

Science, Service, Stewardship

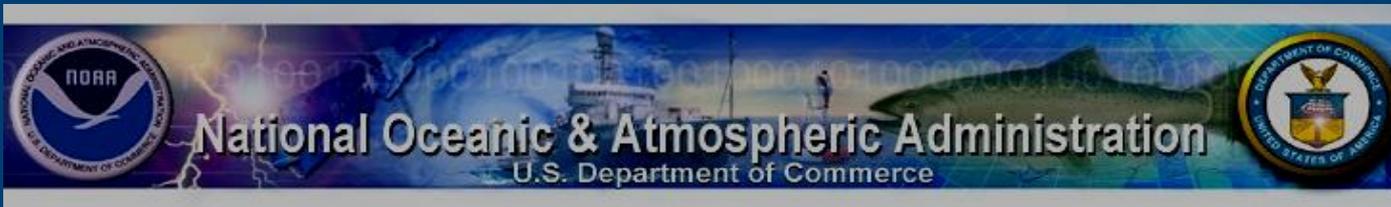
25<sup>th</sup> Northeast Pacific  
Pink and Chum Workshop  
Juneau, Alaska  
13-15 February 2012



# Pink salmon forecasting with ecosystem metrics from the Southeast Alaska Coastal Monitoring project and implications of climate trends on regional pink productivity

*Joe Orsi, Emily Fergusson, Molly Sturdevant  
& Alex Wertheimer (contractor)  
Alaska Fisheries Science Center-Auke Bay Labs*

**NOAA  
FISHERIES  
SERVICE**



# Presentation outline

- ❖ Southeast Coastal Monitoring (SECM) project overview: 1997-2011
- ❖ SECM ecosystem metrics, pink forecast model past performance/assumptions
- ❖ Climate change and pink salmon regional production trends in SEAK
- ❖ Is research needed to identify the "mechanisms" responsible for shifts in regional production trends?

# Poster Session...



## The Southeast Alaska Coastal Monitoring (SECM) Project: Milestones from Research at Sea Over the Past 15 Years

*Joe Ursi, Molly Sturdevant, Emily Fergusson, Alex Wertheimer, Bill Heard, and Ed Farley, Jr.*

SECM collaborators: ADFG, AKSSF, DIPAC, GLOBEC, NPAC, NSRAA, NWFSC, PSC-NF, SSRAA, and UAF



Researchers from the Auke Bay Laboratories of the Alaska Fisheries Science Center have conducted the Southeast Alaska Coastal Monitoring (SECM) project in the vicinity of Icy Strait, a principal migration corridor for salmon in Southeast Alaska (SEAK), since 1997. The SECM project helps to integrate basin-scale climate observations, regional oceanographic monitoring, and fisheries research to provide a sound scientific basis for understanding marine ecosystems. This effort also supports Ecosystem-Based Management by providing data to resource managers. This poster highlights some significant milestones from SECM research on biological interactions of salmon, ecologically-associated species, and biophysical oceanography in order to better understand climate effects and mechanisms influencing regional salmon productivity.

[http://www.afsc.noaa.gov/ABL/MSI/msi\\_secm.htm](http://www.afsc.noaa.gov/ABL/MSI/msi_secm.htm)

### SECM milestones:



**Salmon predators**



**Essential Fish Habitat:** Described habitat utilization patterns of seaward migrating juvenile salmon; documented earliest known occurrence of Columbia River stream-type juvenile Chinook salmon off SEAK



**Regional Stakeholders:** Developed professional relationships and web sites to share published materials and datasets with regional resource stakeholders, managers, and researchers



**Zooplankton**



**Publications:** Produced over 50 publications, reports, and MSc/PhD theses to advance our scientific understanding of salmon ecology in the vicinity of the Gulf of Alaska ecosystem



**Annual Reports:** Produced annual research reports to the North Pacific Anadromous Fish Commission describing stock-specific migration, distribution, and growth of juvenile salmon



**Ecosystem Study:** Compared epipelagic fish assemblages across marine ecosystems from the Alaska Coastal Current to the California Current; contributed to NOAA's Ecosystem Considerations Report on interannual zooplankton trends and pink salmon forecasts



**Lab processing**



**Oceanography**



**Hatchery-Wild Interactions:** Estimated zooplankton consumption rates of hatchery and wild juvenile chum salmon using bioenergetics models; examined carrying capacity and trophic interactions in Icy Strait



**Process Studies:** Conducted laboratory and at-sea studies to address specific research questions, such as predation, starvation, and feeding rhythms



**Juvenile salmon**



**Zooplankton sampling**



**Predation Events:** Characterized predation on juvenile salmon by key piscivores and estimated predation impact of an abundant episodic predator on adult salmon harvests



**Academic Partnerships:** Offered at-sea experiences for students, including those working on MSc and PhD projects, and co-authored university publications



**Fish assemblages**



**Salmon forecasts**



**Salmon Forecasts:** Shared SECM juvenile pink salmon data with the Alaska Department of Fish & Game, and presented SECM pre-season adult pink salmon harvest forecasts to resource stakeholders



**Climate Change:** Identified seasonal and interannual anomalies in temperature and zooplankton trends over a 15-yr time series



**Technical Collaborations:** Hands-on training in sampling methodology and trawl gear operation with foreign, federal, and state researchers



**John N. Cobb 91-08**



**Salmon diet**



**Surface trawling**



**Chlorophyll & nutrients**



**Salmon interactions**



**Diel sampling**



**Students at sea**

The recommendations and general content presented in this poster do not necessarily represent the views or official position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

↑  
**SECM**



## Forecasting Pink Salmon Harvest in Southeast Alaska using Ecosystem Metrics from the Southeast Alaska Coastal Monitoring (SECM) Project

*Joe Ursi, Molly Sturdevant, Emily Fergusson, and Alex Wertheimer*

SECM collaborators: ADFG, AKSSF, DIPAC, GLOBEC, NPAC, NSRAA, NWFSC, PSC-NF, SSRAA, and UAF



Researchers from the Auke Bay Laboratories of the Alaska Fisheries Science Center have provided forecasting information to stakeholders of the pink salmon resource of Southeast Alaska (SEAK) since 2004. The forecasting parameters are derived from an ongoing time series of data collected by the Southeast Alaska Coastal Monitoring (SECM) project. The SECM pink salmon forecasts enable stakeholders to anticipate the harvest with more certainty than previous forecasting methods have allowed. In seven of the past eight years, these forecast estimates have deviated from the actual pink salmon harvests by an average of only 7%. Accurate pre-season SECM pink salmon harvest forecasts help to increase the economic efficiency of the commercial salmon fisheries in SEAK and also help to promote resource sustainability.

