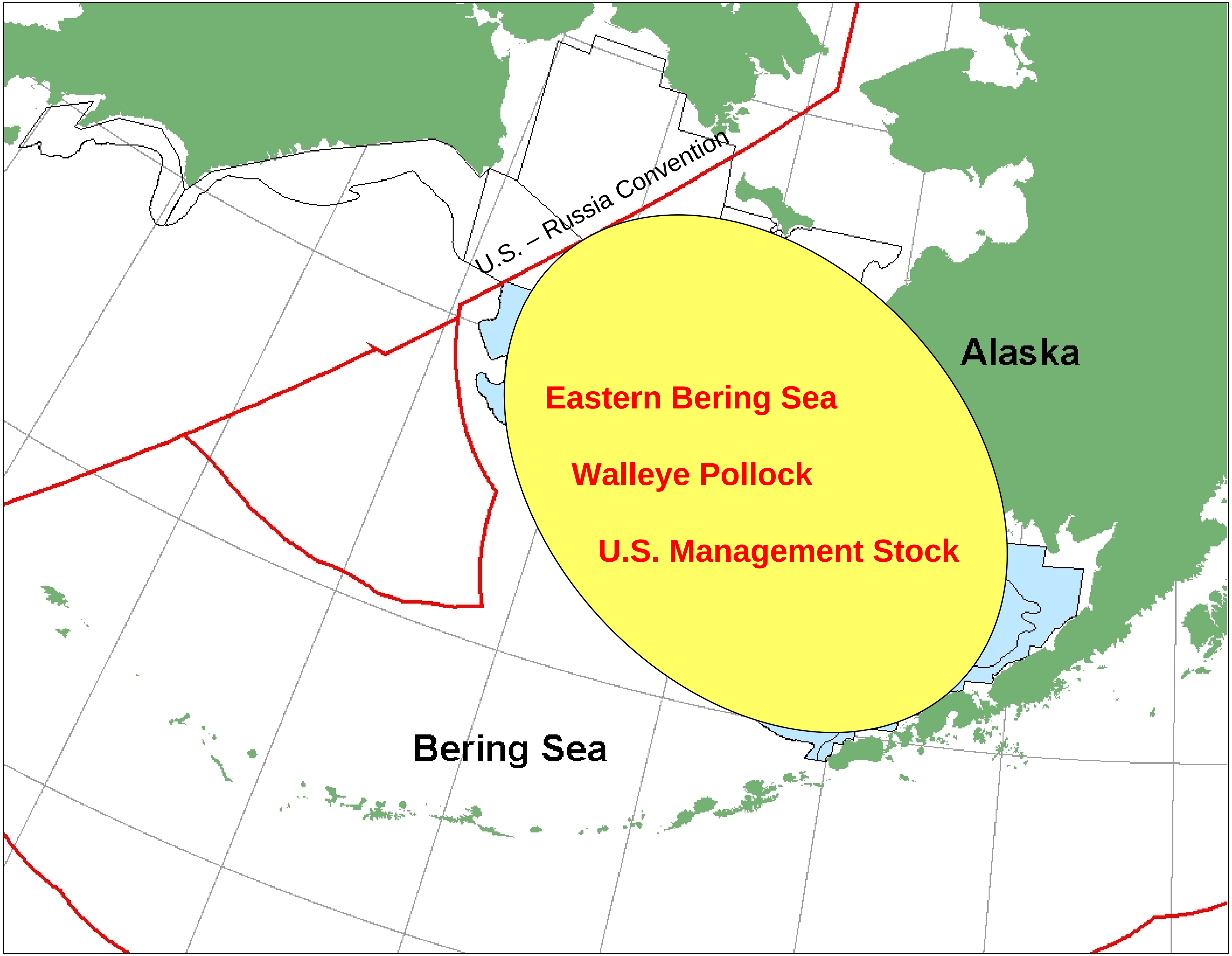
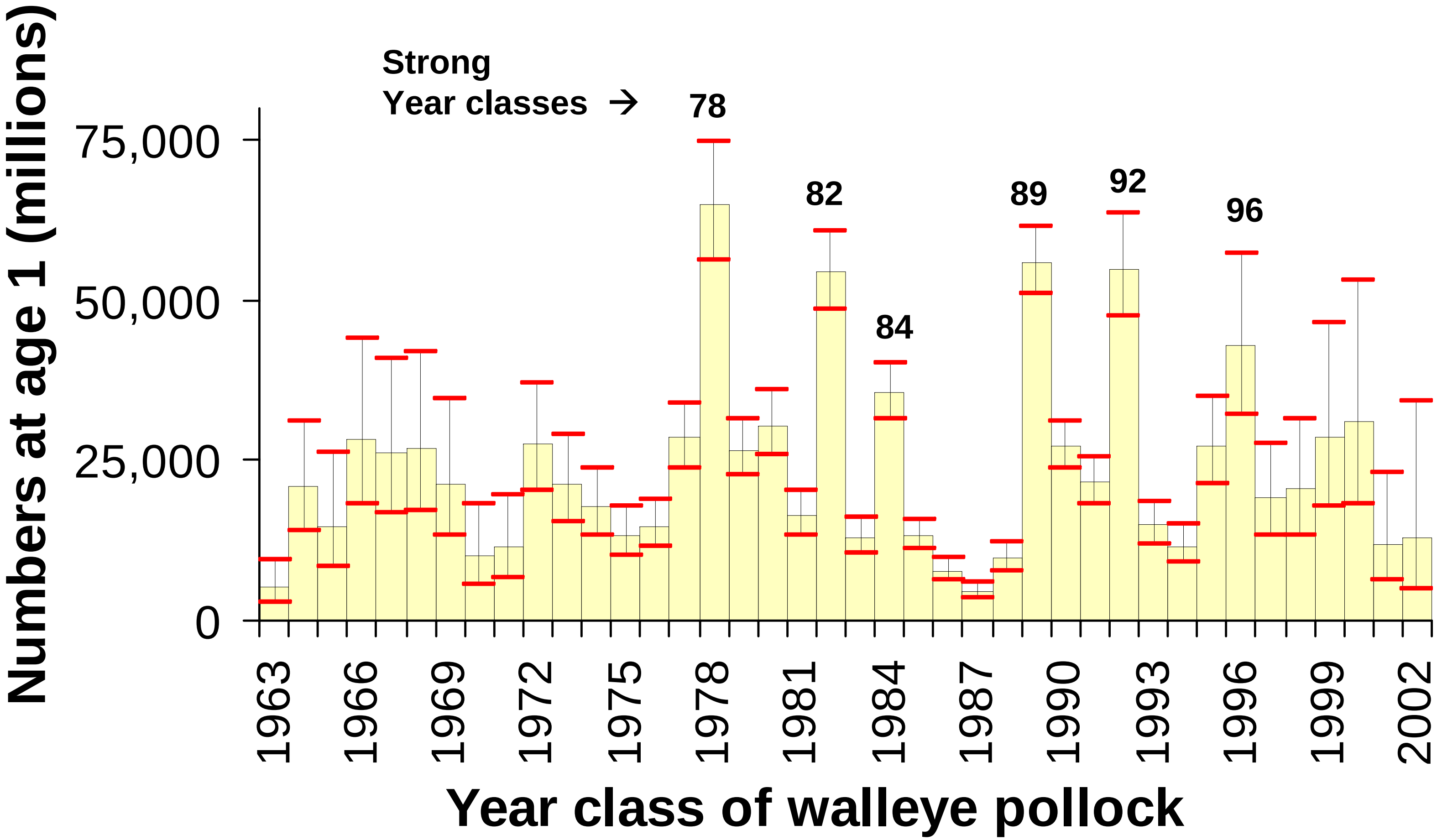
Consideration of spatial scale when assessing the influence of environmental variability on walleye pollock in the eastern Bering Sea

Presenters:
Troy Buckley and
Stanislaw Kotwicki



U.S. – Russia Convention
Alaska
Eastern Bering Sea
Walleye Pollock
U.S. Management Stock
Bering Sea



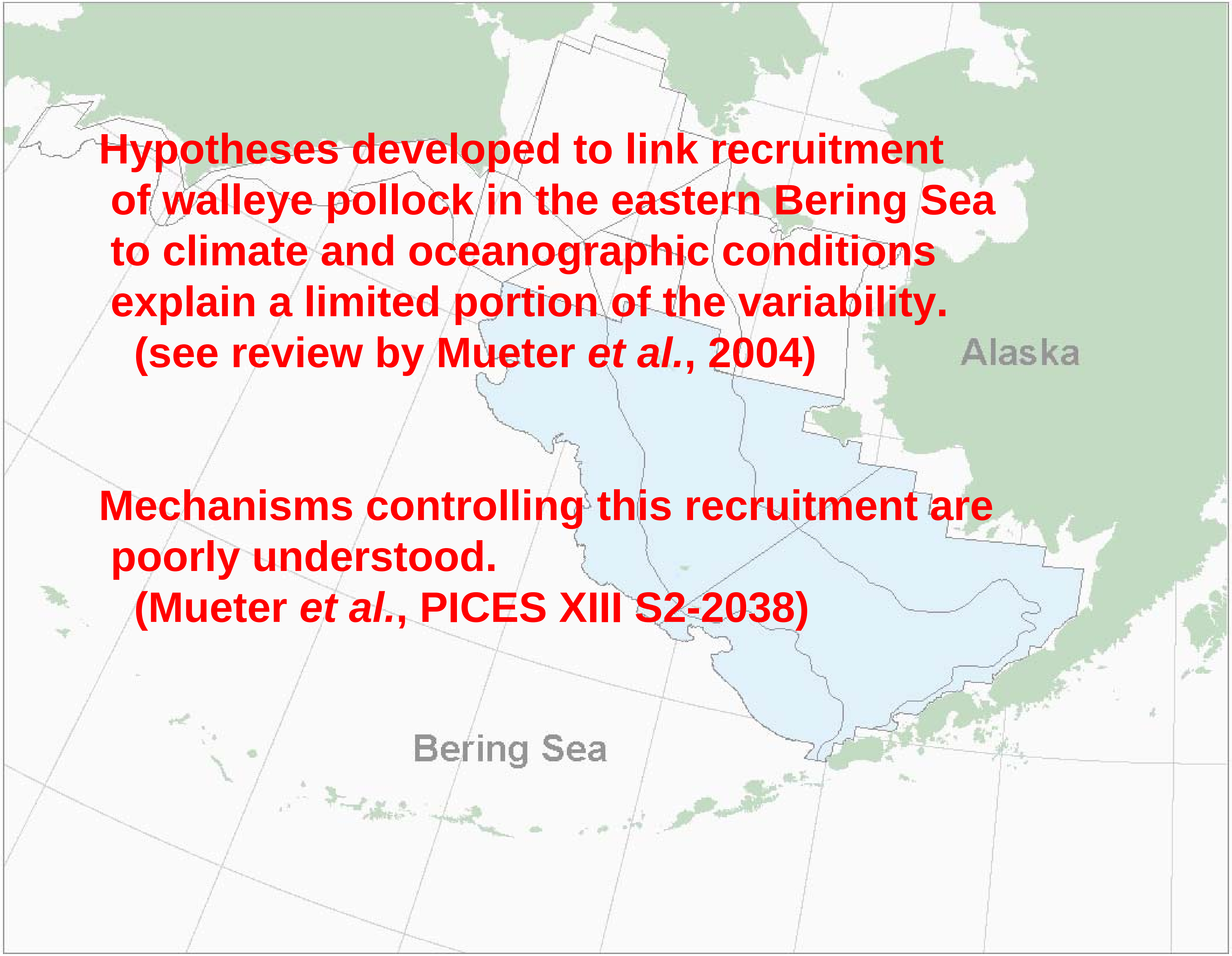
Strong
Year classes →
78
82
84
89
92
96
75,000
50,000
25,000
0
Numbers at age 1 (millions)
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
Year class of walleye pollock

Hypotheses developed to link recruitment of walleye pollock in the eastern Bering Sea to climate and oceanographic conditions explain a limited portion of the variability.

(see review by Mueter *et al.*, 2004)

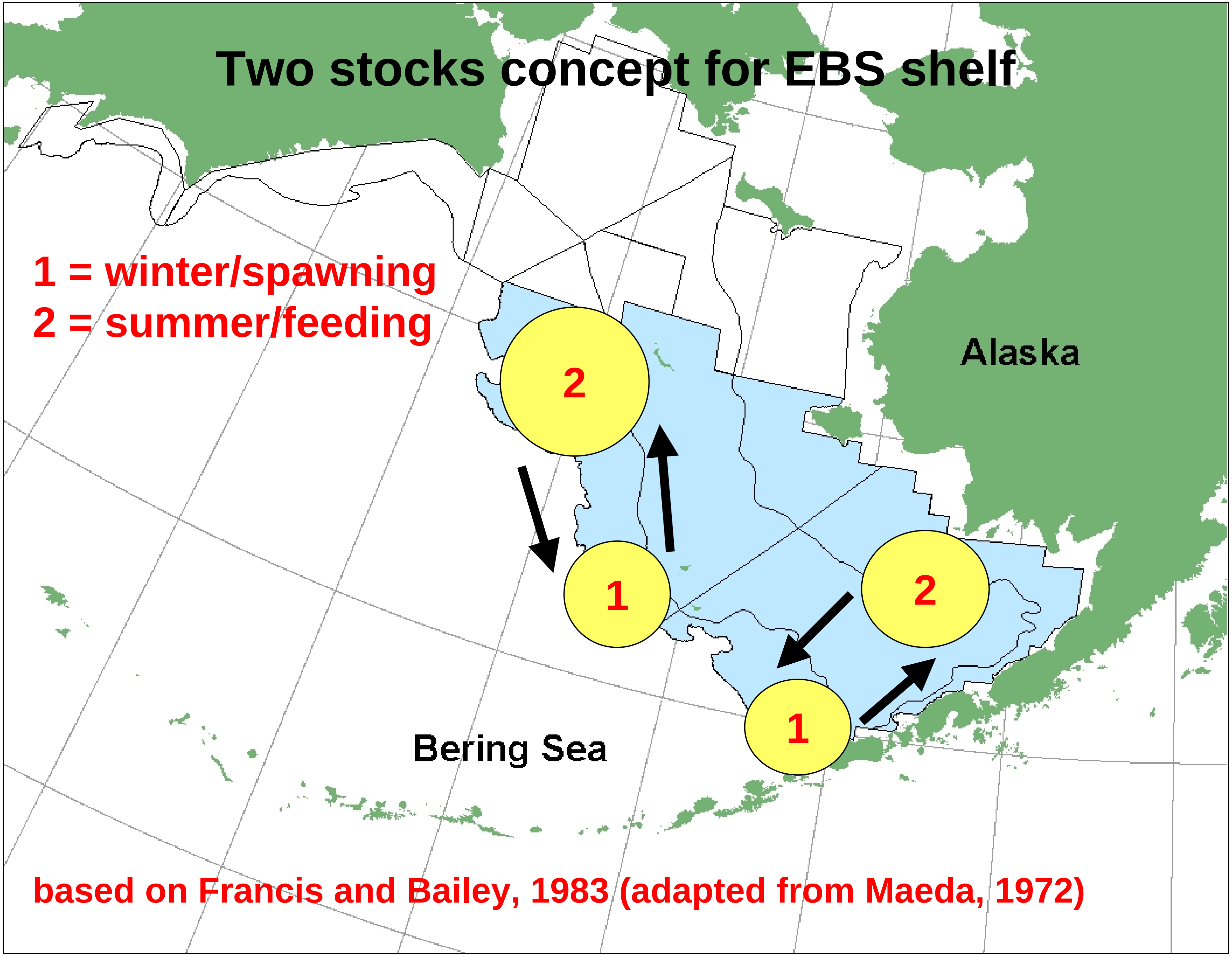
Mechanisms controlling this recruitment are poorly understood.

(Mueter *et al.*, PICES XIII S2-2038)



Perhaps considering the management-scale stock as the response variable lumps groups of pollock that respond differently to the environment or groups respond to conditions at a more localized scale.

The idea of more than one group of pollock inhabiting the EBS shelf is not new.


Two stocks concept for EBS shelf
1 = winter/spawning
2 = summer/feeding
2
1
2
1
Alaska
Bering Sea
based on Francis and Bailey, 1983 (adapted from Maeda, 1972)

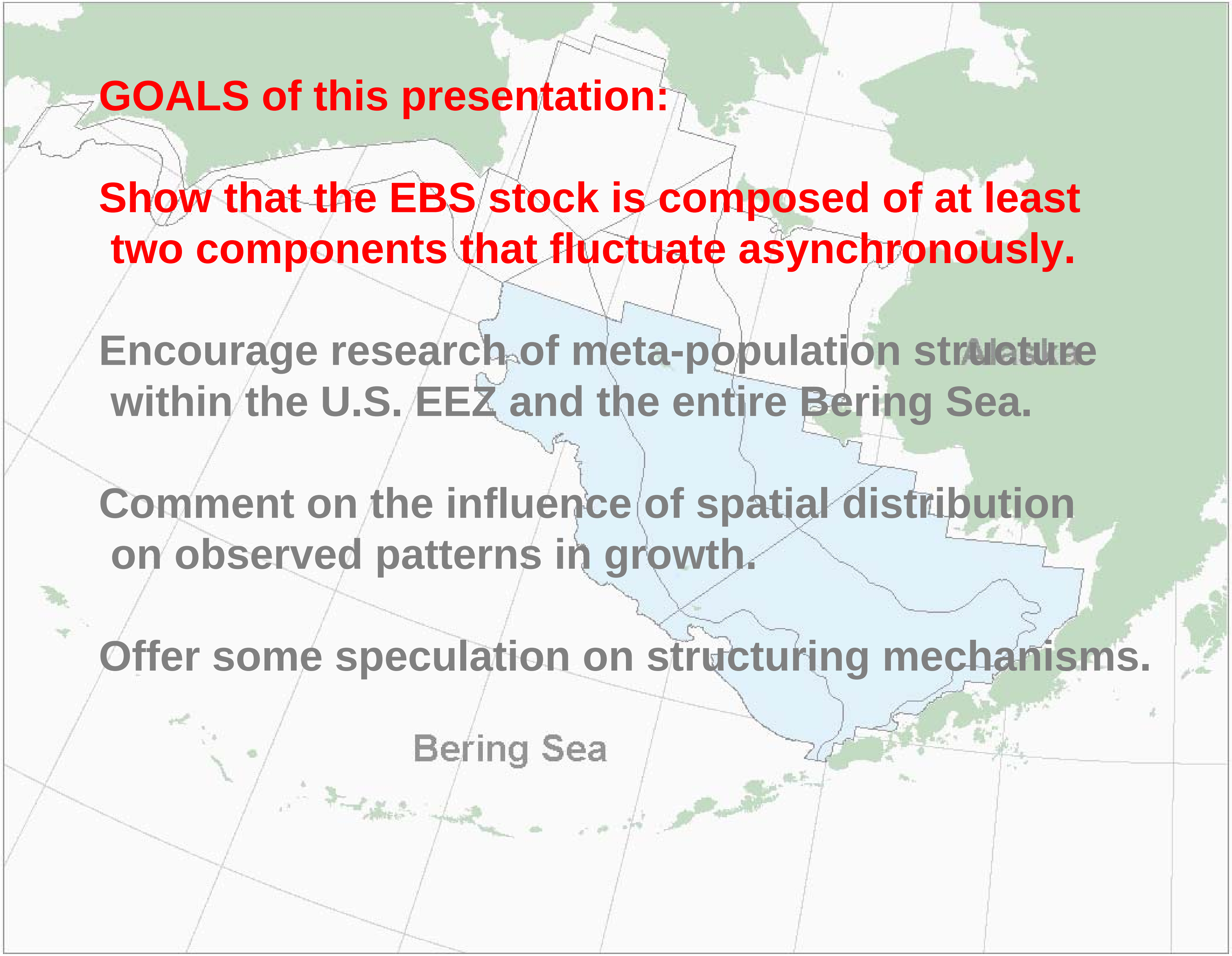
GOALS of this presentation:

Show that the EBS stock is composed of at least two components that fluctuate asynchronously.

