



**NOAA
FISHERIES**

Alaska
Fisheries
Science Center

The NOAA 2015 Southeast Pink Salmon Forecast from Ecosystem Monitoring in Southeast Alaska

**Joe Orsi*, Emily Fergusson, &
Alex Wertheimer**

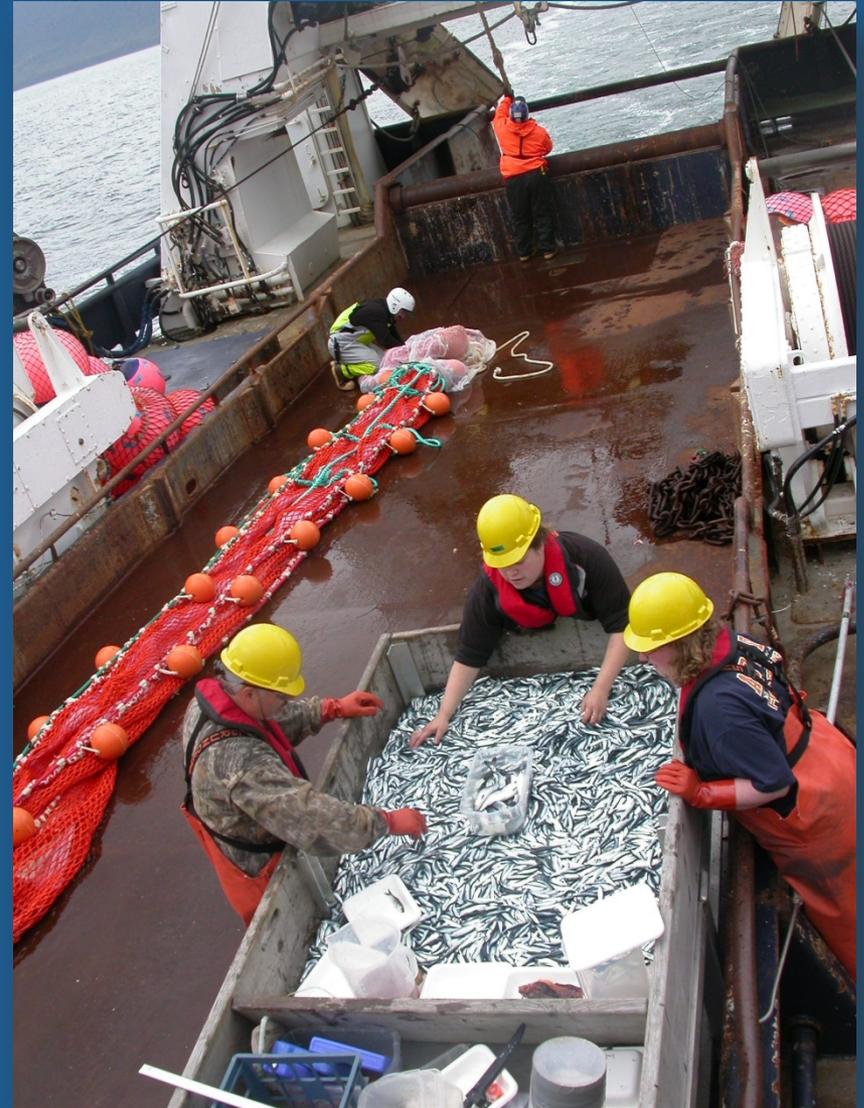
**The views expressed are those of the author and
do not necessarily represent those of NOAA*

**Southeast Alaska Purse Seine Task Force Meeting
Petersburg, Alaska, 03 December 2014**

Presentation outline

- ❖ Overview ABL's Southeast Coastal Monitoring (SECM) project: 1997-2014
- ❖ Introduce ecosystem metrics considered for use in forecasting pink salmon harvest
- ❖ Review past model performances (2004-14) & present the 2015 NOAA pink forecast
- ❖ Discuss alternate forecast models and the implications of ocean conditions in 2014

Southeast Alaska Coastal Monitoring (SECM) monthly sampling: May-Aug, 1997-2014



SECM sampling stations in Southeast Alaska

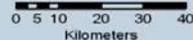
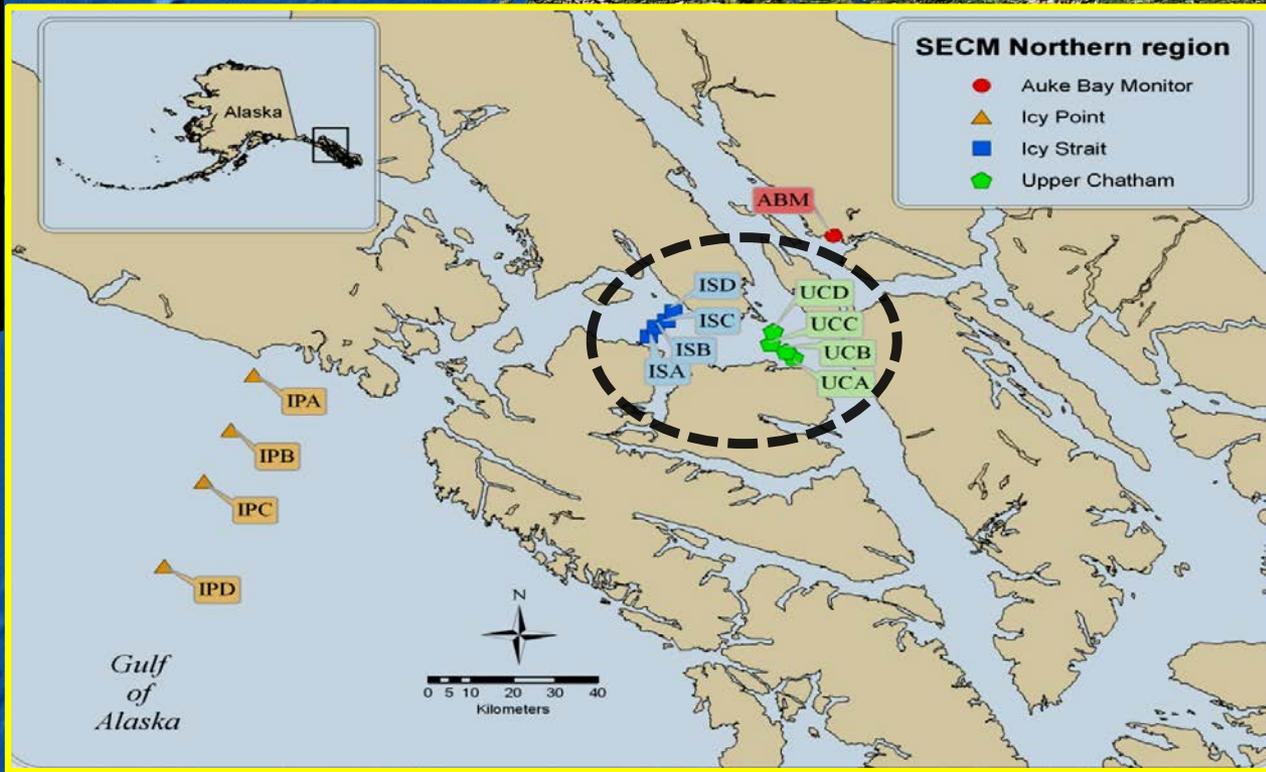
60°N

