southern area to the middle and northern areas
- Spatial shifts most likely associated with environment:
  - Distributional shifts began with the climate regime shift in 1976/1977
  - North (south) shifts are associated with warmer (cooler) temperatures and high (low) values of the PDO
  - Findings are consistent with large-scale shifts in benthic community in other studies

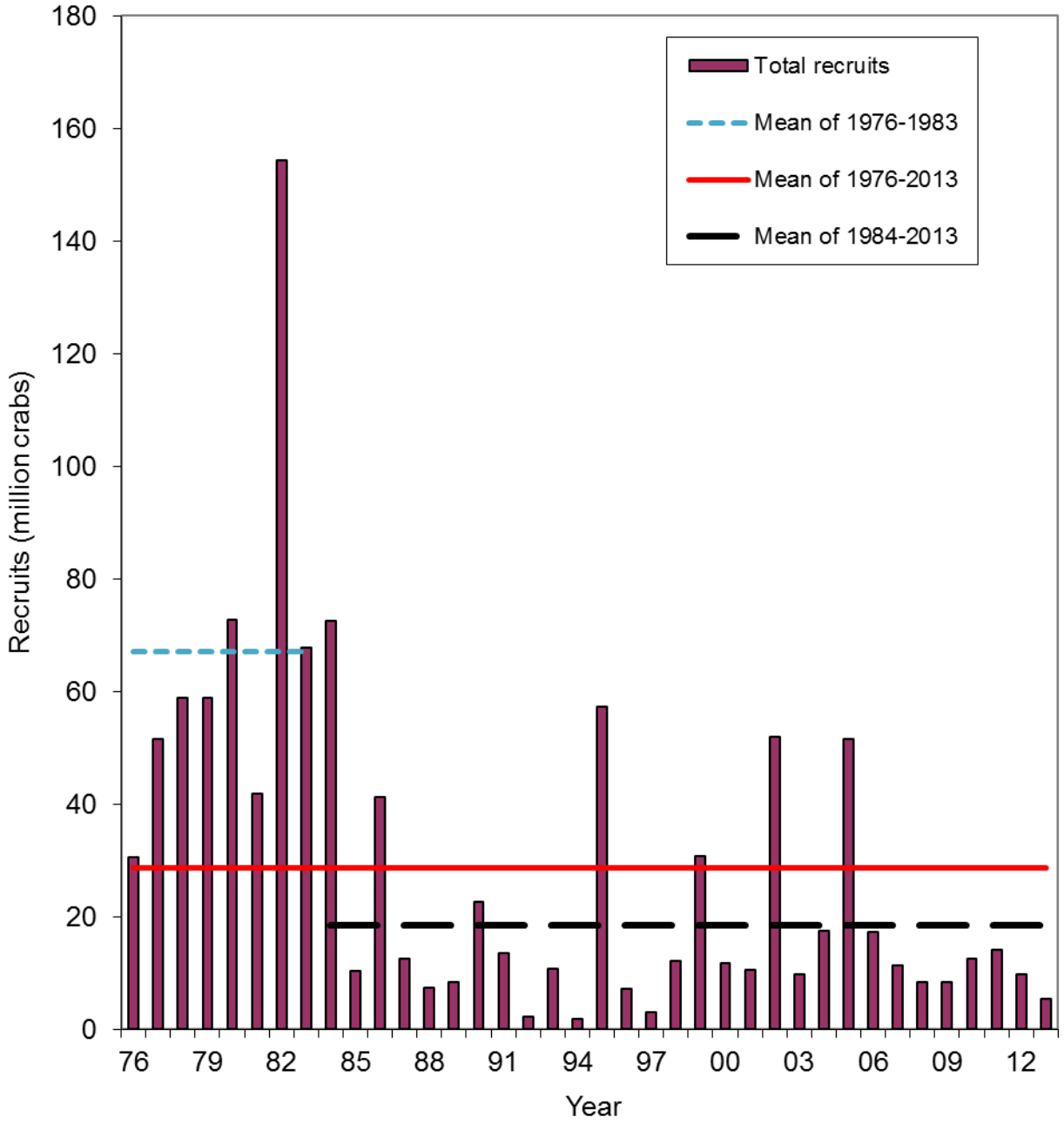
Patterns in Centers of Distribution



Zheng & Kruse (2006)

