Science, Service, Stewardship

Incorporating climate variability into the assessment of Gulf of Alaska Pacific cod

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NOAA FISHERIES SERVICE

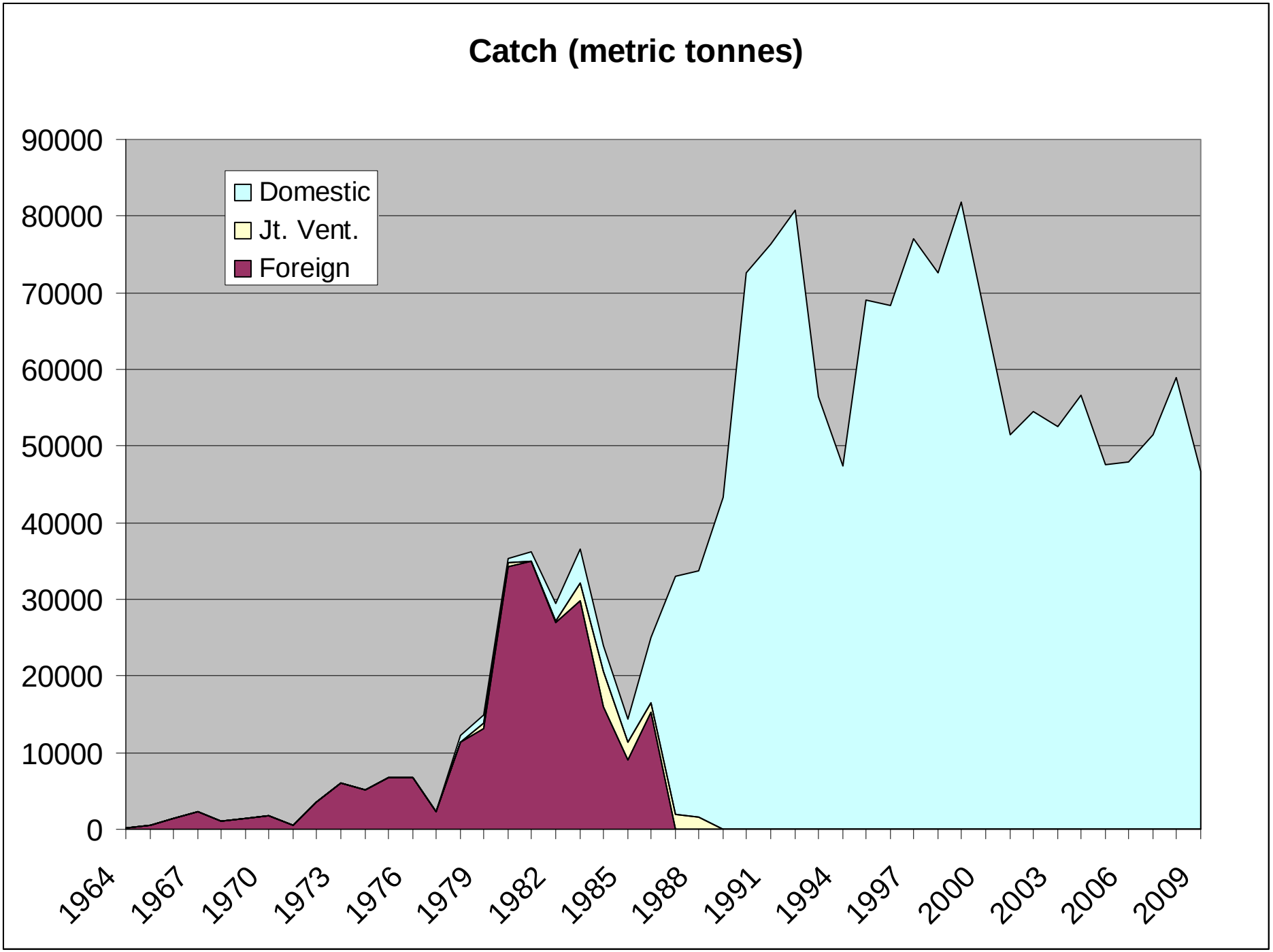
Objectives

- Develop an operating model similar to the Gulf of Alaska (GOA) Pacific cod stock assessment model
- Link local- and basin-scale environmental indices to recruitment
- Compare recruitment, stock status, biological reference points