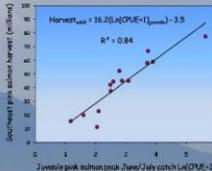
[http://www.afsc.noaa.gov/ABL/MSI/msi\\_sae\\_pst.htm](http://www.afsc.noaa.gov/ABL/MSI/msi_sae_pst.htm)

### Methods:

- Collect SECM ecosystem data during surveys in the Icy Strait vicinity: May-June-July-August
- Evaluate SECM biophysical metrics to develop the "best" forecast model
- Share SECM data with the Alaska Department of Fish & Game
- Present SECM pre-season pink salmon harvest forecast to resource stakeholders

### Assumptions:

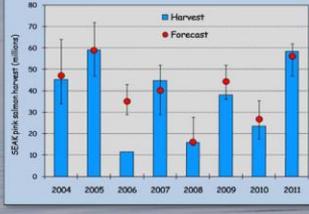
- Icy Strait CPUE represents the entire SEAK region
- The monthly "peak" CPUE adequately captures the magnitude of the seaward migration signal
- No significant mortality events occur after juvenile salmon enter the ocean
- Interannual trawling efficiency of survey vessels is accounted for



Icy Strait - June 2010



Year	Harvest (millions)	Forecast (millions)
2004	45	45
2005	60	60
2006	10	10
2007	45	45
2008	15	15
2009	40	40
2010	25	25
2011	60	60



SEAK pink salmon harvest (millions)

■ Harvest ● Forecast

Ecosystem metrics and SEAK pink salmon harvest

Pink salmon forecast model accuracy: 2004-2011

The recommendations and general content presented in this poster do not necessarily represent the views or official position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service. Background photo credit: Rebecca Okamoto

↑  
**Forecasting**



# SECM sampling stations in Southeast Alaska

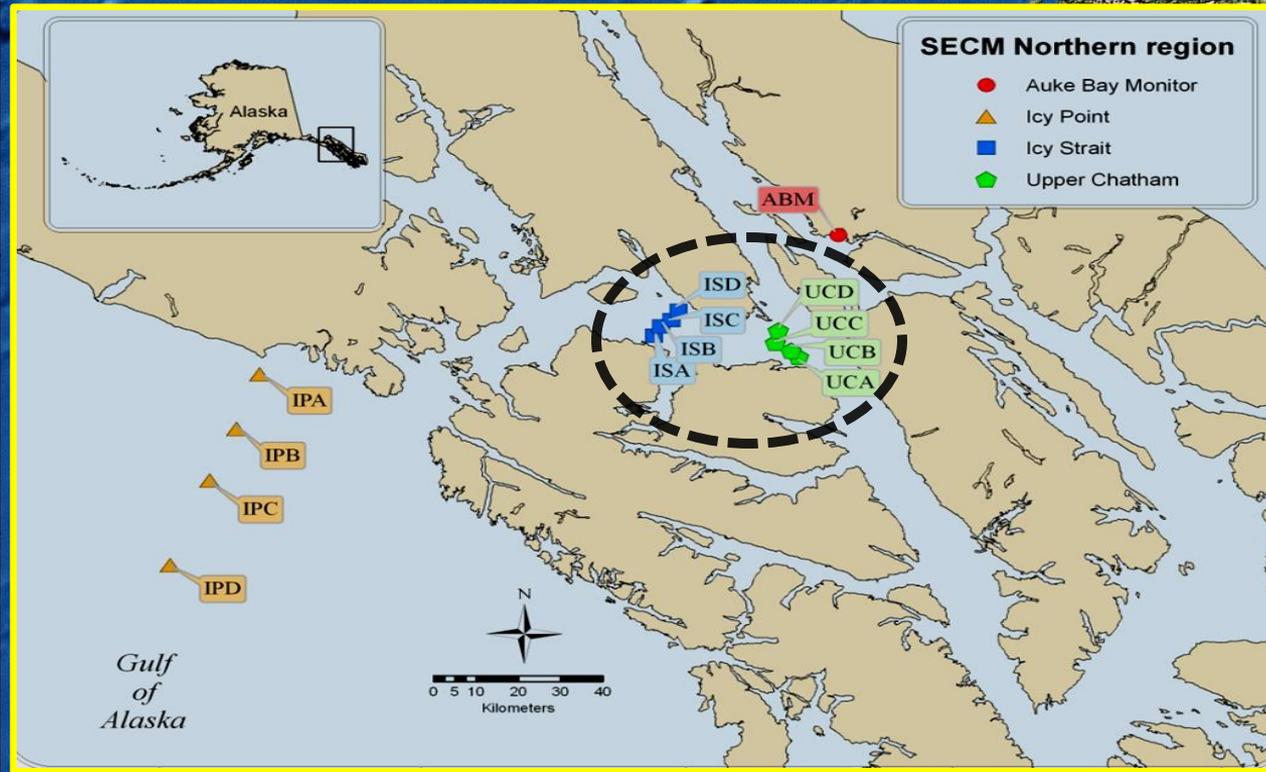
## May, June, July, August 1997-2011

60°N

55°N

50°N

45°N



145°W

140°W

135°W

130°W

125°W

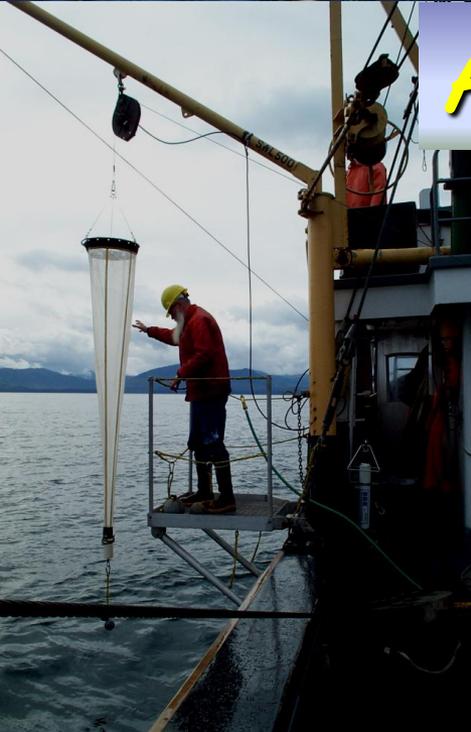
120°W

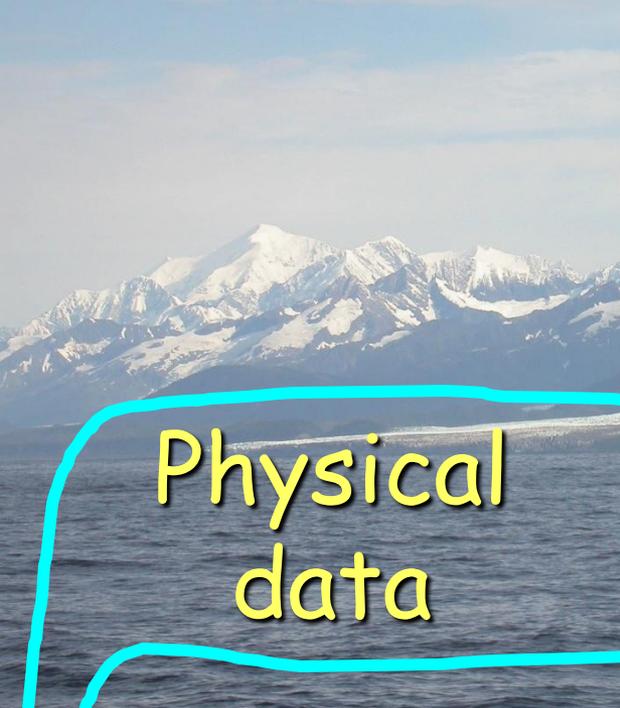


## Routine sampling at each station includes:

- CTD profile to 200 m
- 20-m vertical NORPAC
- 200-m oblique Bongo
- 20 min rope trawl haul