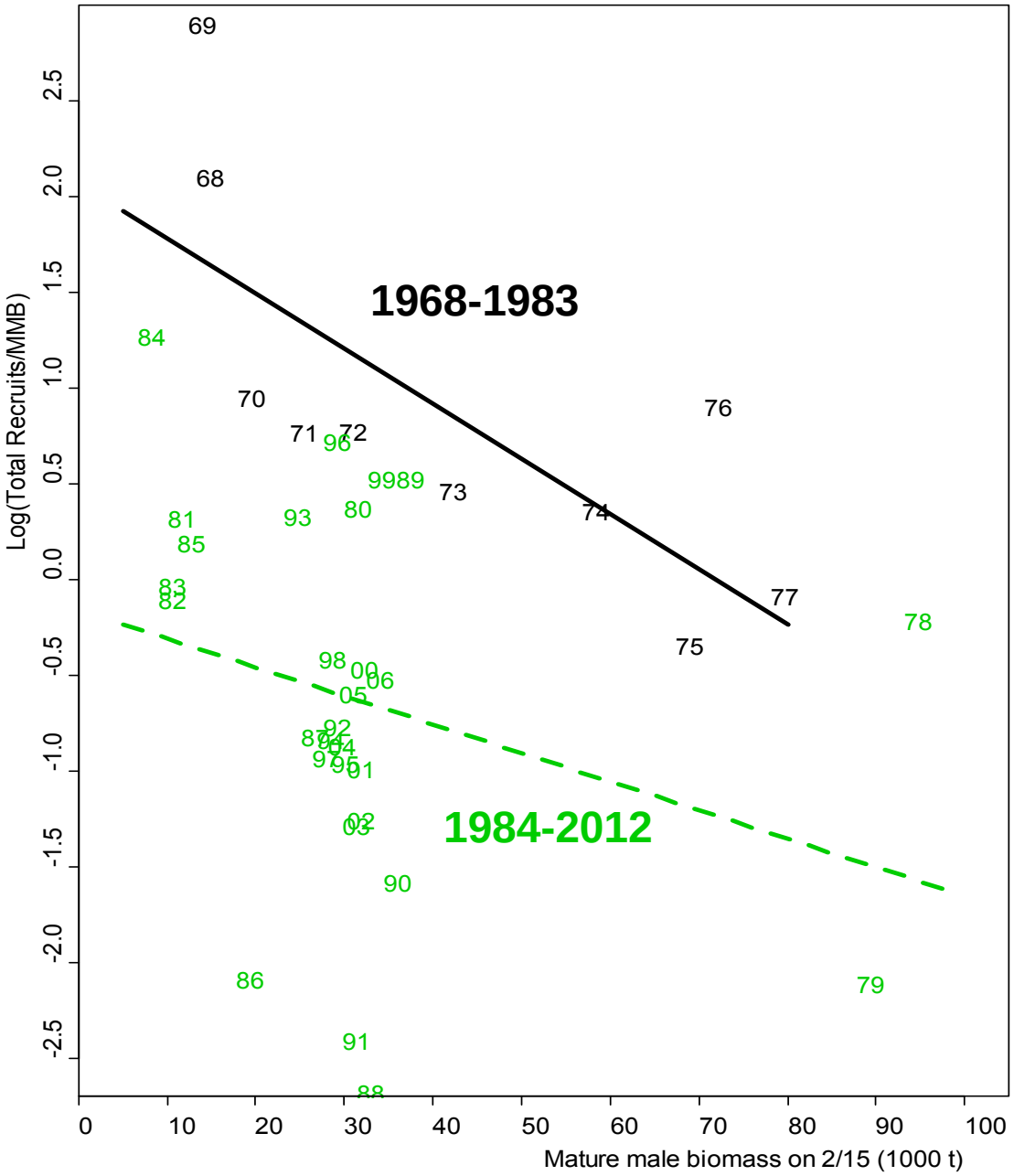
Effects on Larval Advection on Recruitment?





Recruitment

- Crabs recruit to model at ~6 yr
- Higher during 1976-1983 (1970-1977 brood years)
- Lower since 1984 (1978 brood year)



Drop in Productivity

- Recruits per spawner shifted to lower productivity from 1968-1983 to 1984-2012
- Implications on biological reference points (e.g. B_0 & $F_{35\%}$)


Questions?