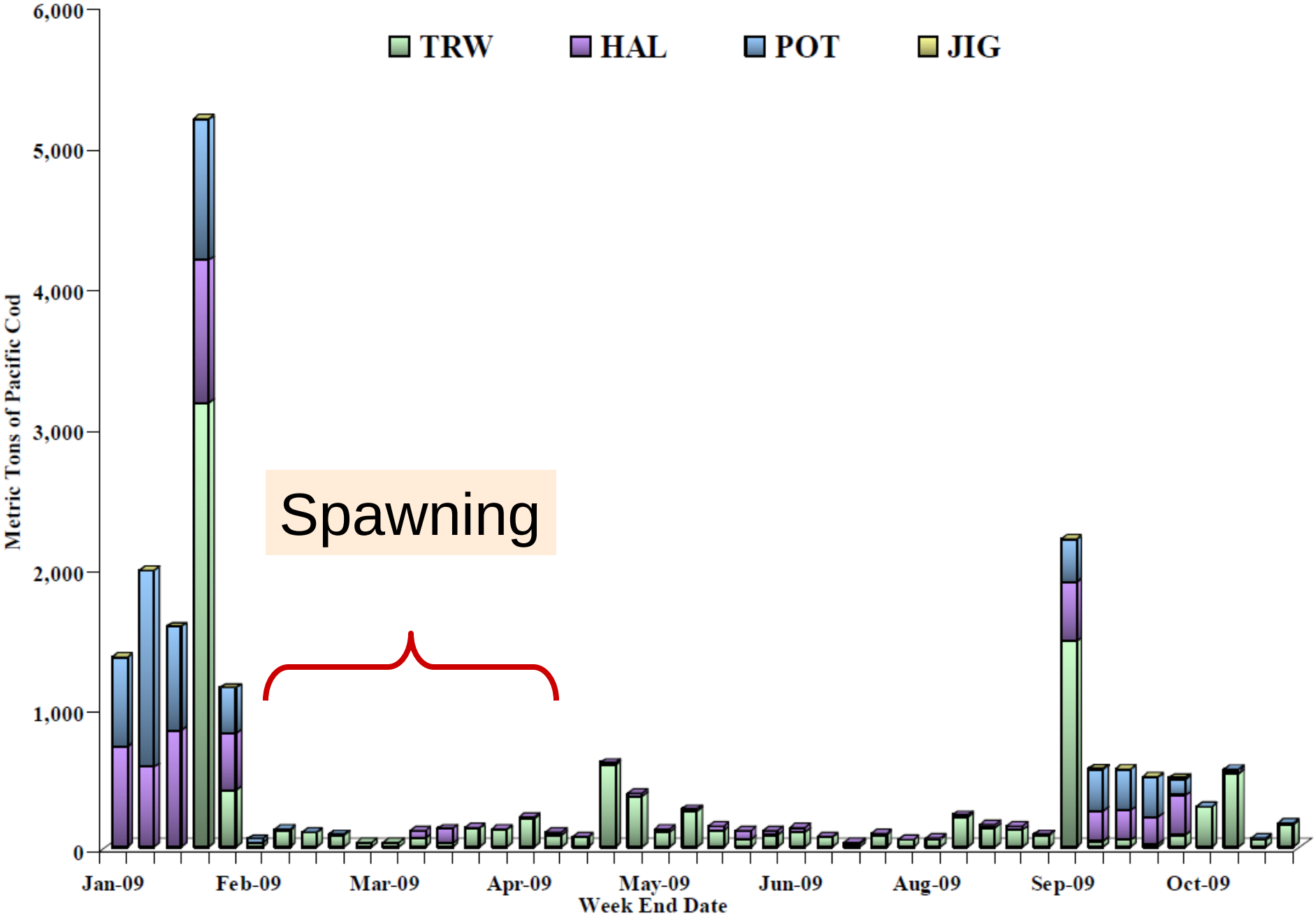
GOA Pacific cod

- The stock
  - Movement between the EBS and AI
- Spawning
  - Late winter
- Fisheries
  - 3 fishing seasons, 4 gear types
- Management
  - ABC is apportioned by season
  - MSC-certified in January 2010


GULF OF ALASKA REPORTING AREAS
ALASKA
CANADA
649
640
659
650
630
620
610
LEGEND
EASTERN GOA
649 + 640 + 659 + 650
CENTRAL GOA
620 + 630
WESTERN GOA = 610


Catch (metric tonnes)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Domestic
Jt. Vent.
Foreign
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009