55°N

50°N

45°N

Gulf of AK Integrated
Research Project
July 2010-14



145°W

140°W

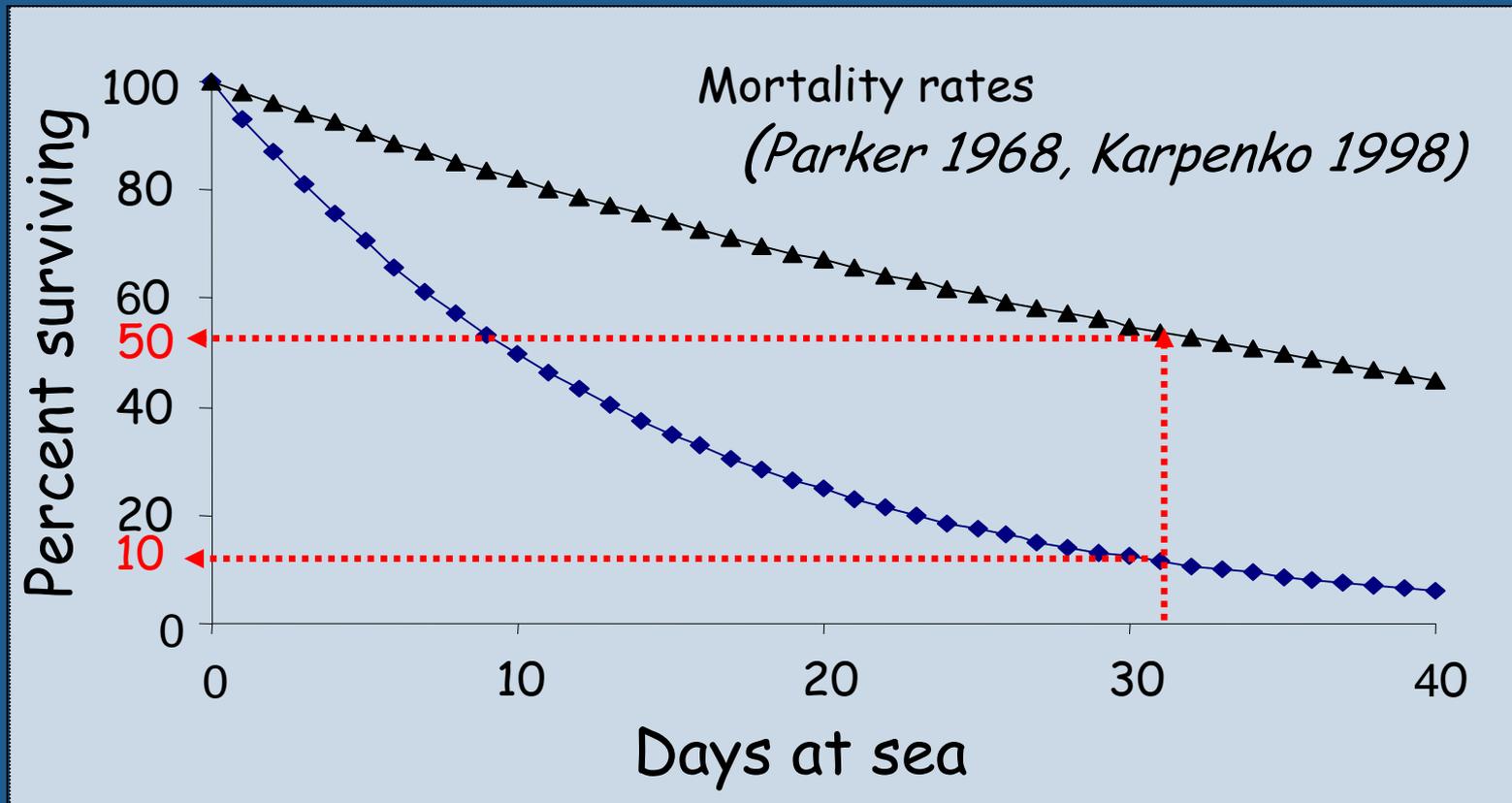
135°W

130°W

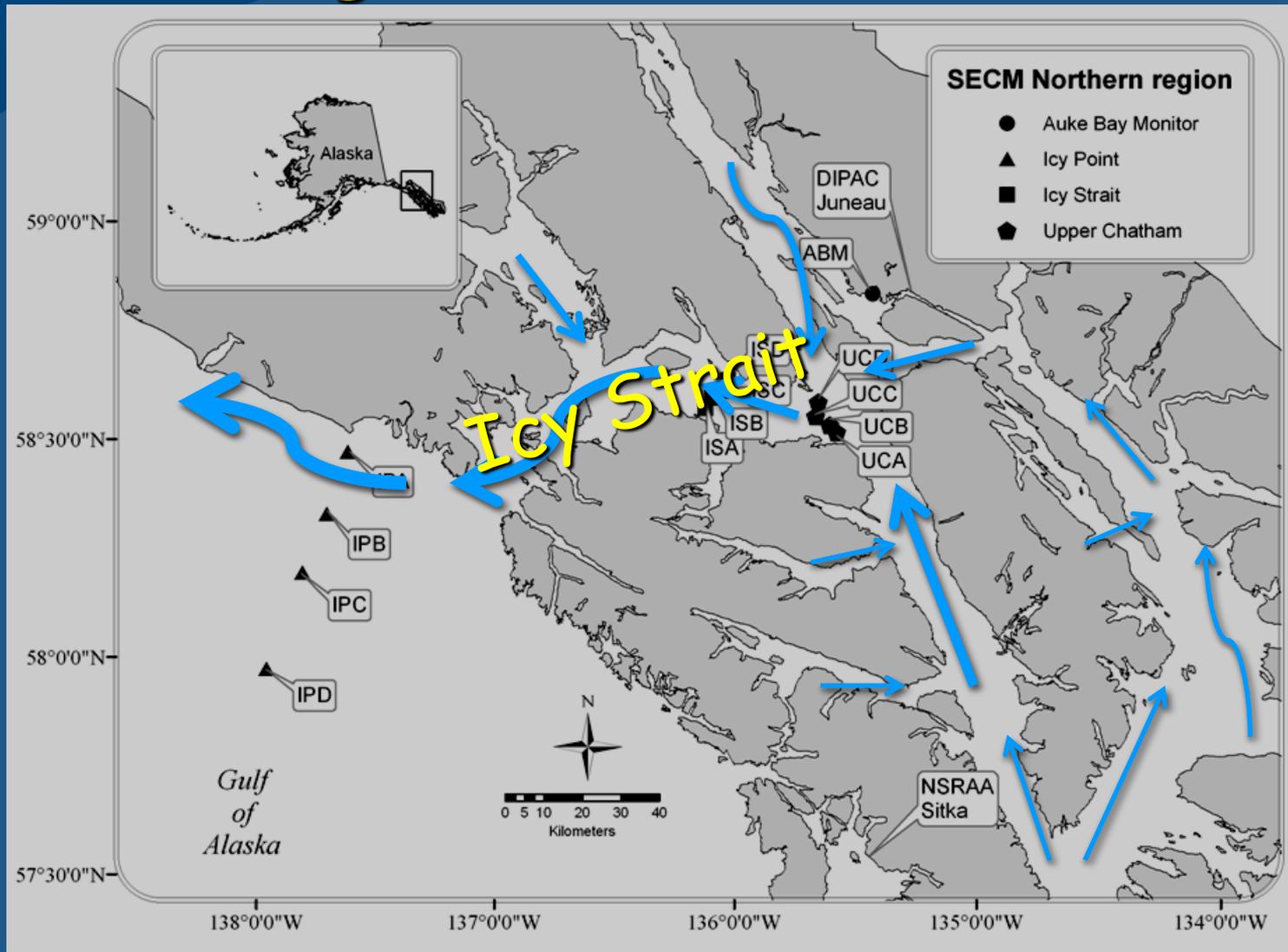
125°W

120°W

Paradigm of pink salmon biology: Mortality during early marine life is high, variable, and impacts year class strength

