The NOAA 2014 Southeast Pink Salmon Forecast from Ecosystem Monitoring in Southeast Alaska

NOAA FISHERIES
Alaska Fisheries Science Center

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

Southeast Alaska Purse Seine Task Force Meeting
Ketchikan, Alaska, 03 December 2013

Presentation outline

- Overview ABL's Southeast Coastal Monitoring (SECM) project: 1997-2013
- Introduce ecosystem metrics considered for use in forecasting pink salmon harvest
- Review past model performances (2004-13) & present the 2014 NOAA pink forecast
- Explore "new tools" to better forecast regional pink harvest patterns in Southeast

Factors influencing SE pink salmon production

Aug-Sept (parent brood year established)
- Need adequate adult pink salmon escapements

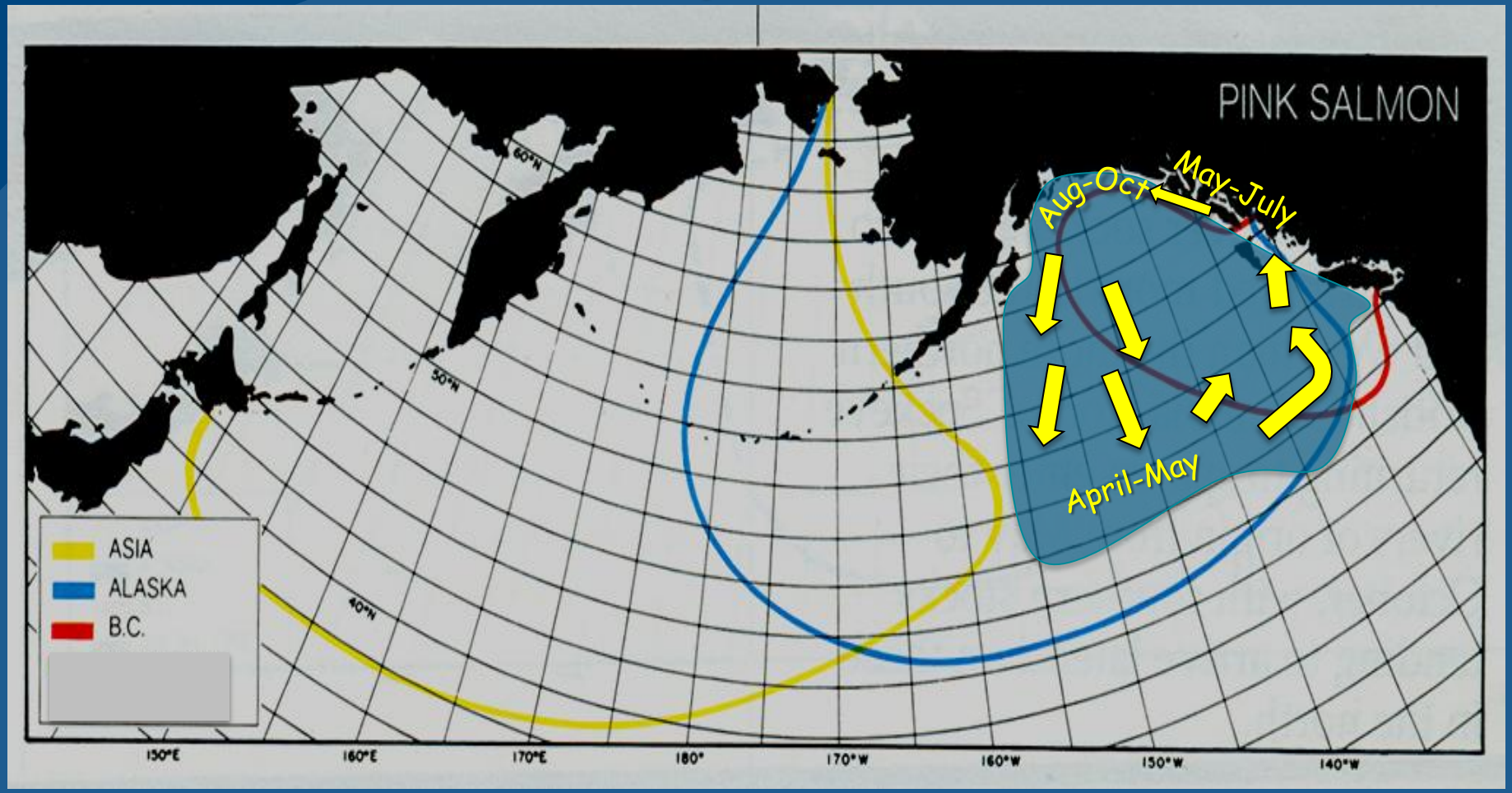
Oct-March (egg to emergence)
- Favorable fall stream flow and overwinter conditions for egg survival and fry production

April-May (fry nearshore marine: MAJOR critical period)
- Favorable estuarine conditions (temp & food) needed to facilitate size-dependant offshore movement of fry

June-Aug (juvenile offshore coastal migration)
- Rapid seaward migration, lower rates of coastal predation

Sept-Dec (juveniles open ocean) → Jan-June (adults return)
- Low predation in open ocean until harvest

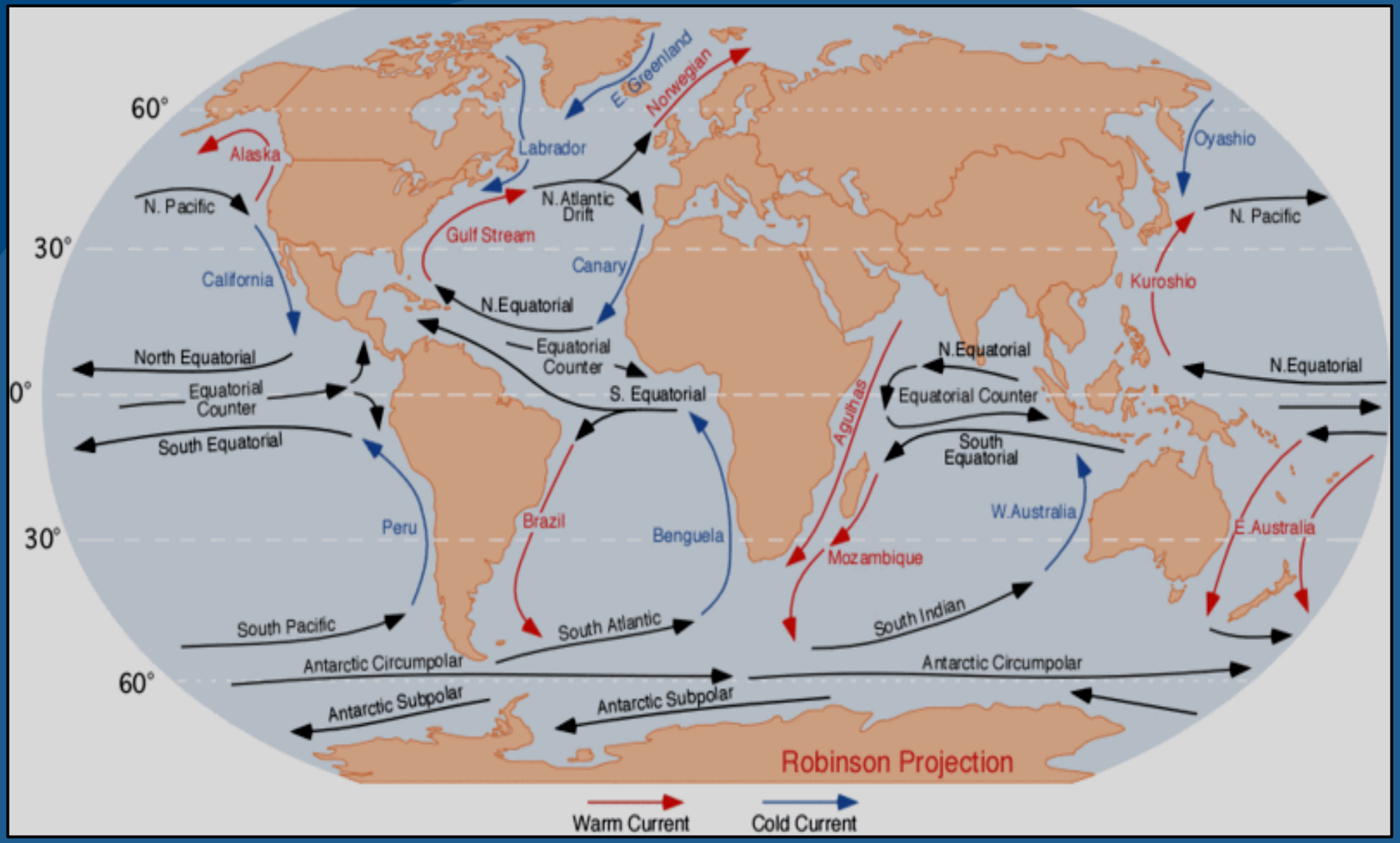
Generalized ocean distribution of pink salmon
Southeast Alaska pinks shaded in blue