Encourage research of meta-population structure within the U.S. EEZ and the entire Bering Sea.

Comment on the influence of spatial distribution on observed patterns in growth.

Offer some speculation on structuring mechanisms.



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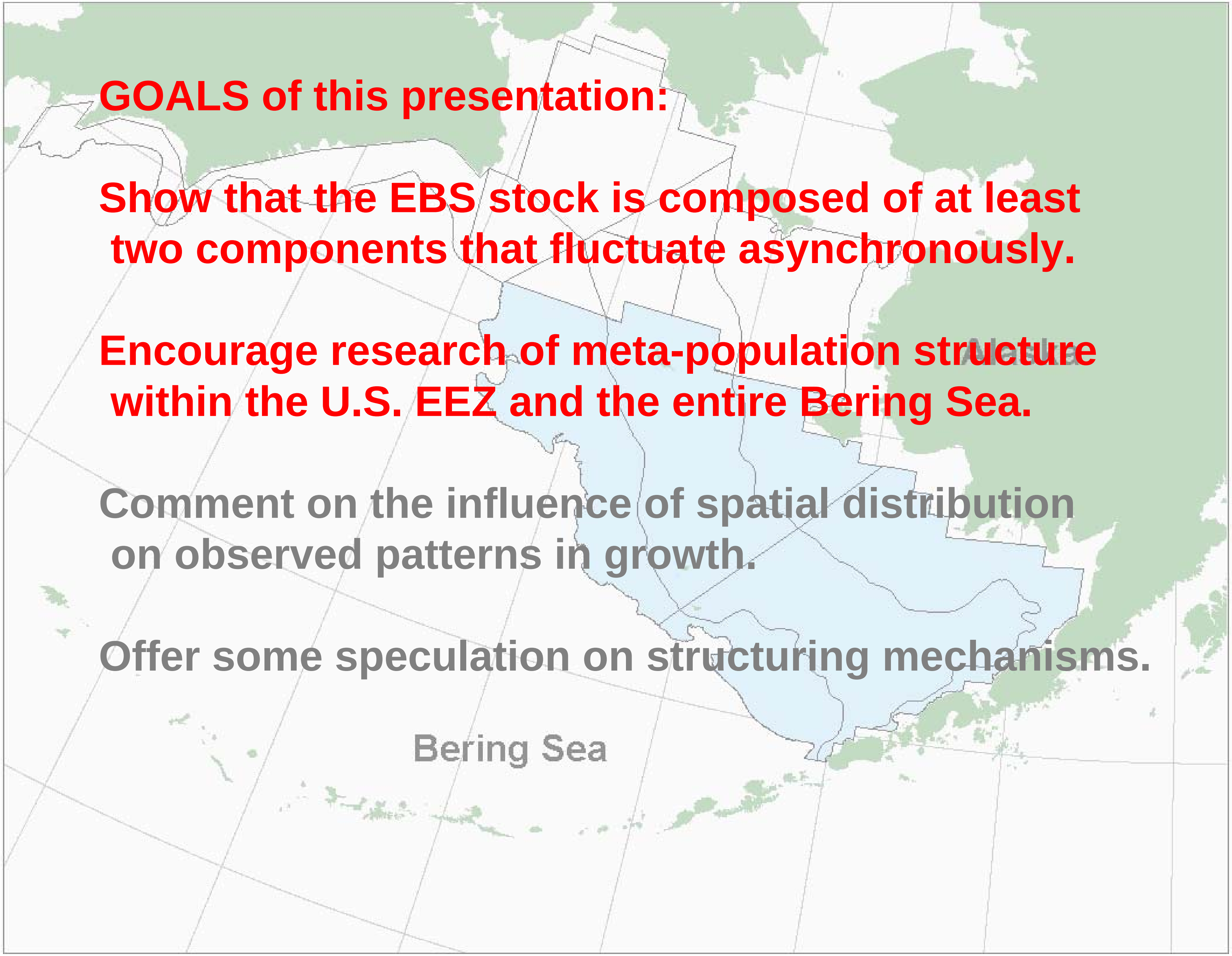

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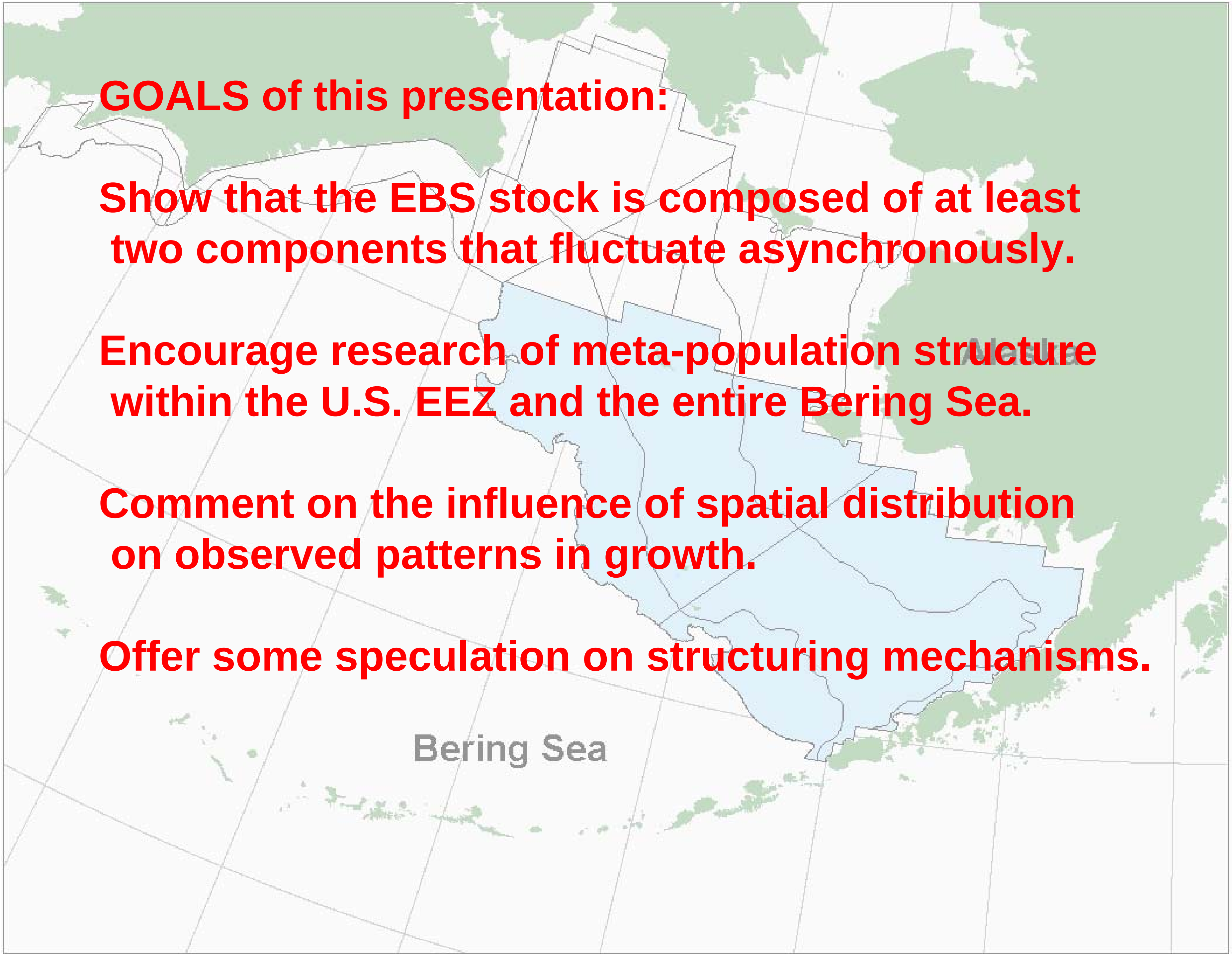
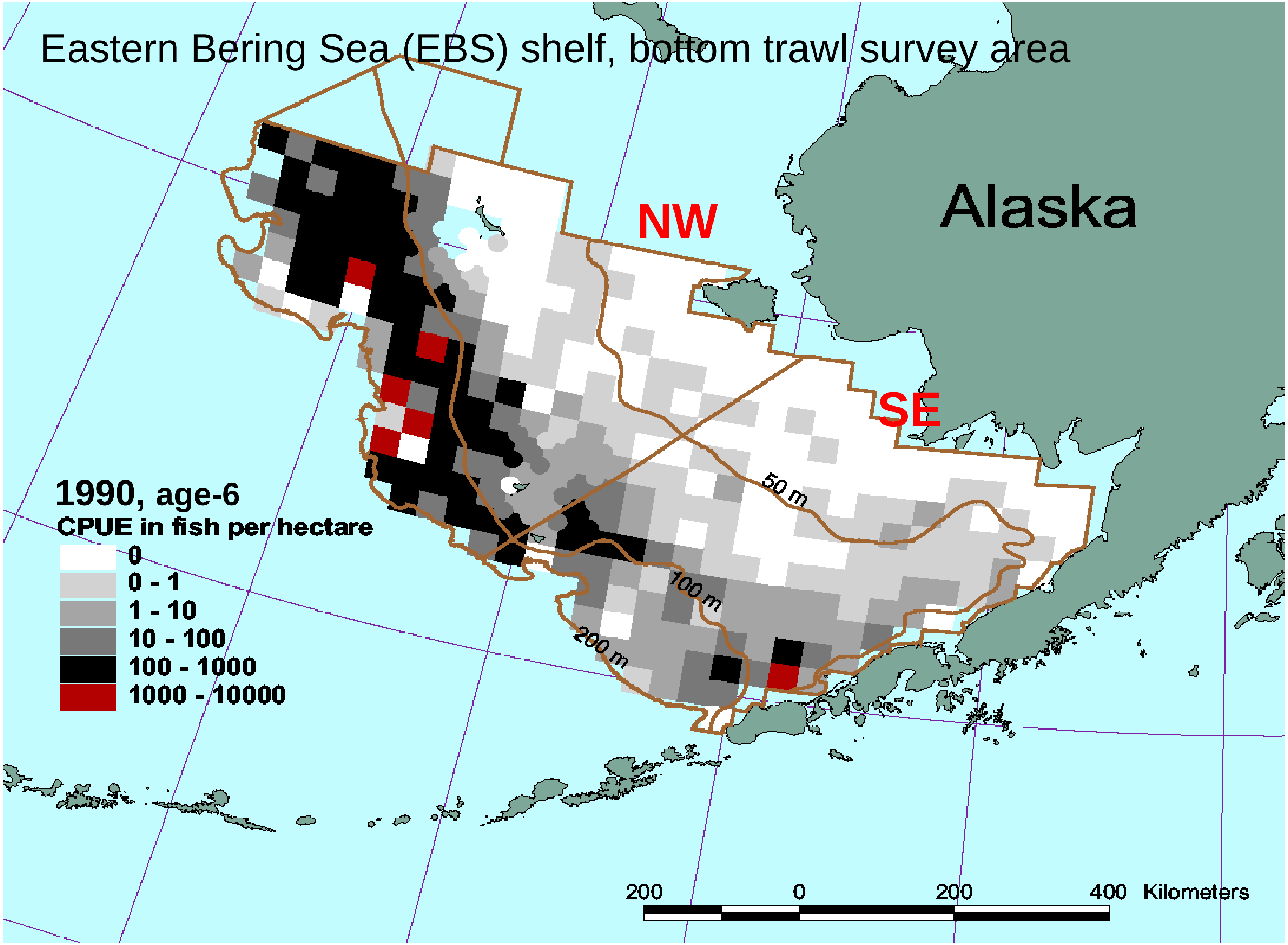
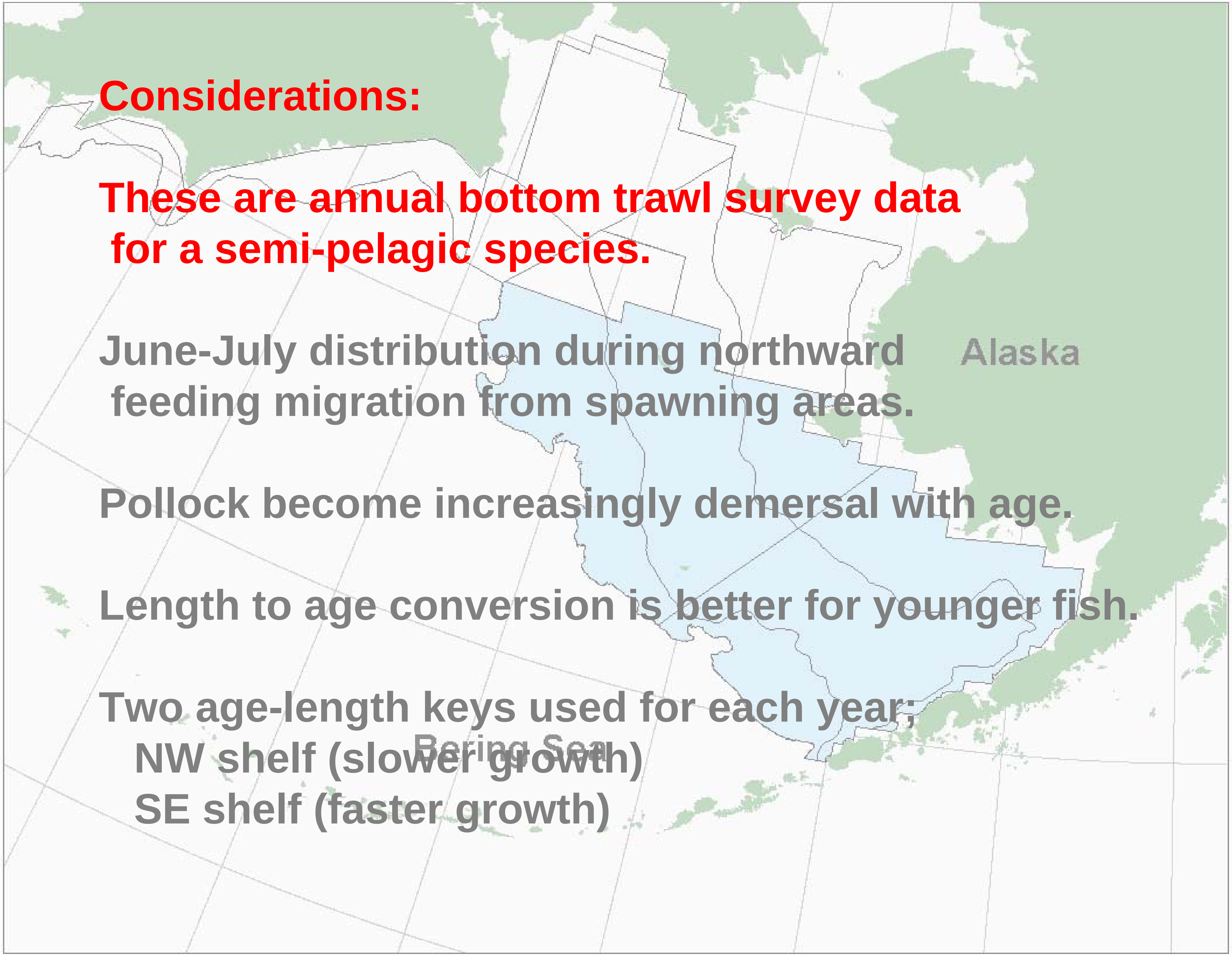




Eastern Bering Sea (EBS) shelf, bottom trawl survey area
NW
SE
Alaska
1990, age-6
CPUE in fish per hectare
0
0 - 1
1 - 10
10 - 100
100 - 1000
1000 - 10000
50 m
100 m
200 m
200
0
200
400
Kilometers



Considerations:

These are annual bottom trawl survey data for a semi-pelagic species.

June-July distribution during northward feeding migration from spawning areas.

Pollock become increasingly demersal with age.

Length to age conversion is better for younger fish.