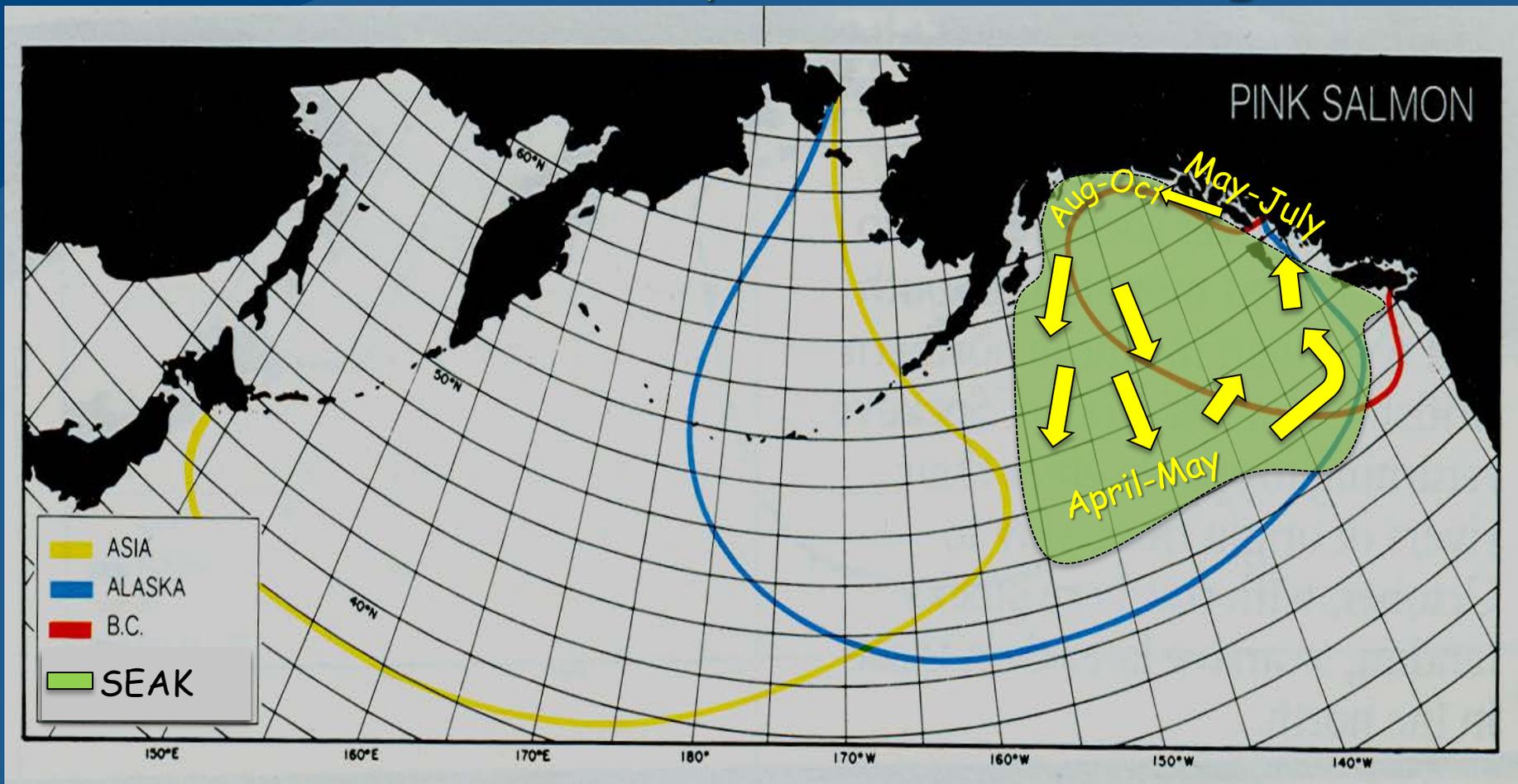


SECM project stations along a primary seaward migration corridor in Southeast



Generalized ocean distribution of pink salmon

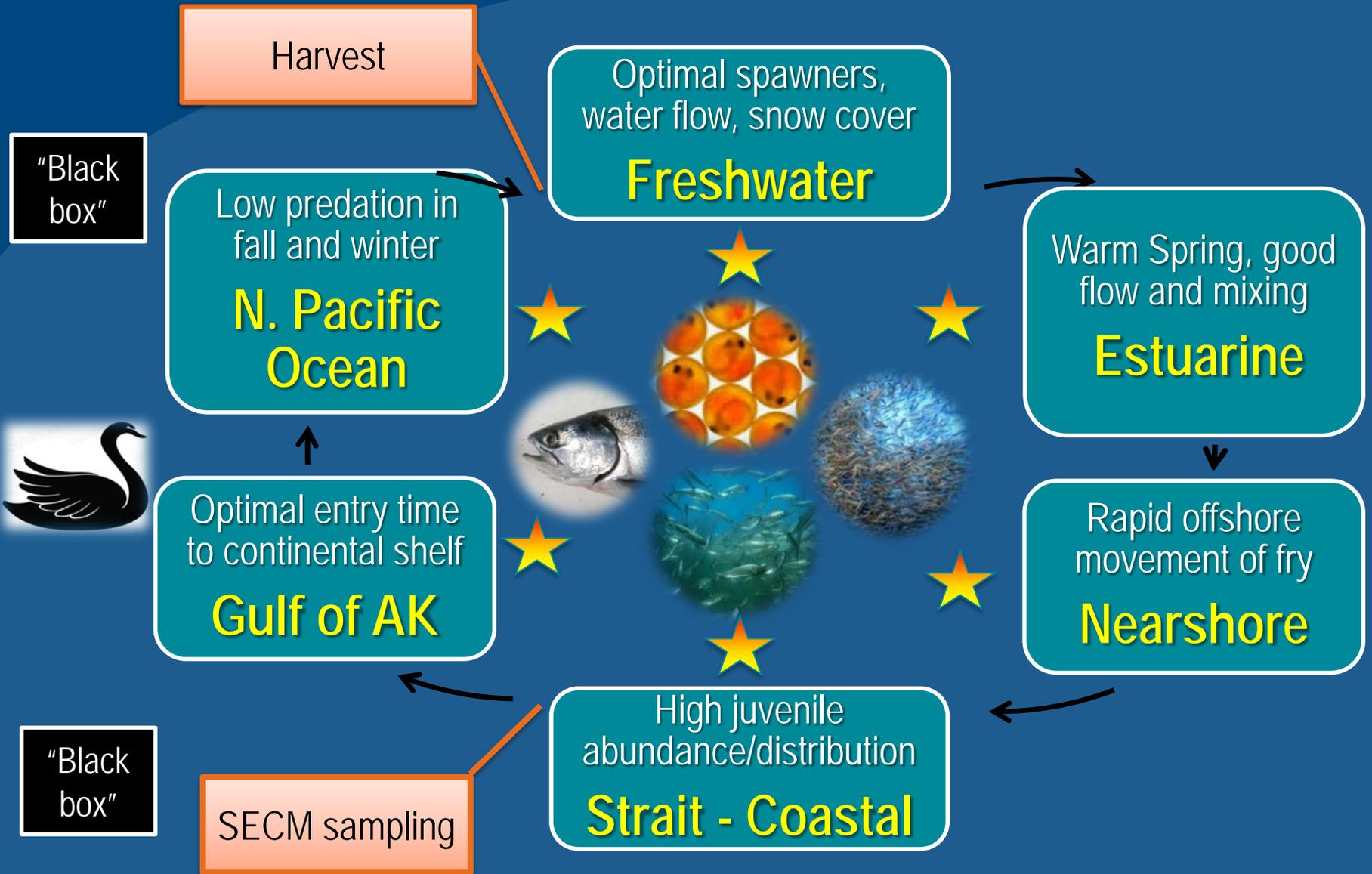
Southeast Alaska pinks shaded in green



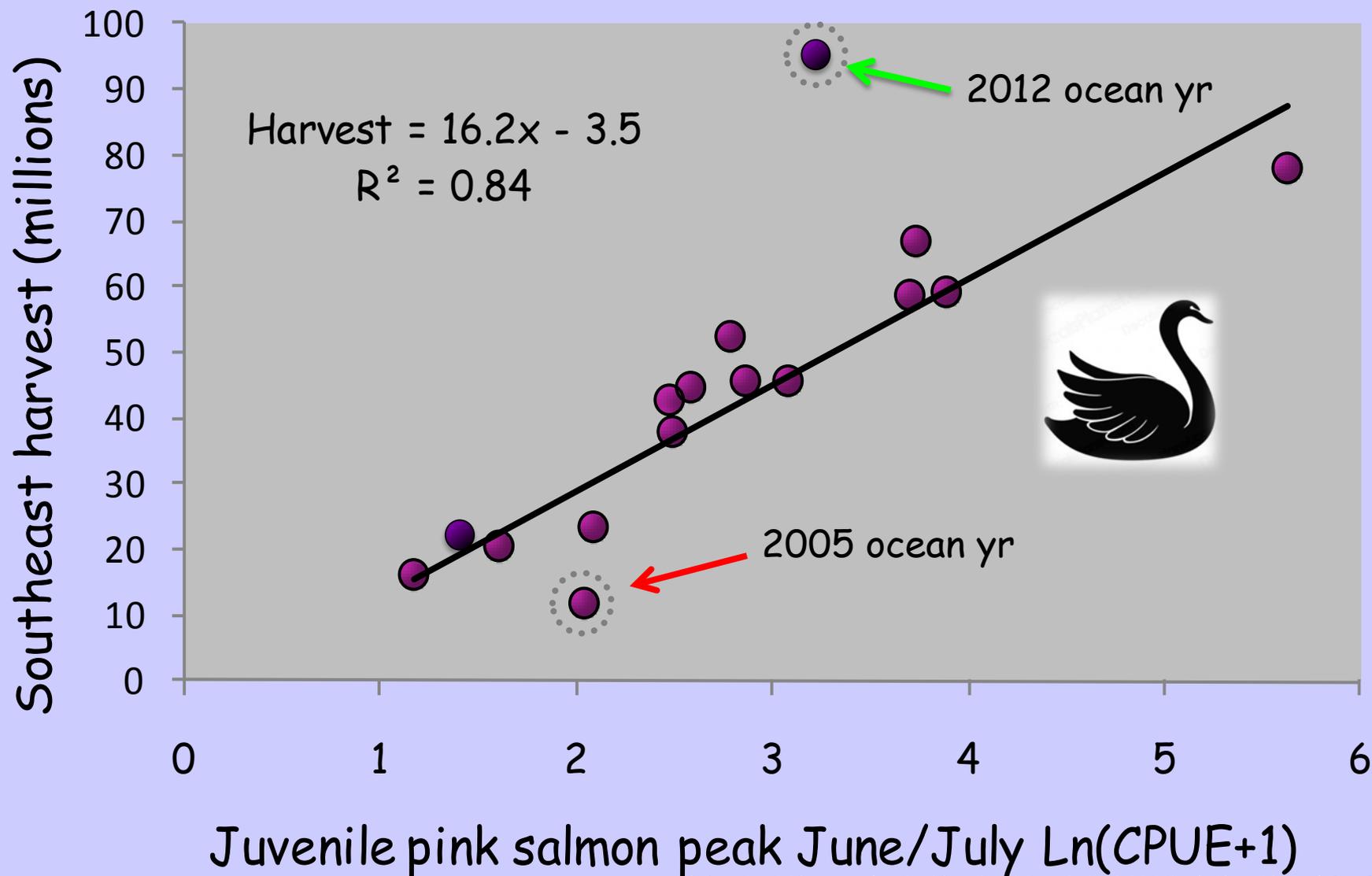
<http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/salmon-saumon/facts-infos/pink-rose-eng.html>

Takagi et al. 1981, INPFC Bulletin 40, Distribution and origin of pink salmon....

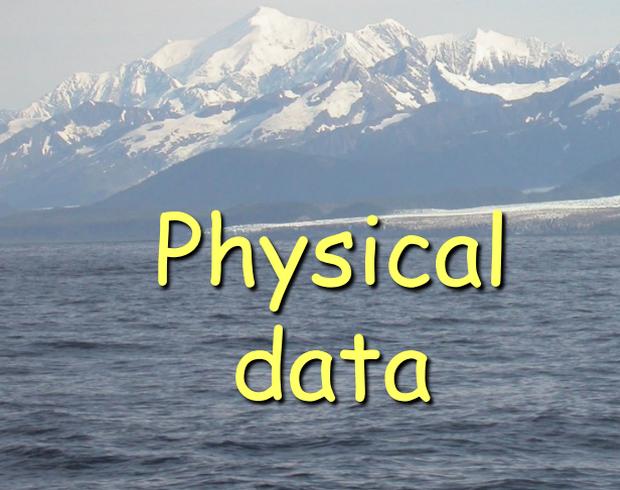
Key pink salmon life history phases



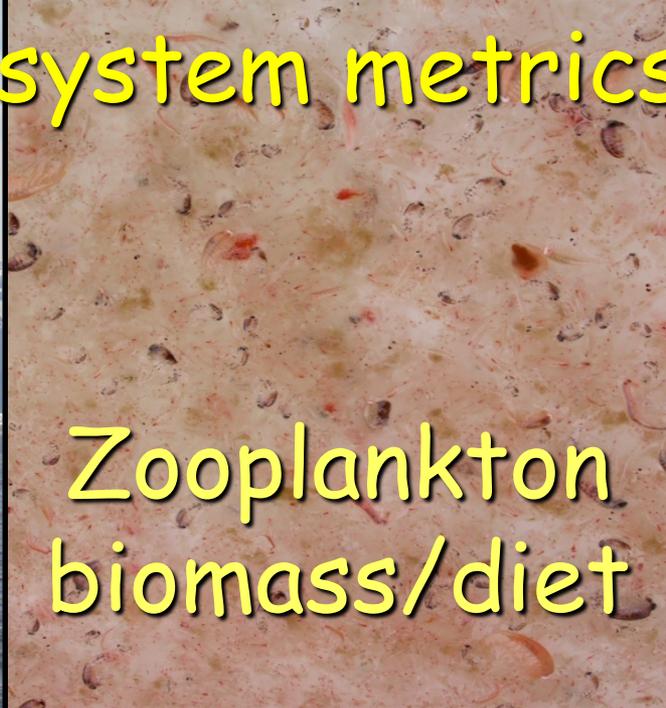
Strong relationship between SECM juvenile pink catch and adult harvest 1998-2013



SECM ecosystem metrics considered



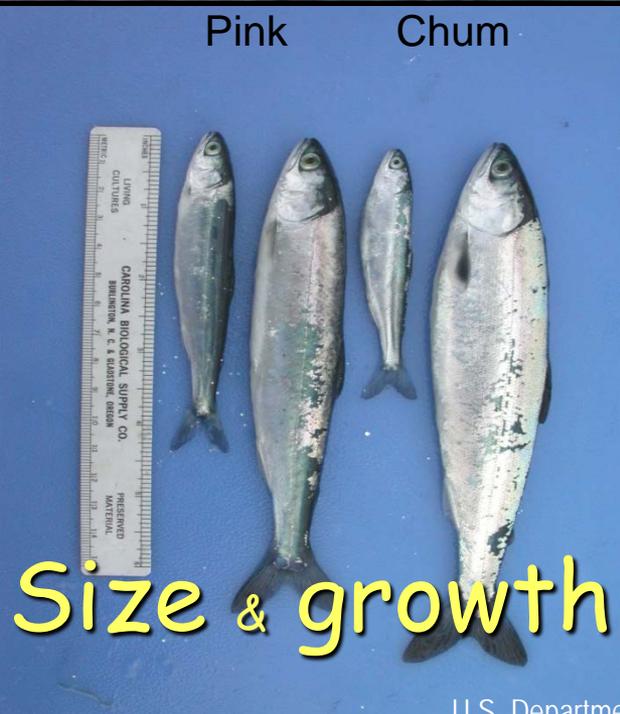
Physical data



Zooplankton biomass/diet



Catches (CPUE)



Pink Chum

Size & growth



Stock comp



Predation

Selected biophysical factors considered for forecasting Southeast pink salmon harvest

Biological (region)

J-pink salmon: Peak CPUE_{cal & ttd}, peak migration month, catch composition, growth, size at time, condition

Trophic: Surface and integrated measures of zooplankton, and predation (adult coho)

Physical (region & ocean basin)

Region: Temperature (surface + integrated-"ISTI"), salinity, & mixed layer depth

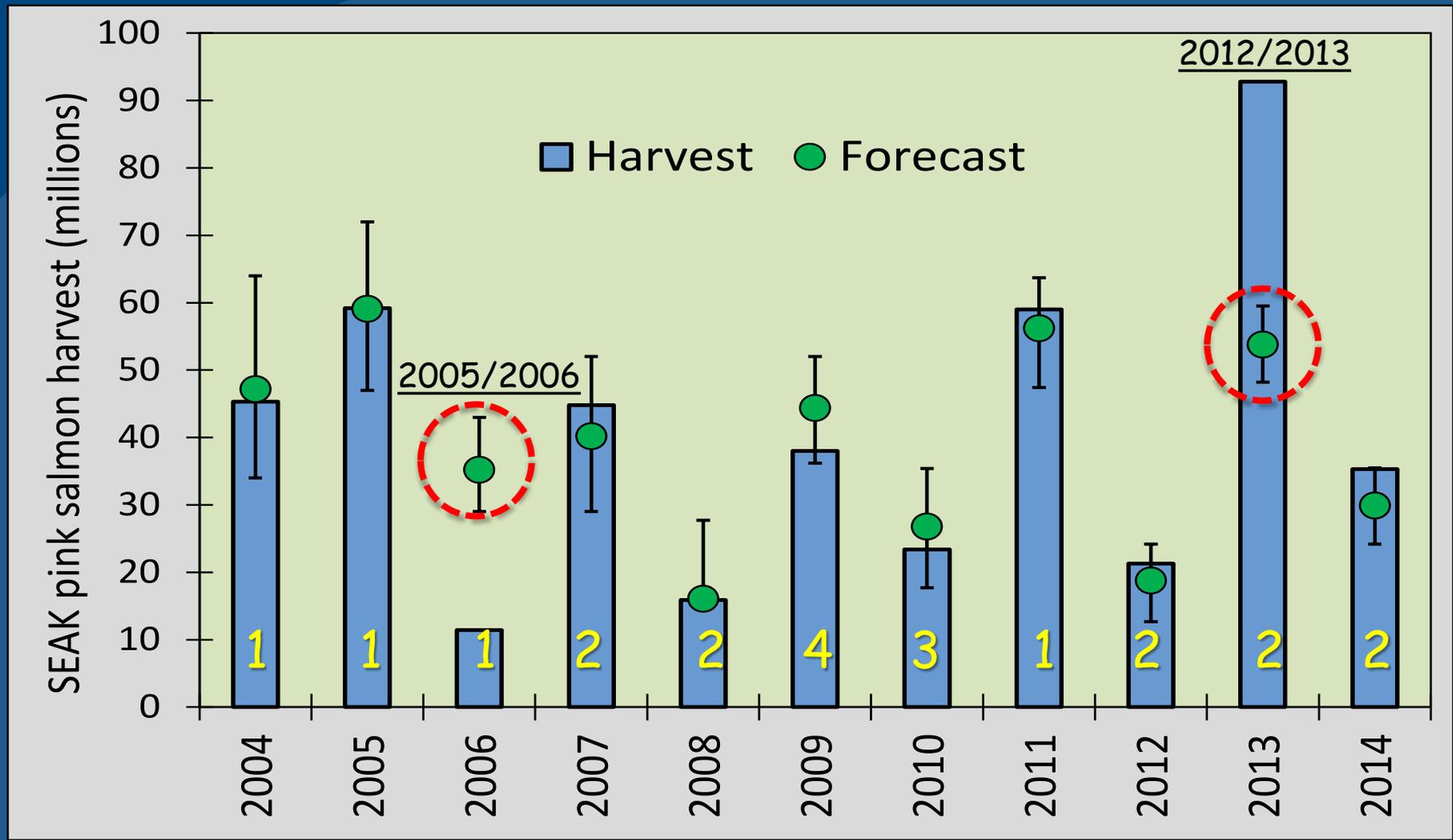
Ocean basin: ENSO (El Niño Southern Oscillation Index), PDO (Pacific Decadal Oscillation Index), & NPI (North Pacific Index)

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

SECM pink salmon forecast models 2004-2014:

In 9 of 11 years, forecasts 0-20% of harvest, \bar{x} deviation 9%



Number of parameters in each model (1=CPUE only)

2014 SECM sampling results

May oceanographic sampling completed w/ RV *Sashin*

June, July, and August trawl and oceanographic sampling conducted with chartered FV *Northwest Explorer* (used past four years)

High juvenile pink catches: 5th highest ($CPUE_{cal}$, vessel calibrated) and 3rd highest ($CPUE_{\text{td}}$, trawl track distance), and a high proportion of pinks/catch