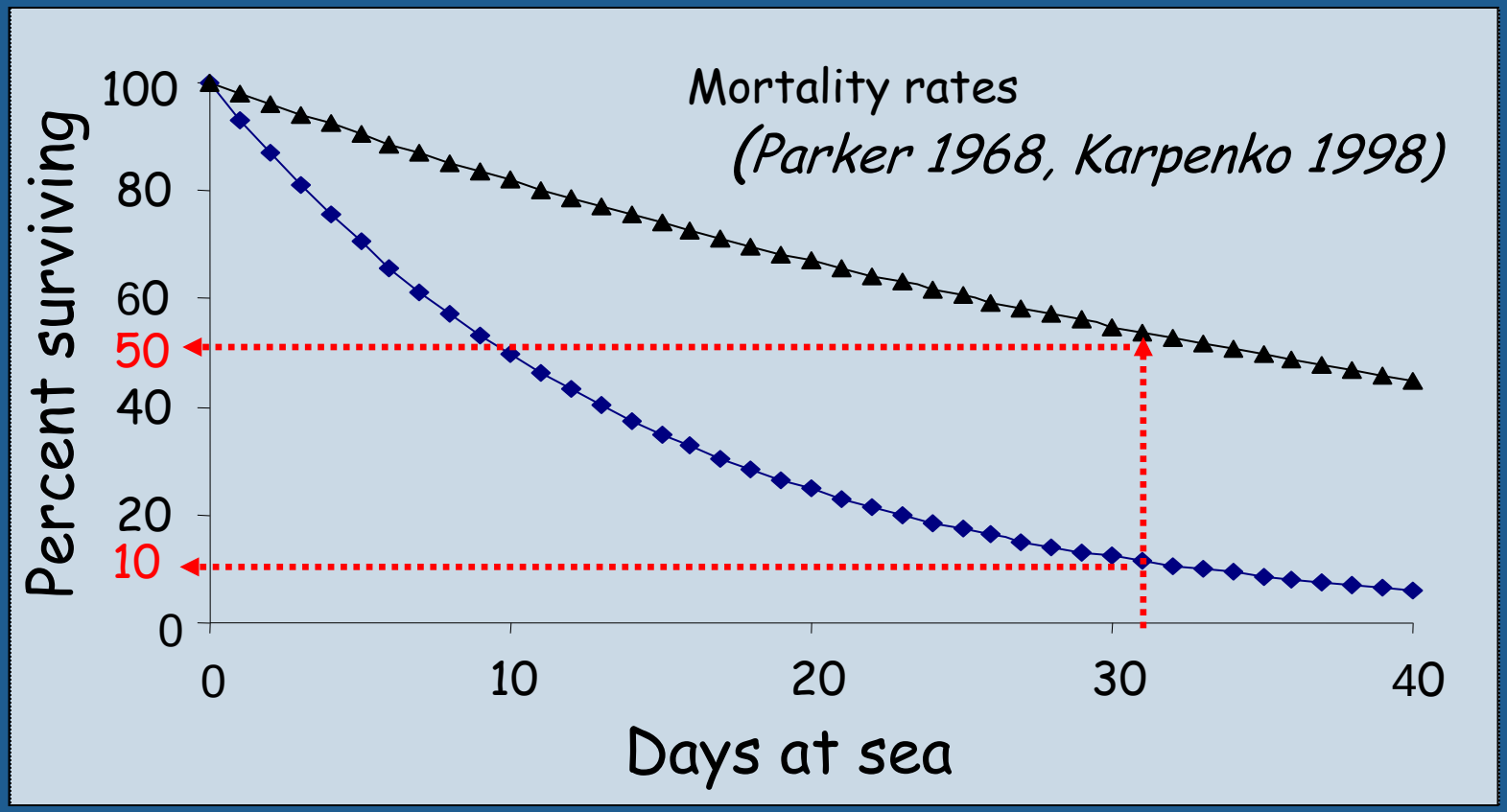
http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/salmon-saumon/facts-infos/pink-rose-eng.html

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

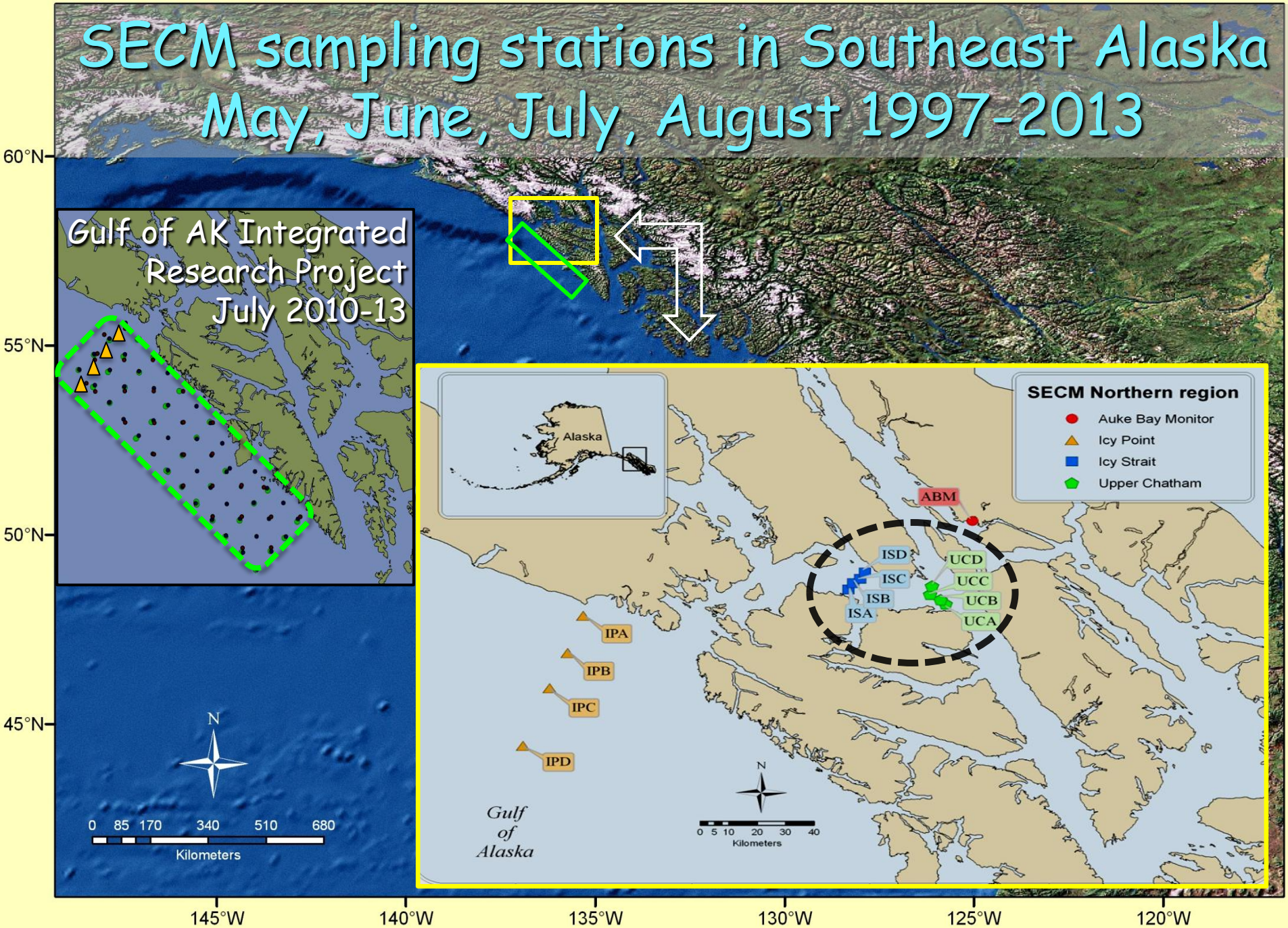
Generalized ocean current patterns



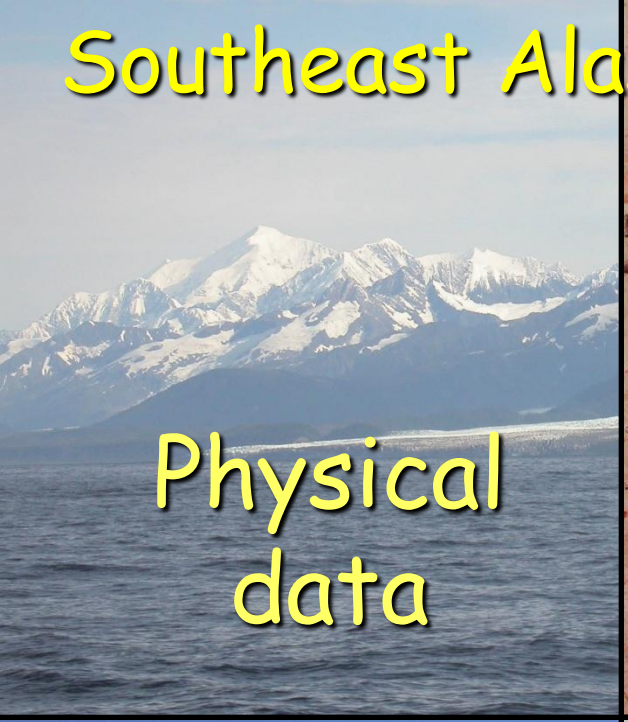
Paradigm of pink salmon biology: Mortality during early marine life is high, variable, and influences year class strength



SECM sampling stations in Southeast Alaska May, June, July, August 1997-2013



Southeast Alaska Coastal Monitoring (SECM)



Selected biophysical factors considered for forecasting Southeast pink salmon harvest

Biological (region)

J-pink salmon: Peak CPUE*, 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 Akiake Information Criteria (AIC_c) to check for "over parameterization"

3) "Jackknife" procedure to evaluate models over time series

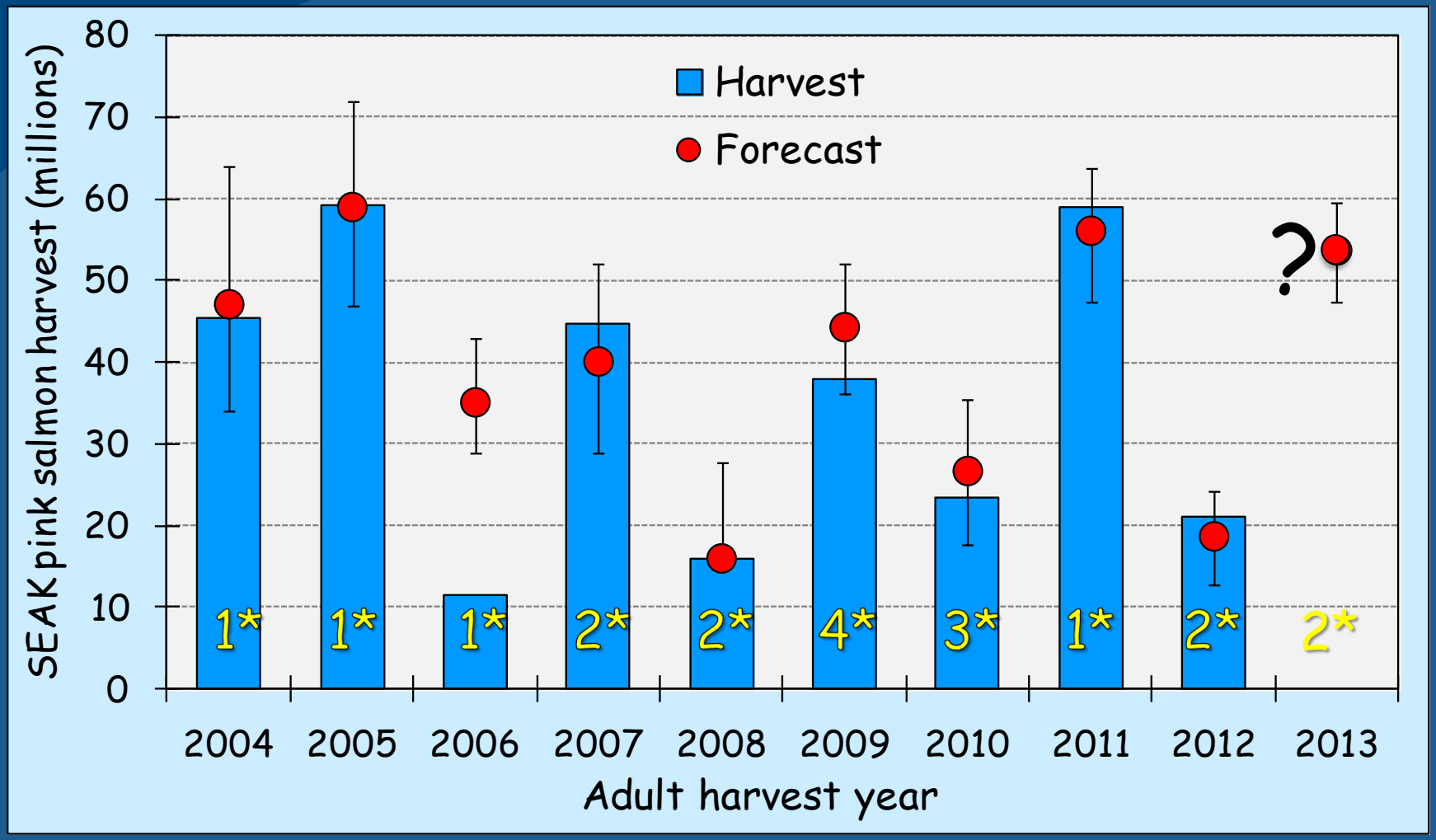
4) Bootstrap re-sampling of CPUE data to generate forecast confidence intervals and examine effect of measurement error