Two age-length keys used for each year;
NW shelf (slower growth)
SE shelf (faster growth)

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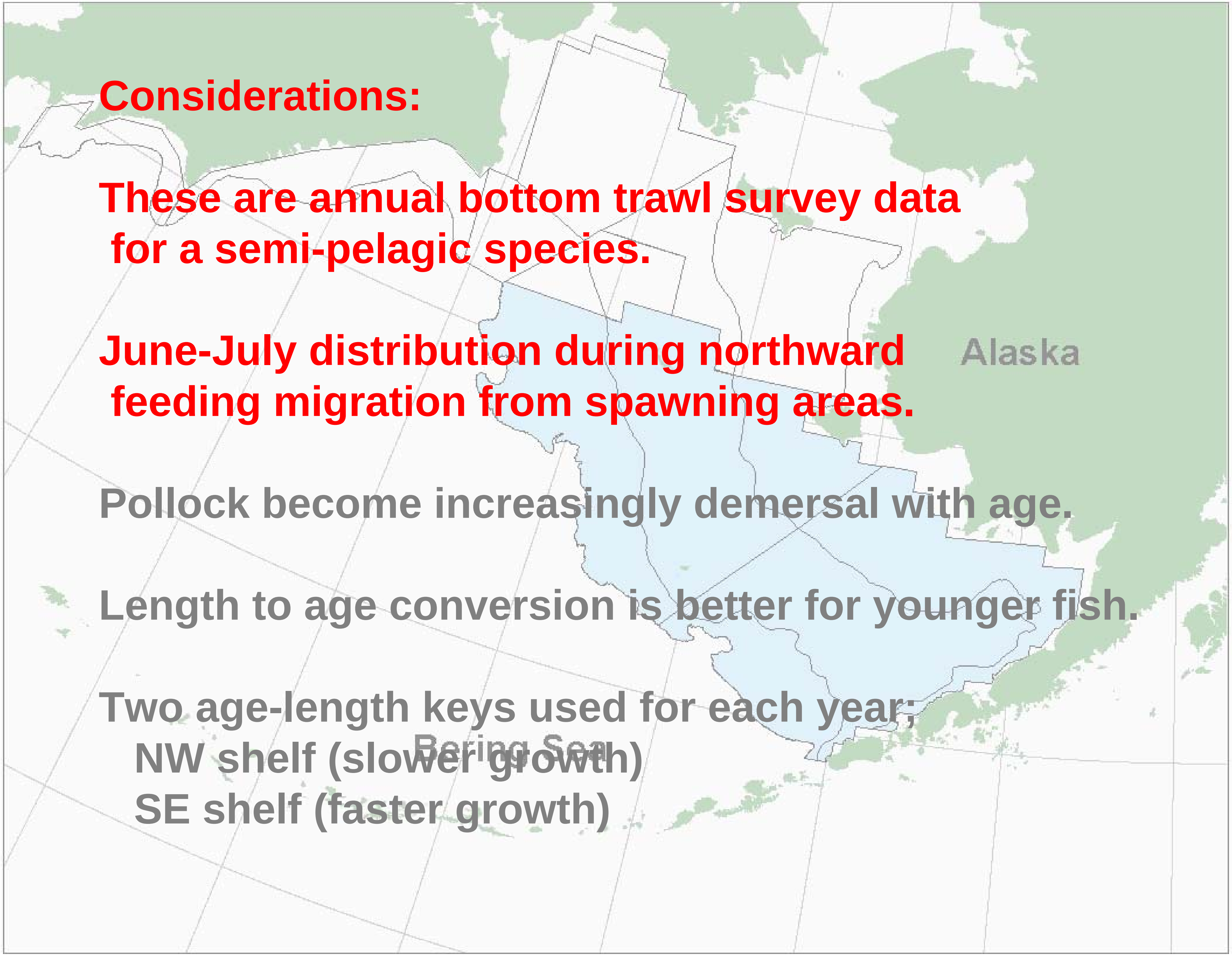

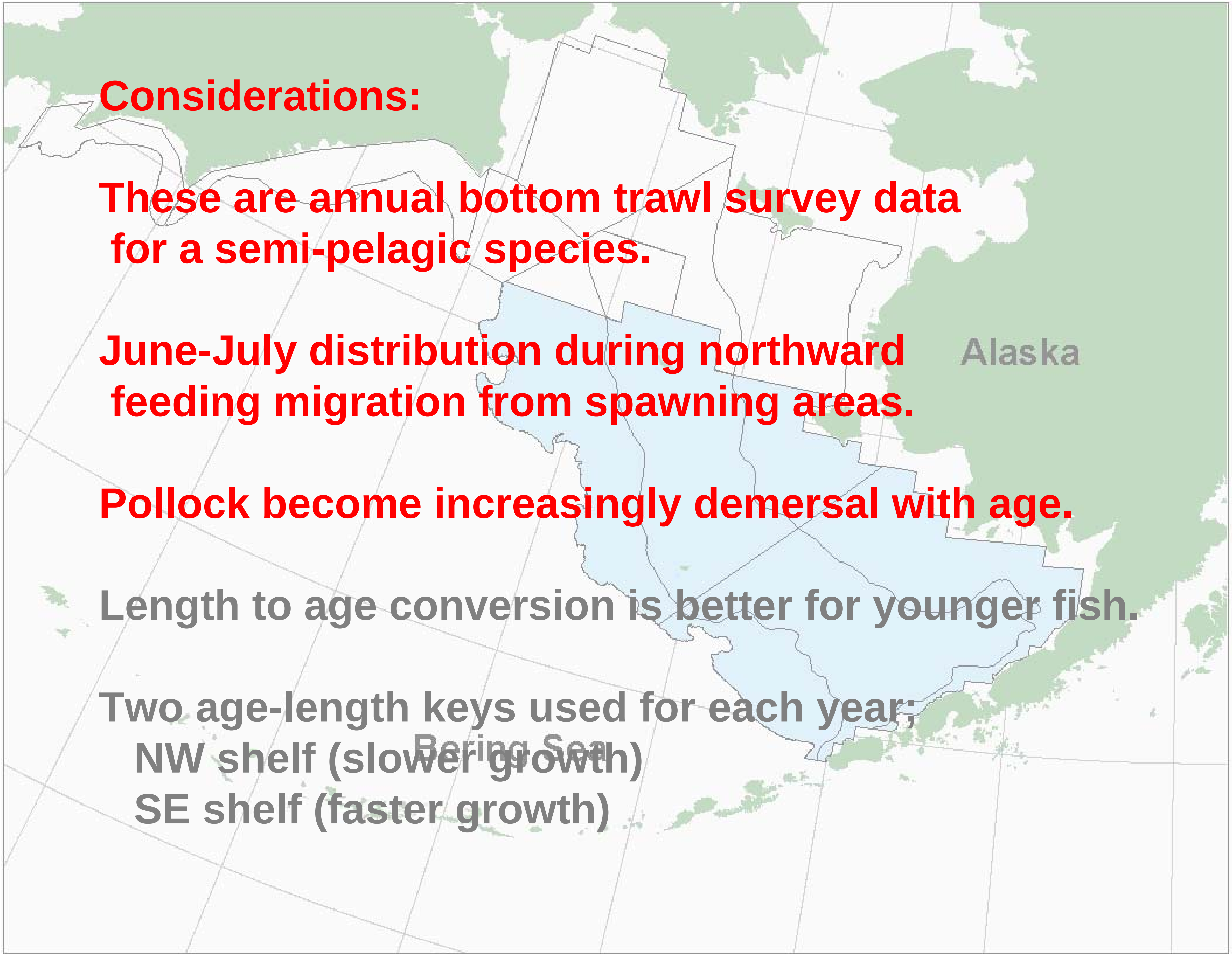

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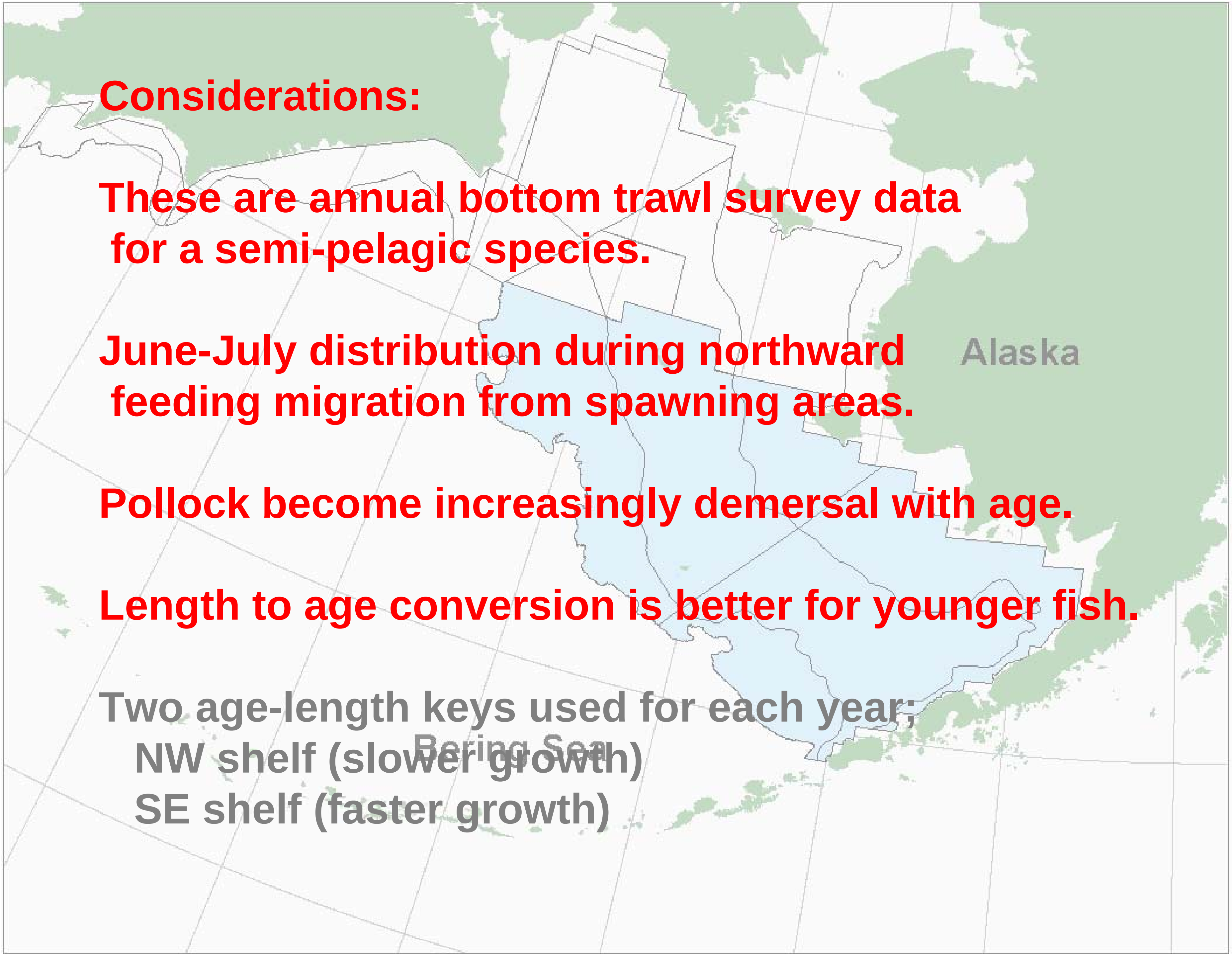

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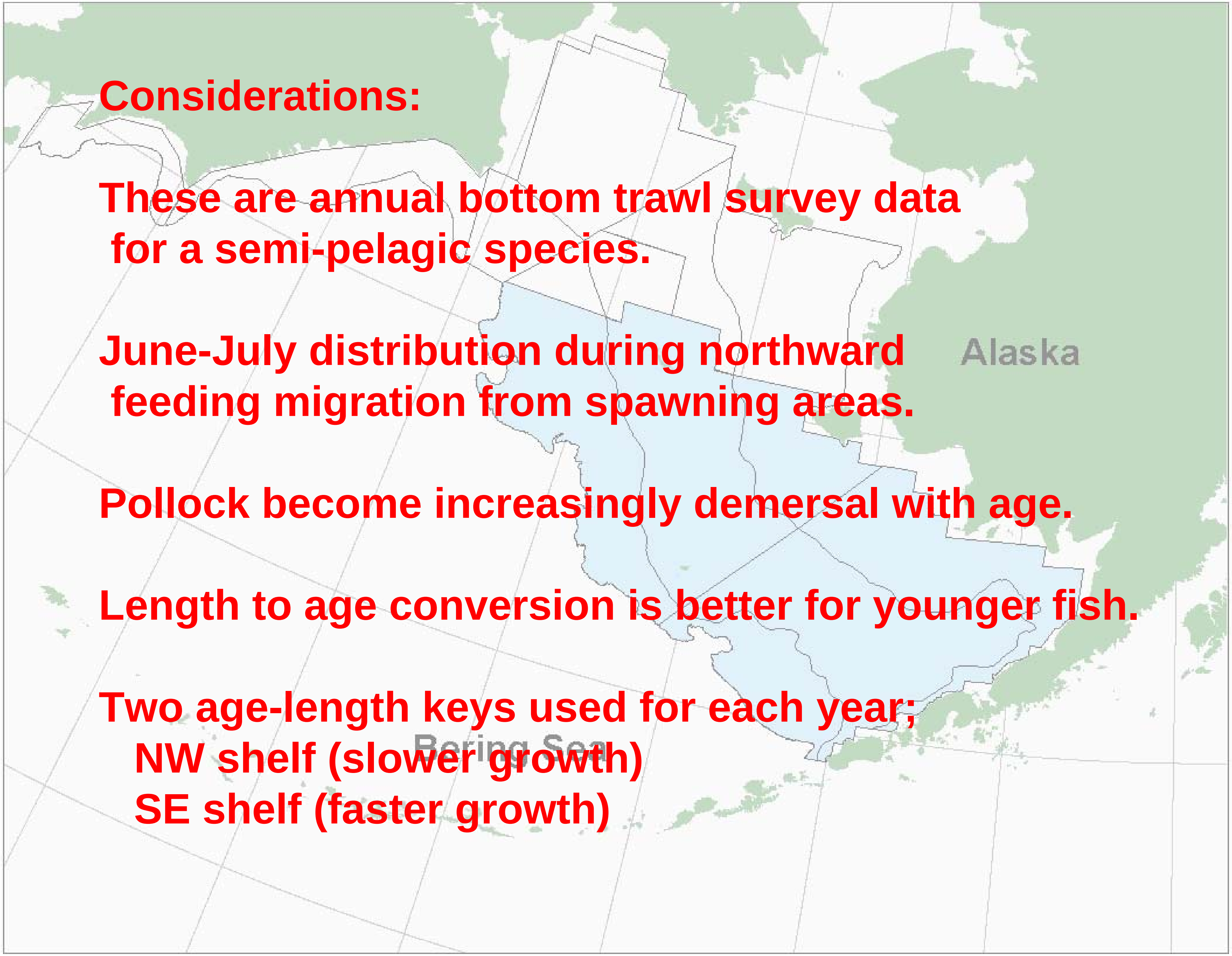