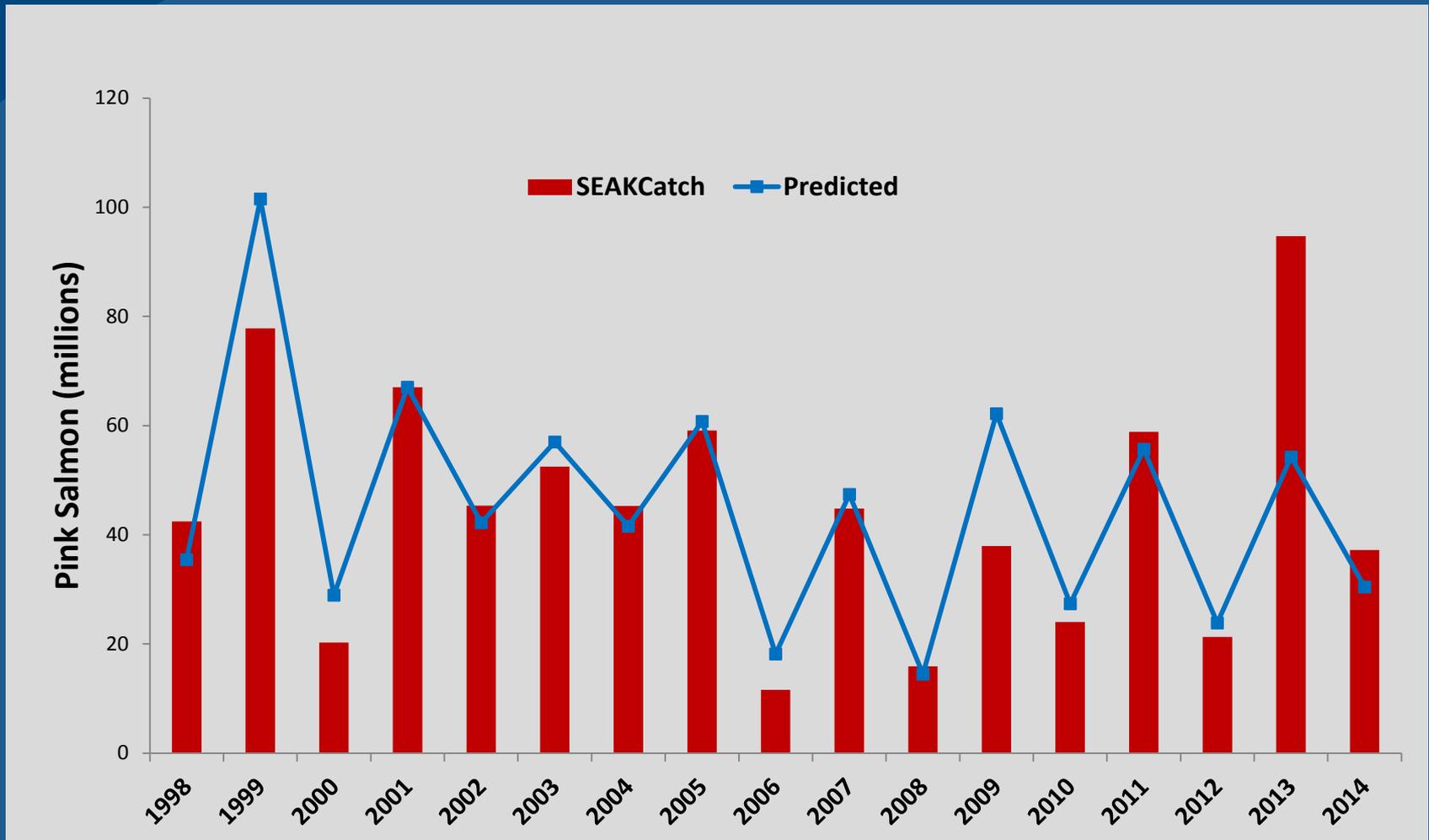
Average migration time, coho predation index, North Pacific Index, and Icy Strait temperatures

A strong indication of avian predation on pinks

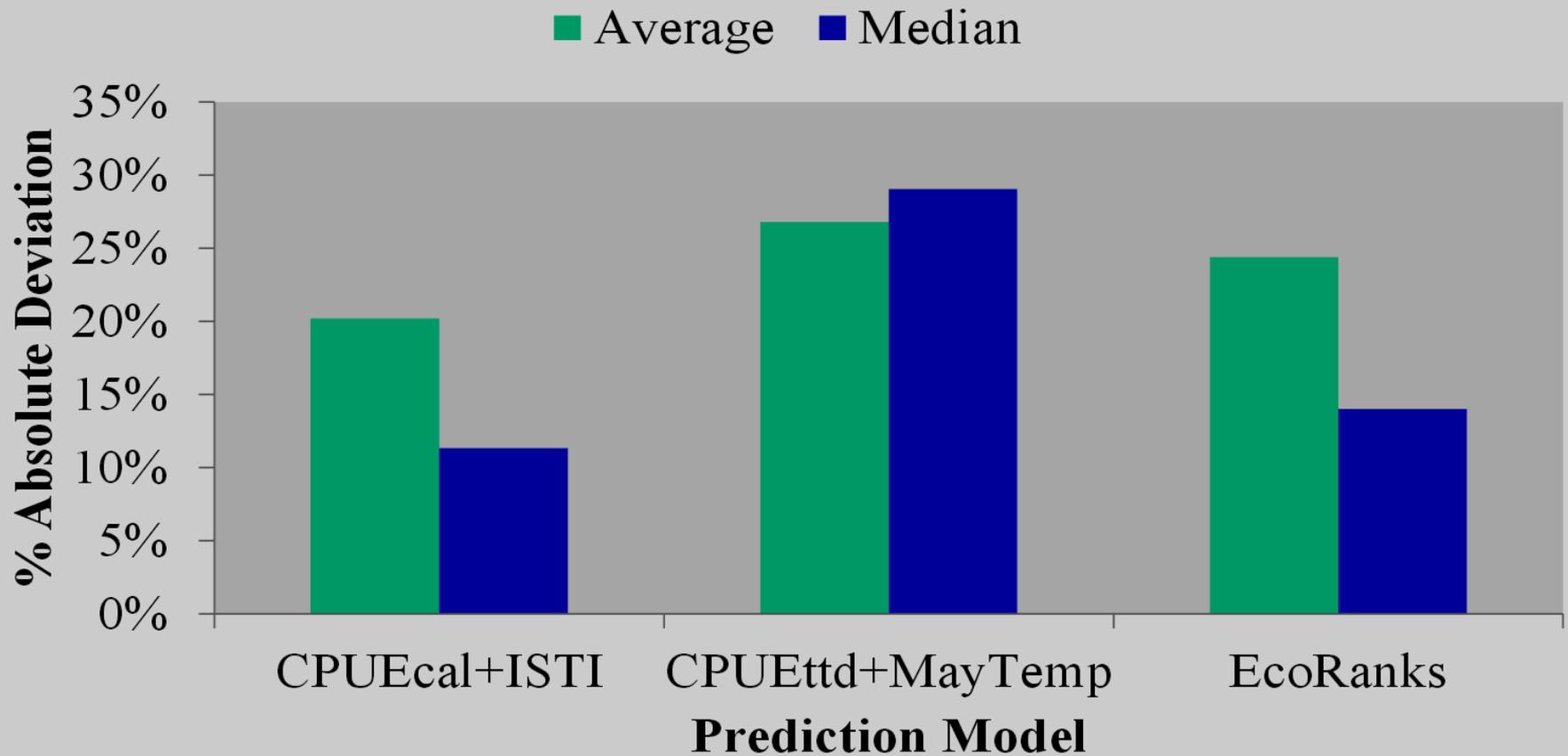
2015 pink salmon forecast models

Models considered	Regre. P value	Adj. R^2	AIC_c	Jack-knife % error avg/med	Prediction for 2015 (80% CI)
CPUEcal + ISTI	< 0.001	74%	139.7	20/11	54.5 M (38-71)
CPUEtttd + MayTemp	< 0.001	81%	134.4	27/29	71.5 M (57-86)
Ecorank (6 variables)	< 0.001	73%	138.3	24/14	57.9 M (42-74)

Jackknife "Leave-One-Out" forecasts CPUEcal + ISTI model: 1998-2014



Jackknife prediction errors for $PeakCPUE_{cal}$, $PeakCPUE_{tttd}$, and Ecorank models