2013 SECM sampling & conditions

- Sampled osho with R/V *Sashin* in May, & trawled with a charter vessel in late June, July, & August
- 4th year using NW *Explorer;* assumed maximum fish catchability for vessel calibration
- 4th lowest (calibrated) juvenile peak pink $CPUE_{cal}$
- Low % pink in catch, average migration time, temperature (ISTI) , and NPI
- High predation rates observed: developed an index
- Great personnel support: ADFG, University, & Canada on surveys: Andy Piston, Michelle Morris, Noel Sme, Bryce Mecum, and Charmaine

SECM pink salmon forecast models 2004-2012:

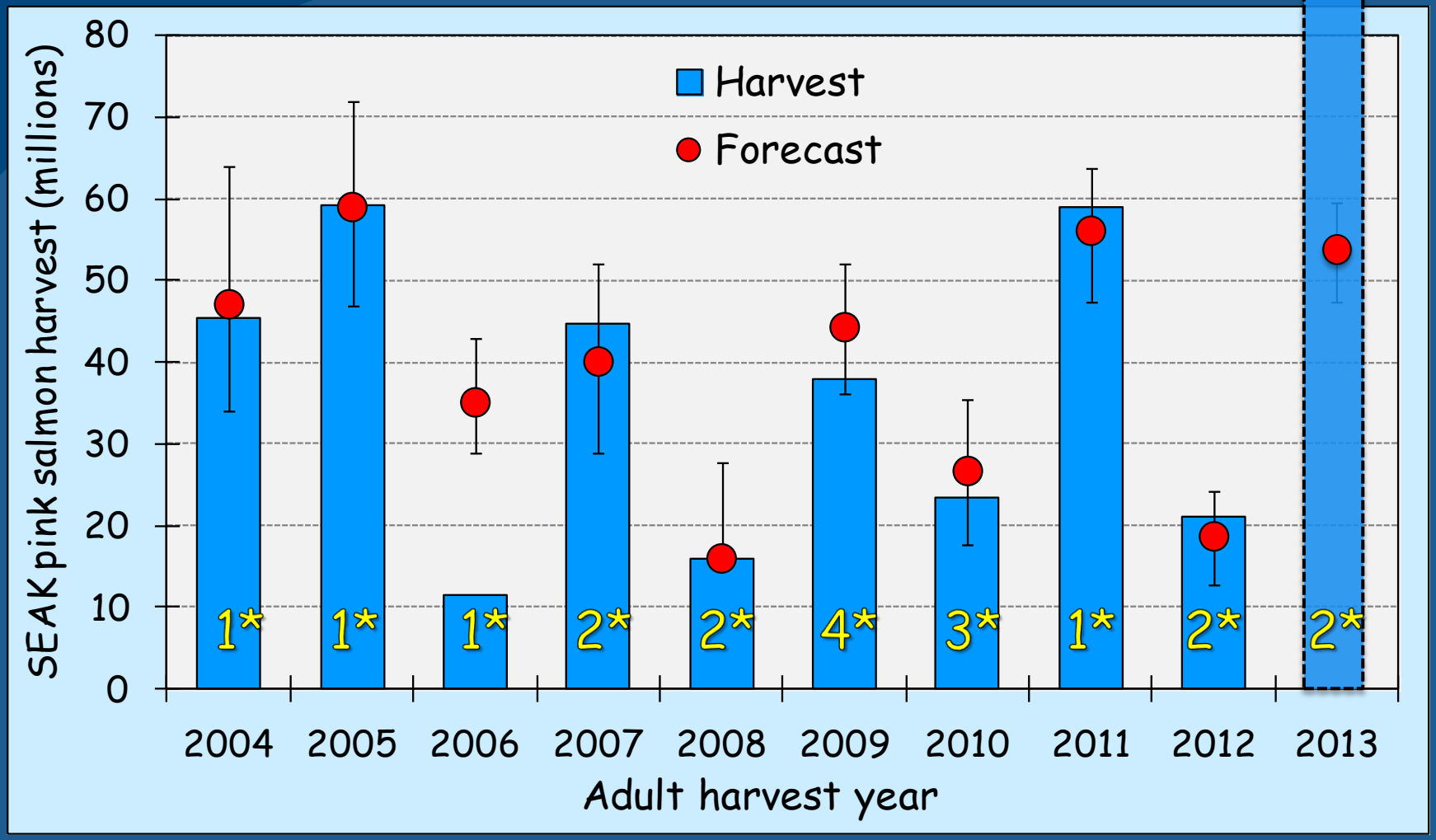
Average deviation 7% of harvest in 8 of 9 yrs



*Number of model parameters (1=CPUE only)

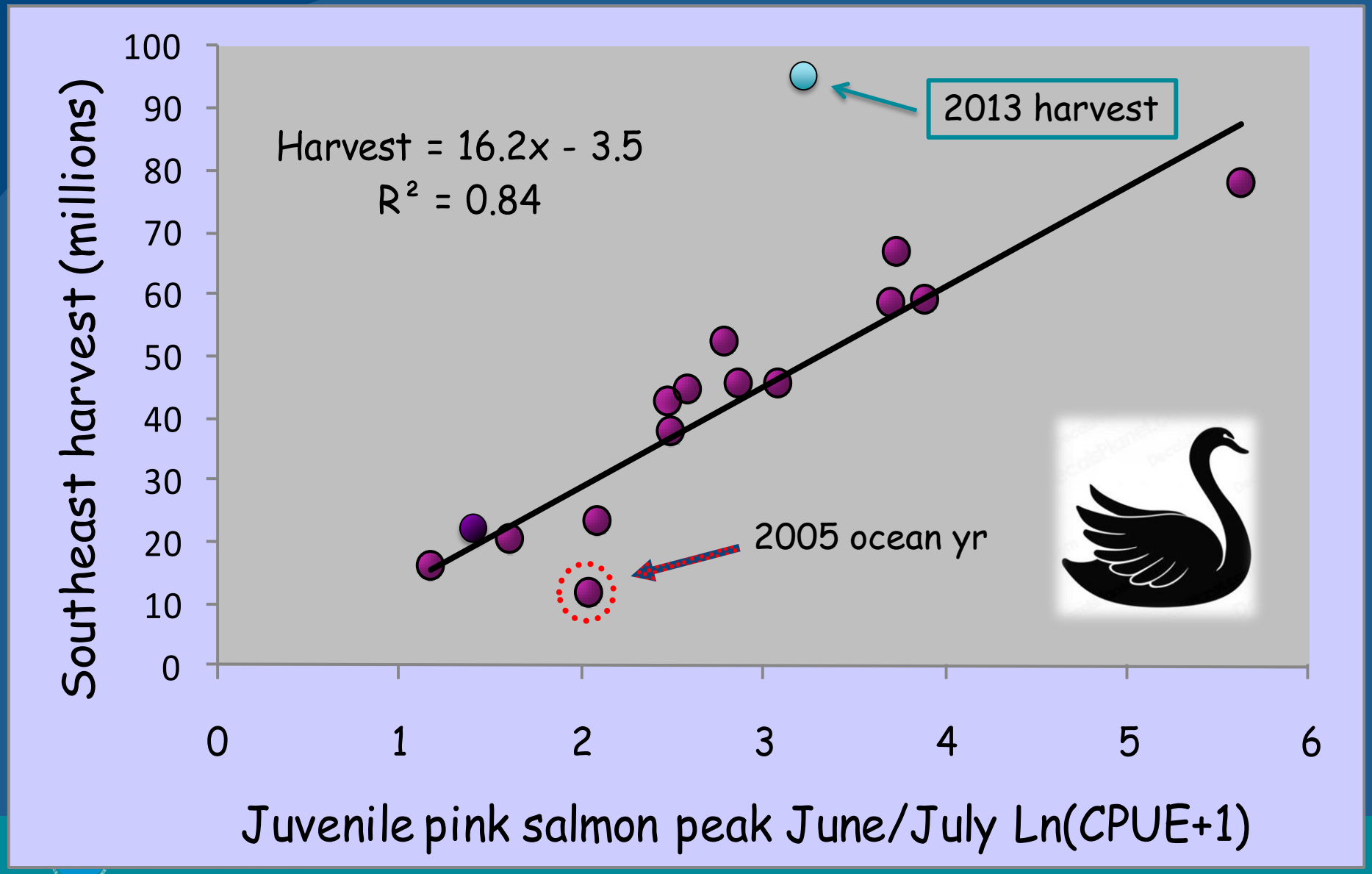
SECM pink salmon forecast models 2004-2013:

Average deviation 7% of harvest in 8 of 10 yrs

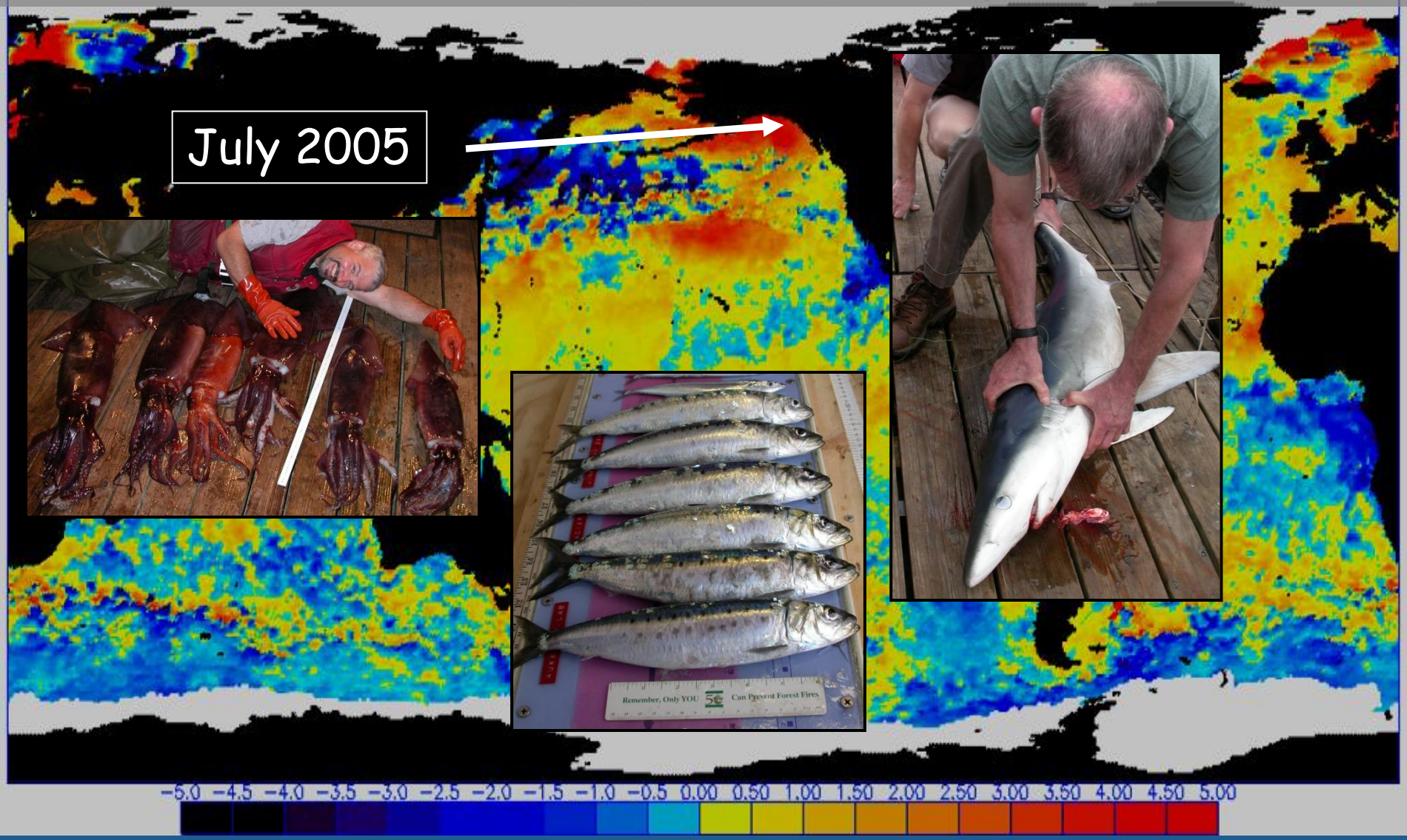


*Number of model parameters (1=CPUE only)

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

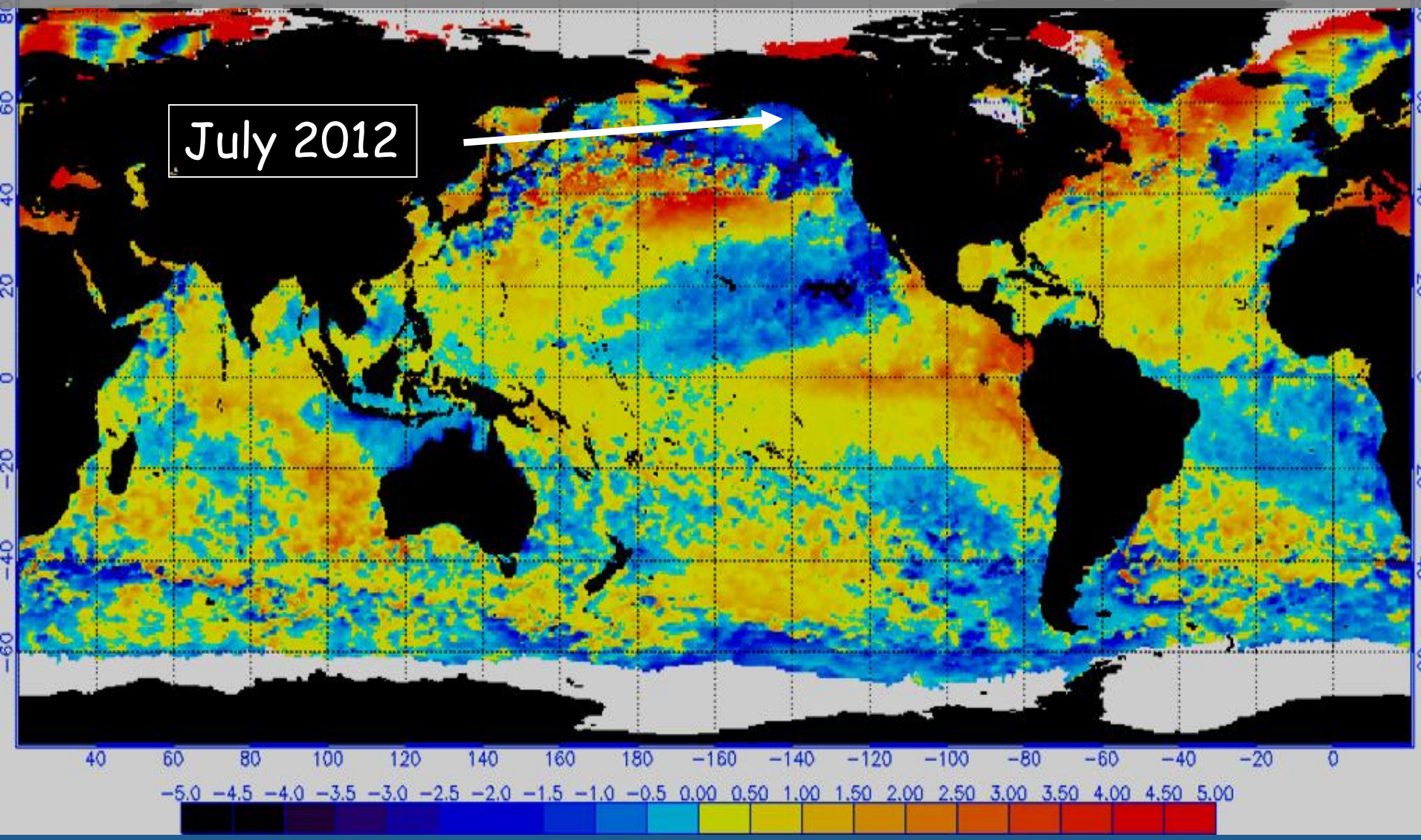


Diel epipelagic distribution of juvenile salmon, rockfish, sablefish and ecological interactions in offshore habitats of the NE Pacific Ocean (*Orsi et al. 2006*)



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

Anomalously cold summer conditions in eastern GOA in 2012



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

2014 pink salmon forecast models

Models considered	Adj. R^2	AIC_c	Regression *P* value	Prediction for 2014 (80% CI)
Peak $CPUE_{cal}$	67%	135.8	< 0.001	30.0 M
Peak $CPUE_{cal}$ + ISTI	77%	131.2	< 0.001	29.9 M (26-38)

Historical survey vessels + catch calibrations

July 2007

July 2008

July 2009

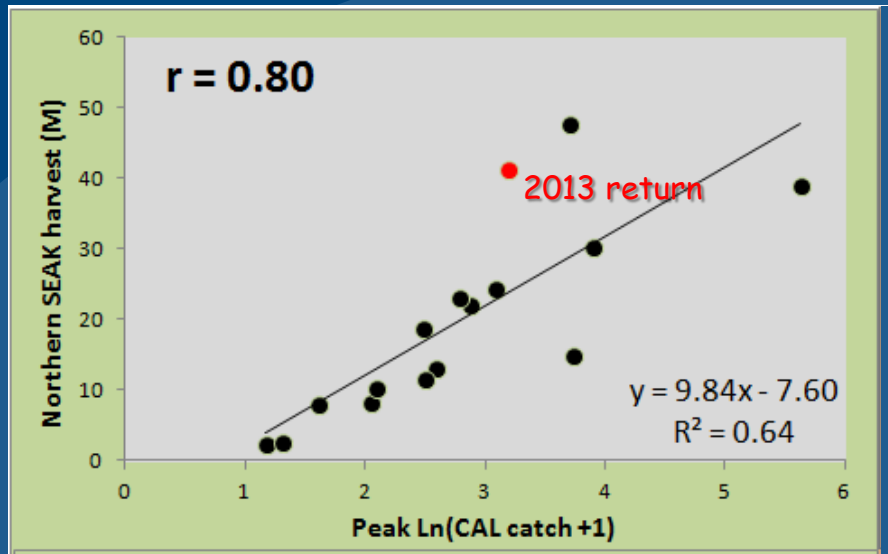
Northwest Explorer 2010-2013: no calibration assumed catchability with this vessel was the same as the Chellissa (the most efficient vessel)