## ABL's SECM project

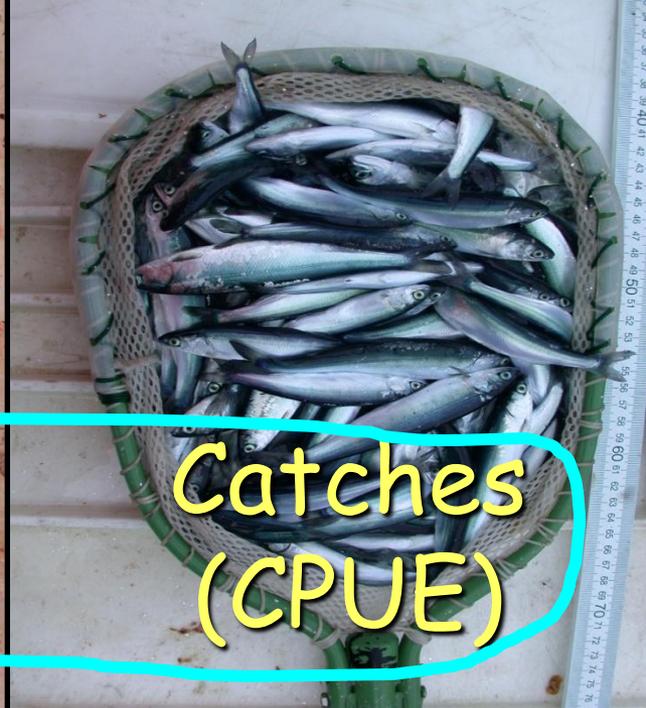




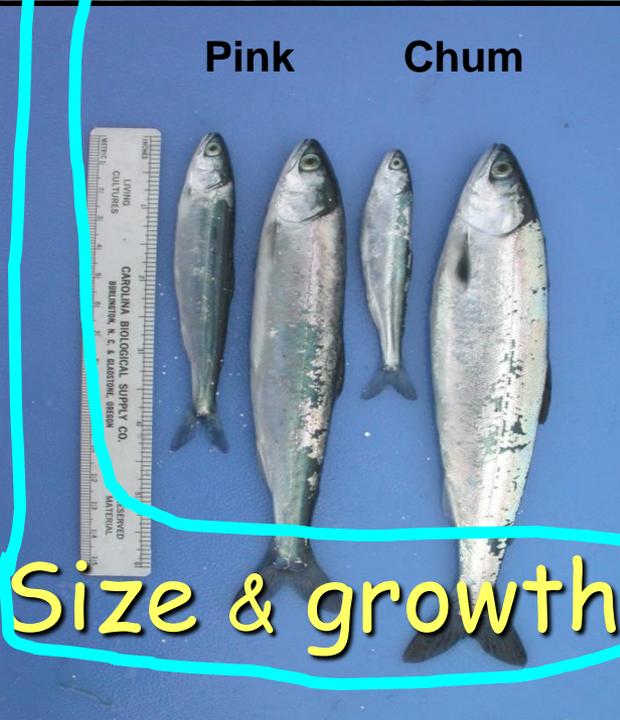
Physical data



Zooplankton biomass/diet



Catches (CPUE)



Pink

Chum

Size & growth



Pink

Chum

Sockeye

Coho

Stock comp



Predation

# Selected biophysical factors considered for forecasting Southeast pink salmon harvest

## Biological (region)

J-pink salmon: \*Peak CPUE<sub>JT</sub>, growth, size at time, condition, peak migration month, catch composition, etc.

Prey fields: Surface and integrated measures of zoopl., stomach fullness (% of body weight), etc.

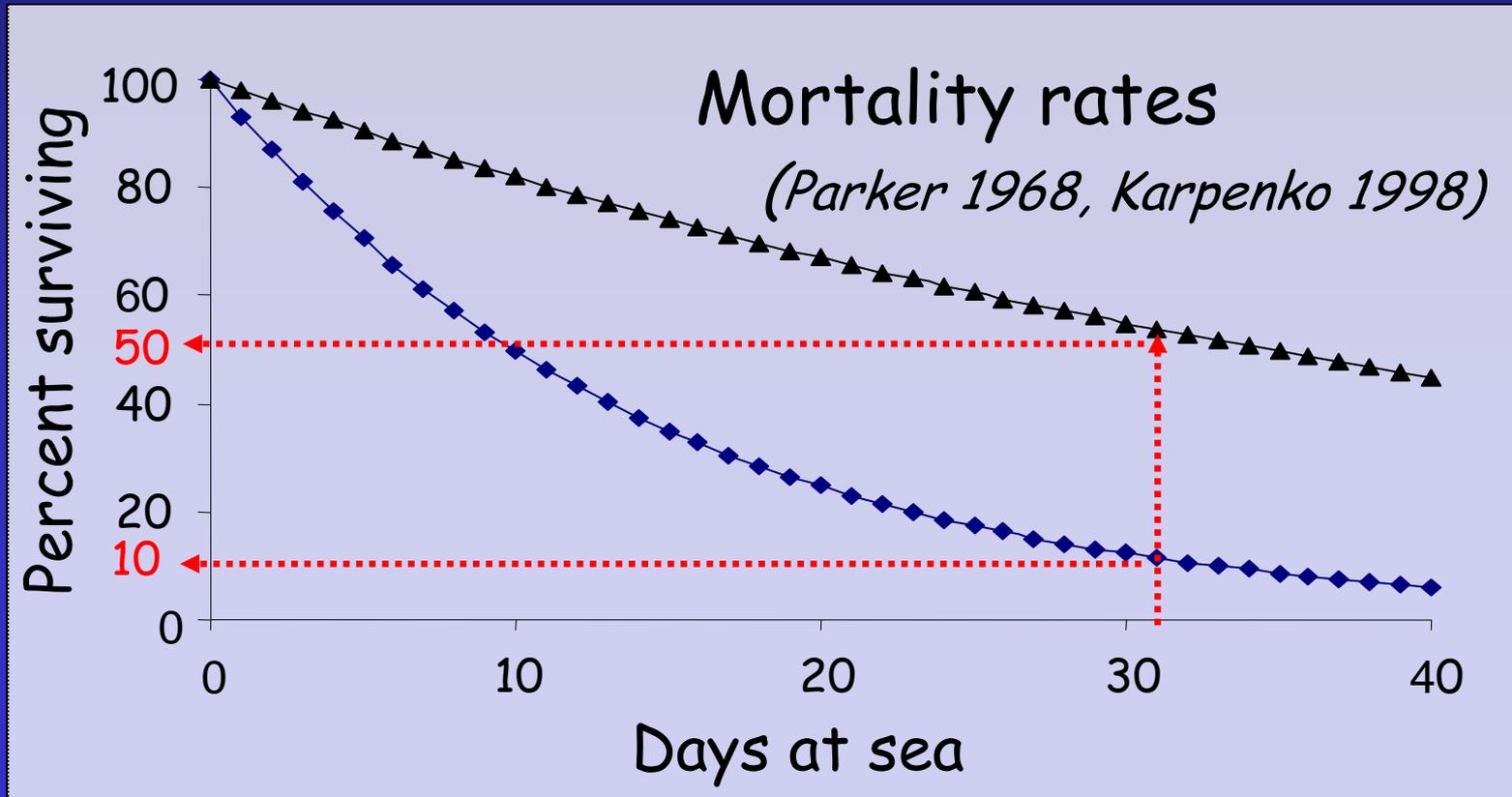
## Physical (region & ocean basin)

Region: Temperature (surface + integrated), salinity, & mixed layer depth, etc.