2009 Central Gulf Inshore Pacific Cod Catch by Week and Gear



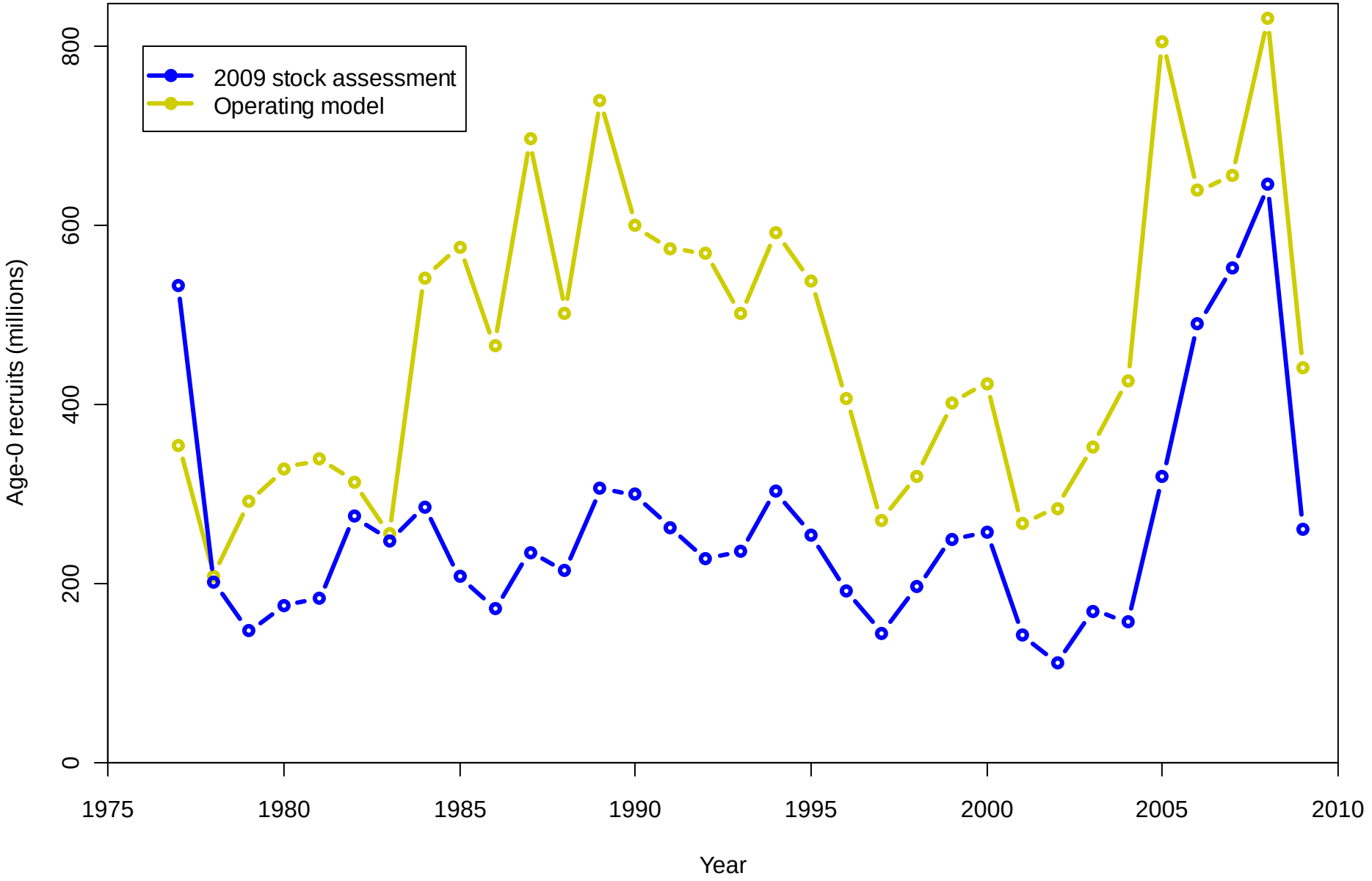
The stock assessment model

- Statistical catch-at-age population dynamics model – Stock Synthesis
- No stock-recruitment relationship
- Fit to fisheries and survey data
- Estimates time-varying catchability, selectivity, growth parameters
- Estimates stock status and biological reference points