Juv. pink CPUE methods & regional pink harvest 98-13

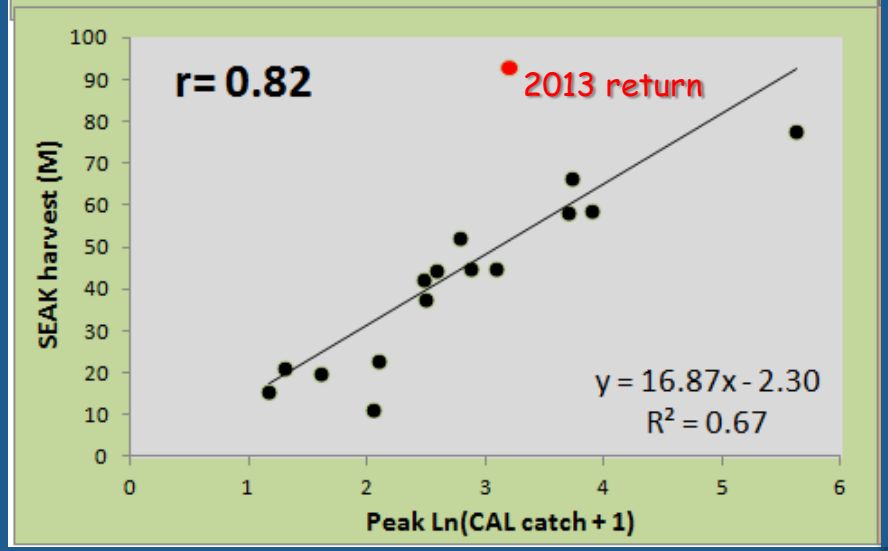
Vessel calibrated (cal)

Trawl track distance (ttd)

NSEAK



Total SEAK

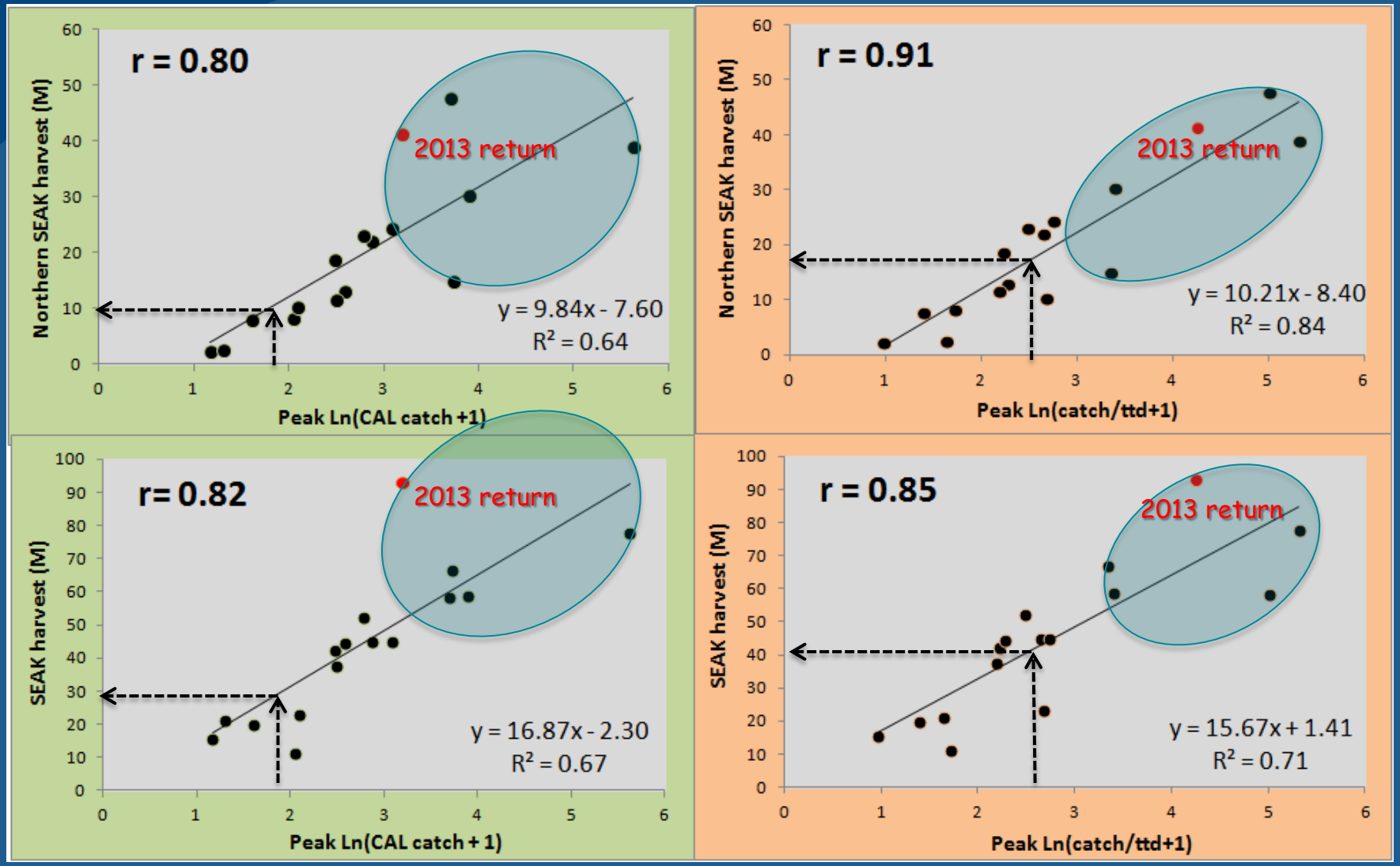


Juv. pink CPUE methods & regional pink harvest 98-13

Vessel calibrated (cal) Trawl track distance (ttd)

NSEAK

Total SEAK



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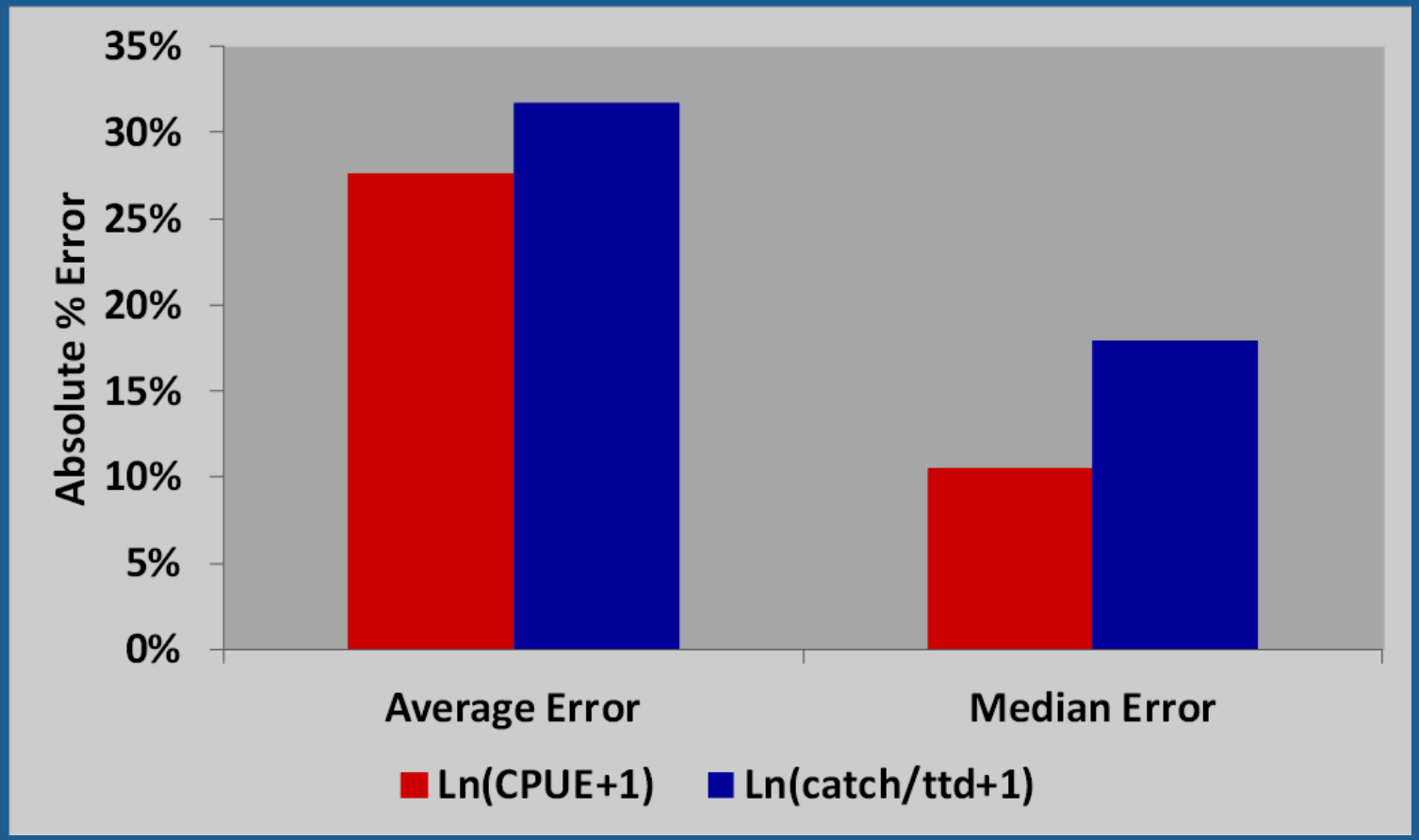
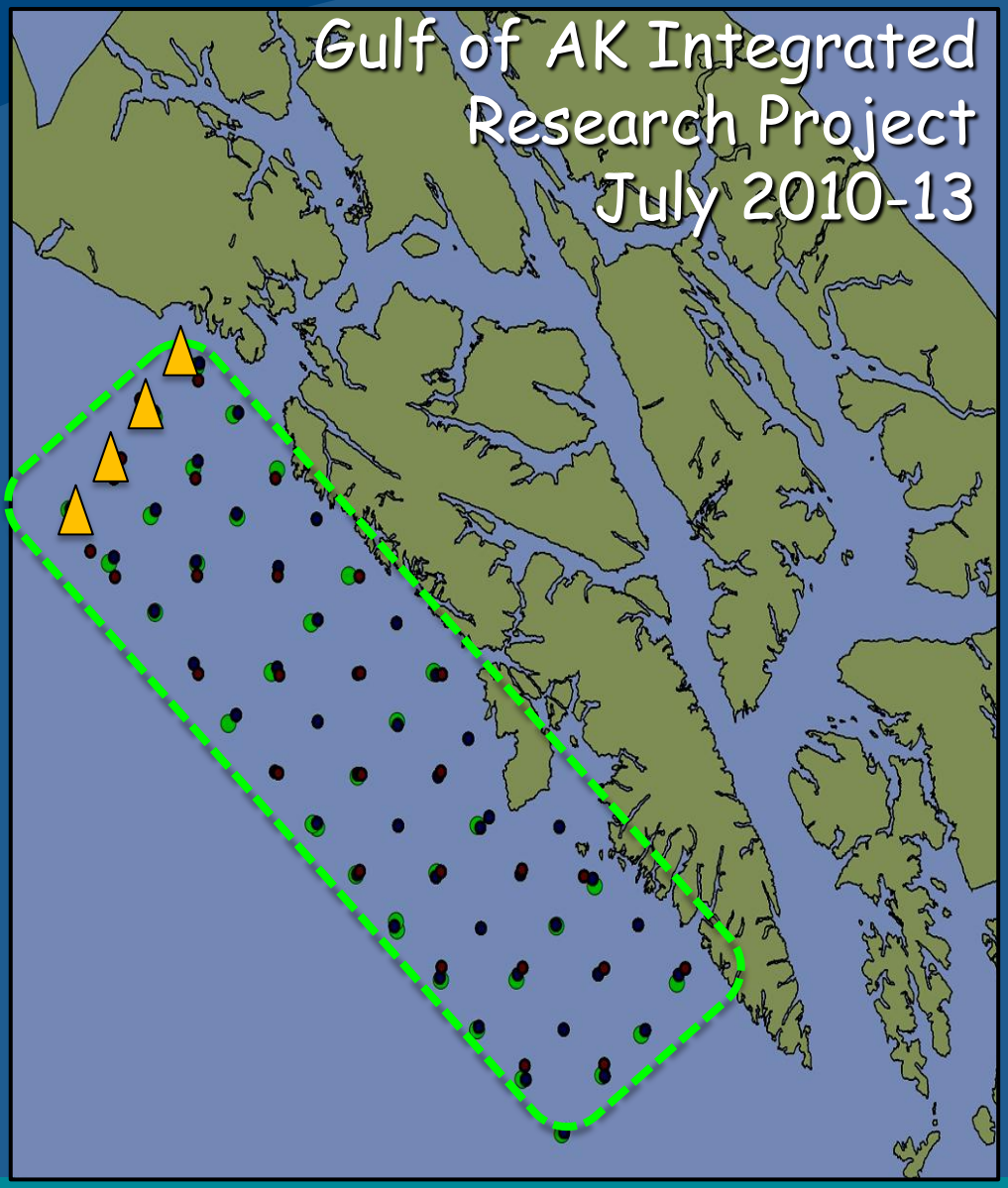
Peak $CPUE_{cal}$ + ISTI	77%	131.2	< 0.001	29.9 M (26-38)
Peak $CPUE_{trawl\ track\ dist(ttd)}$	70%	133.5	< 0.001	43.3 M
Peak $CPUE_{ttd}$ + MayT	84%	125.6	< 0.001	51.4 M