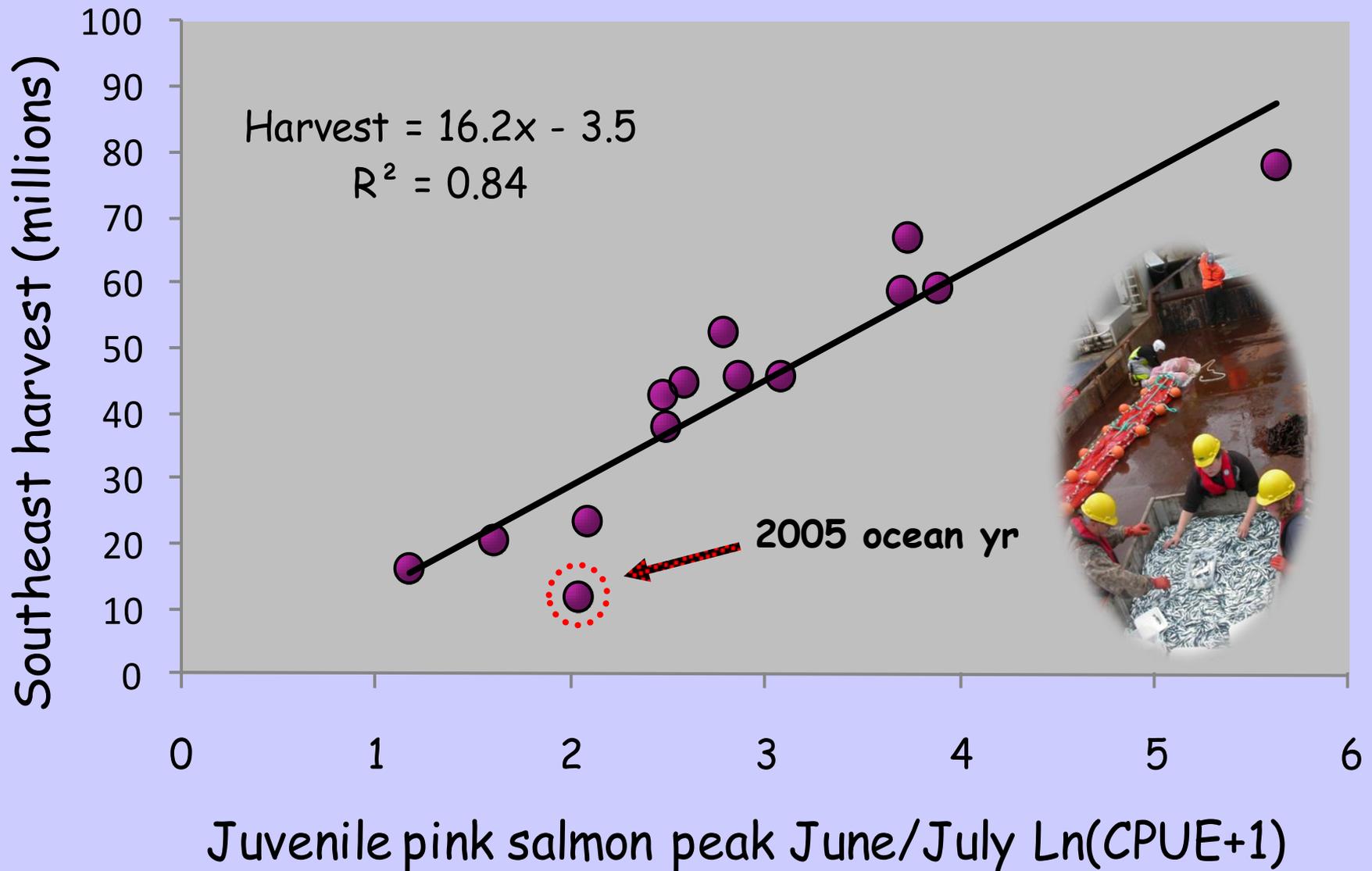
Ocean basin: ENSO (El Niño Southern Oscillation Index), NPI (North Pacific Index), PDO (Pacific Decadal Oscillation Index), etc.

# Paradigm of pink salmon biology:

*Mortality during early marine life is high, variable, and affects year class strength*



# Strong relationship between SECM juvenile pink catch and adult harvest 1998-2011



(white regions indicate sea-ice)