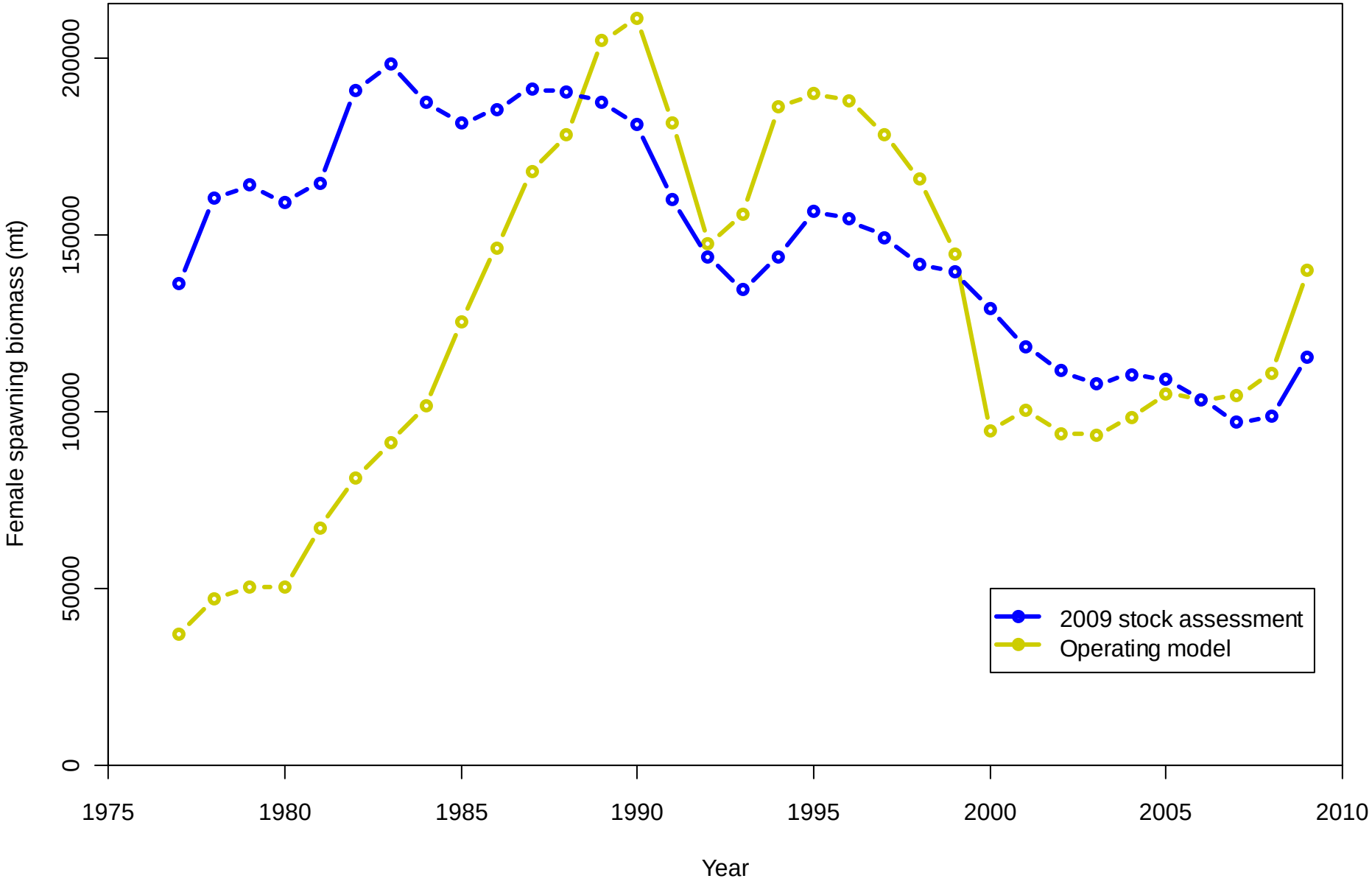
The operating model

- Less complex than the stock assessment model
  - Fewer time-varying selectivity and catchability parameters
  - No change in growth over time
- Fits to the stock assessment data
- Additional data from an annual nearshore survey
  - Provides information on age-0 recruitment