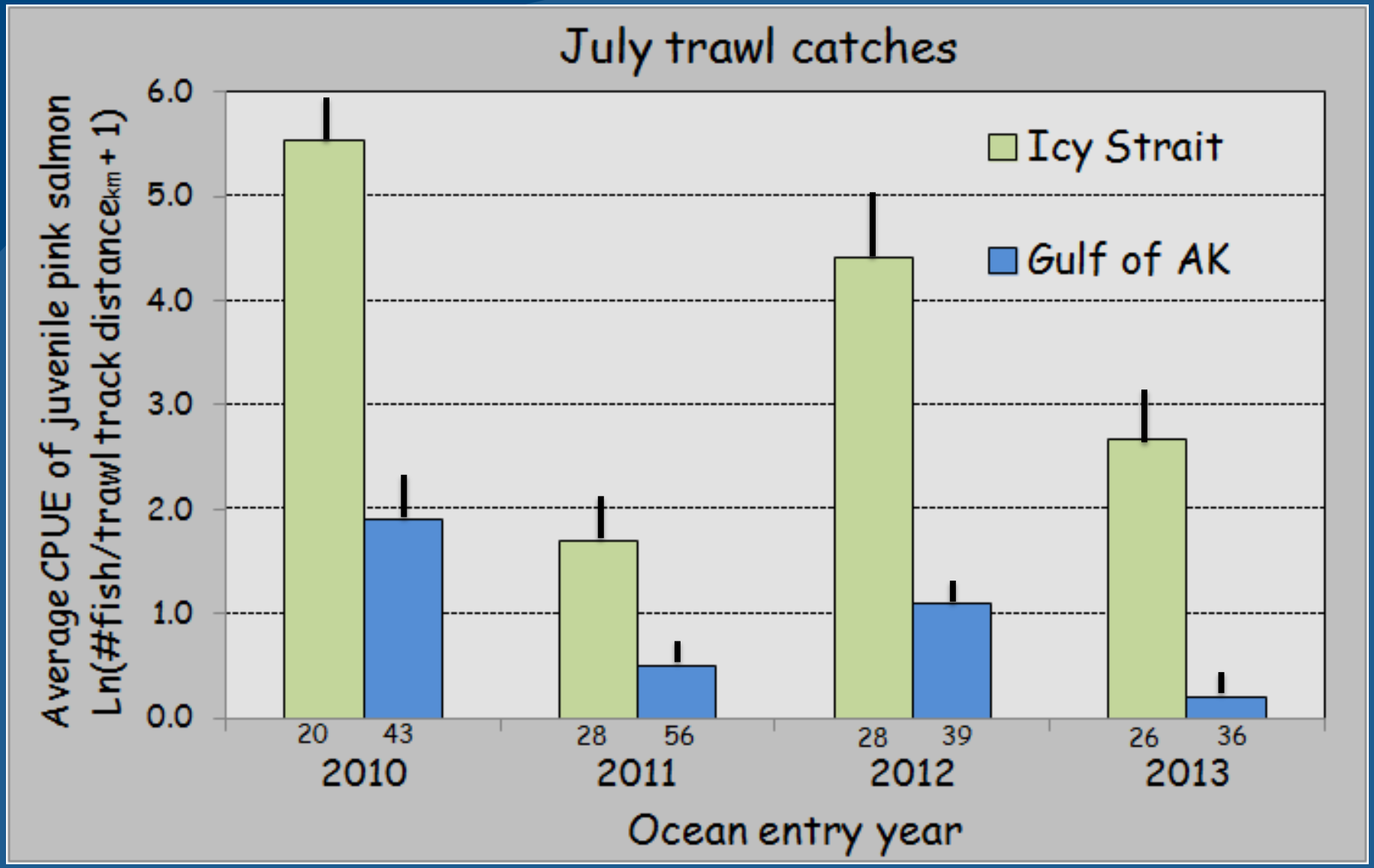
Jackknife "Leave-One-Out" forecasts prediction errors for $PeakCPUE_{cal}$ and $PeakCPUE_{ttd}$ models for SEAK harvests



Gulf of AK pink catches



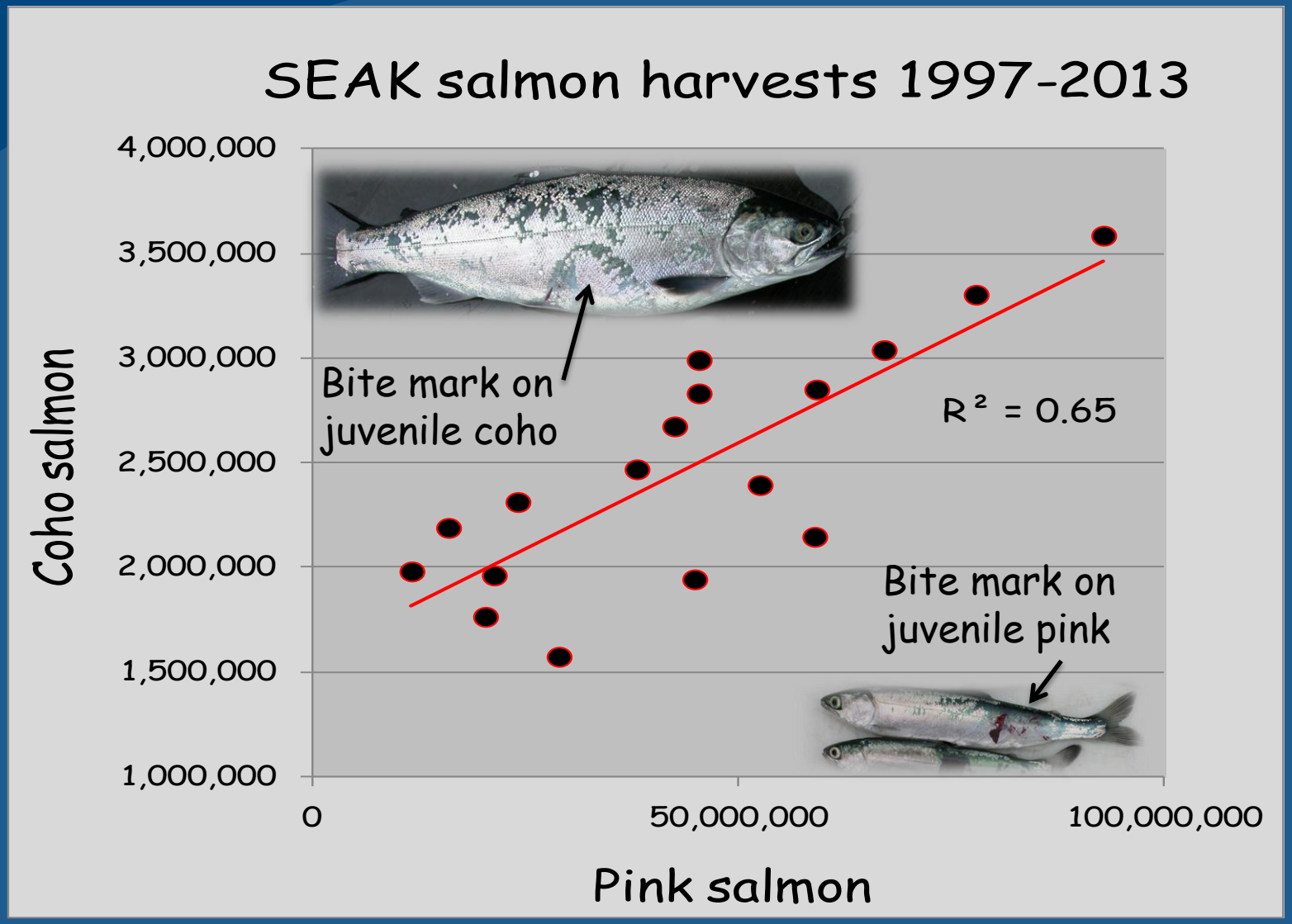
Icy Strait vs. Gulf of AK pink catches



Predators of juvenile/immature salmon?

Adult coho salmon: most consistent predator on pinks

Relationship of pink to coho harvest



What is the impact of adult coho salmon predation on juvenile pink salmon ?