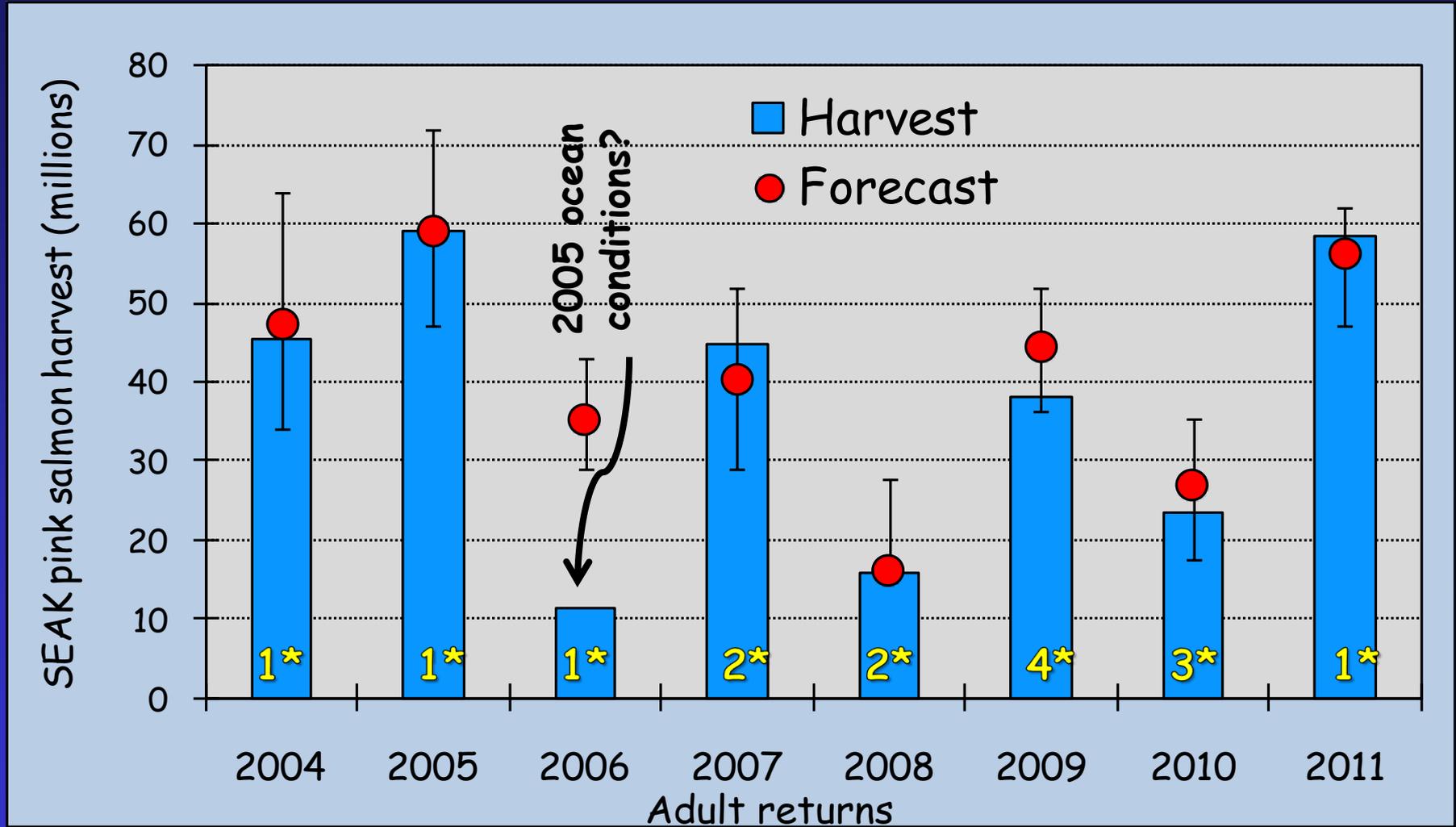
July 2005



-5.0 -4.5 -4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00



# SECM pink salmon forecast models 2004-2011: Accurate (<1-16% of harv.) in 7 of 8 past years



\*Model parameters: 1=CPUE only, 2=CPUE+MayTemp, 3=CPUE+MayTemp+ENSOj, & 4=CPUE+MayTemp+ENSOj+MLD



# Forecasting procedures using a general linear model

- 1) Forward-Backward Stepwise Regression considering all variables,  $P < 0.05$
- 2) Use Corrected Akaike Information Criteria ( $AIC_c$ ) to check for "over parameterization"
- 3) "Jackknife" procedure to evaluate models over time series
- 4) Bootstrap re-sampling of CPUE data to generate forecast confidence intervals and examine effect of measurement error

# 2012 pink salmon forecast model

Models	Adj. $R^2$	$AIC_c$	Regression $P$ value	Prediction for 2011 (80% CI)
Peak CPUE	83%	99.3	< 0.001	17.7 M (13-24)
Peak CPUE + May20temp	89%	95.9	< 0.001	18.8 M (13-25)

Ecosystem metrics (over the SECM time series) considered for forecasting pink salmon harvest to Southeast Alaska for 2012

"BEST" values (upper 3<sup>rd</sup>)

"OK" values (middle 3<sup>rd</sup>)

"WORST" values (lower 3<sup>rd</sup>)

Brood year (BY) +2		BY +1					BY	BY +1	BY +1
Adult pink salmon return year	SE pink harvest (response variable)	Ocean entry year	Juvenile peak pink CPUE <sub>June-July</sub>	Peak seaward migration month	N Pacific Index (June, July, Aug)	% pink in juvenile salmon catch	ADF&G adult pink escapement index SEAK	Auke Creek fry outmigration (1,000s) Lat 58° N	Upper water column (1-20 m) Icy Strait temperatures -May
Data sources: --->		NOAA	NOAA	CGD	NOAA		ADFG	NOAA	NOAA
1998	42.5	1997	2.5	July	15.6	18%	18.1	31.1	7.3
1999	77.8	1998	5.6	June	18.1	69%	14.8	60.8	7.8
2000	20.2	1999	1.6	July	15.8	22%	14.3	53.5	6.5
2001	67.0	2000	3.7	July	17.0	29%	27.3	132.1	6.6
2002	45.3	2001	2.9	July	16.8	39%	10.8	61.5	7.1
2003	52.5	2002	2.8	July	15.6	48%	18.6	150.1	6.4
2004	45.3	2003	3.1	July	16.1	42%	16.6	95.1	7.4
2005	59.1	2004	3.9	June	15.1	40%	20.0	169.6	7.6
2006	11.6	2005	2.0	Aug	15.5	31%	15.7	87.9	8.3
2007	44.8	2006	2.6	June	17.0	44%	19.9	65.9	6.7
2008	15.9	2007	1.2	Aug	15.7	21%	10.2	81.9	7.0
2009	38.0	2008	2.5	Aug	16.1	59%	17.6	117.6	6.1
2010	23.4	2009	2.1	Aug	15.1	24%	9.5	34.8	7.3
2011	58.5	2010	3.7	June	17.6	59%	12.7	121.6	8.3
2012	18.8	2011	1.3	Aug	15.7	36%	11.2	30.9	6.7
Pearson correlation "r" =		0.92	-0.75	0.64	0.63		0.48	0.40	0.08
P-value (* = significant @ <.05) =		0.00*	0.00*	0.01*	0.02*		0.08	0.16	0.79

# Assumptions in using our SECM juvenile pink CPUE data to predict SEAK harvest:

1. Icy Strait CPUE represents the entire region,
2. The monthly "peak" CPUE adequately captures the magnitude of the seaward migration signal,
3. No significant mortality events occur after juveniles enter the ocean, and
4. Fishing efficiency among the survey vessels is reasonably taken into account each year

# Climate change and pink salmon production trends in SEAK?



# Pink salmon seasonal mortality periods



Fall  
stream  
conditions  
adults

Winter  
conditions  
egg-fry

Summer  
harvest  
adults

**SECM**  
forecast  
model



Summer sampling

Fall-Spring  
ocean  
conditions  
juv-imm

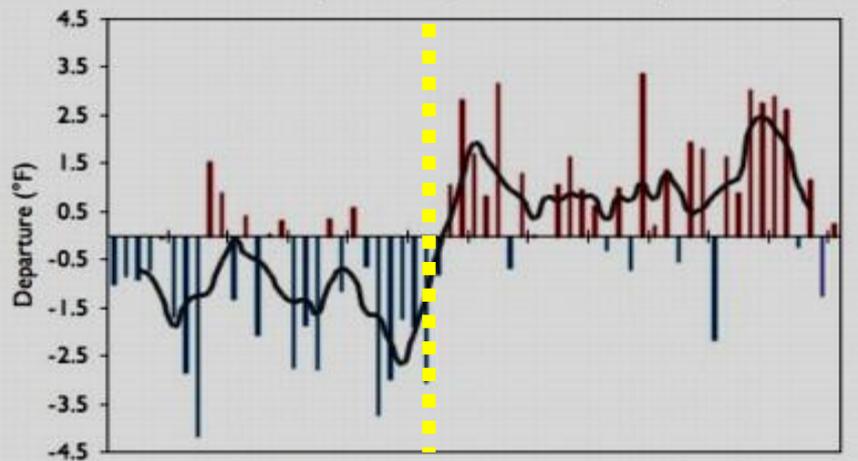
Spring  
estuarine  
conditions  
fry

"Black Box" ?