Comparison – age-0 recruitment

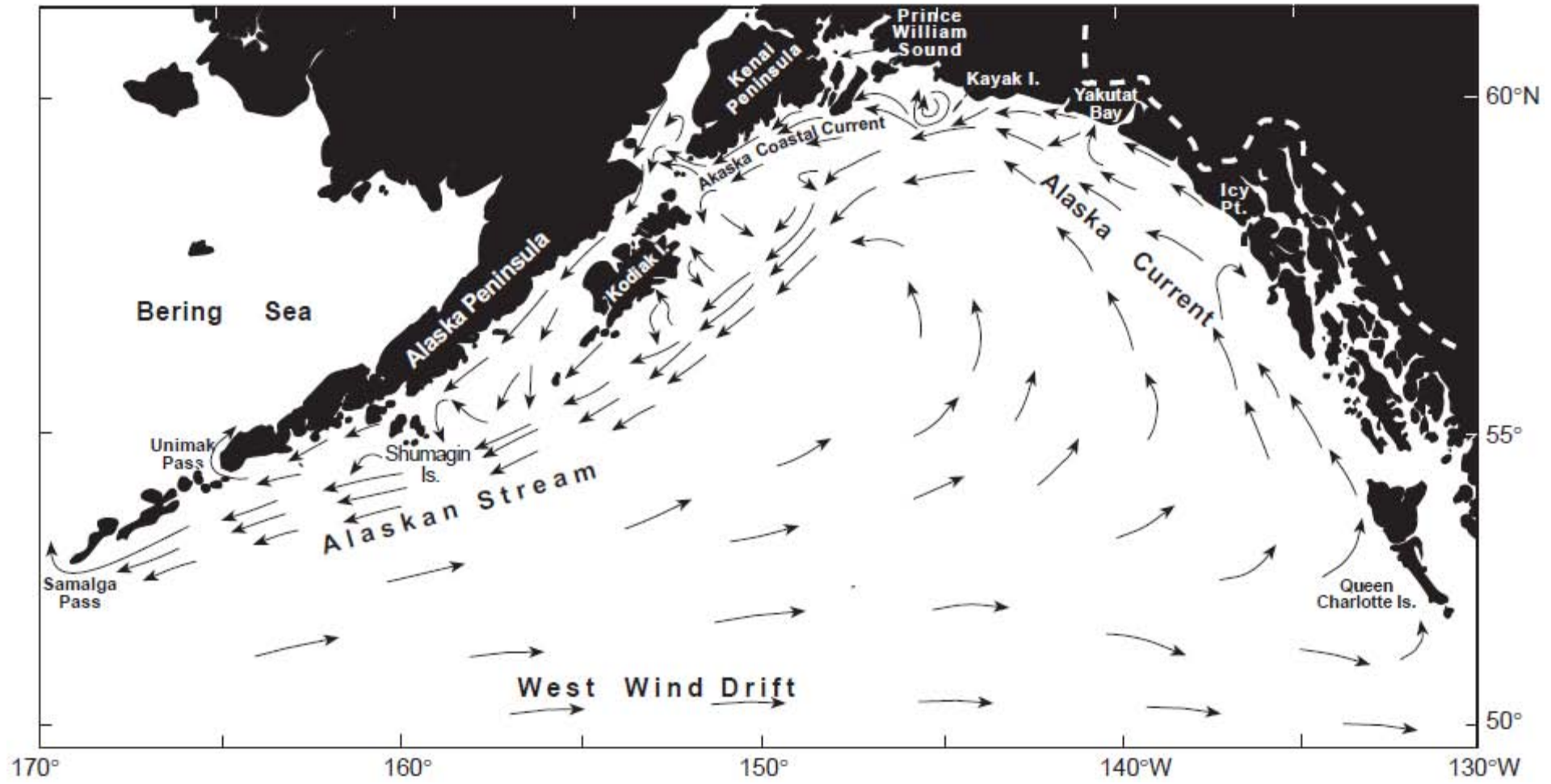


Comparison – spawning biomass



Comparison – biological reference points

	2009 stock assessment	***Operating model***
Total biomass in 2010	*738 300*	*809 200*
SB in 2010	*117 600*	*182 300*
Unfished equil. SB	*291 500*	*465 600*
$SB_{40\%}$	*116 600*	*186 200*
Average recruitment	*262 million*	*470 million*



From Stabeno et al. 2004 Continental Shelf Research

The impacts of climate

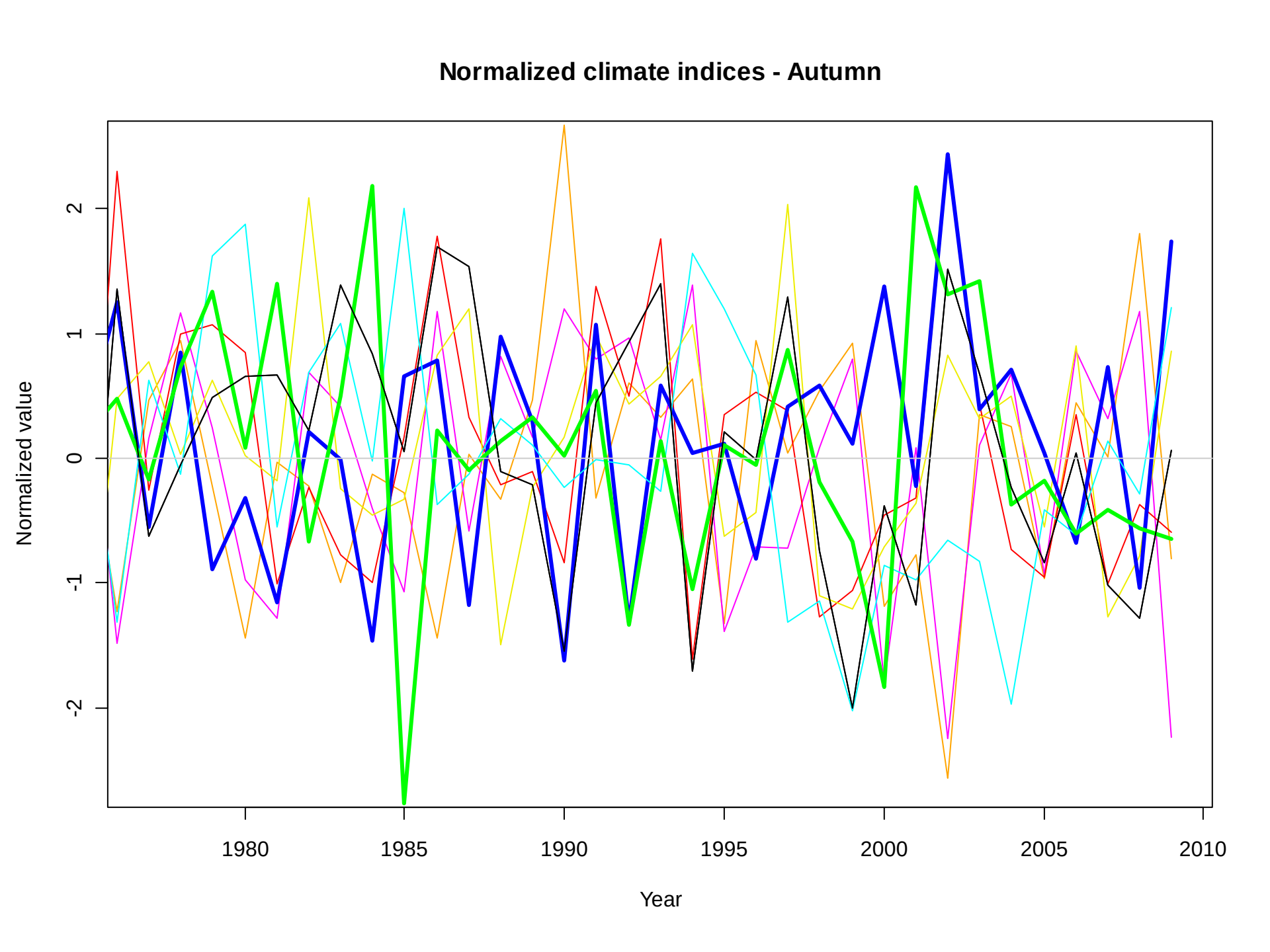
- Climate influences on GOA Pacific cod may be similar to those on walleye pollock
- Less data available for GOA Pacific cod
  - How to validate hypotheses
- Start with studies on GOA walleye pollock
- Include links hypothesized in Doyle et al. 2009 Prog. Ocean.
  - Larval abundance and winter/spring environmental indices for 1981 through 2003