Field data on adult coho stomach samples 1997-2013

- Examined some adult coho every year
- 16% of fish feeding on juvenile salmon
- Average # juveniles found in stomach= 1.6
- Of juvenile salmon prey, 79% were pinks

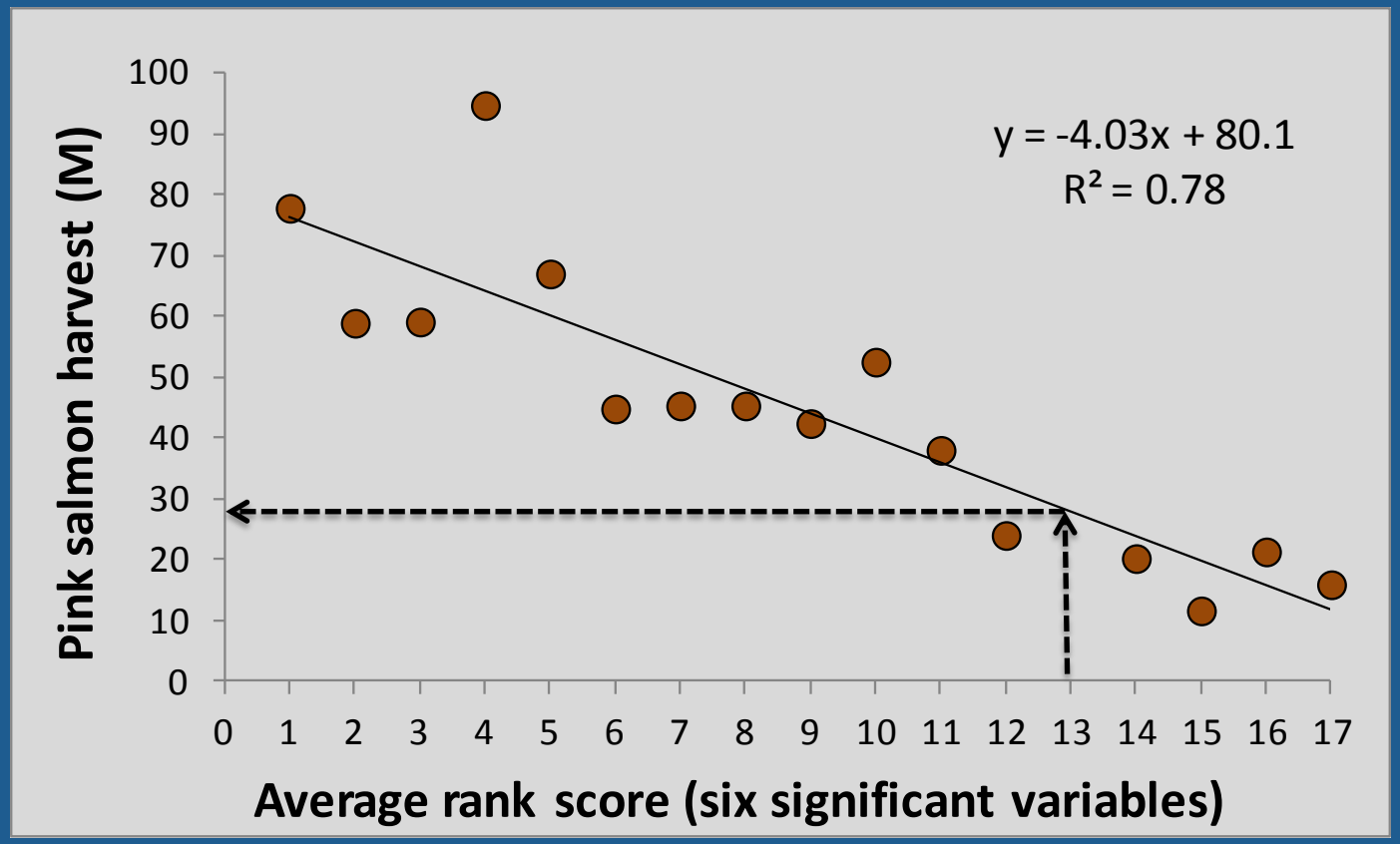
Developed an adult coho predation impact index:
Millions of adult coho(H+E)/juvenile pink $CPUE_{ttd}$

Pink salmon parent brood year				Chronological ecosystem variables										Pink salmon harvest	
Brood year (BY)	SEAK pink harvest (M)	Adult 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 June or July	Juvenile peak pink (TTD) CPUE June or July	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)	Rank score of avearges 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 2***			***NOAA 1***	***NOAA 2***	***NOAA 2***	***NOAA 2***	***NOAA 2***	***NOAA 2***	***NOAA 2 ADFG 3***	***CGD***			***ADFG 1***
1996	64.6	18.1		1997	31.1	9.5	2.5	2.2	July	12%	1.4	15.6	9	1998	42.4
1997	28.9	14.8		1998	60.8	9.6	5.6	5.3	June	57%	0.8	18.1	1	1999	77.8
1998	42.4	14.3		1999	53.5	9.0	1.6	1.4	July	8%	3.4	15.8	14	2000	20.2
1999	77.8	27.3		2000	132.1	9.0	3.7	3.3	July	18%	0.9	16.9	5	2001	67.0
2000	20.2	10.8		2001	61.5	9.4	2.9	2.6	July	19%	1.8	16.8	8	2002	45.3
2001	67.0	18.6		2002	150.1	8.6	2.8	2.5	July	14%	2.2	15.6	10	2003	52.5
2002	45.3	16.6		2003	95.1	9.8	3.1	2.7	July	24%	1.6	16.1	7	2004	45.3
2003	52.5	20.0		2004	169.6	9.7	3.9	3.4	June	29%	1.2	15.1	3	2005	59.1
2004	45.3	15.7		2005	87.9	10.3	2.0	1.7	Aug	19%	2.8	15.5	15	2006	11.6
2005	59.1	19.9		2006	65.9	8.9	2.6	2.3	June	30%	1.7	17.0	6	2007	44.8
2006	11.6	10.2		2007	81.9	9.3	1.2	1.0	Aug	9%	3.0	15.7	17	2008	15.9
2007	44.8	17.6		2008	117.6	8.3	2.5	2.2	Aug	14%	1.9	16.1	11	2009	38.0
2008	15.9	9.5		2009	34.8	9.6	2.1	2.7	Aug	22%	2.2	15.1	12	2010	24.0
2009	38.0	12.7		2010	121.6	9.6	3.7	5.0	June	66%	1.3	17.6	2	2011	58.9
2010	24.0	11.2		2011	30.9	8.9	1.4	1.6	Aug	21%	4.6	15.7	16	2012	21.3
2011	58.9	14.3		2012	61.8	8.7	3.2	4.3	July	40%	1.5	16.7	4	2013	94.7
2012	21.3	11.0		**2013**	51.2	9.2	1.9	2.7	July	9%	3.7	16.0	13	**2014**	?
Harvest correlations	0.46	0.38			0.29	-0.20	0.81	0.84	-0.65	0.66	-0.75	0.61	Pearson correlation "*r*"		
Probability value=	0.07	0.15			0.28	0.46	0.00*	0.00*	0.01*	0.01*	0.00*	0.01*	(*=significant@<0.05)		

Data sources: ADFG (S. Heinl$_1$, A. Piston$_2$, and L. Shaul$_3$), CGD = Climate & Global Dynamics (J. Hurrell, http://www.cgd.ucar.edu/cas/jhurrell/indices.data.html), & NOAA Auke Bay Laboratories (J. Joyce$_1$ - Auke Creek research station & E. Fergusson/J. Orsi/M. Sturdevant$_2$ - Southeast Coastal Monitoring project)

SEAK harvest vs. average rank score of the six significant variables

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



Rank 13 (2014) = 27.8 M

What drives the variability in pink salmon harvest patterns in SEAK (north vs. south)?

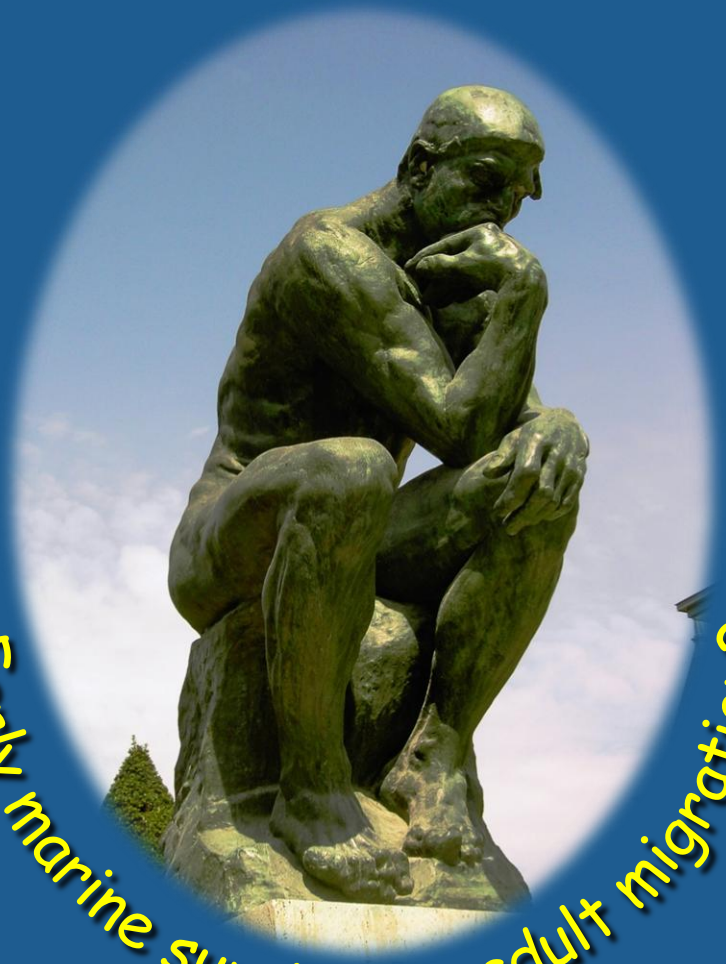
Past four years:

2013 high harvest year
94.7 M (44% North)