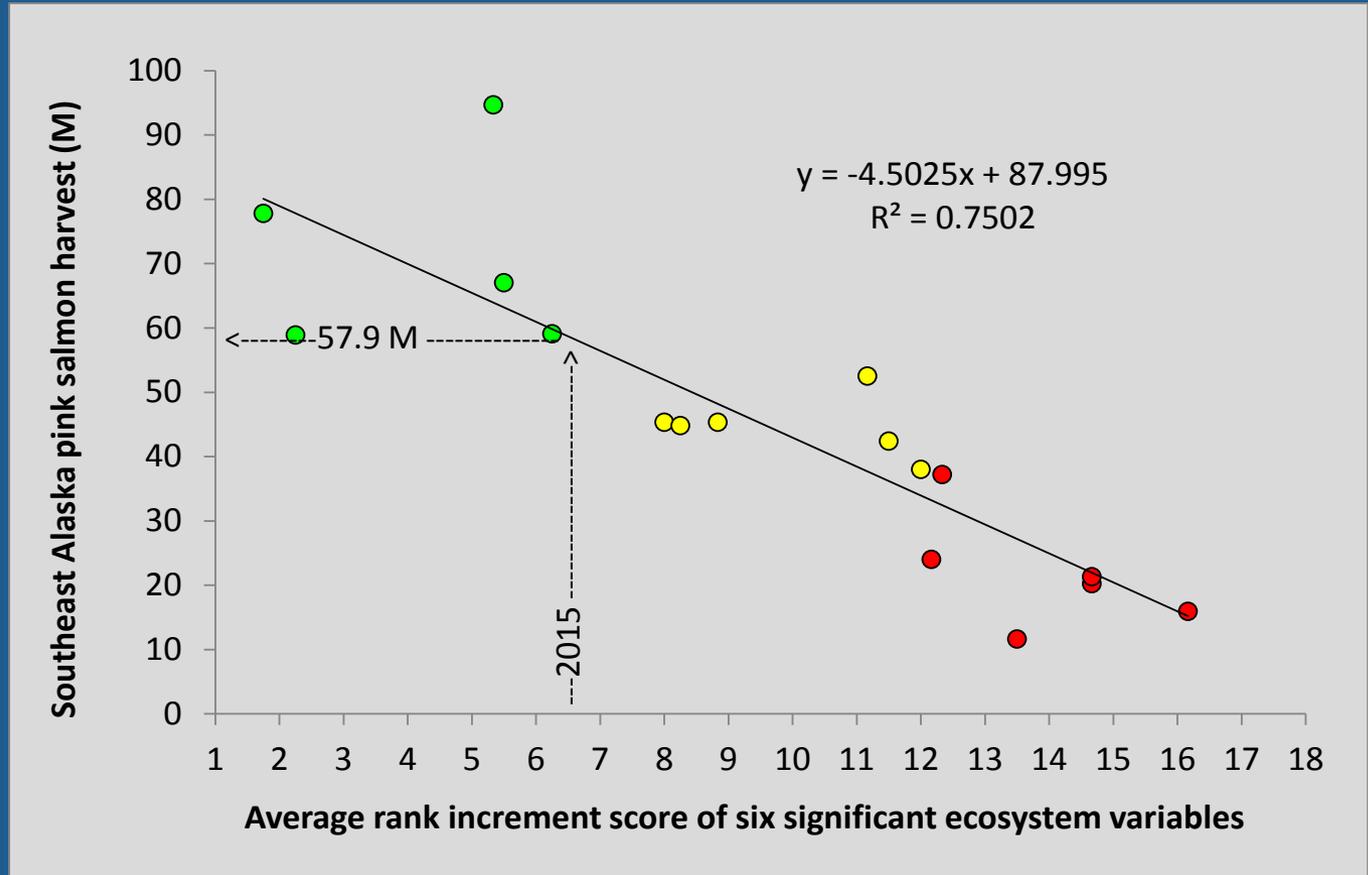


Pink salmon parent brood year				Chronological ecosystem variables										Pink salmon harvest		
Brood year (BY)	SEAK pink harvest (M)	Pink regional proportionality (% Northern harvest: Green= 40-60%, Yellow= >20<40%, or >60<80%. Red = <20%>80%)	Pink escapement index for SEAK	Ocean entry year (BY lagged 1 yr later)	Auke Creek fry outmigration (1,000s) Lat 58°N	Upper 1-20 m avg. Icy Strait temp. "ISTI" May-Aug	Juvenile peak pink (CAL) CPUE <small>June or July</small>	Juvenile peak pink (TTD) CPUE <small>June or July</small>	Peak seaward migration month	Proportion of pink in trawl hauls in June-July-Aug	Adult coho predation impact Coho total #s/J-pink CPUE	North Pacific Index (June, July, Aug)	Ranking of the average annual scores of the six significant variables	SEAK pink harvest (M) (BY lagged 2 yrs later)	SEAK pink harvest (M) (response variable)	
Data source	ADFG ₁	ADFG	ADFG ₂		NOAA ₁	NOAA ₂	NOAA ₂	NOAA ₂	NOAA ₂	NOAA ₂	NOAA ₂	NOAA ₂ ADFG ₃	CGD	↓		ADFG ₁
1996	64.6	17%	18.1	1997	31.1	9.5	2.5	2.2	July	18%	1.5	15.6	11	1998	42.4	
1997	28.9	47%	14.8	1998	60.8	9.7	5.6	5.3	June	46%	0.8	18.1	1	1999	77.8	
1998	42.4	44%	14.3	1999	53.5	9.0	1.6	1.4	July	9%	3.9	15.8	16	2000	20.2	
1999	77.8	50%	27.3	2000	132.1	9.0	3.7	3.3	July	28%	1.0	16.9	4	2001	67.0	
2000	20.2	39%	10.8	2001	61.5	9.5	2.9	2.6	July	30%	2.0	16.8	8	2002	45.3	
2001	67.0	22%	18.6	2002	150.1	8.6	2.8	2.5	July	26%	2.5	15.6	10	2003	52.5	
2002	45.3	49%	16.6	2003	95.1	9.8	3.1	2.7	July	20%	1.8	16.1	9	2004	45.3	
2003	52.5	44%	20.0	2004	169.6	9.7	3.9	3.4	June	32%	1.4	15.1	5	2005	59.1	
2004	45.3	54%	15.7	2005	87.9	10.2	2.0	1.7	Aug	35%	3.3	15.5	15	2006	11.6	
2005	59.1	51%	19.9	2006	65.9	8.9	2.6	2.3	June	23%	1.9	17.0	7	2007	44.8	
2006	11.6	72%	10.2	2007	81.9	9.3	1.2	1.0	Aug	17%	3.7	15.7	18	2008	15.9	
2007	44.8	29%	17.6	2008	117.6	8.2	2.5	2.2	Aug	24%	2.1	16.1	12	2009	38.0	
2008	15.9	14%	9.5	2009	34.8	9.5	2.1	2.7	Aug	26%	1.7	15.1	13	2010	24.0	
2009	38.0	31%	12.7	2010	121.6	9.6	3.7	5.0	June	60%	0.9	17.6	2	2011	58.9	
2010	24.0	43%	11.2	2011	30.9	8.9	1.3	1.6	Aug	27%	4.1	15.7	17	2012	21.3	
2011	58.9	81%	14.3	2012	61.8	8.7	3.2	4.3	July	49%	1.1	16.7	3	2013	94.7	
2012	21.3	13%	11.0	2013	51.2	9.2	1.9	2.6	July	13%	2.8	16.0	14	2014	37.2	
2013	94.7	44%	25.2	2014	47.4	9.4	3.4	4.6	July	57%	2.1	15.8	6	2015	???	
Harvest correlations	0.46	0.24	0.39		0.29	-0.20	0.81	0.84	-0.65	0.61	-0.81	0.61	Pearson correlation "r"			
Probability value=	0.06	0.36	0.13		0.28	0.46	0.00*	0.00*	0.01*	0.01*	0.00*	0.01*	(*=significant@p<0.05)			

Data sources: ADFG (S. Hein₁, A. Piston₂, and L. Shaul₃), CGD = Climate & Global Dynamics (J. Hurrell, <http://www.cgd.ucar.edu/cas/jhurrell/indices.data.html>), & NOAA Auke Bay Laboratories (J. Joyce₁ - Auke Creek research station & E. Fergusson/J. Orsi/E. Yasumiishi₂ - Southeast Coastal Monitoring project)

Ecorank model: SEAK harvest vs. avg rank score of the six significant variables

Year	Ave. rank	Harvest
1998	11	42.4
1999	1	77.8
2000	16	20.2
2001	3	67.0
2002	8	45.3
2003	10	52.5
2004	9	45.3
2005	4	59.1
2006	15	11.6
2007	7	44.8
2008	18	15.9
2009	12	38.0
2010	14	24.0
2011	2	58.9
2012	17	21.3
2013	5	94.7
2014	13	37.2
2015	6	??



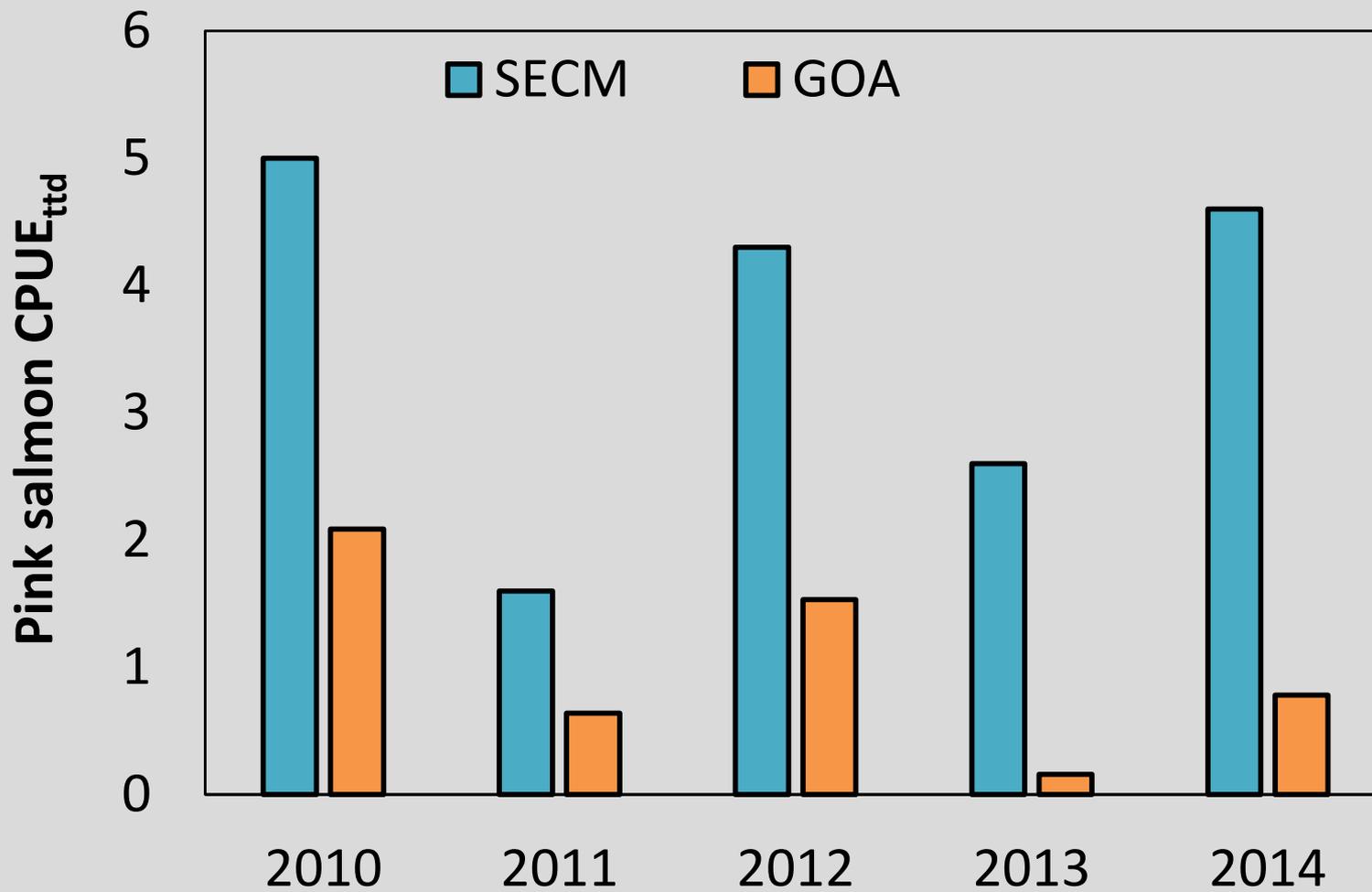
Rank 6 (2014 ocean conditions) = 57.9 M harvest in 2015

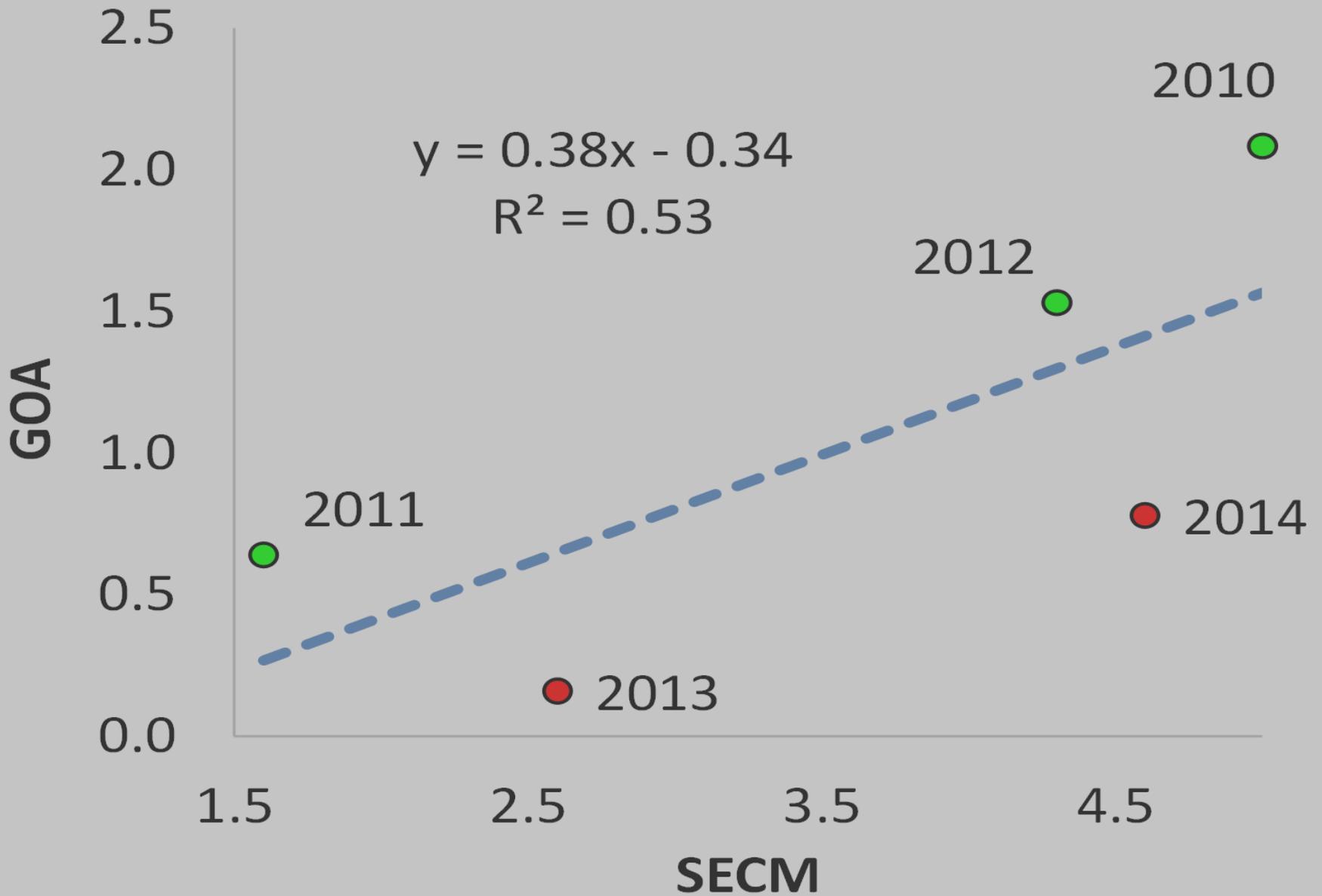
Gulf of AK pink catches



Icy Strait vs. Gulf of AK pink catches

Juvenile pink catches in Strait and GOA waters





Predators of juvenile/immature salmon?