Environmental effects on pollock recruitment

Mechanism	***Index***	***Season***	***Source/Citation***
Primary production	*Precipitation*	*Winter*	*Bailey et al. 2005*
Primary production	*Wind mixing energy*	*Winter*	*Bailey et al. 2005*
Concentration of prey and larvae	*Eddy formation due to freshwater runoff and precipitation*	*Spring*	*Kendall et al. 1996*
Concentration of prey and larvae	*Upwelling and transport – Wind mixing energy*	*Spring*	*Kendall et al. 1996*
Stage duration	*Water temperature*	*Spring*	*Kendall et al. 1996*
Water column turbulence, eddies, transport, advection, upwelling	*Precipitation and freshwater runoff*	*Spring*	*Ciannelli et al. 2004, Bailey et al. 2005*
Water column turbulence, eddies, transport, advection, upwelling	*Wind mixing energy*	*Spring, Summer*	*Bailey and Macklin 1994, Ciannelli et al. 2004, Bailey et al. 2005*
Temperatures affect amount of prey and amount of pelagic habitat for juveniles and age-0 animals	*Water temperature (may interact with other environmental factors)*	*Summer, Autumn*	*Bailey 2000, Bailey et al. 2005*

Seasonal climate indices for 1971 - 2009

- Basin-scale indices
  - Pacific Decadal Oscillation (PDO)
  - North Pacific Index (NP)
  - Arctic Oscillation Index (AO)
  - East Pacific-North Pacific pattern (EP-NP)
  - Multivariate El Niño-Southern Oscillation Index (MEI)
- Local-scale indices
  - Precipitation
  - Wind mixing energy
  - Sea surface temperature
- Correlation between some indices


Normalized climate indices - Autumn
Normalized value
2
1
0
-1
-2
1980
1985
1990
1995
2000
2005
2010
Year

Linking climate and recruitment

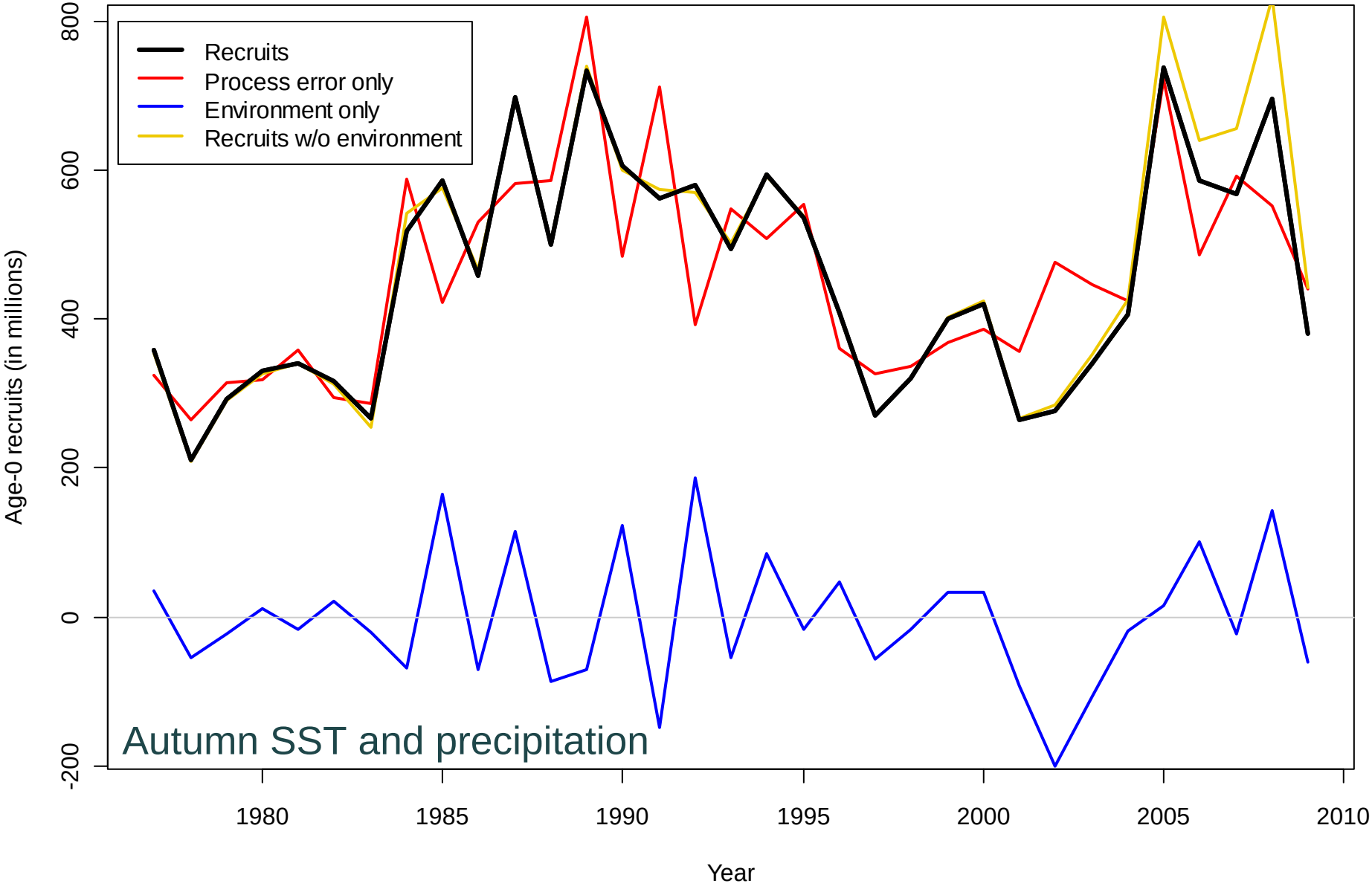
$$R_y = \bar{R}_0 \exp\left(\sum_{i=1}^{n} a_i I_{i,y}\right) \exp\left(\varepsilon_y\right)$$