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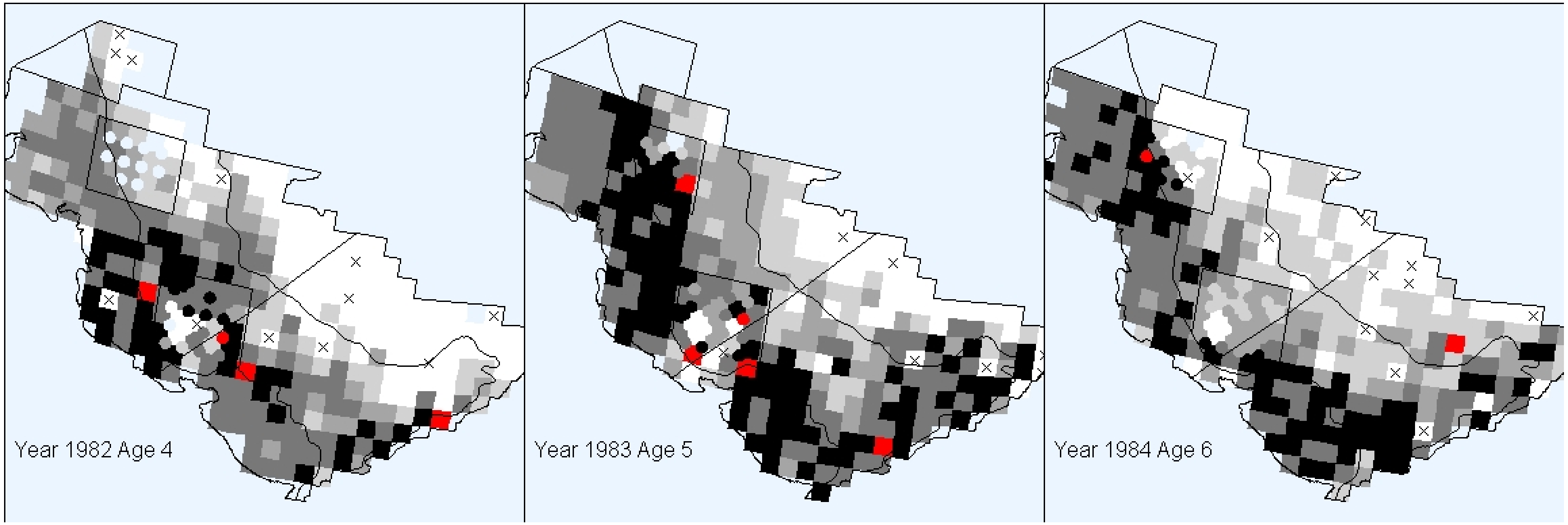
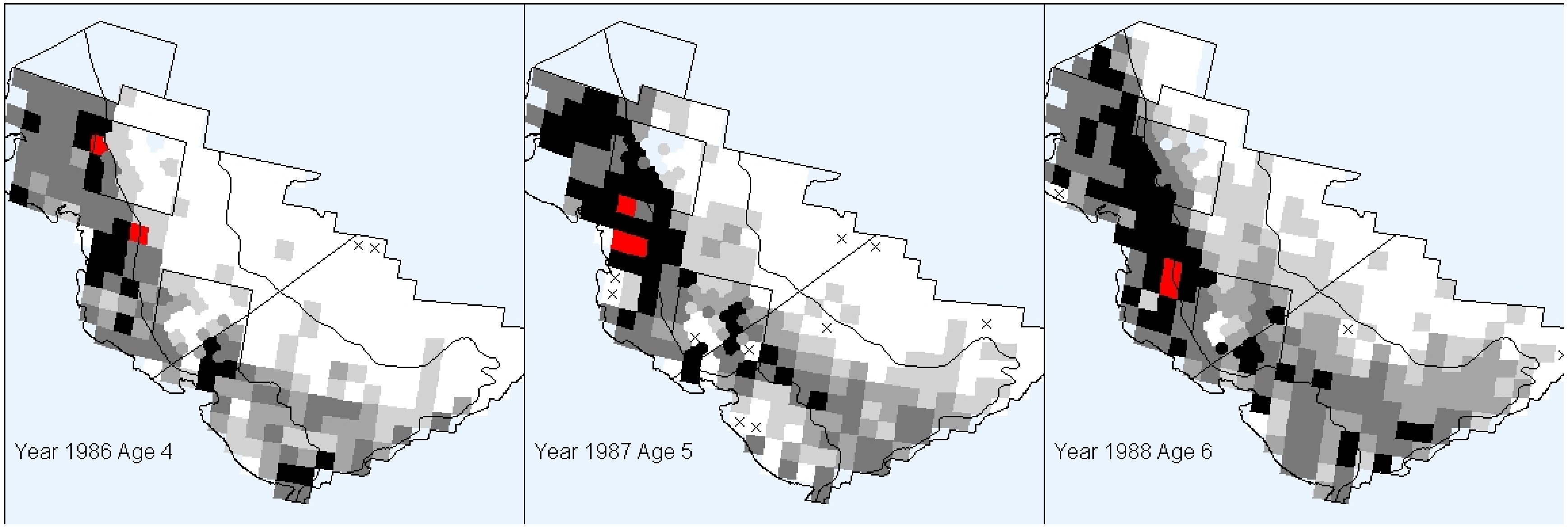
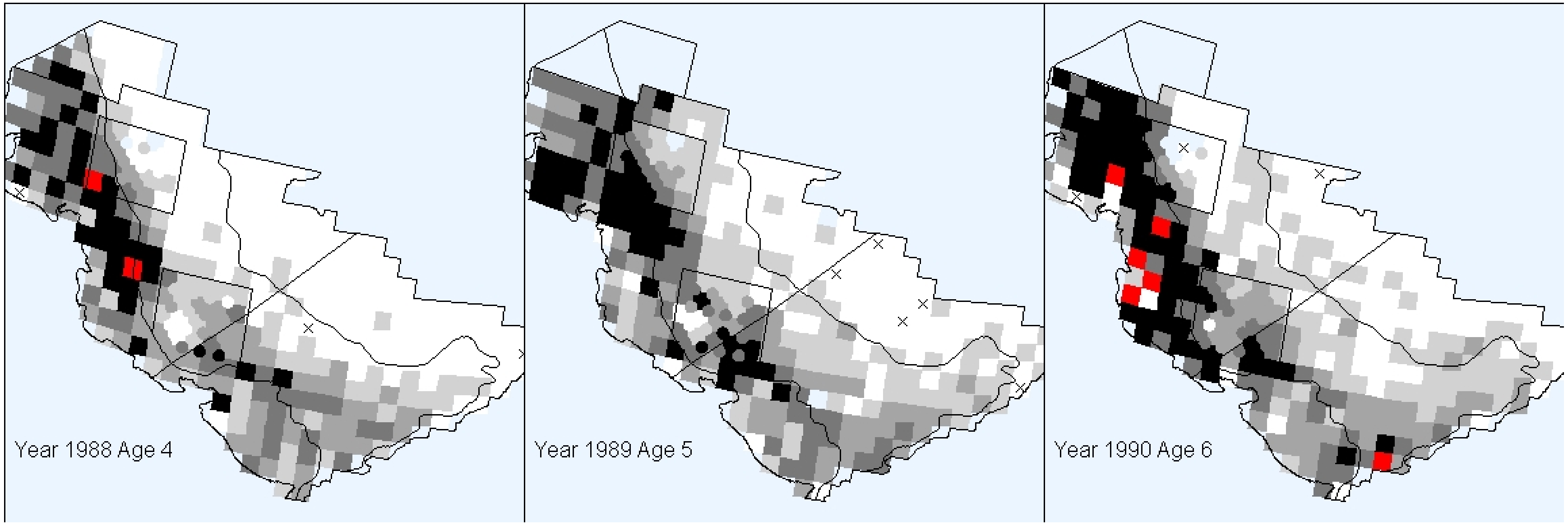
78 yearclass, ages 4-6 (a "SE" yearclass)



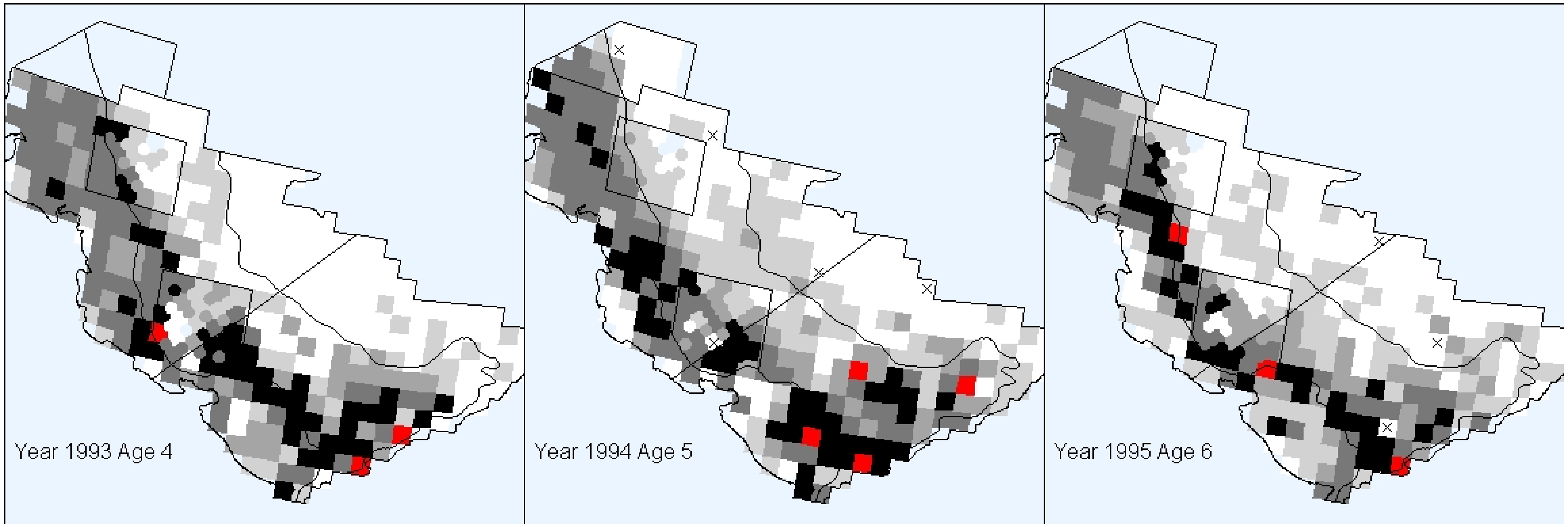
82 yearclass, ages 4-6 (a "NW" yearclass)

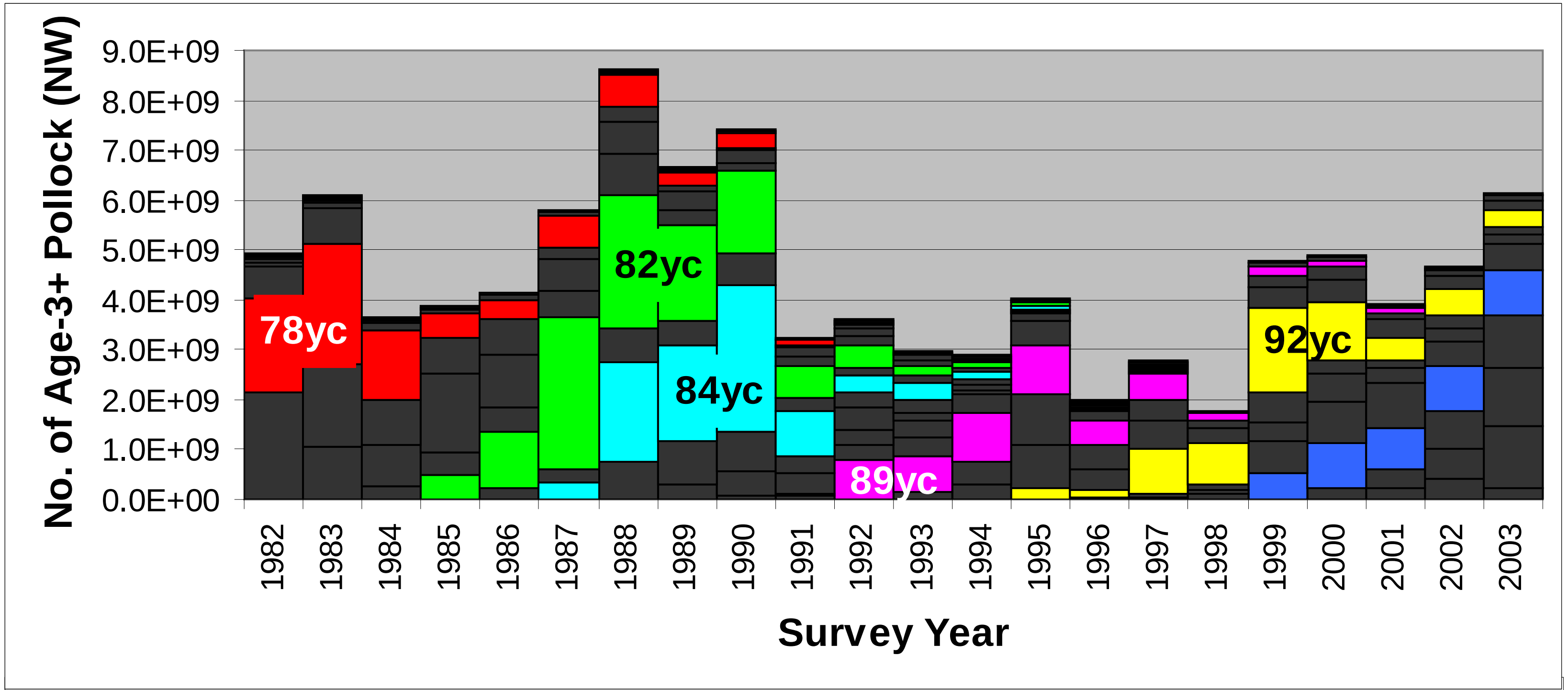


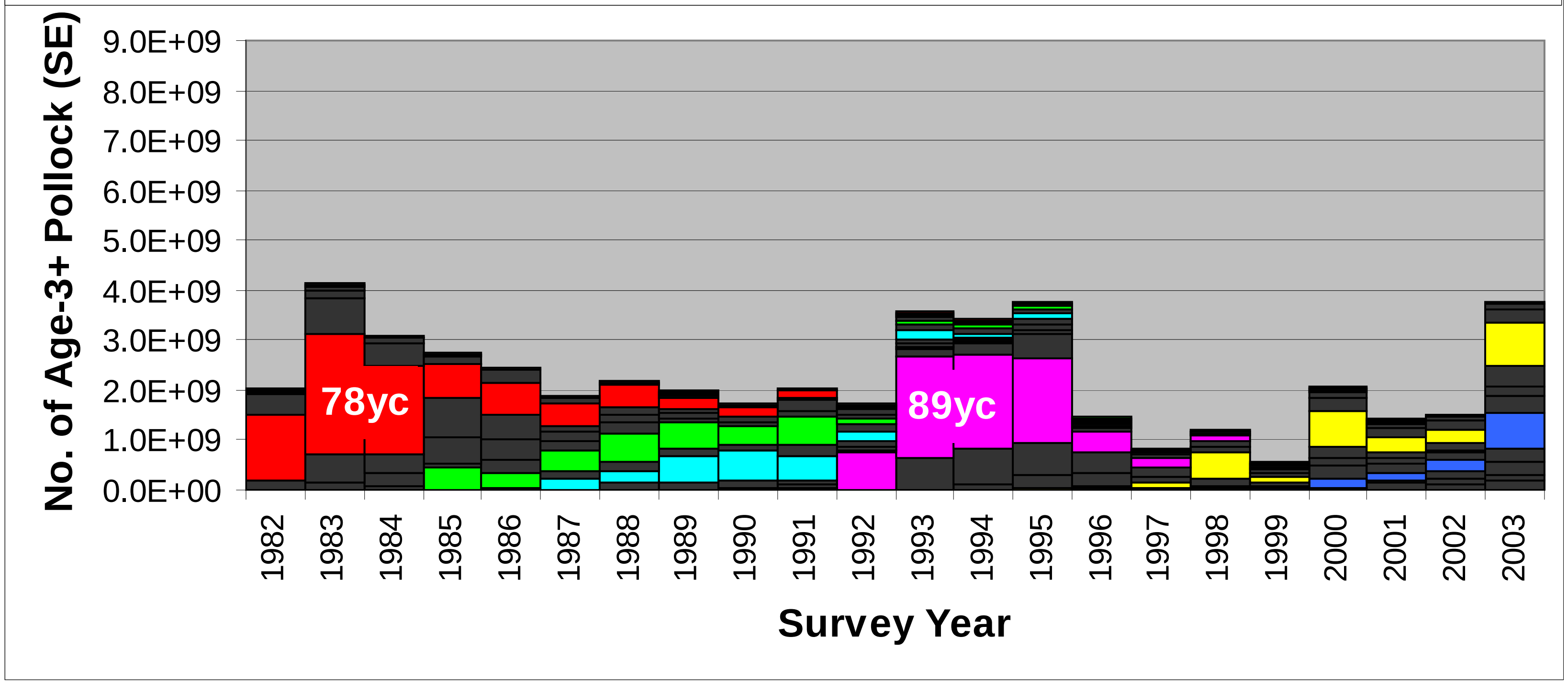
84 yearclass, ages 4-6 (a "NW" yearclass)

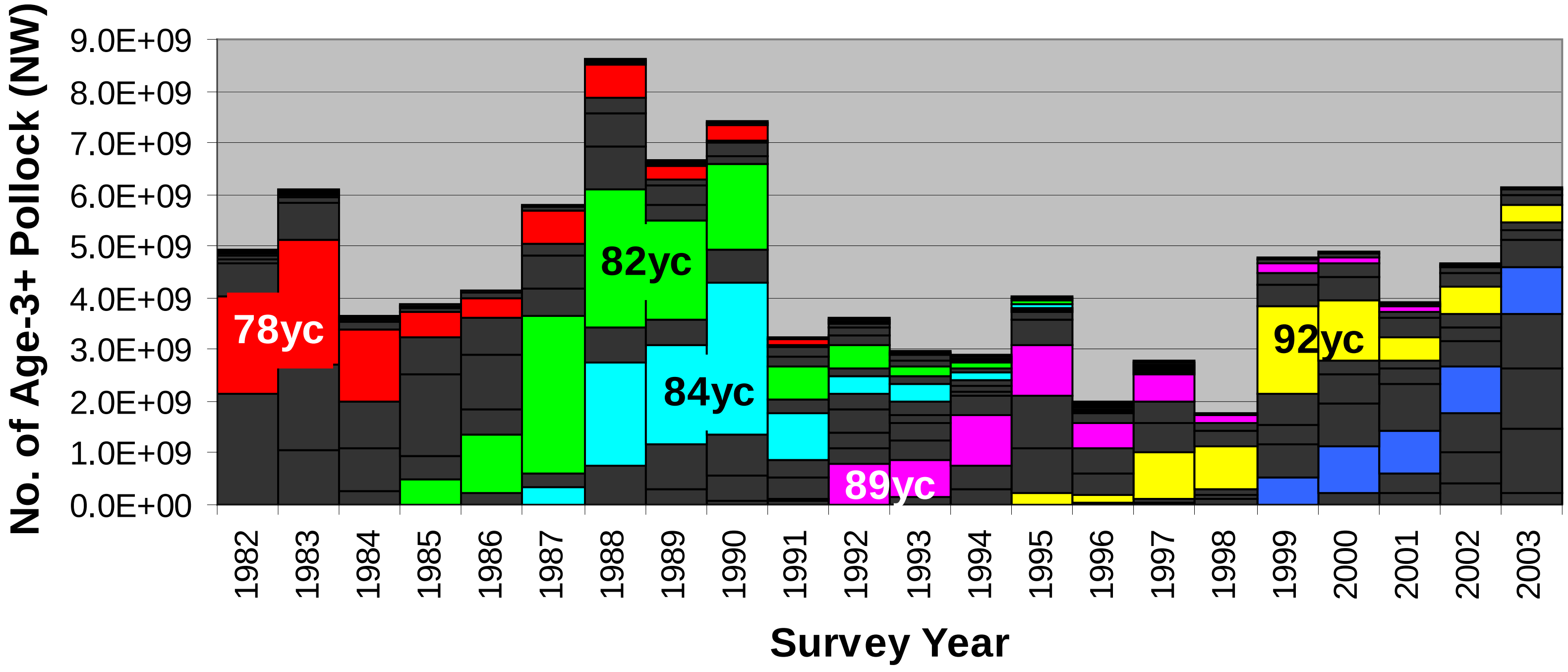


89 yearclass, ages 4-6 (a "SE" yearclass)