Pink salmon observed after bird strike injuries, sampled in Icy Strait trawls, 30-31 July 2014



Haul – station examined	Pinks observed	Pinks with bird strikes	Percent “marked”
18062 - ISC	1,061	15	1.4%
18064 - UCA	95	0	0.0%
18065 - UCB	337	4	1.2%
18067 - UCC	120	2	1.7%
Total	1,613	21	1.5%

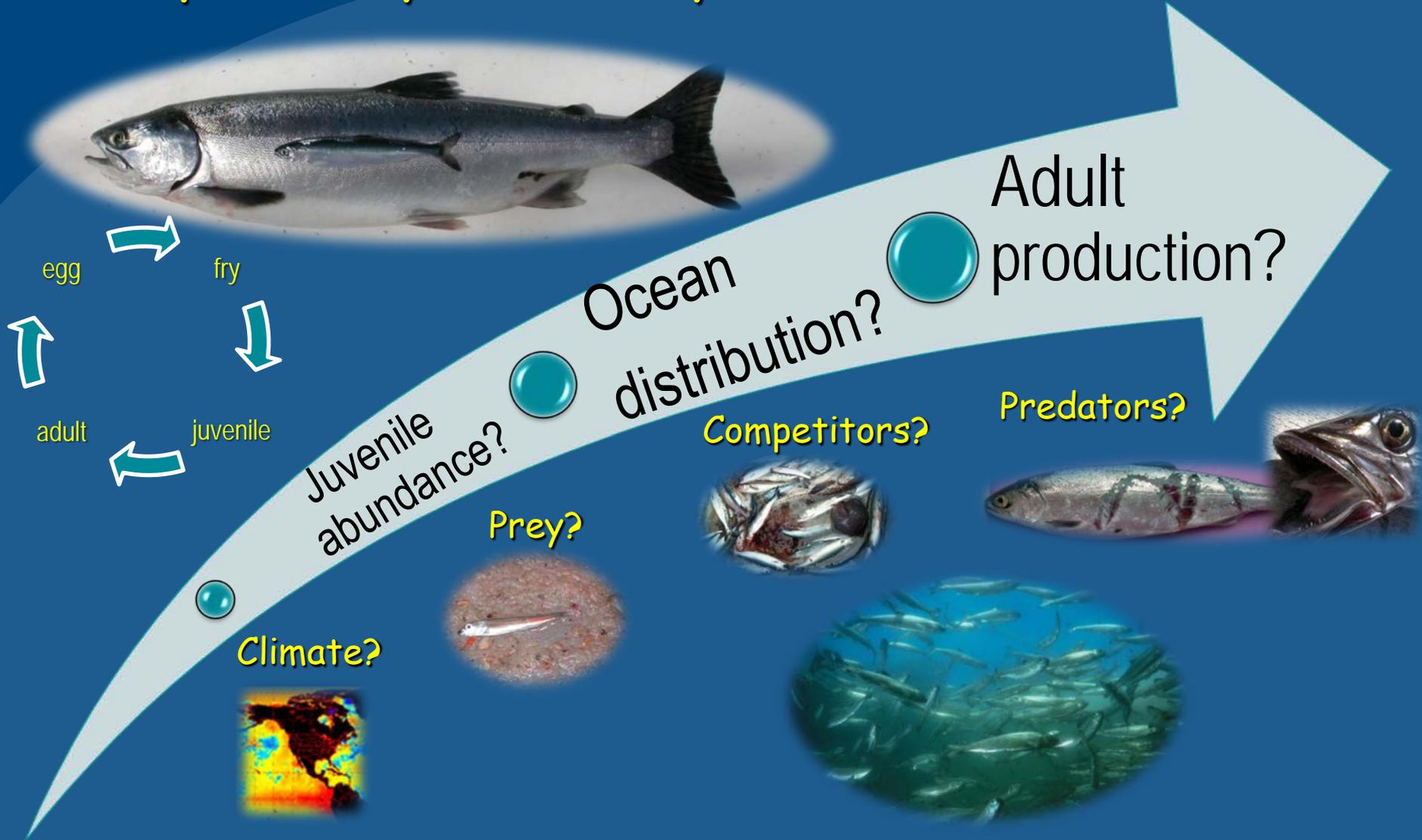
See predator scars most years, but this type was prevalent in 2014 so we quantified “marked survivors”

Implications of climate, 2014 ocean conditions and pink salmon production

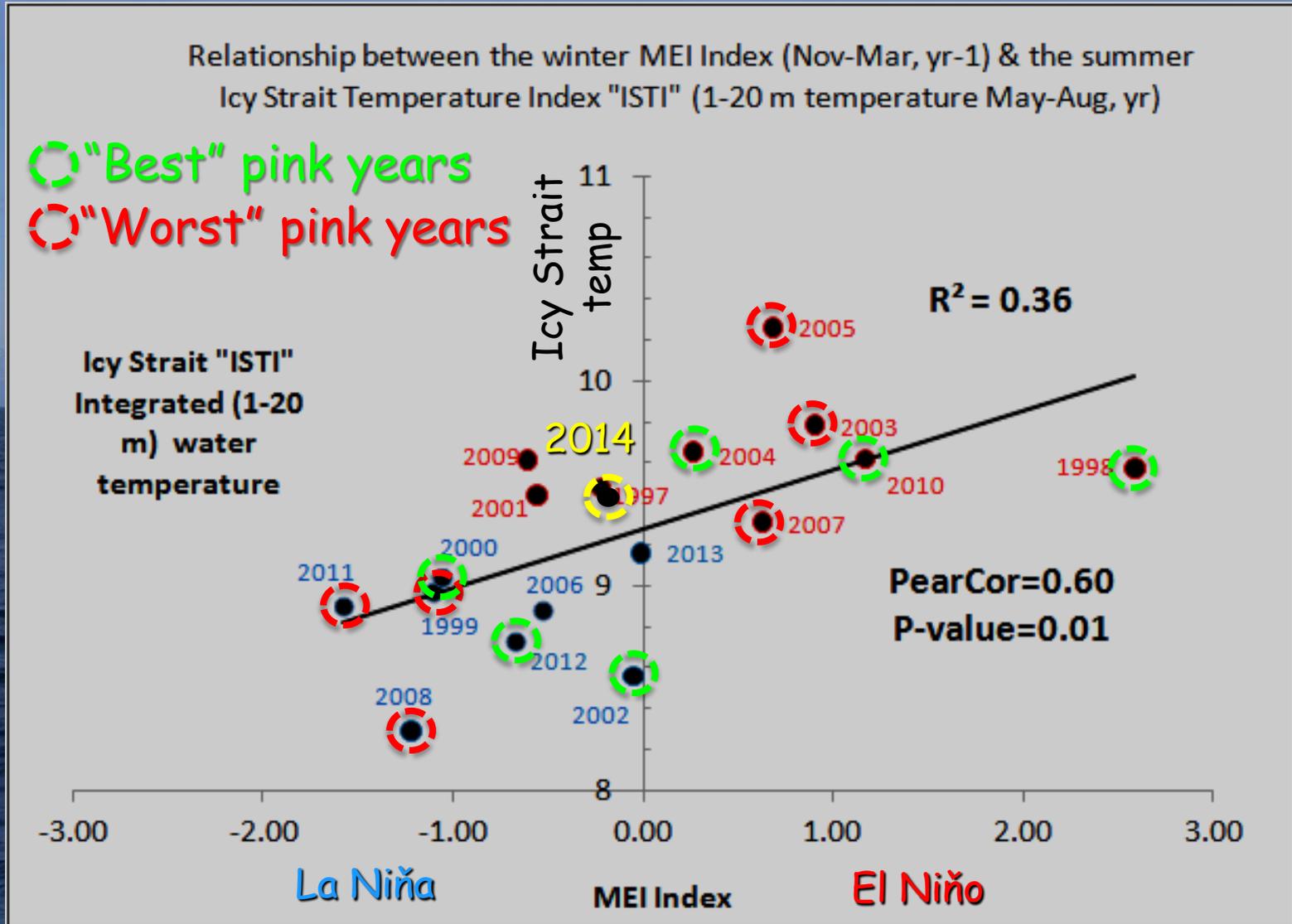


Model of potential pink salmon productivity drivers

--- Simple two year life cycle - one ocean winter ---

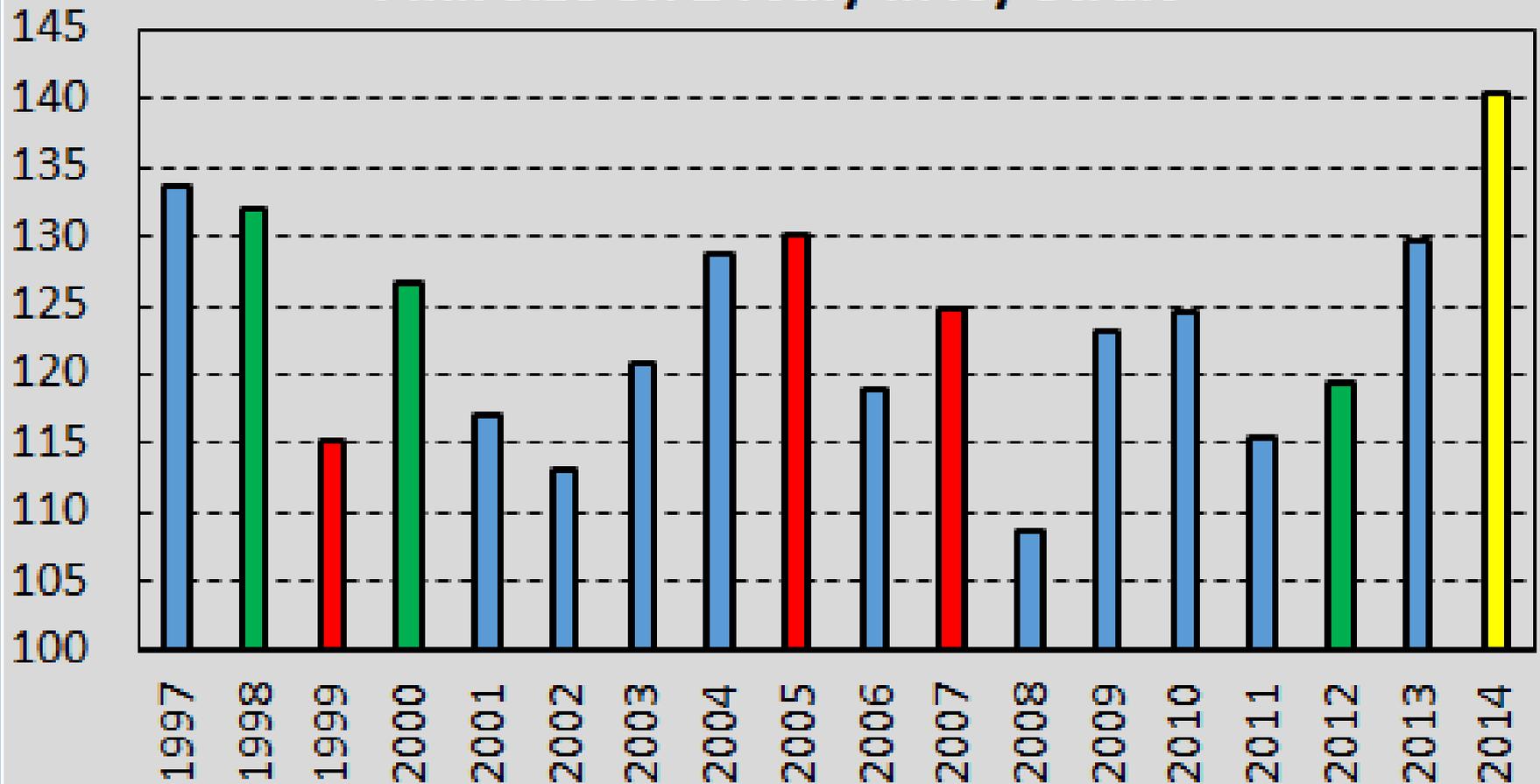


Climate connection between the MEI (winter) and Icy Strait 20-m integrated °C (summer)



How well did pinks grow in 2014 ocean conditions?