- Account for some of the process error using the environmental indices
- The operating models incorporate climate forcing on age-0 recruitment
  - Model selection using AIC

Preliminary results

- AIC: None of the environmental forcing models fit better than the model without environment
- Models which included Autumn SST had lower AIC
- Environmental model with lowest AIC
  - Autumn SST
    - -0.152 (0.044)
  - Autumn precipitation
    - -0.142 (0.050)

Process error and environment



Comparison – biological reference points

	2009 stock assessment	***Operating model (env)***
Total biomass in 2010	*738 300*	*725 100*
SB in 2010	*117 600*	*169 400*
Unfished equil. SB	*291 500*	*453 300*
$SB_{40\%}$	*116 600*	*181 300*
Average recruitment	*262 million*	*458 million*

Next steps

- Continue this work
  - Refine recruitment estimation for models with no environmental forcing
  - Explore additional environment-recruitment hypotheses
- Compare the results with Doyle (currently updating data through 2008)

Acknowledgments

- Grant Thompson, NOAA AFSC
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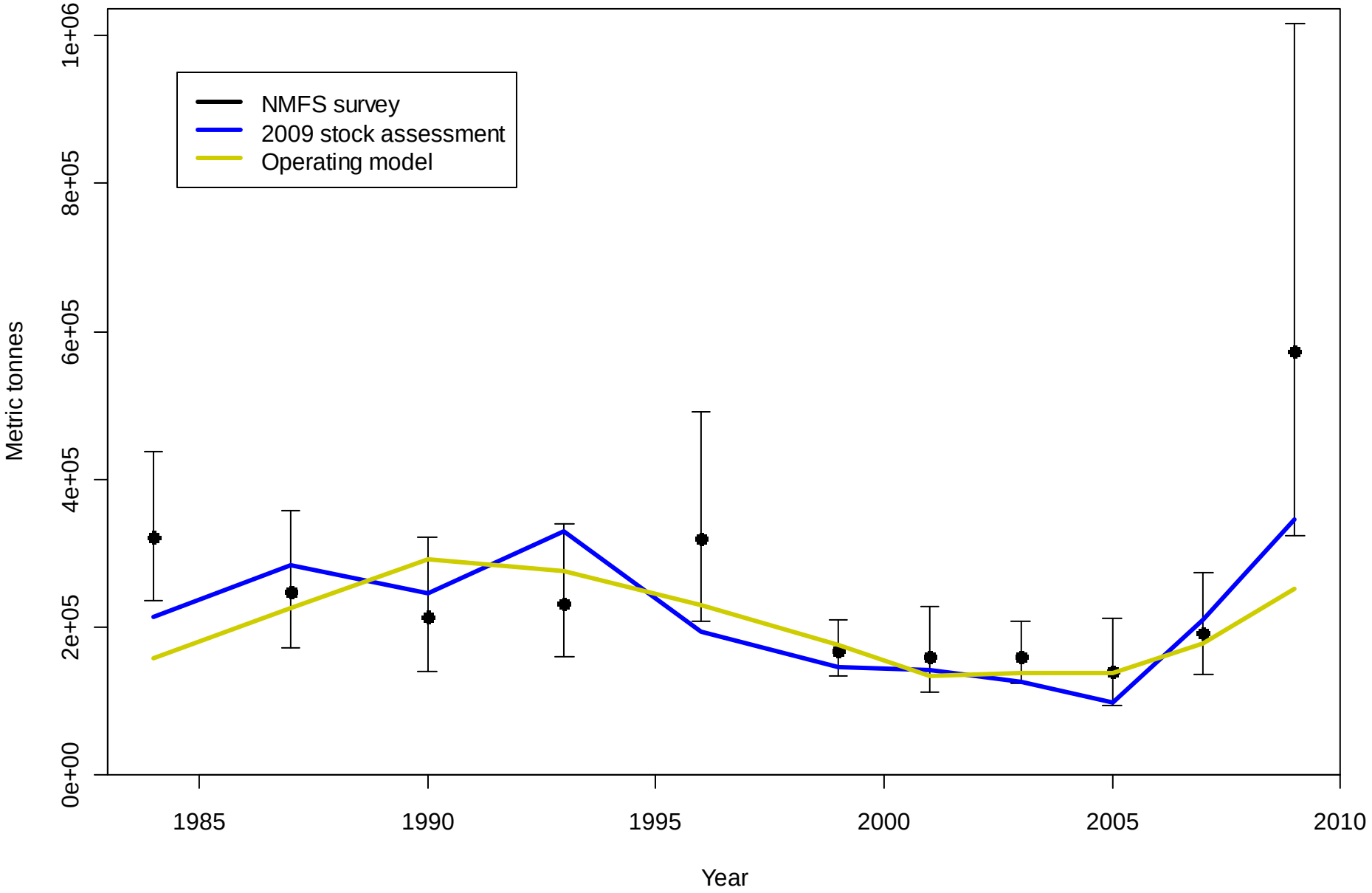
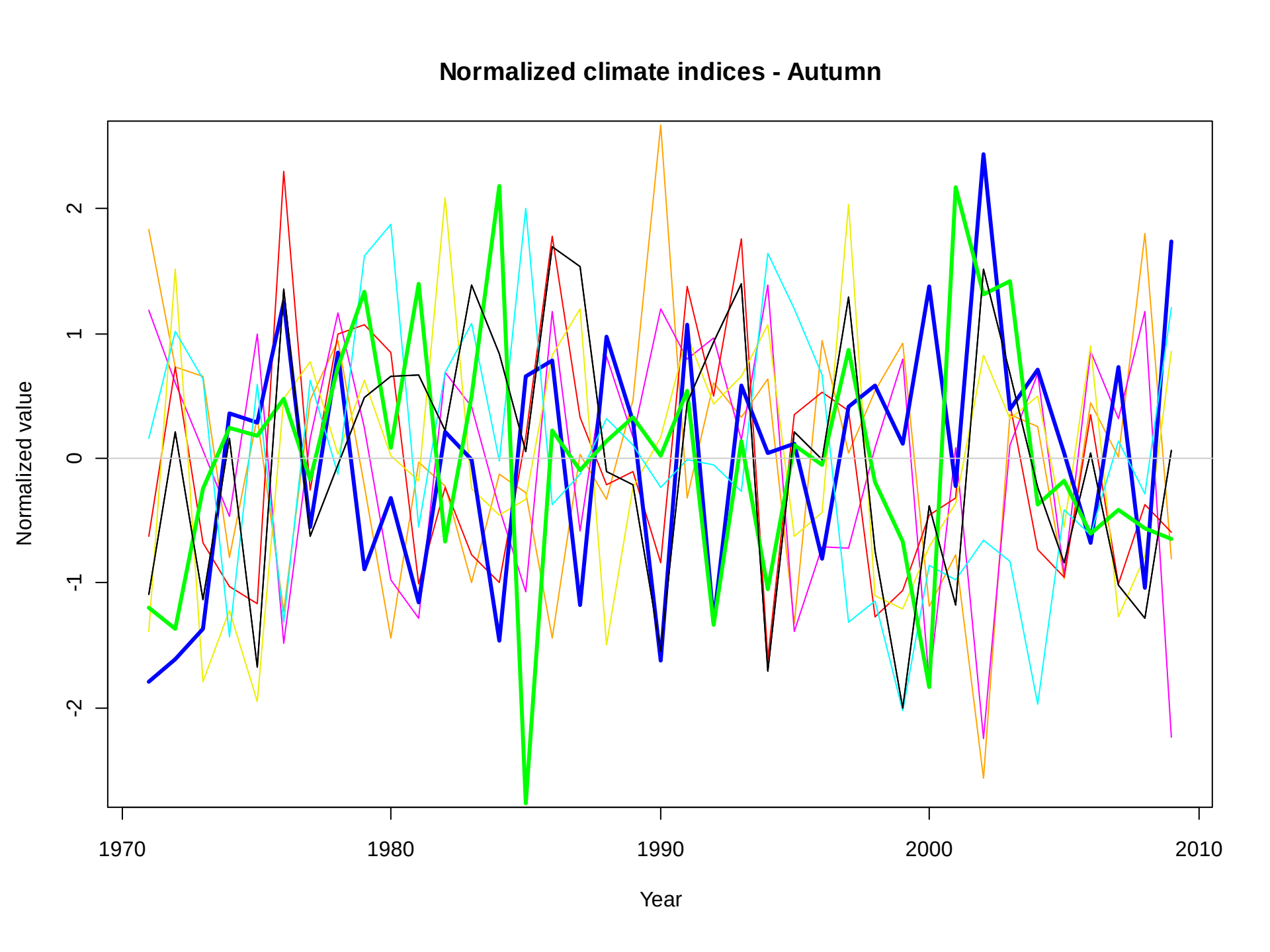
Comparison – NMFS survey




Normalized climate indices - Autumn
Normalized value
2
1
0
-1
-2
1970
1980
1990
2000
2010
Year

Index correlations

Autumn	PDO	NPI	AOI	EP-NP	MEI	precip	wme
NPI	-0.540	-	-	-	-	-	-
AOI	-0.384	0.647	-	-	-	-	-
EP-NP	0.685	-0.373	-0.201	-	-	-	-
MEI	0.533	-0.137	-0.053	0.481	-	-	-
precip	0.207	-0.613	-0.381	0.295	0.084	-	-
wme	0.001	-0.043	-0.015	0.018	0.070	-0.202	-
sst	0.301	-0.242	-0.106	0.187	0.046	0.032	-0.258