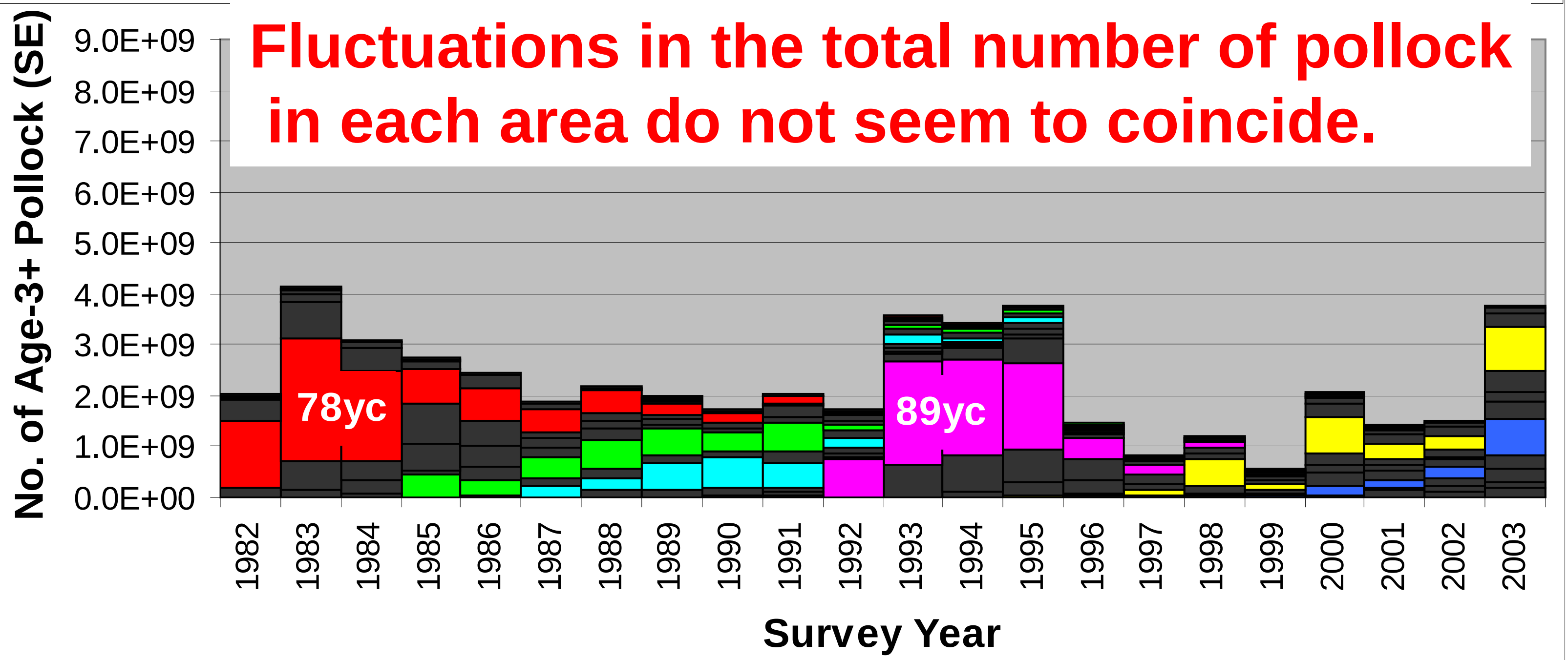


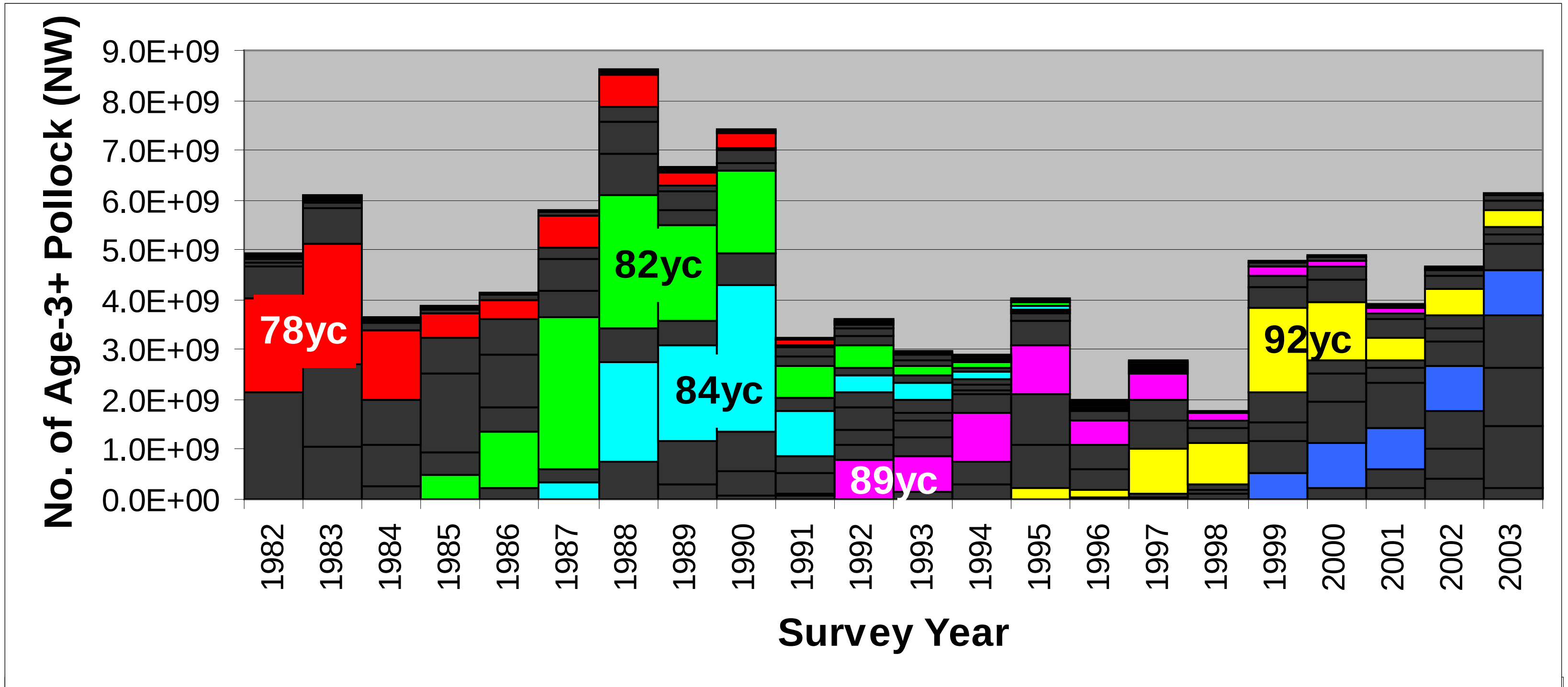

No. of Age-3+ Pollock (NW)
9.0E+09
8.0E+09
7.0E+09
6.0E+09
5.0E+09
4.0E+09
3.0E+09
2.0E+09
1.0E+09
0.0E+00
78yc
82yc
84yc
89yc
92yc
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Survey Year


No. of Age-3+ Pollock (SE)
9.0E+09
8.0E+09
7.0E+09
6.0E+09
5.0E+09
4.0E+09
3.0E+09
2.0E+09
1.0E+09
0.0E+00
78yc
89yc
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Survey Year

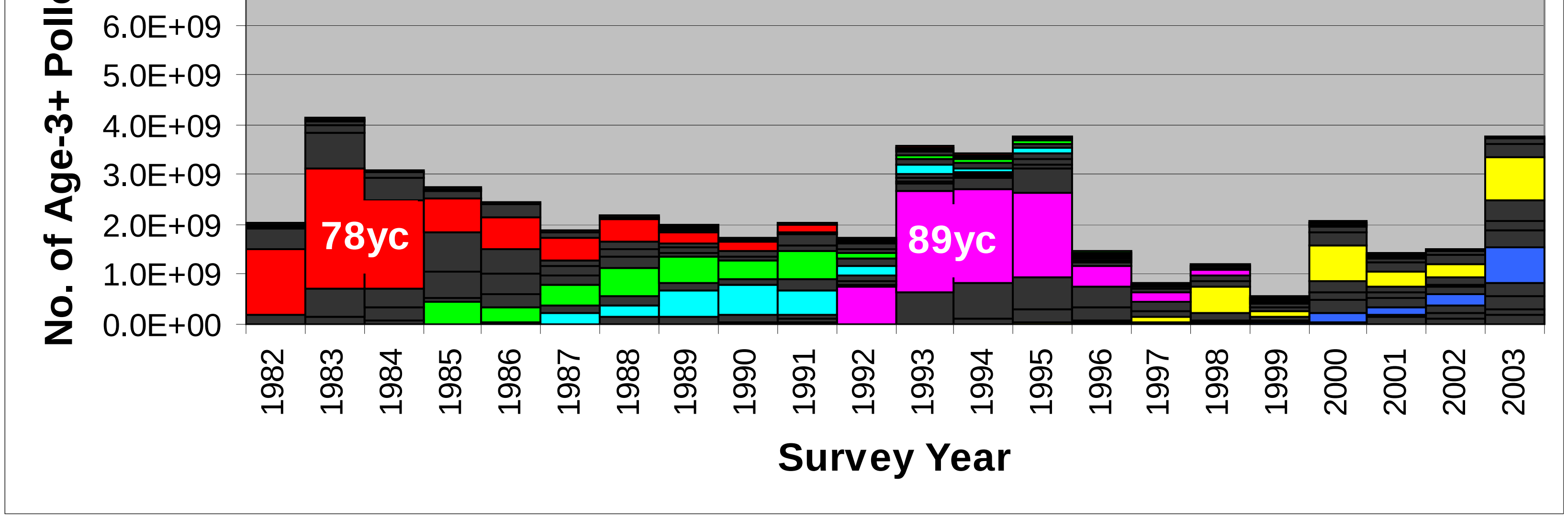


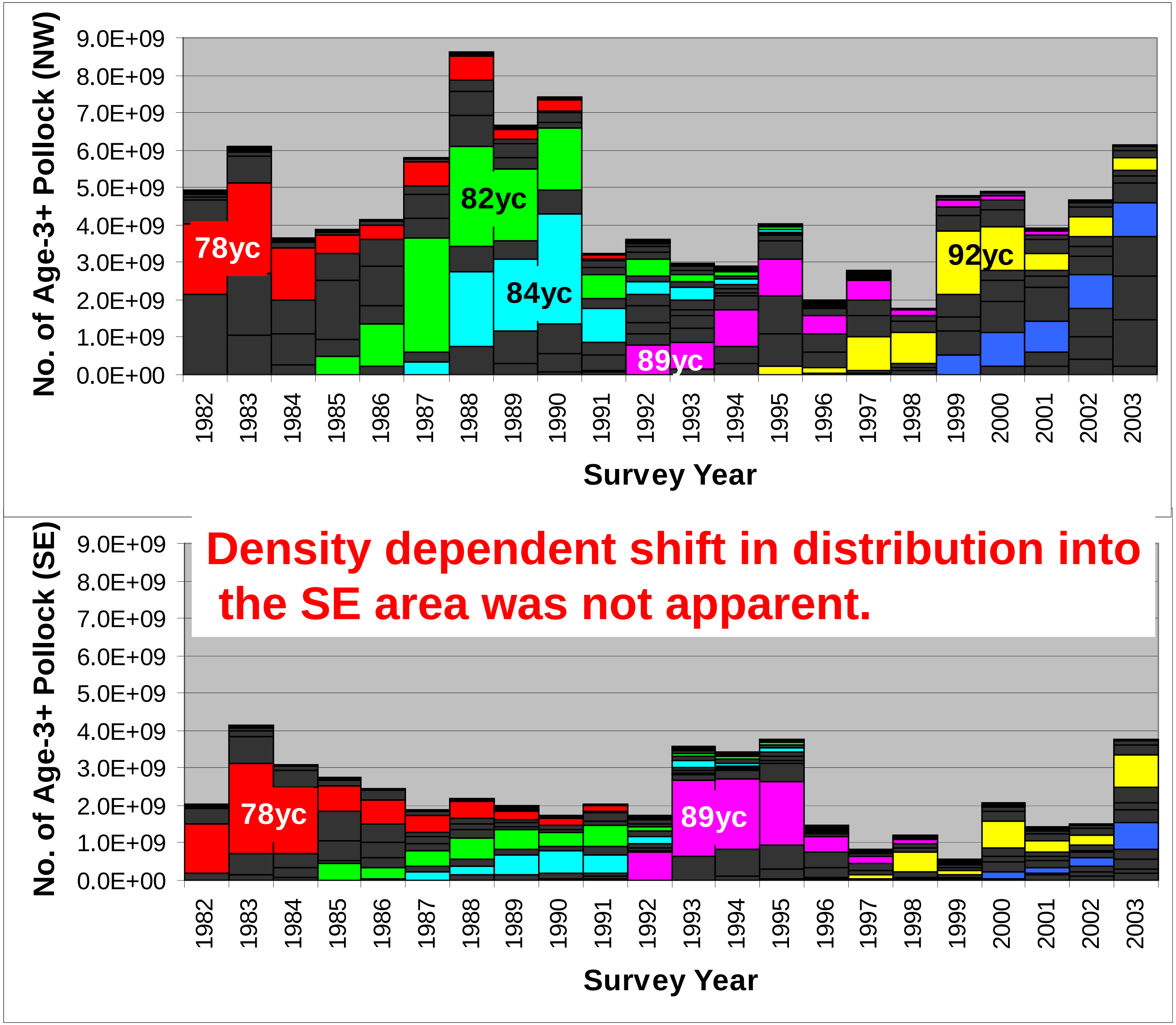
Fluctuations in the total number of pollock in each area do not seem to coincide.





Recruitment of the 82 and 84 yearclasses was very strong in the NW, but not the SE.



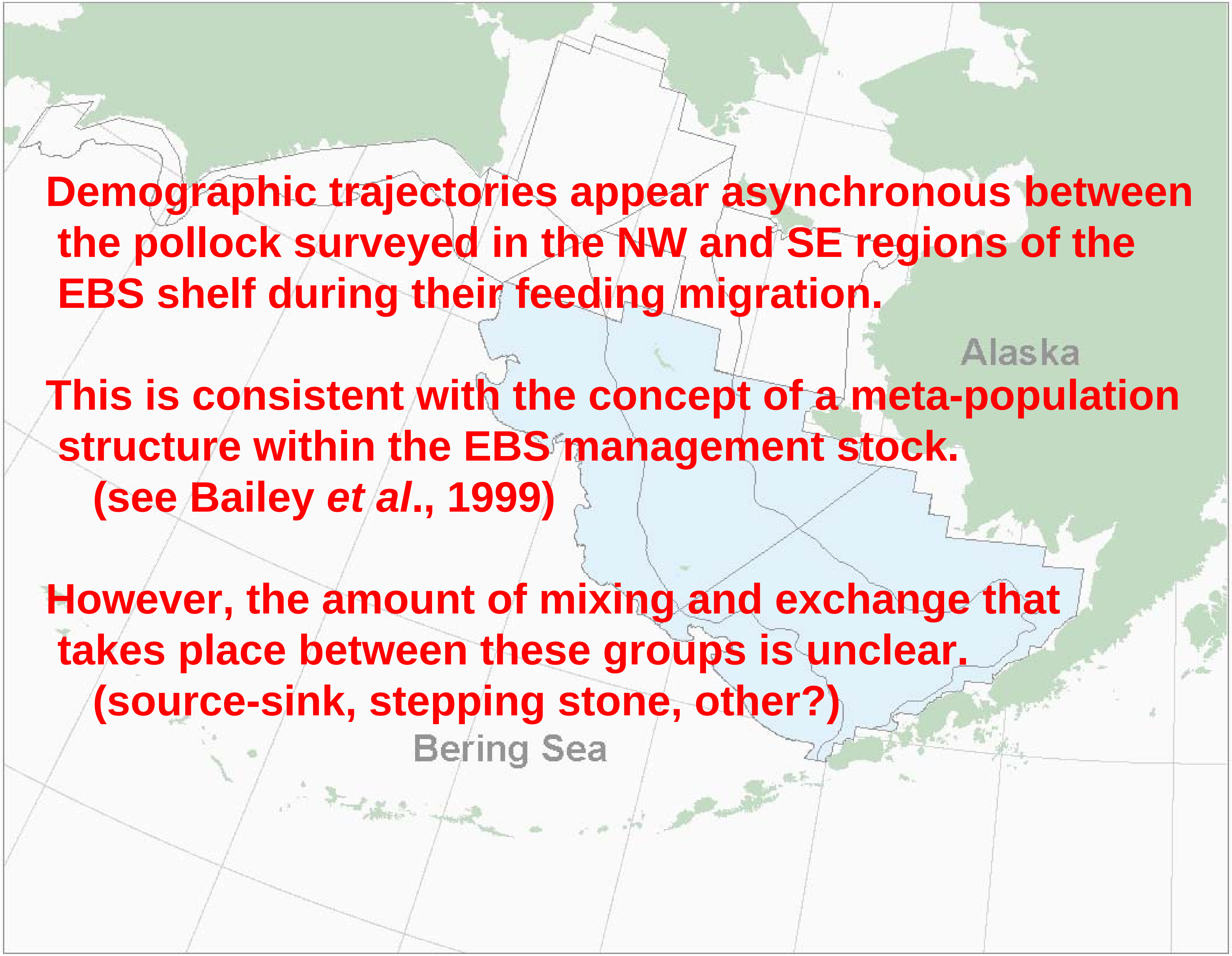


No. of Age-3+ Pollock (NW)
9.0E+09
8.0E+09
7.0E+09
6.0E+09
5.0E+09
4.0E+09
3.0E+09
2.0E+09
1.0E+09
0.0E+00
78yc
82yc
84yc
89yc
92yc
1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Survey Year
Density dependent shift in distribution into the SE area was not apparent.
No. of Age-3+ Pollock (SE)
9.0E+09
8.0E+09
7.0E+09
6.0E+09
5.0E+09
4.0E+09
3.0E+09
2.0E+09
1.0E+09
0.0E+00
78yc
89yc
1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Survey Year

Demographic trajectories appear asynchronous between the pollock surveyed in the NW and SE regions of the EBS shelf during their feeding migration.

This is consistent with the concept of a meta-population structure within the EBS management stock.
(see Bailey *et al*., 1999)

However, the amount of mixing and exchange that takes place between these groups is unclear.
(source-sink, stepping stone, other?)



FUTURE DIRECTIONS

We have presented data for two convenient geographic areas that may not fully represent biological units.