Pink size on 24 July in Icy Strait



Anomalously warm summer conditions in eastern GOA in 2005

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

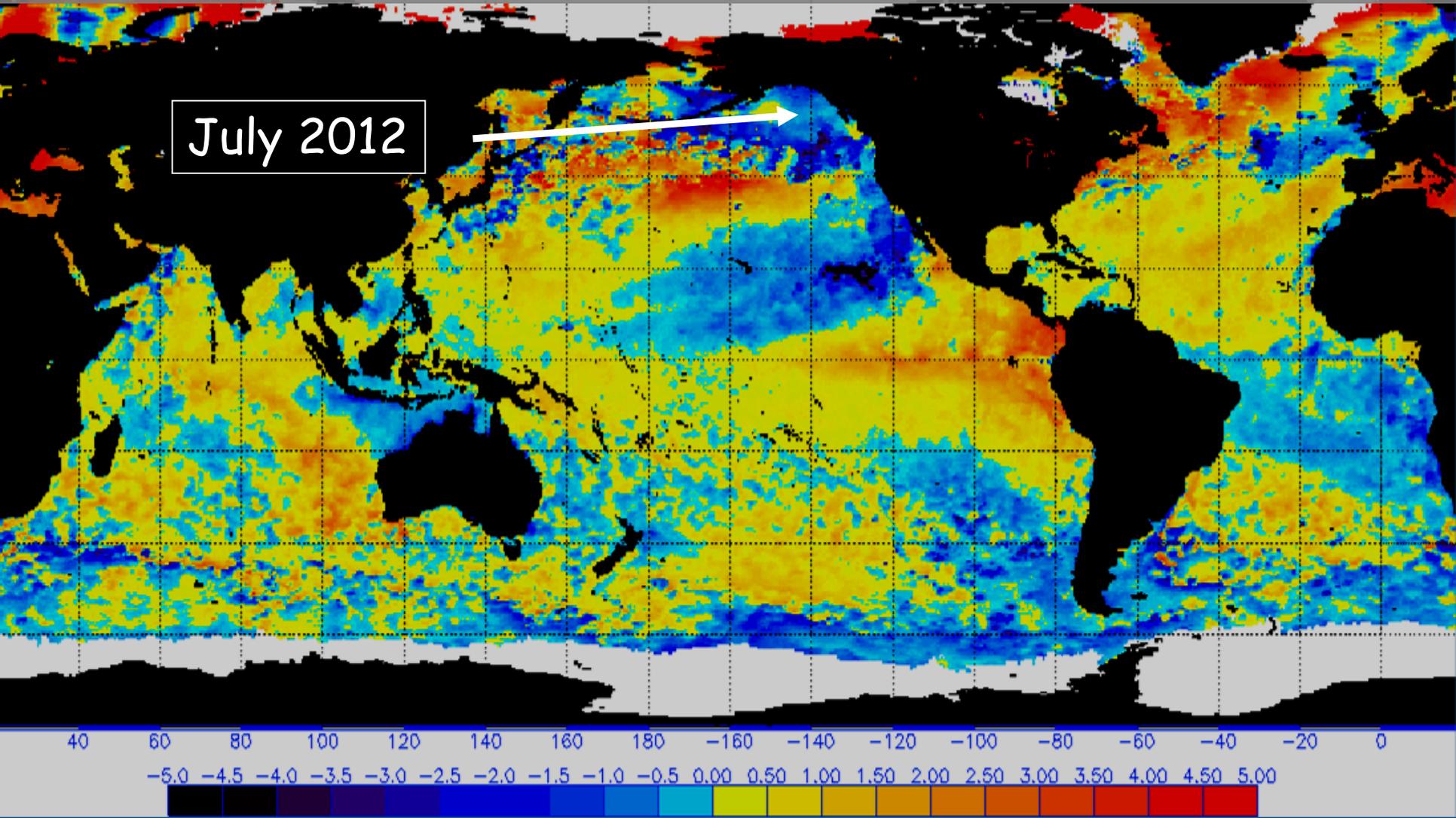
<http://www.osdpd.noaa.gov/PSB/EPS/SST/data/anomnight.7.12.2005.gif>



NOAA OFFICE OF SATELLITE AND PRODUCT OPERATIONS

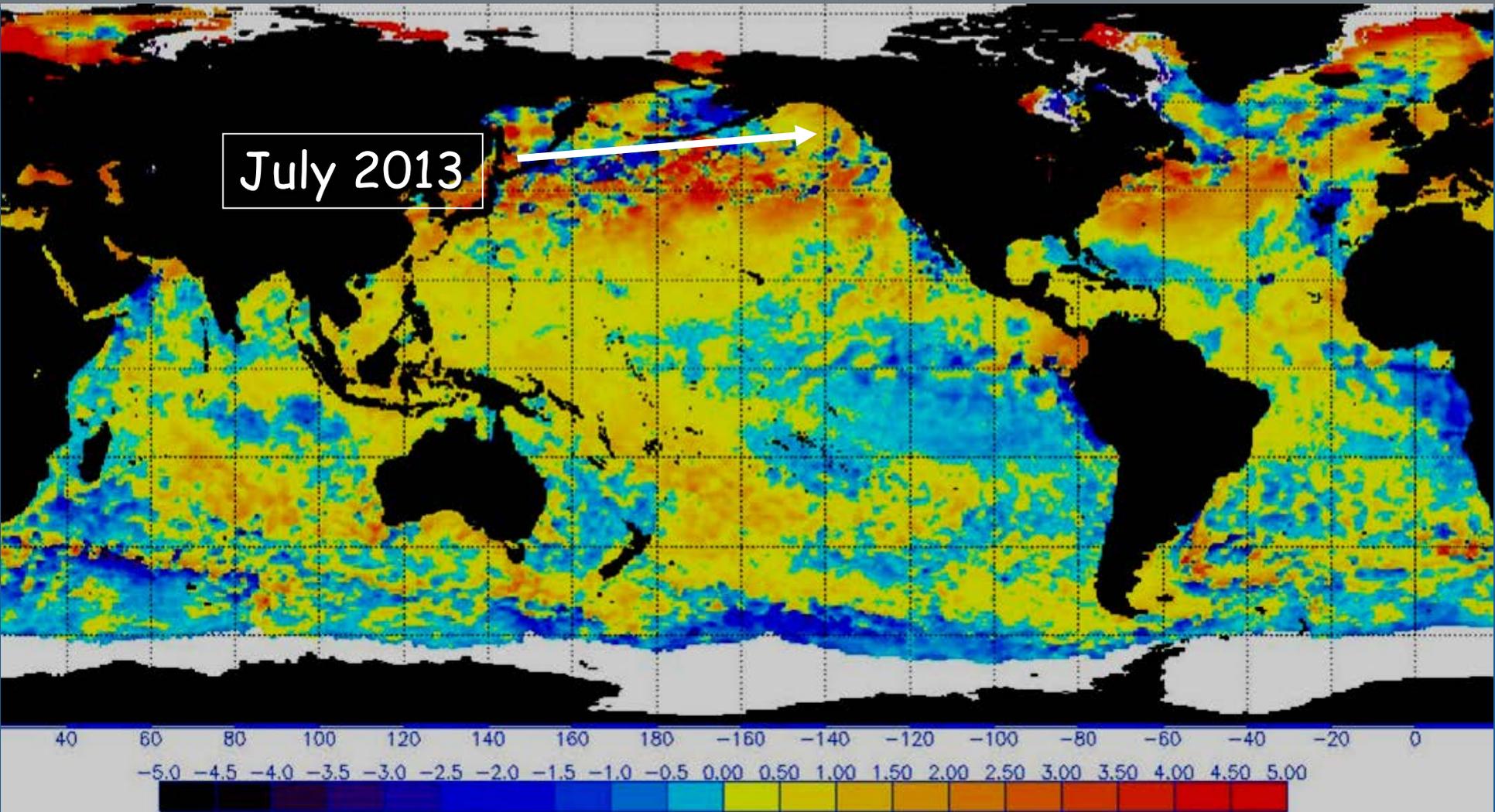
NATIONAL ENVIRONMENTAL SATELLITE DATA AND INFORMATION SERVICE

Anomalously cold summer conditions in eastern GOA in 2012



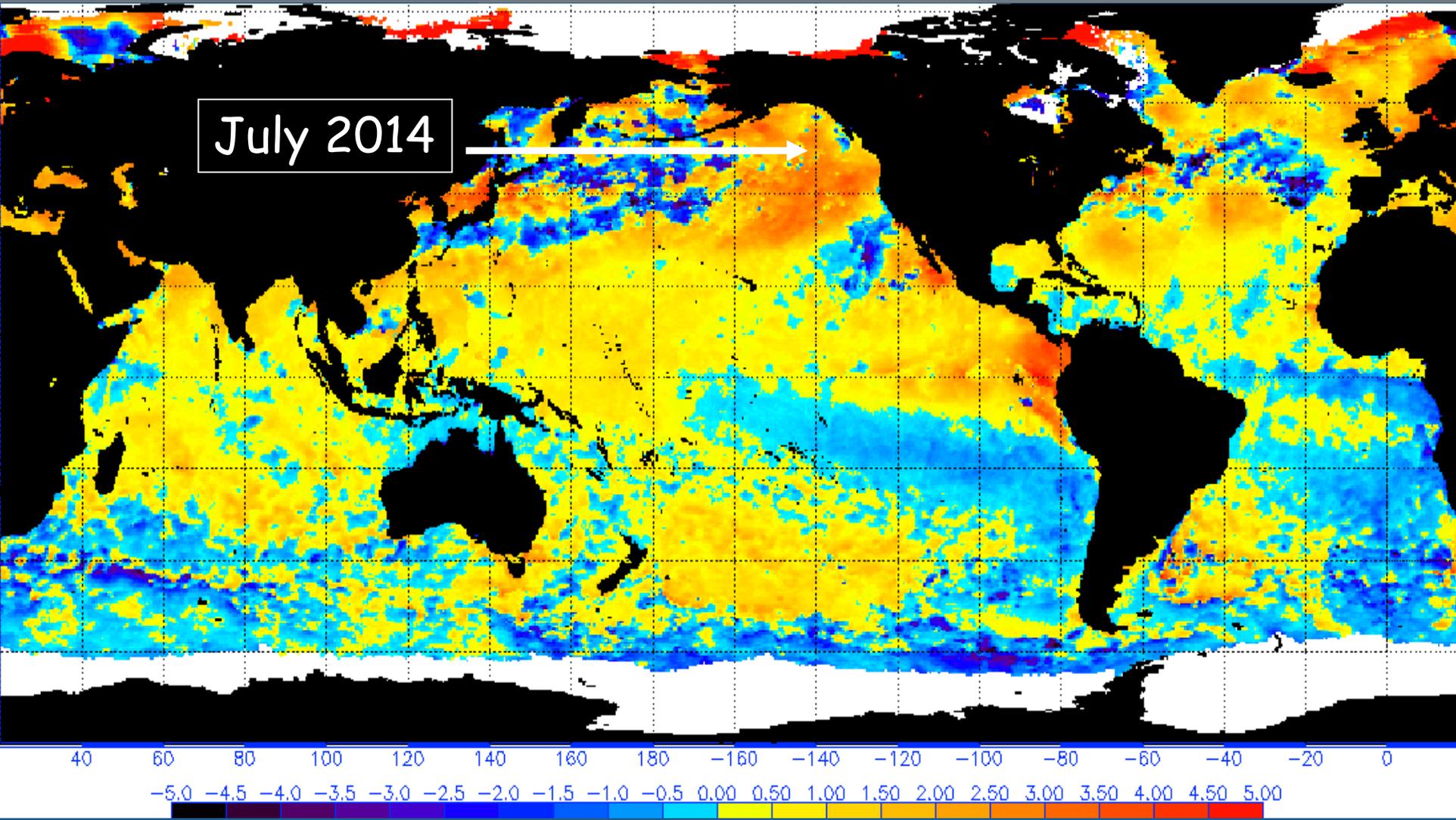
<http://www.osdpd.noaa.gov/PSB/EPS/SST/data/anomnight.7.12.2012.gif>