# Alaska air temperature trends...1949-2009

Mean Annual Temperature Departure for Alaska (1949 - 2009)



1949 1954 1959 1964 1969 1974 1979 1984 1989 1994 1999 2004 2009

Alaska Climate Research Center

Geophysical Institute - UAF

Total Change in Mean Annual Temperature (°F), 1949 - 2009



Statewide Average: 3.0°F

Alaska Climate Research Center

Geophysical Institute, University of Alaska Fairbanks

## THE ALASKA CLIMATE RESEARCH CENTER

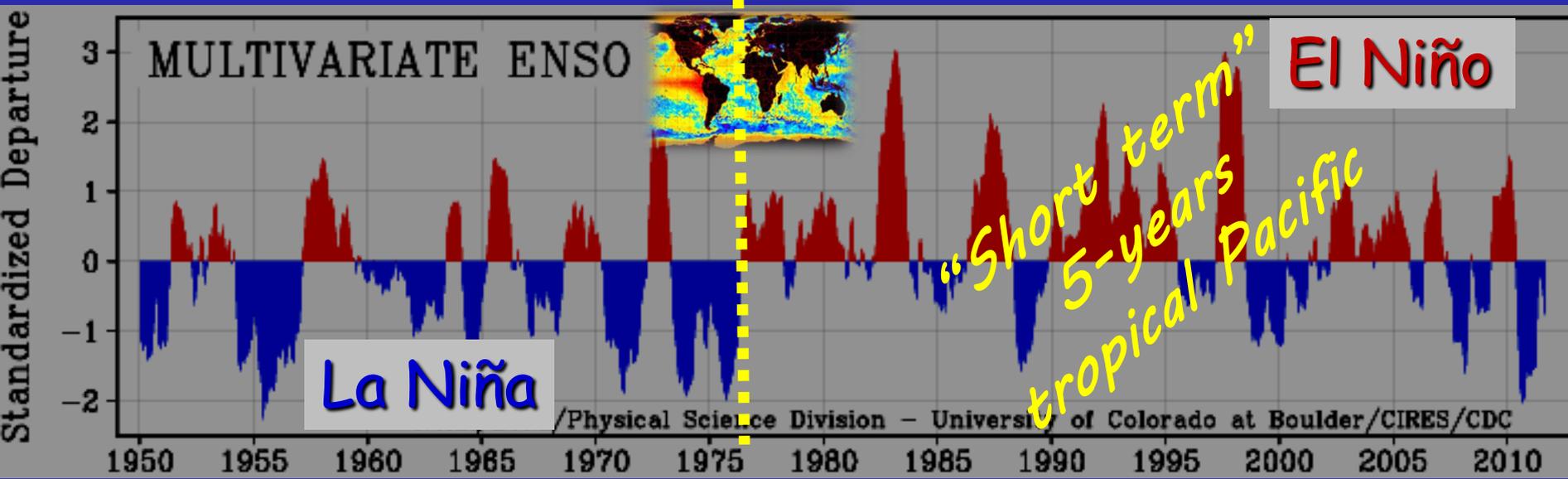
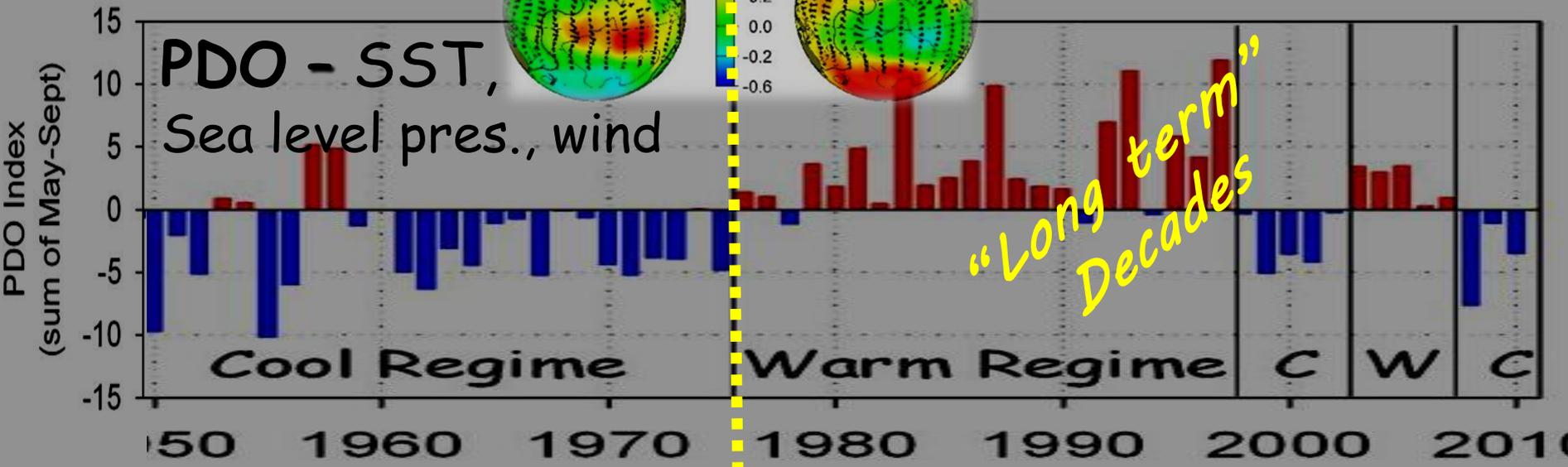
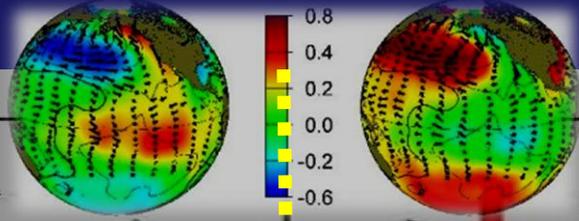
Total Change in Mean Seasonal and Annual Temperature (°F), 1949 - 2009

Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	6.7	4.5	3.0	3.7	4.5
	Interior	Bettles	8.1	4.3	1.8	1.1
West Coast	Big Delta	8.9	3.4	1.2	0.0	3.4
	Fairbanks	7.4	3.6	2.3	-0.2	3.3
	McGrath	7.4	4.6	2.7	0.8	3.9
	Kotzebue	6.3	1.8	2.6	1.4	3.1
	Nome	4.2	3.3	2.5	0.4	2.6
Southcentral	Bethel	6.6	4.8	2.3	0.0	3.5
	King Salmon	7.9	4.5	1.7	0.6	3.7
	Cold Bay	1.5	1.6	1.7	0.8	1.4
	St Paul	0.8	2.1	2.6	1.1	1.6
	Anchorage	5.8	3.3	1.6	1.5	3.0
	Talkeetna	8.4	5.2	3.1	2.4	4.9
	Gulkana	7.7	2.4	1.0	0.1	2.8
Southeast	Homer	5.9	3.8	3.3	1.8	3.8
	Kodiak	0.7	2.1	1.2	-0.4	0.9
	Yakutat	4.6	2.8	1.8	0.4	2.5
	Juneau	6.2	2.9	2.2	1.4	3.2
	Annette	3.4	2.3	1.8	0.3	2.0
Average		5.7	3.3	2.1	0.9	3.0