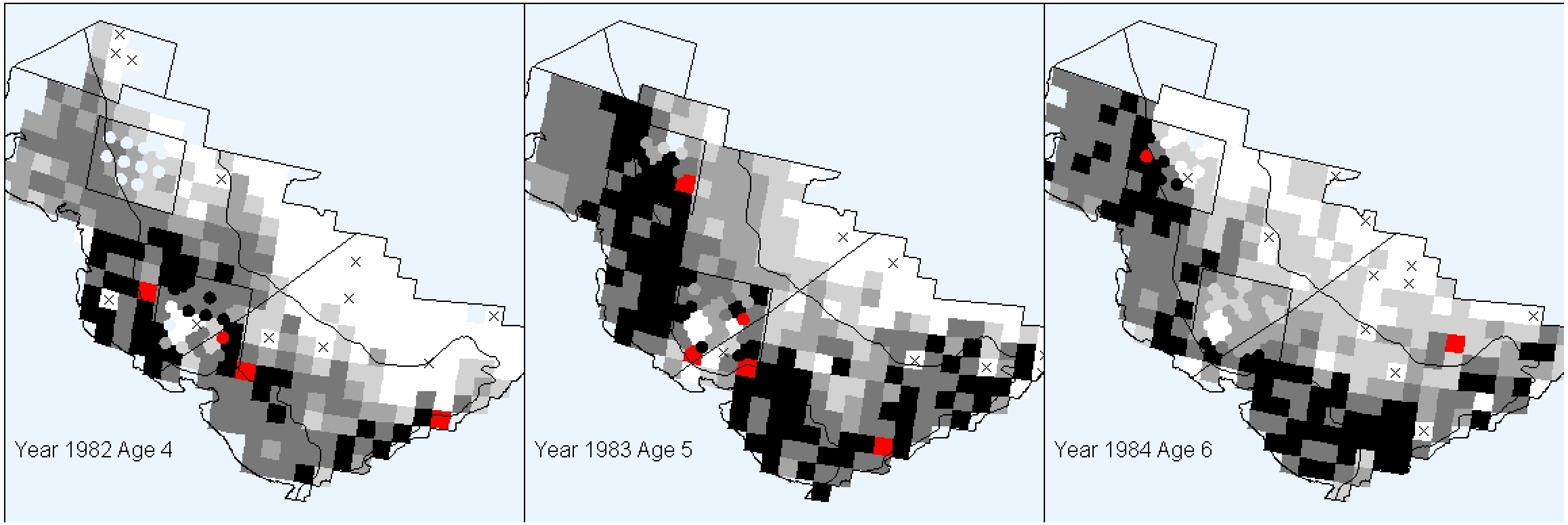
Identifying groups or clusters that persist or are repeated by multiple yearclasses is one approach. Hydroacoustic survey and fishery data should also be incorporated.

But consistent oceanographic features can also create some clustering and patterns.

We think following the distribution of yearclasses over time is important, but other approaches are also needed.

GENETIC STUDIES

78 yearclass, ages 4-6



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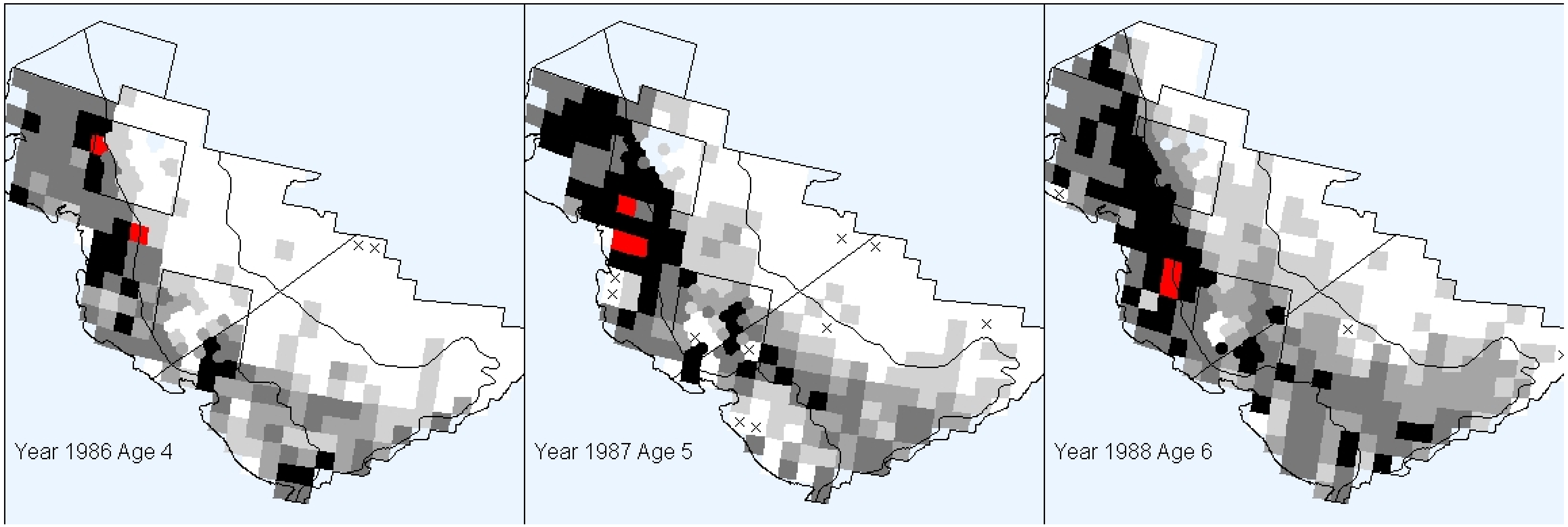
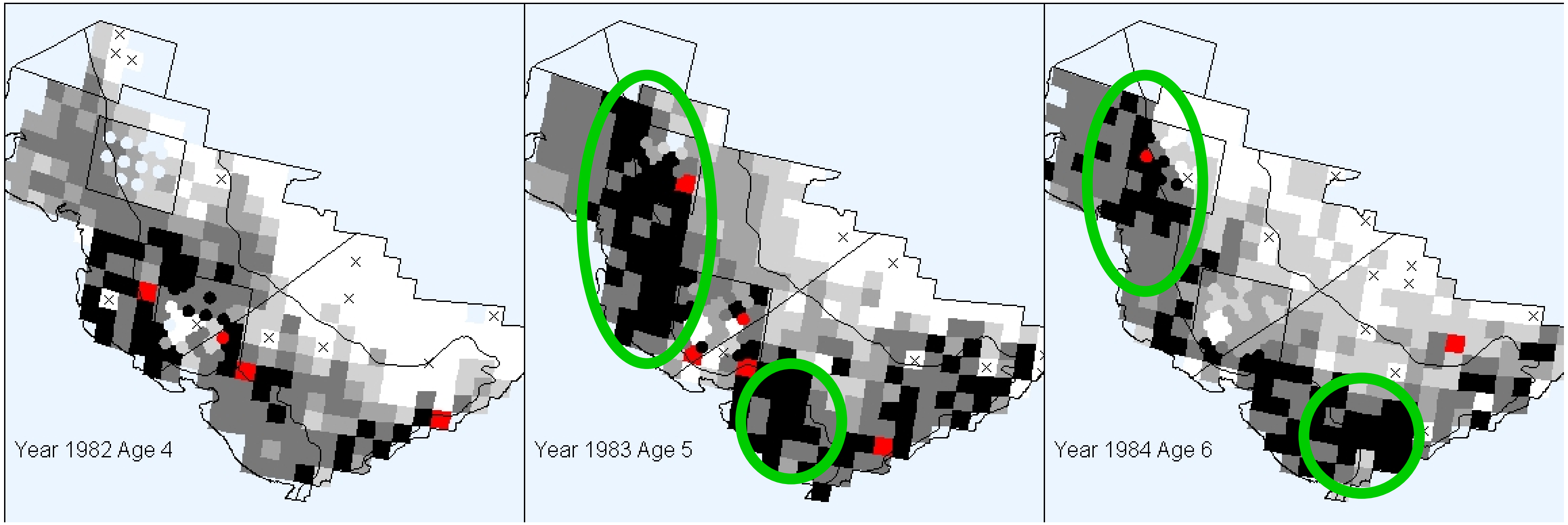
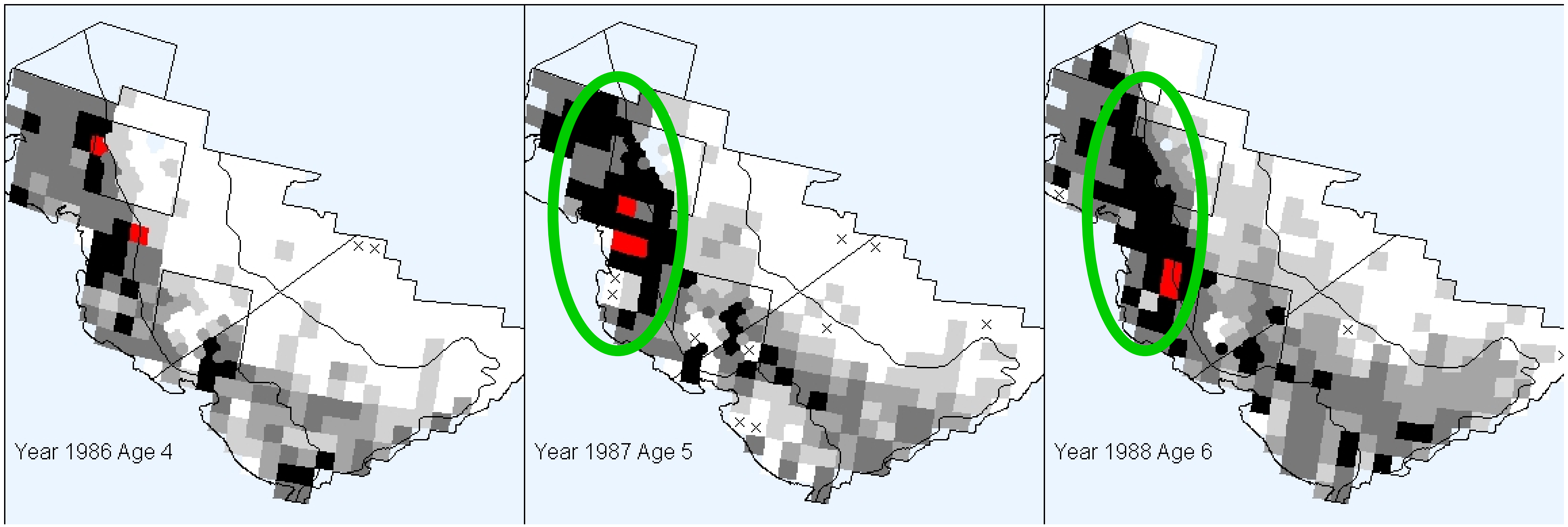


78 yearclass, ages 4-6

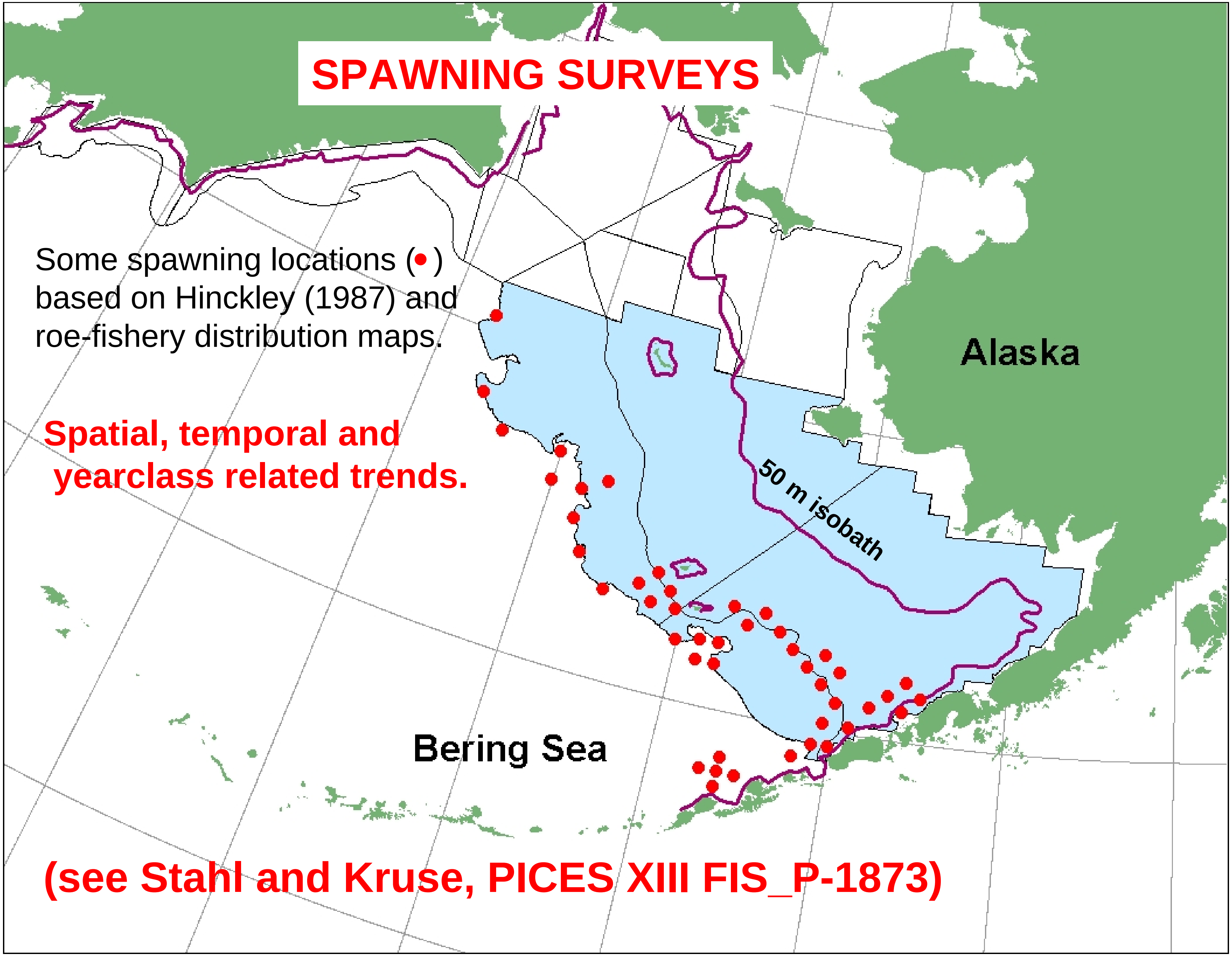
GENETIC STUDIES (otoliths?)



82 yearclass, ages 4-6



SPAWNING SURVEYS

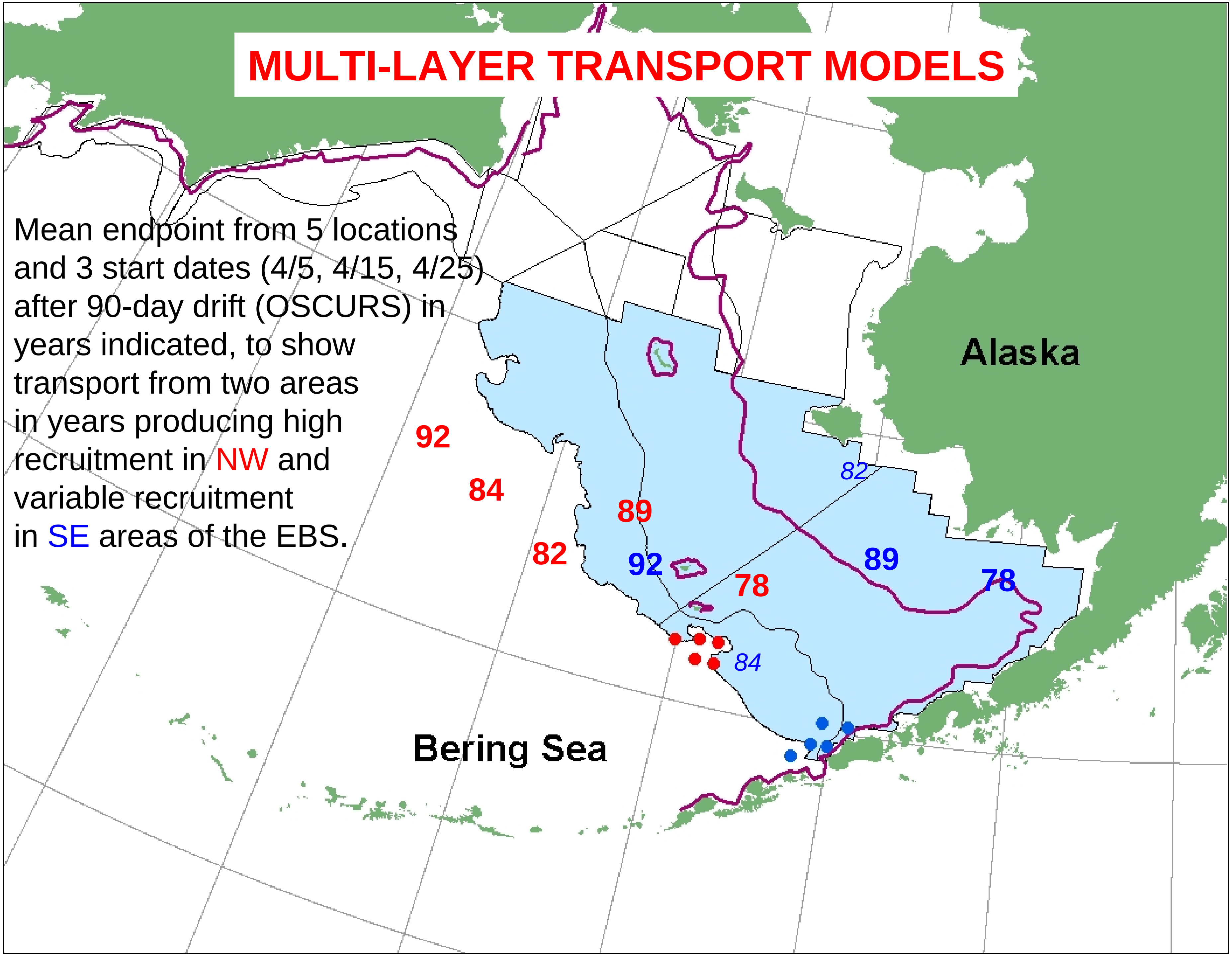


Some spawning locations (•) based on Hinckley (1987) and roe-fishery distribution maps.