Intermediate summer conditions in eastern GOA in 2013



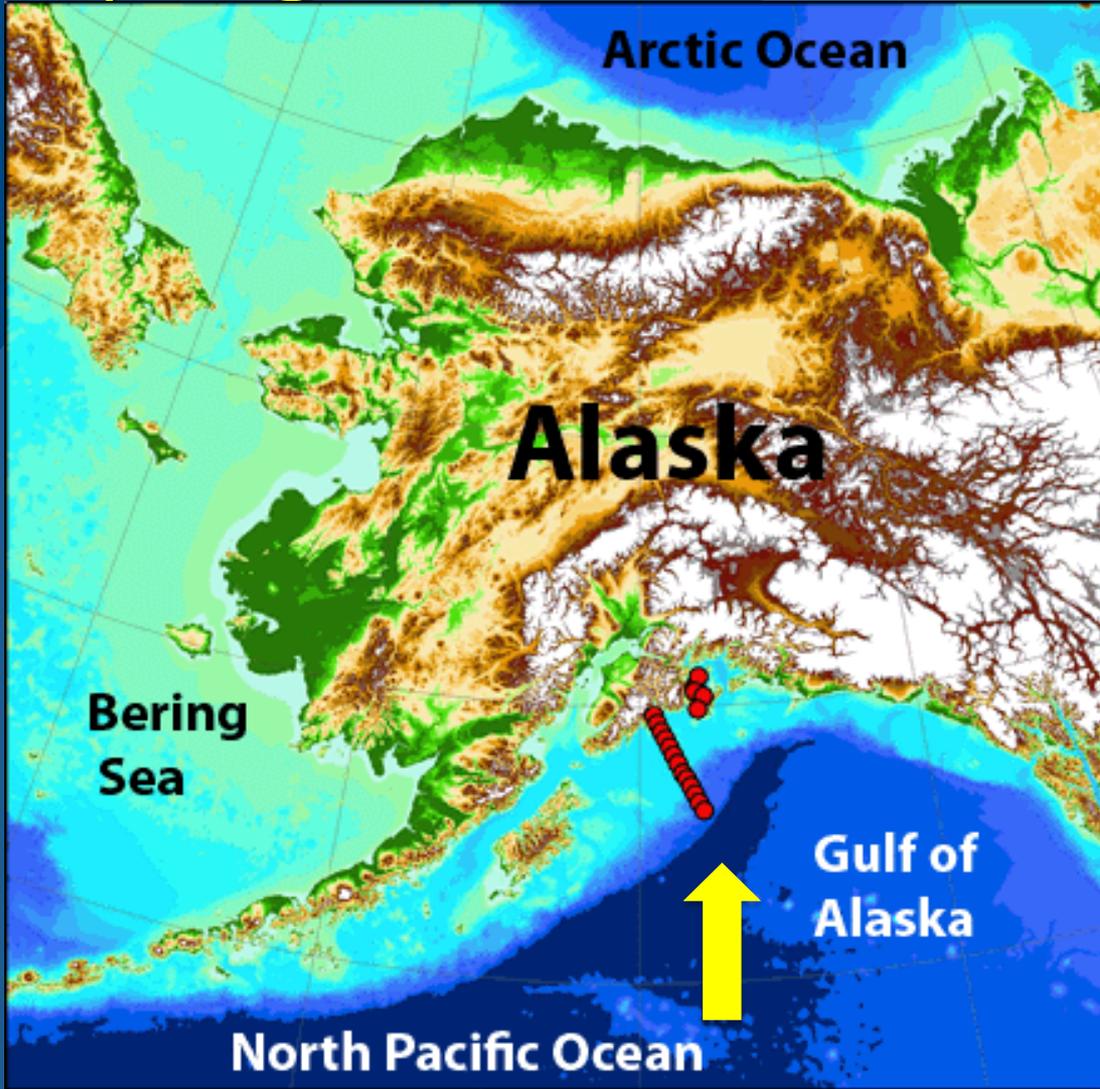
<http://www.ospo.noaa.gov/data/sst/anomaly/2013/anomnight.7.11.2013.gif>

“Warm blob” summer conditions in eastern GOA in 2014



<http://www.ospo.noaa.gov/data/sst/anomaly/2014/anomnight.7.10.2014.gif>

Spring & summer conditions in NW GOA



Seward Line website
accessed 13 Nov 2014

Spring 2014 status

Water temperatures: **Average**

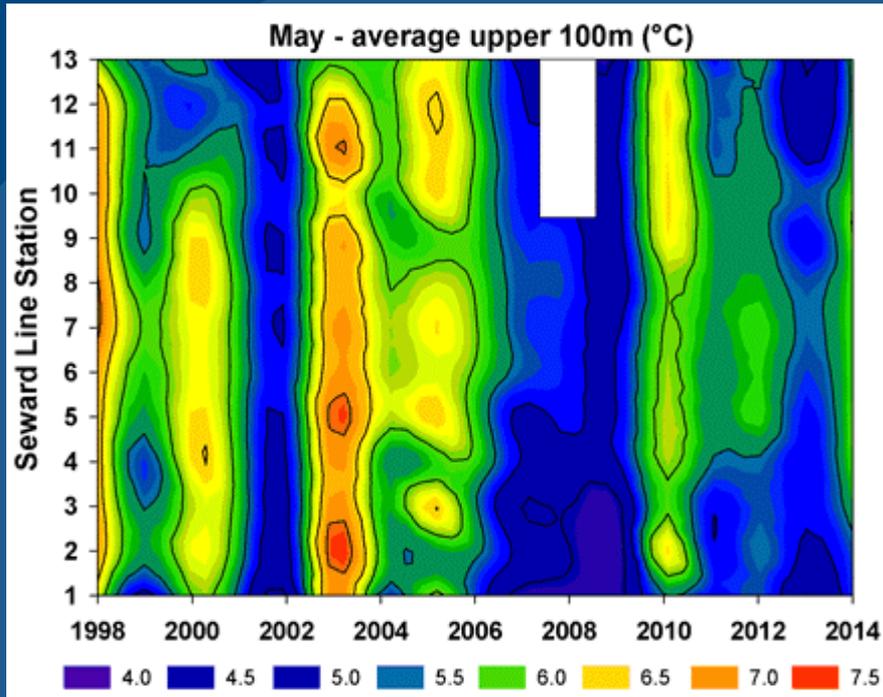
Summer 2014 status

Water temperatures: **HOT** (1.0°C
above average)

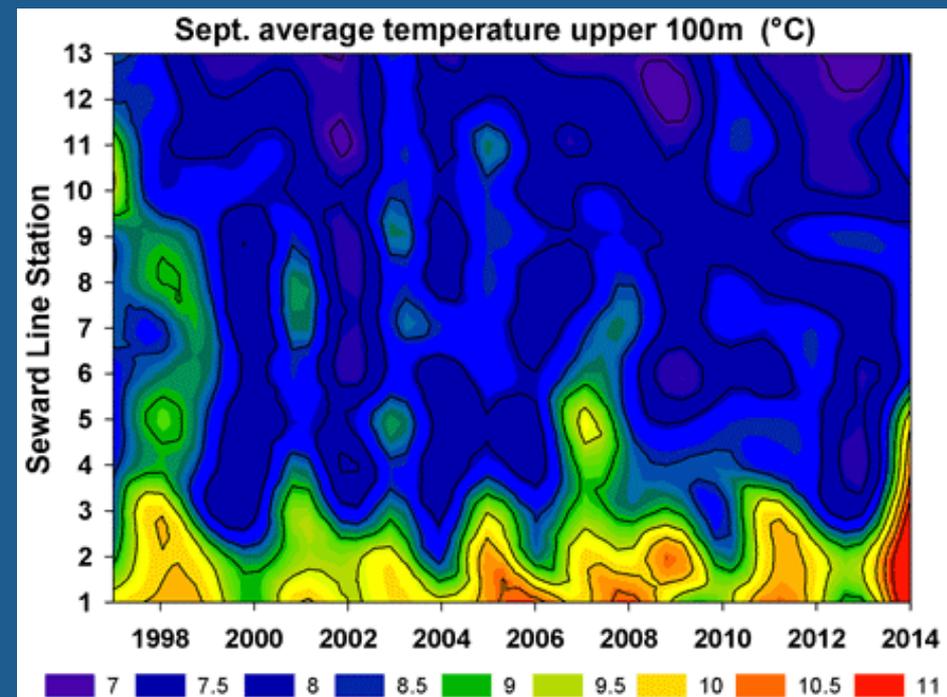
Zooplankton abundance: **Low**,
southern zooplankton species
present

Seward "GAK" Line temperatures 1998-2014

May temperature



September temperature



Upper 100m integrated water column temperatures at stations along the Seward line in the NW GOA

https://www.sfos.uaf.edu/sewardline/Physics_time-series.html

Conclusions:

- ❖ 54.5 M pink salmon harvest forecast for 2015
- ❖ Both alternative forecast models predicted higher harvests: 58 M eco rank & 72 M ttd 
- ❖ Precautionary lower forecast prudent due to anomalously warm ocean conditions in GOA, CPUE relatively lower in GOA compared to Icy Strait, & additional evidence of high avian predation
- ❖ Unknown ecological impacts of subtropical fish species (tuna, ocean sunfish, thresher sharks) in the GOA on pink salmon (competition/predation)

We will update our NOAA pink salmon forecast web page soon



NOAA FISHERIES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ALASKA FISHERIES SCIENCE CENTER



[General Info](#) [Species](#) [Programs](#) [Publications](#) [Data & Tools](#) [Images](#) [Education & Outreach](#) [Search](#)

EMA: Forecasting Pink Salmon Harvest in Southeast Alaska

Understanding how ocean conditions and climate impact salmon year class strength is an objective of the Auke Bay Laboratories (ABL) [Southeast Alaska Coastal Monitoring \(SECM\)](#) project. The SECM project has collected a time series of indexes that include juvenile salmon and their associated biophysical data in coastal Southeast Alaska (SEAK) since 1997.

**2014 NOAA Forecast
29.9 million pink salmon
with an 80% bootstrap
confidence interval of 26-38 M**



Juvenile and adult pink salmon captured during [SECM](#) sampling

Pink salmon returns are notoriously difficult to forecast because their two-year life history cycle only involves one ocean winter and precludes the use of younger returning age classes to predict cohort abundance. Moreover, year-class success varies widely, with harvests ranging from 3 to 95 million fish annually in SEAK since 1960.



Purse seiners harvest pink salmon worth upwards of \$125 million annually in SEAK.

Fortunately, direct measures of juvenile pink salmon abundance at sea from SECM sampling have provided a powerful tool to improve forecasts. Juvenile salmon marine mortality is reported to be high and variable during their initial spring nearshore residency. The SECM sampling of juveniles, which occurs later in the summer in seaward migration corridors, has proven to be an effective index for use in pink salmon forecast models for SEAK.

SECM has been using juvenile pink salmon catch and associated biophysical data to forecast adult pink salmon harvest in SEAK since 2004. Several models have been used in this annual forecasting. However, the primary biophysical factor correlated with harvest each year is the peak average catch per unit effort (CPUE) of juvenile pink

[ABL Home](#)

[Ecosystem Monitoring & Assessment](#)

[Projects](#)

BASIS

[SE Bering Sea Ecosystem Assessment](#)

[NE Bering Sea Ecosystem Assessment](#)

[Gulf of Alaska Ecosystem Assessment](#)

[Southeast Alaska Coastal Monitoring](#)

[Chukchi Sea Ecosystem Assessment](#)

[Anadromous Fish](#)

[Autonomous Underwater Vehicles](#)

[Program Info](#)

[Datasets](#)

[History](#)

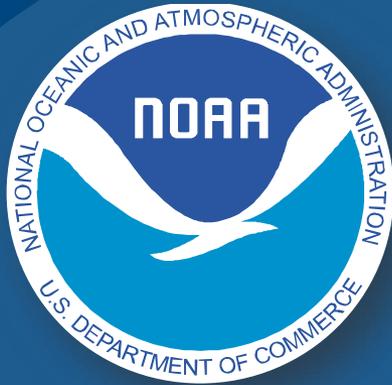
[Personnel](#)

[Posters](#)



NOAA FISHERIES

For financial & collaborative support we thank:



NOAA
AK Fisheries
Science
Center



Northern Fund
of the Pacific
Salmon
Commission



Alaska
Department
of Fish &
Game

MERRY CHRISTMAS!