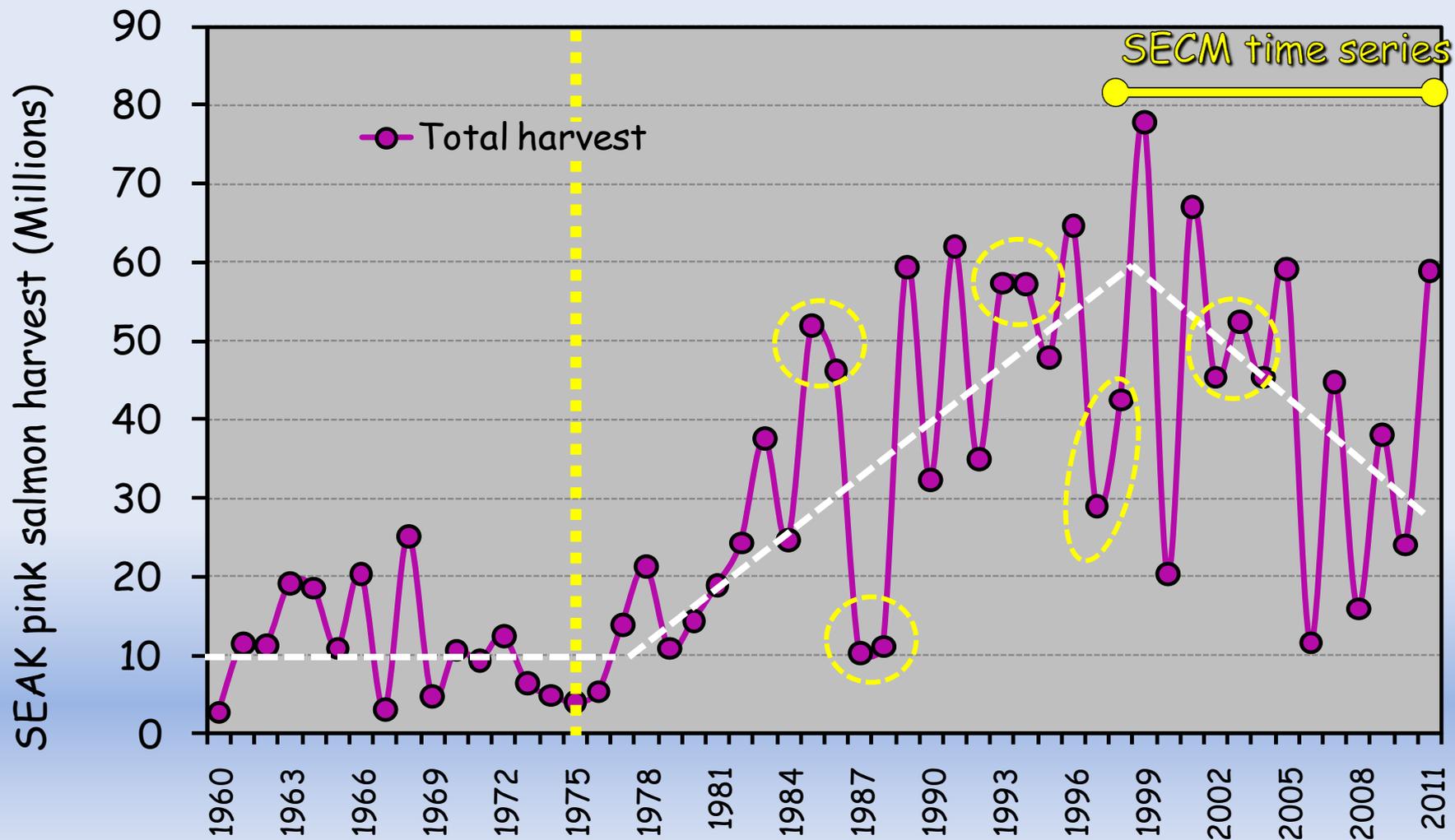
Alaska Climate Research Center

Geophysical Institute, University of Alaska Fairbanks

# What ocean basin-scale signals indicate...



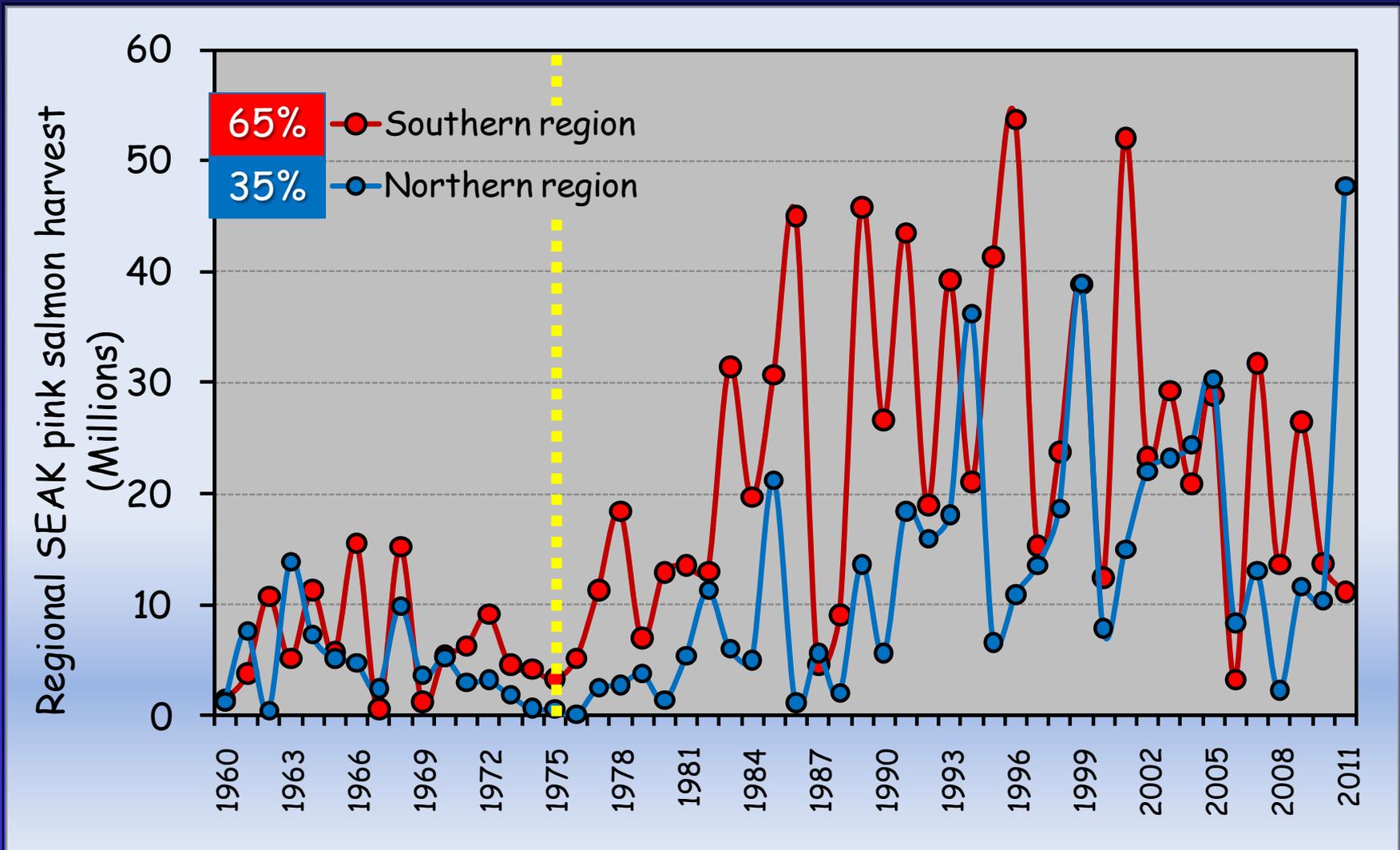
# SEAK pink salmon harvests 1960-2011



Data courtesy of Steve Heintz, ADFG



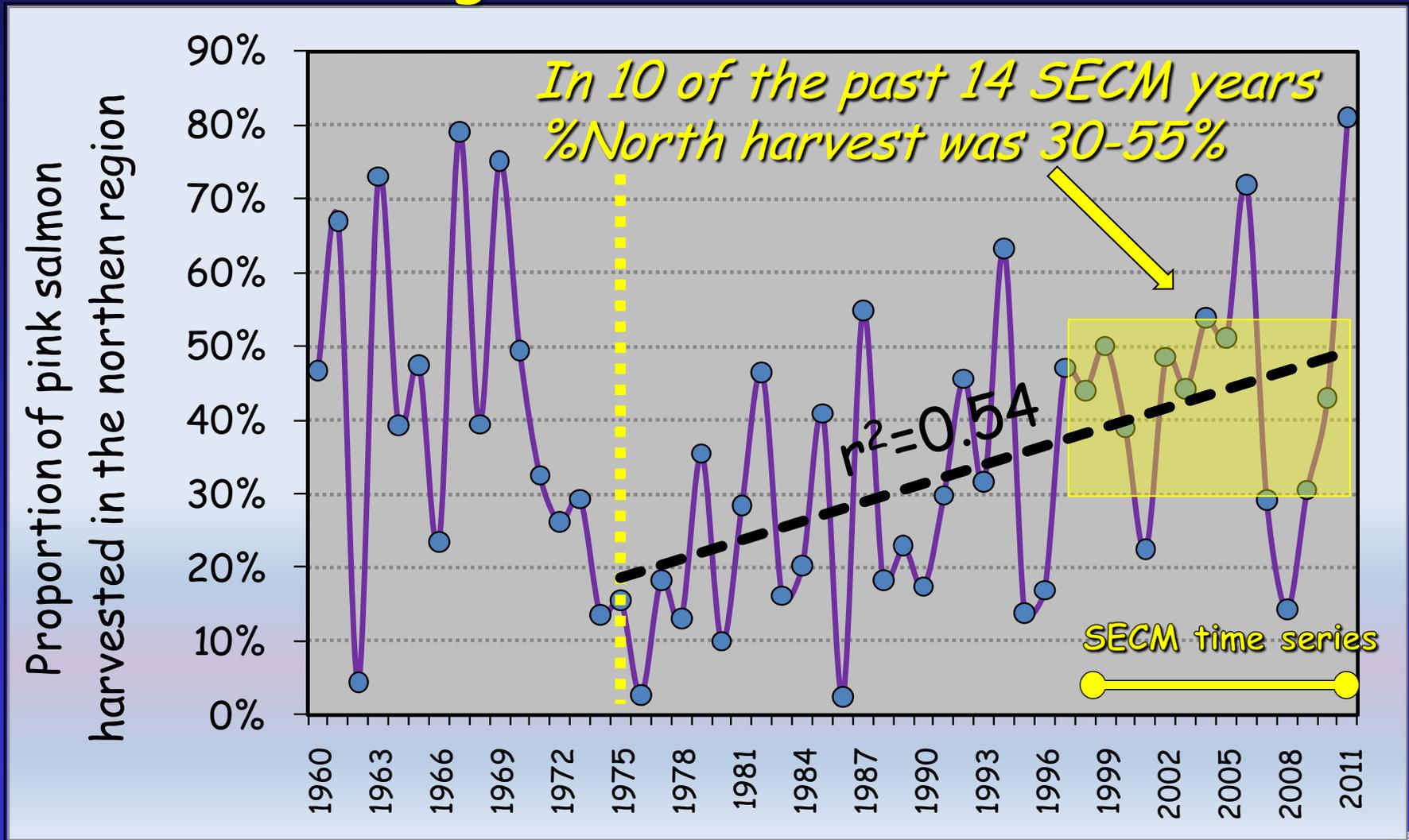
# SEAK pink salmon harvest: north vs. south



Data courtesy of Steve Heintz, ADFG



# SEAK pink salmon harvest proportion increasing in north since mid-70's!



Data courtesy of Steve Heintz, ADFG



# Future challenge in forecasting pink salmon in SEAK

Unless we can identify and “parameterize” a mechanism responsible for the apparent shift in regional pink salmon productivity...

SECM forecasting using juvenile pink salmon metrics in the northern region may not align with harvest over the entire region

# The \$1,000,000 Workshop question is...

What's changed between N & S SEAK pinks since the mid-70's?

## Stream related characteristics?

- flow, temp, timing of precip./snow pack, extreme events

## Spawning habitat?

- more newly formed, compromised, or glacial rebounding

## Life histories strategies?

- run timing (early-middle-late) and % intertidal spawners

## Estuarine, migration corridor, or ocean conditions?

- predator complexes (sablefish, dogfish, whales...)
- competitor complexes (fish, birds, mammals)
- water temps, AK Coastal Current, ENSOs, eddies, etc.