Spatial, temporal and yearclass related trends.

(see Stahl and Kruse, PICES XIII FIS_P-1873)

MULTI-LAYER TRANSPORT MODELS

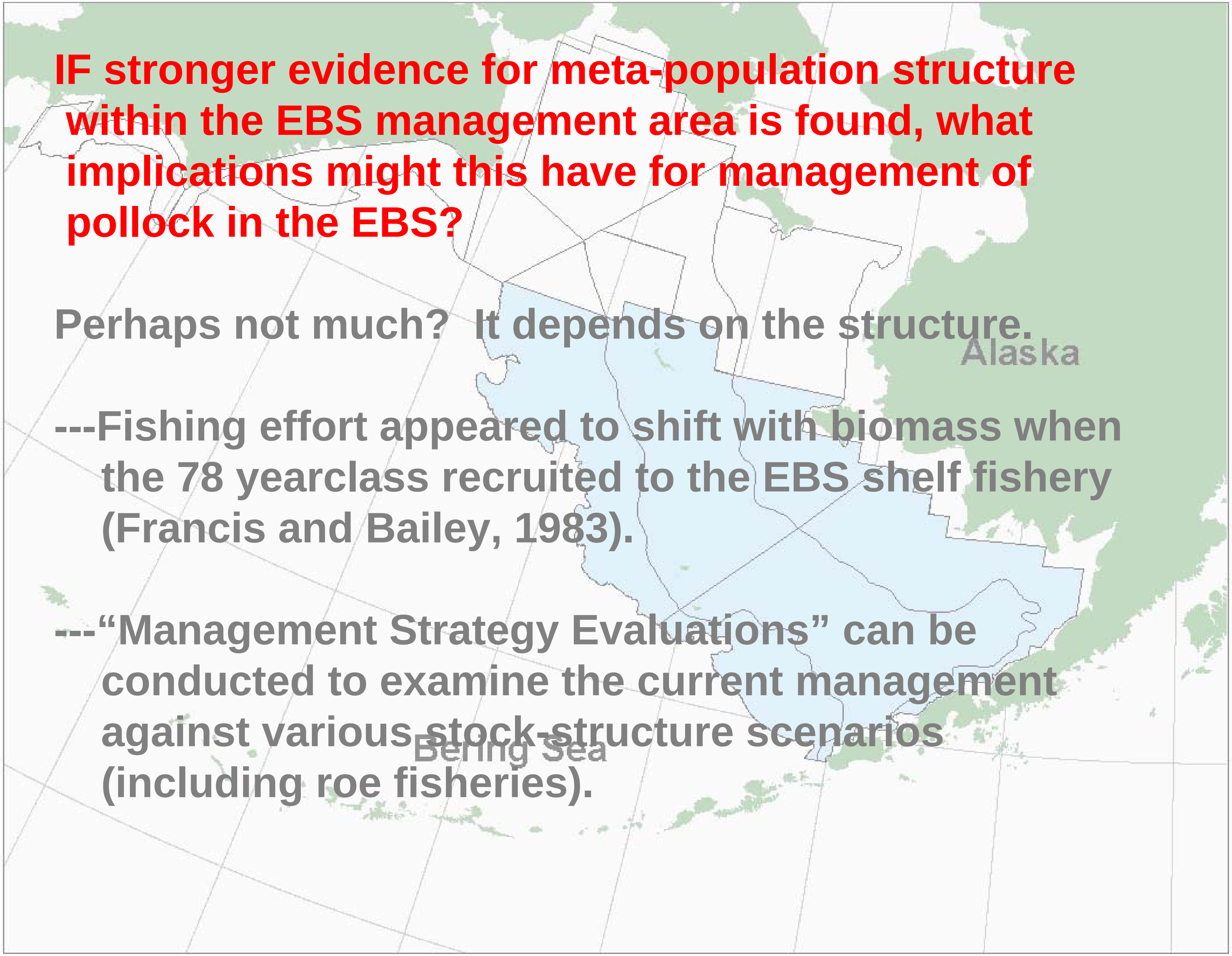


IF stronger evidence for meta-population structure within the EBS management area is found, what implications might this have for management of pollock in the EBS?

Perhaps not much? It depends on the structure.

---Fishing effort appeared to shift with biomass when the 78 yearclass recruited to the EBS shelf fishery (Francis and Bailey, 1983).

---"Management Strategy Evaluations" can be conducted to examine the current management against various stock-structure scenarios (including roe fisheries).



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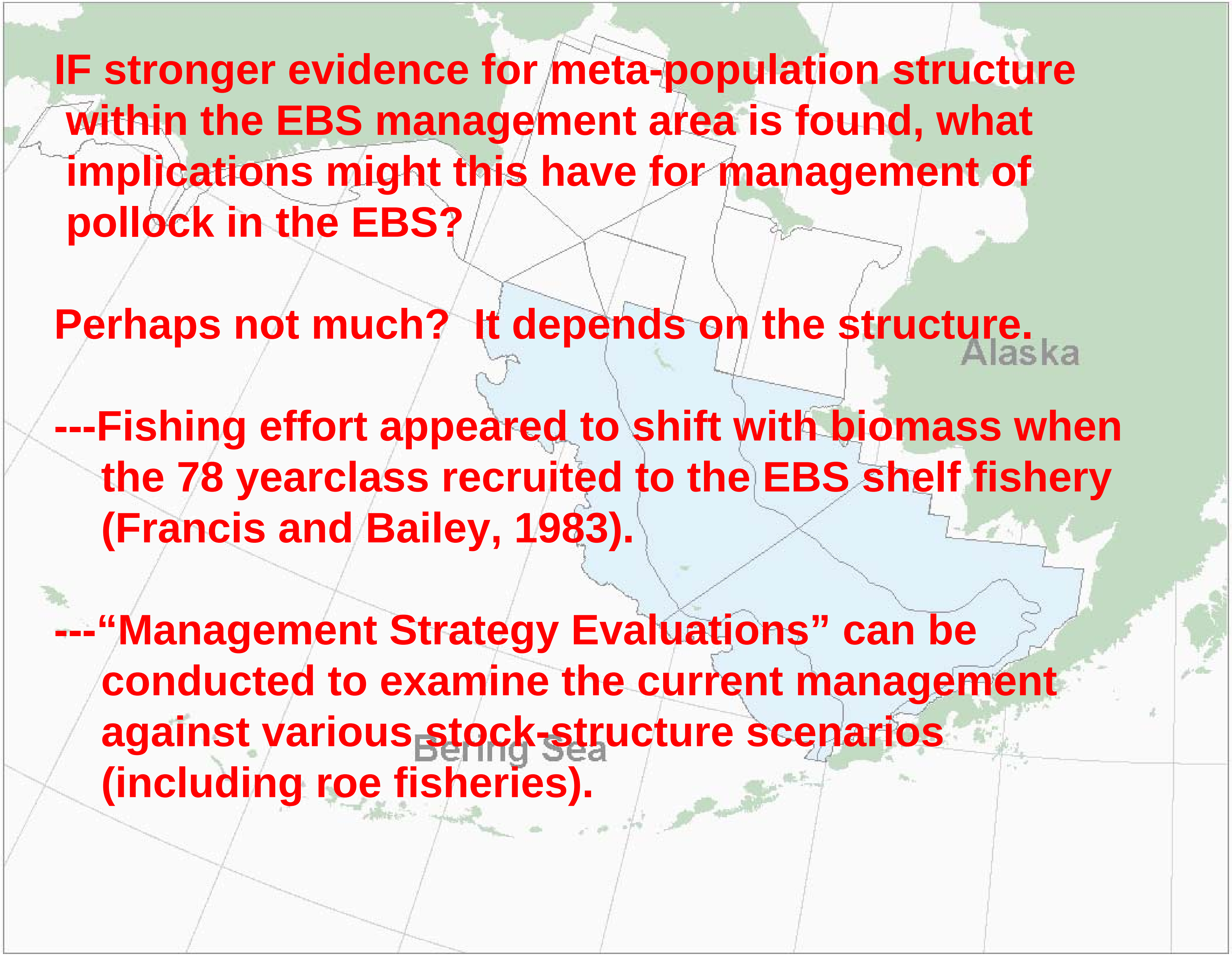
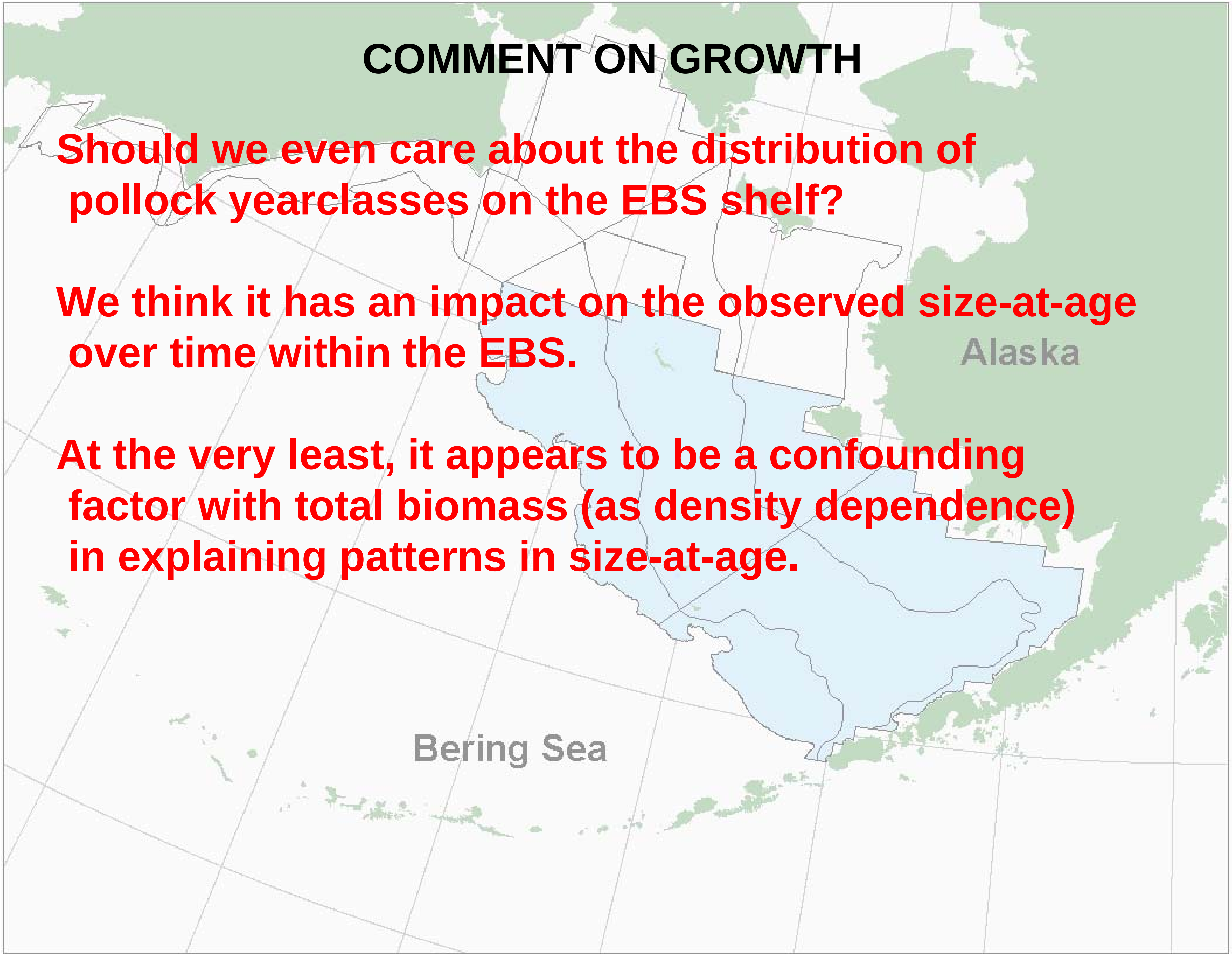


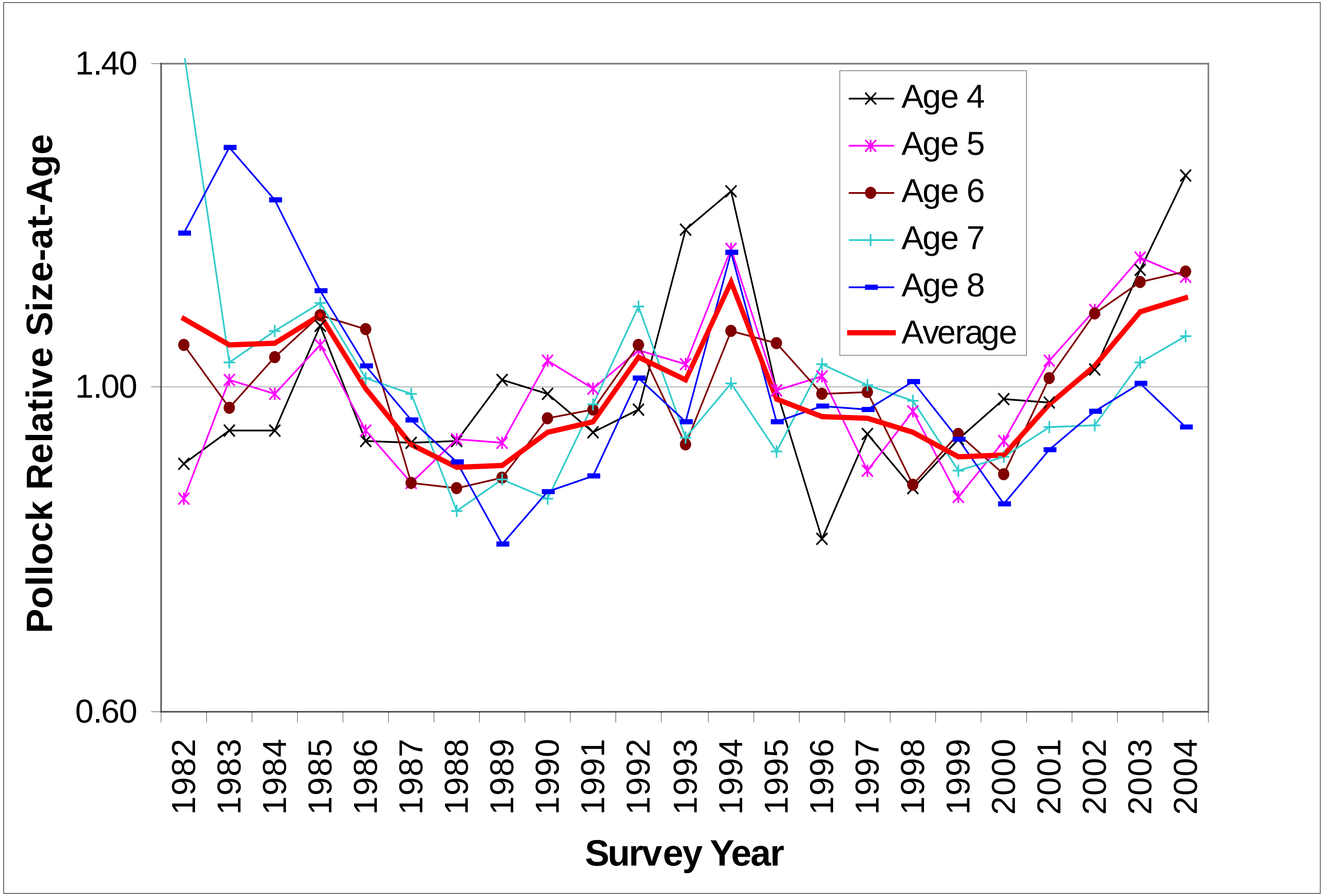
COMMENT ON GROWTH

Should we even care about the distribution of pollock yearclasses on the EBS shelf?

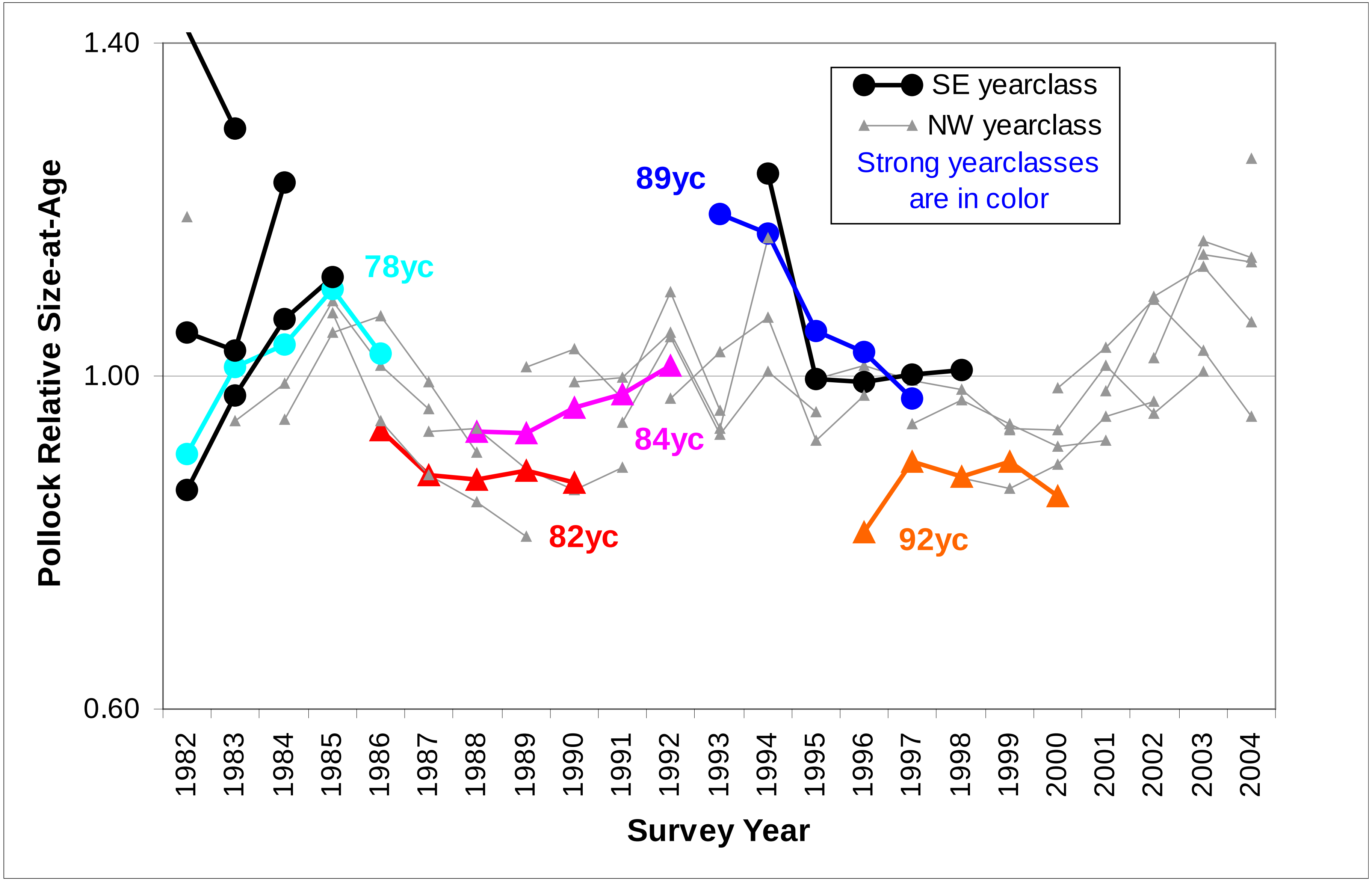
We think it has an impact on the observed size-at-age over time within the EBS.

At the very least, it appears to be a confounding factor with total biomass (as density dependence) in explaining patterns in size-at-age.





(based on data from Stock Assessment, from J. Ianelli)



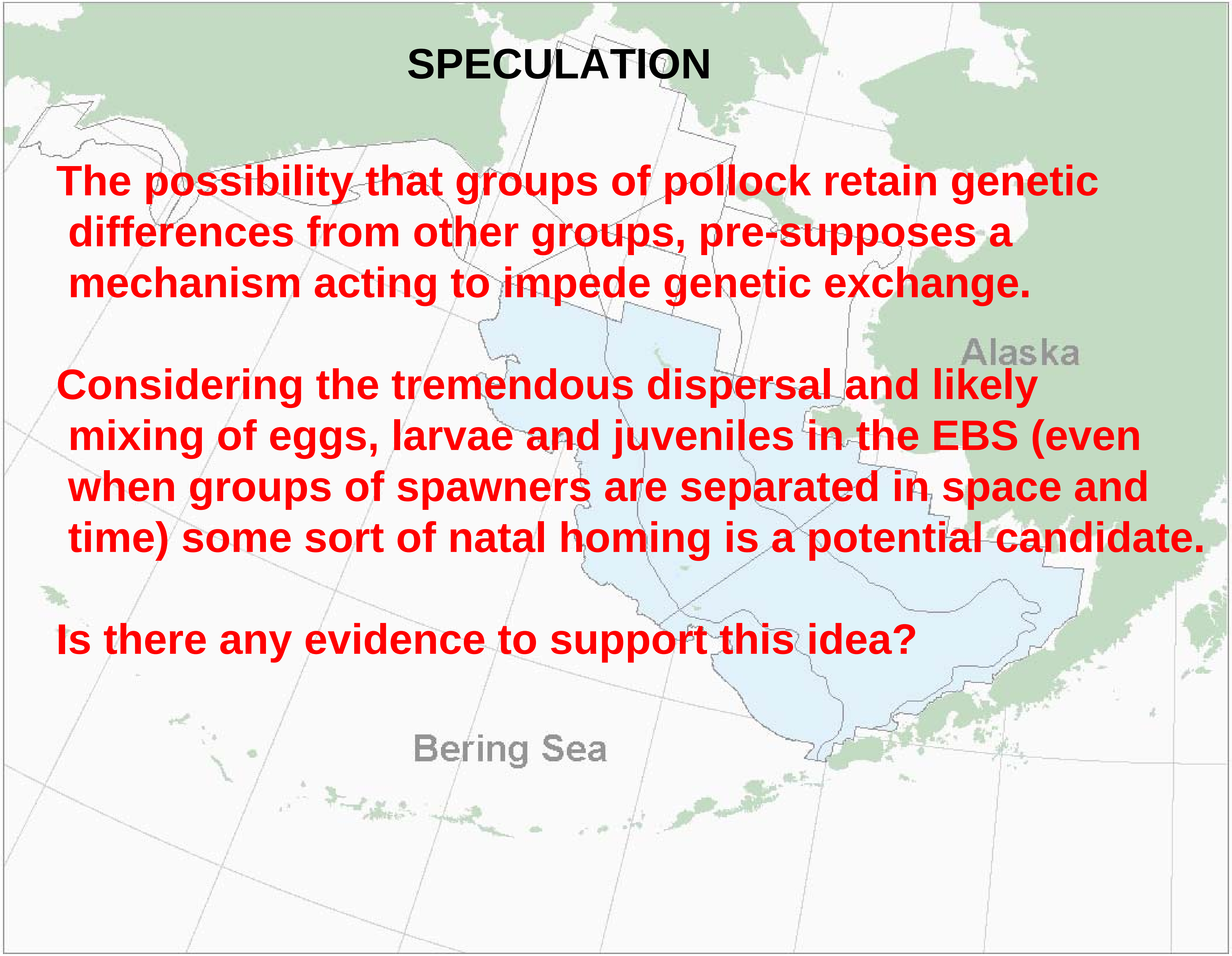
Pollock Relative Size-at-Age
1.40
1.00
0.60
Survey Year
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
SE yearclass
NW yearclass
Strong yearclasses are in color
78yc
82yc
84yc
89yc
92yc

SPECULATION

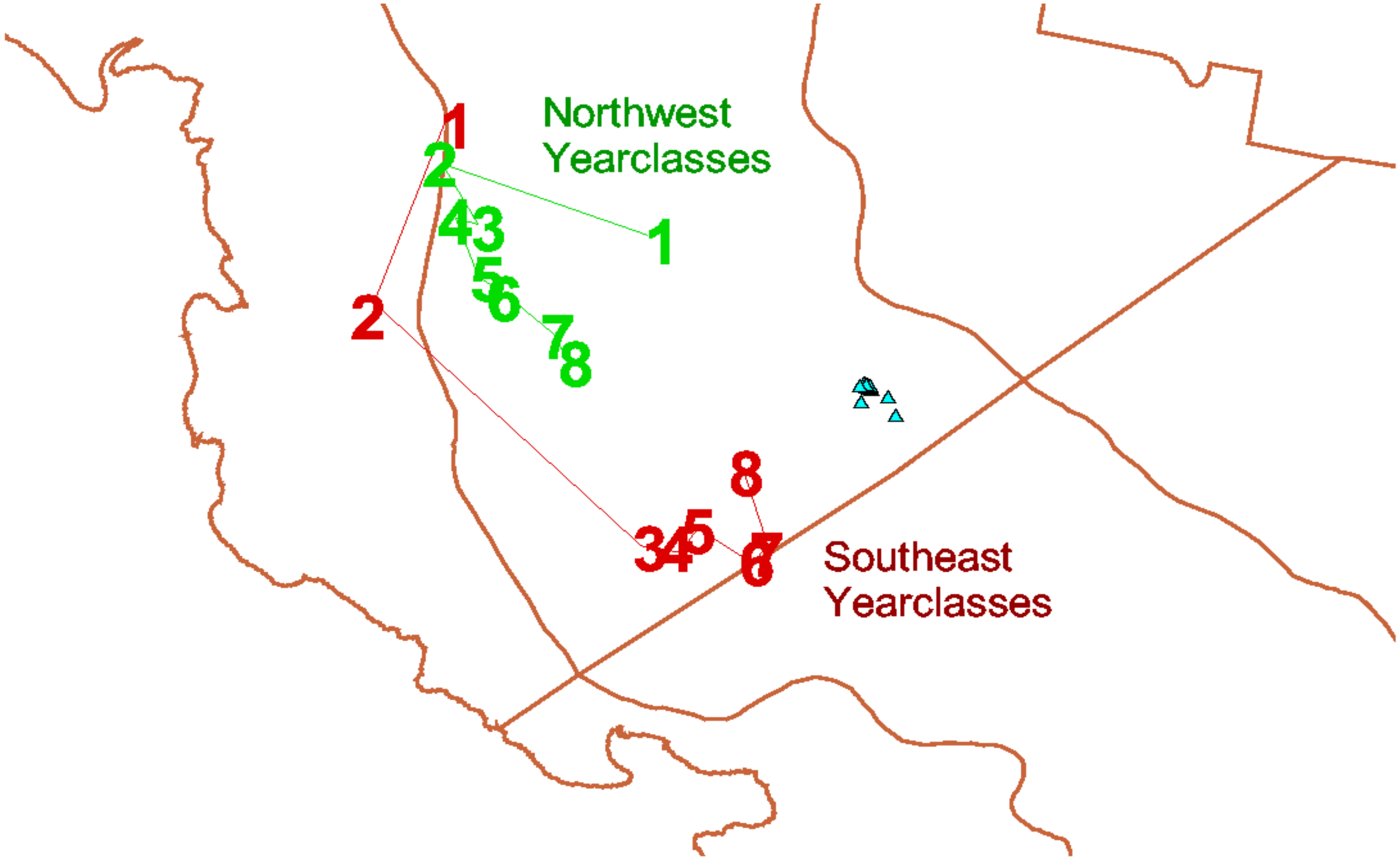
The possibility that groups of pollock retain genetic differences from other groups, pre-supposes a mechanism acting to impede genetic exchange.

Considering the tremendous dispersal and likely mixing of eggs, larvae and juveniles in the EBS (even when groups of spawners are separated in space and time) some sort of natal homing is a potential candidate.

Is there any evidence to support this idea?



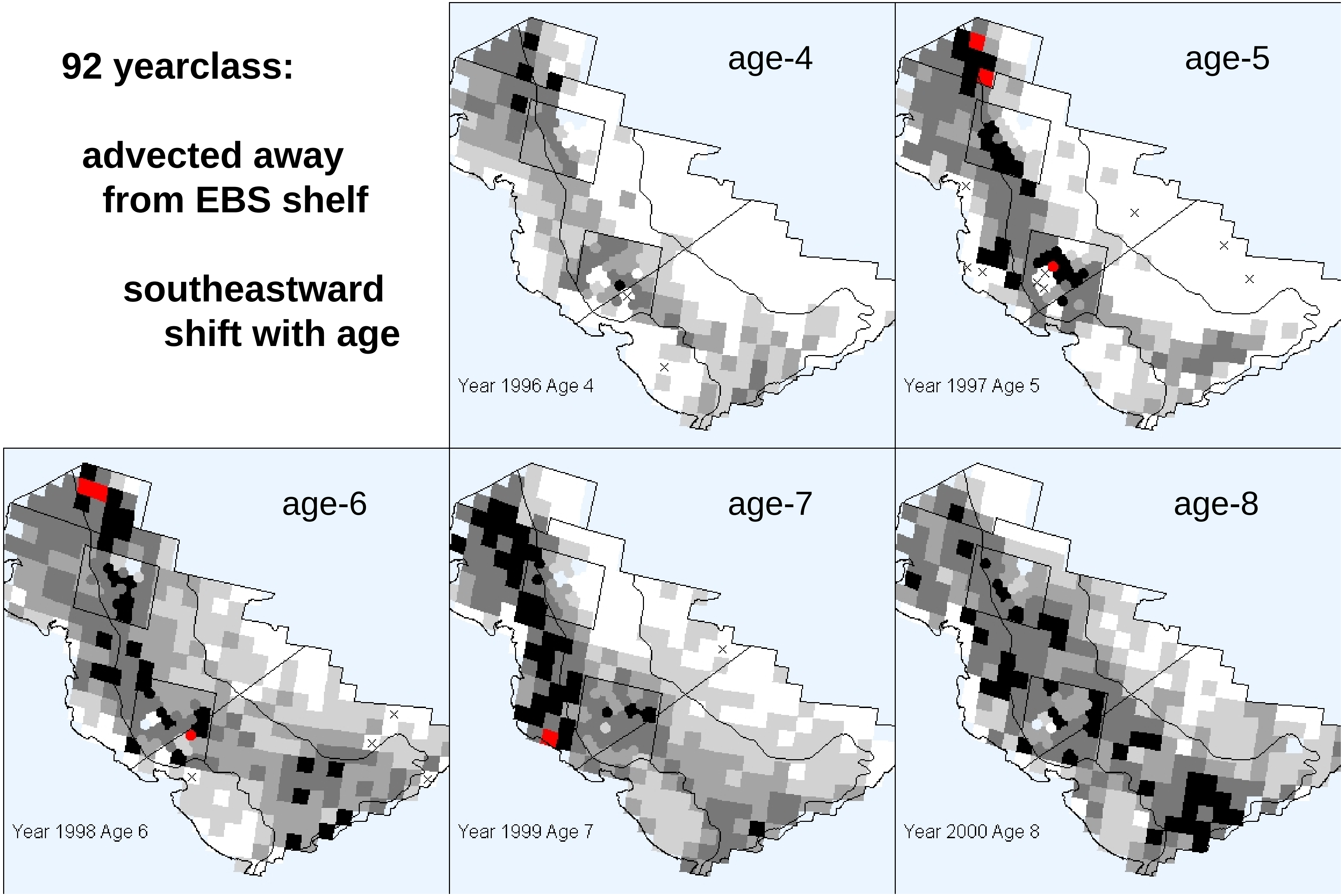
Mean centroids of pollock abundance by age within the EBS bottom trawl survey area for "NW" and "SE" yearclasses. NOTE: most separation occurs near onset of maturity (age 3).



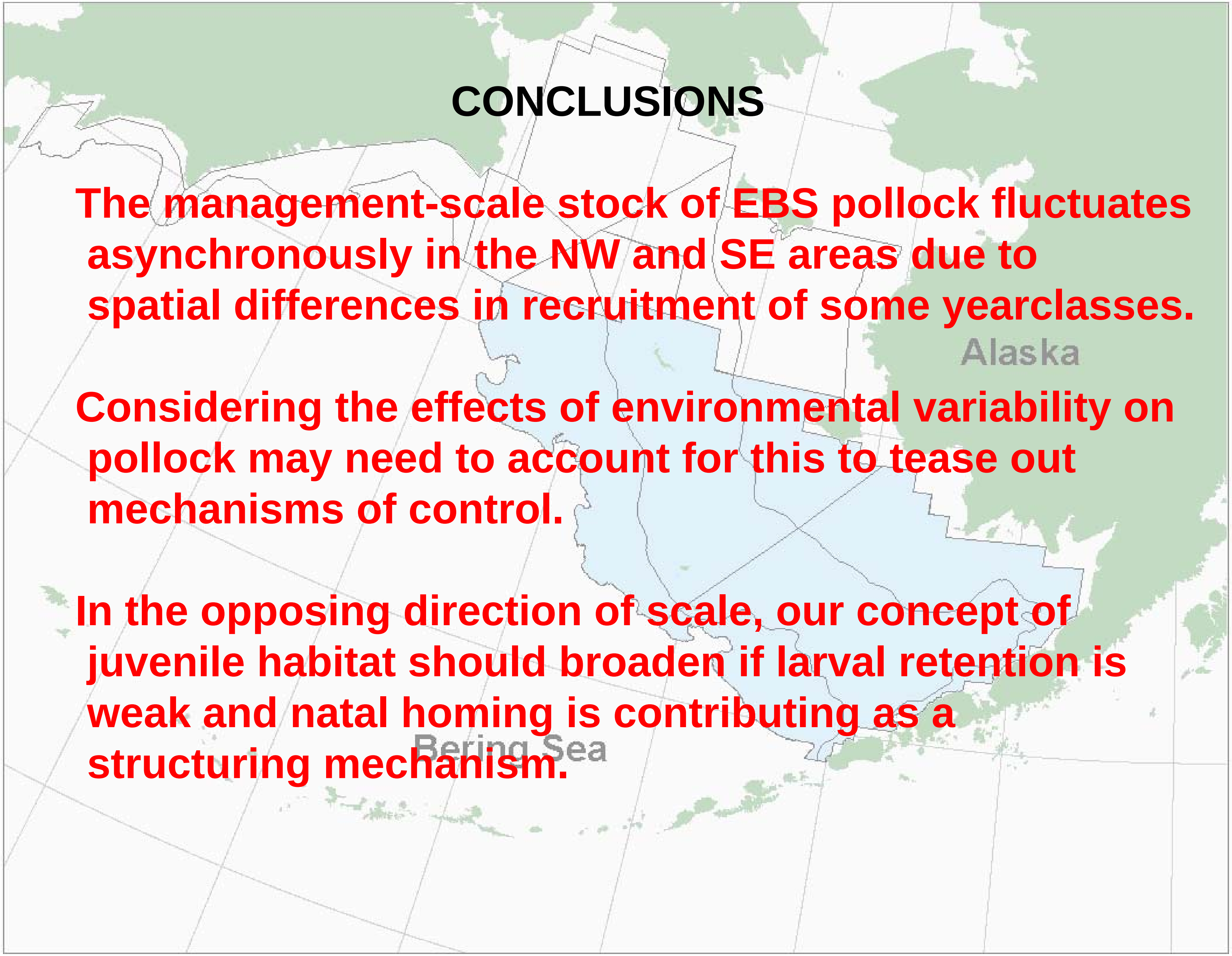
92 yearclass:

advected away from EBS shelf

southeastward shift with age



CONCLUSIONS



The management-scale stock of EBS pollock fluctuates asynchronously in the NW and SE areas due to spatial differences in recruitment of some yearclasses.

Considering the effects of environmental variability on pollock may need to account for this to tease out mechanisms of control.

In the opposing direction of scale, our concept of juvenile habitat should broaden if larval retention is weak and natal homing is contributing as a structuring mechanism.

Acknowledgements:

Jim Ianelli, Kevin Bailey, Mike Canino
Angie Greig, Jennifer Boldt