- phenology-timing of seaward and homeward migrating fish
- migration directions.....are southern fish intercepted in N

## Commercial fishing effort or management practices?

# Future pink salmon research?

to explain regional harvest trend discontinuity

Examine SEAK stream flow/temp/hydrologic data

Assess pink salmon spawning habitat utilization patterns of different run components

Monitor a S-SEAK stream for pink salmon life history and compare it to Auke Creek in N-SEAK

Explore "newer" genetic methods to determine regional (N/S) or run time (E/M/L) stock IDs

Continue monitoring marine ecosystem metrics and look for signals: predation, temp. anomal., etc.

# Have SEAK pink salmon arrived at the "crossroads"?

Record value  
\$92 M

Predominately  
97% "wild"

2,000+ stocks, however, survival/life history data



are currently available from only one wild system

Stock  
structure?

Regional shifts  
in production?



# Conclusions:

Best SECM forecast model predicts a low (18.8 M) SEAK pink harvest for 2012

Low SECM Icy Strait juvenile pink CPUE was corroborated by ecosystem metrics

SEAK pink salmon productivity has changed over time...as has the climate

Further study is needed to understand the recent discontinuity of pink salmon harvest trends within Southeast

Science, Service, Stewardship

For more SECM forecasting info:



Google:

AFSC SECM pink salmon forecast



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