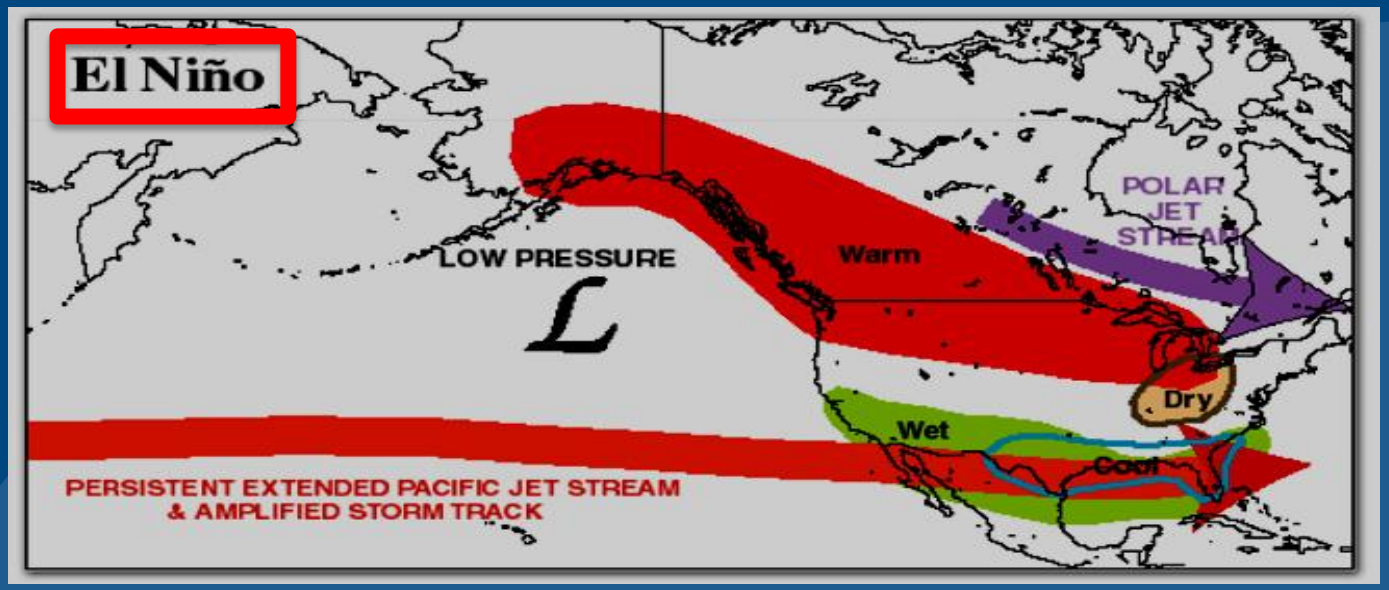
2012 low harvest year
21.3 M (13% North)

2011 high harvest year
58.9 M (81% North)

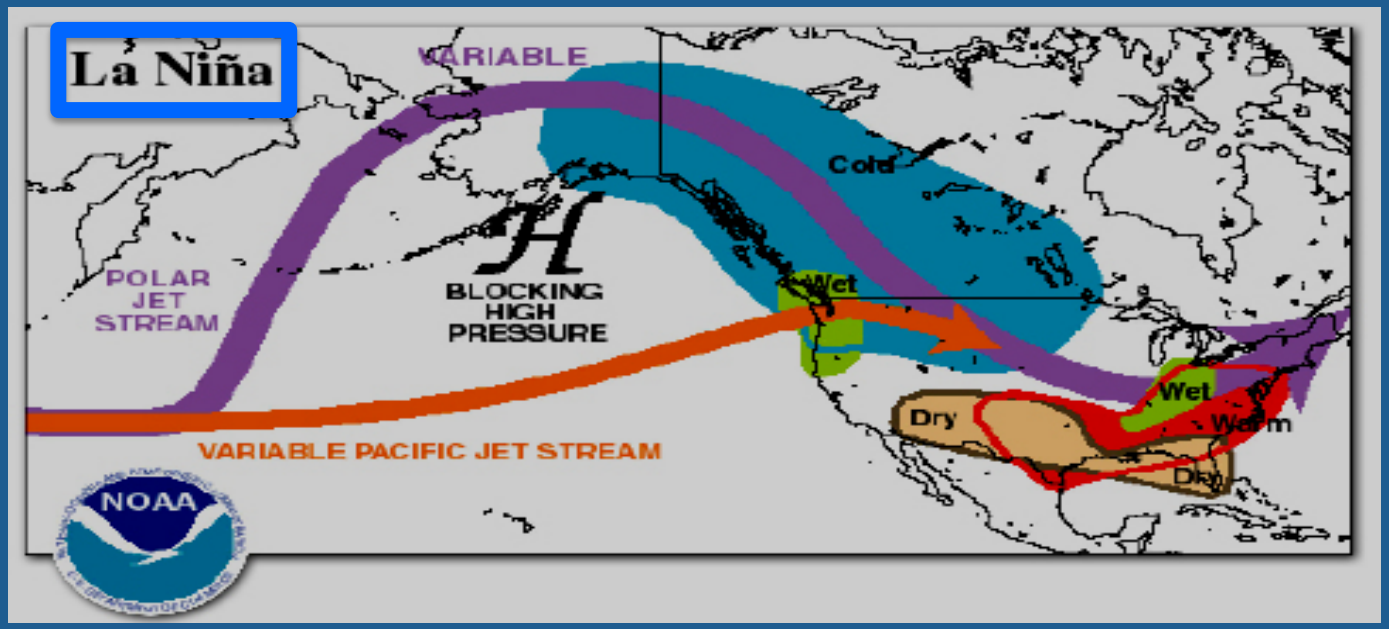
2010 low harvest year
24.0 M (43% North)



Early marine survival or adult migration?



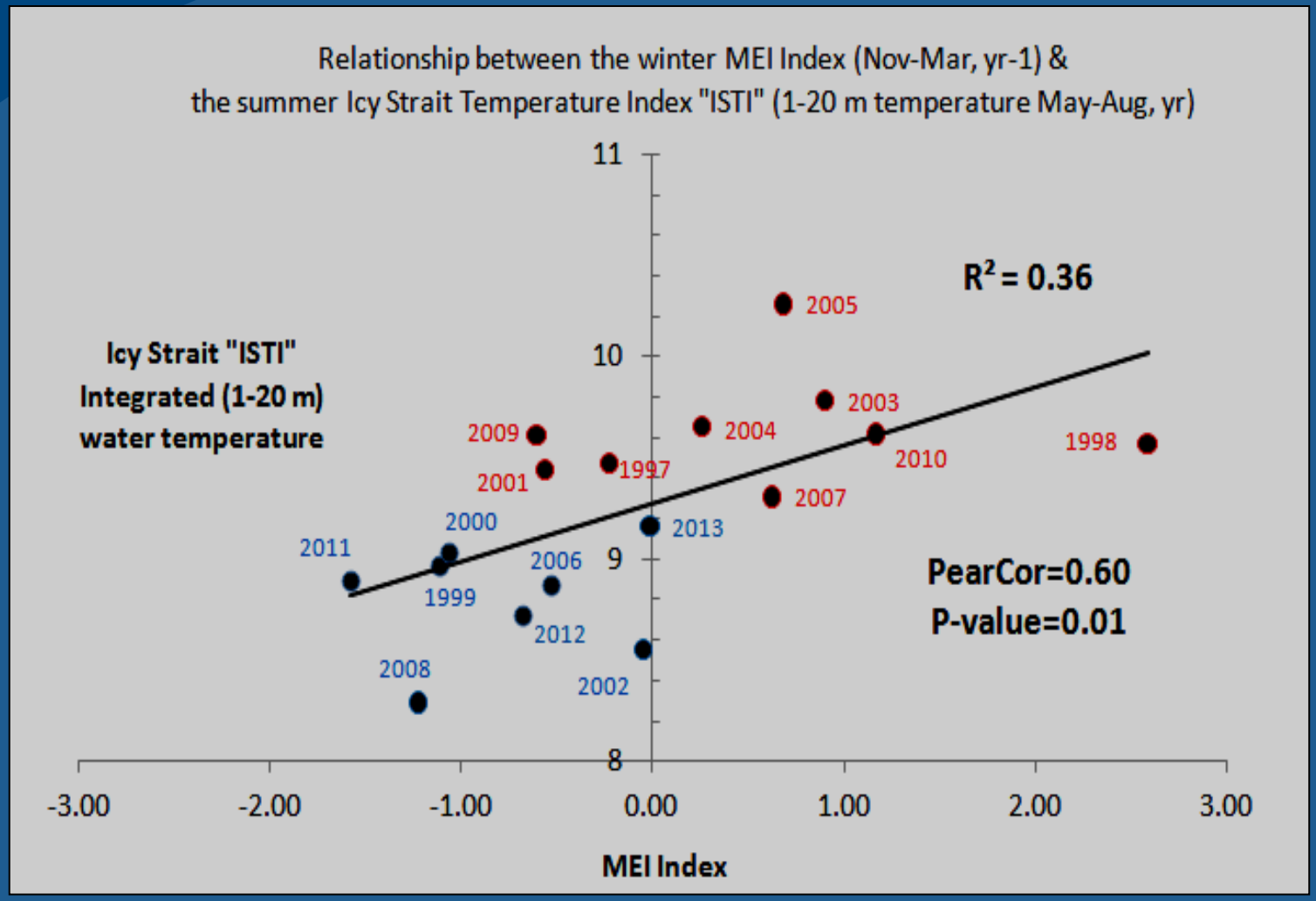
The El Niño/ La Niña phenomena are the main sources of year-to-year variability in weather and climate for many areas of the world.



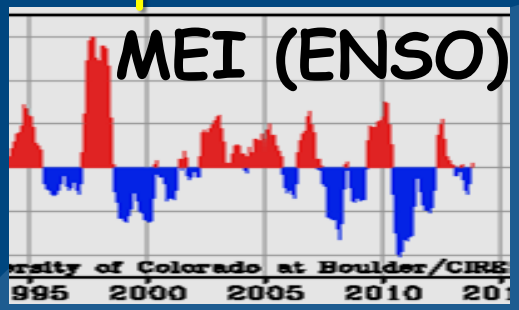
El Niño and La Niña tend to alternate in an irregular cycle, which is often referred to as the ENSO cycle.

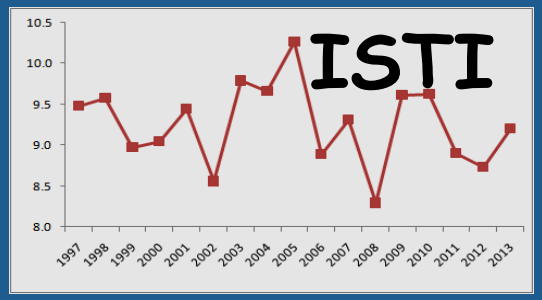
http://www.nws.noaa.gov/om/brochures/climate/El_NinoPublic.pdf

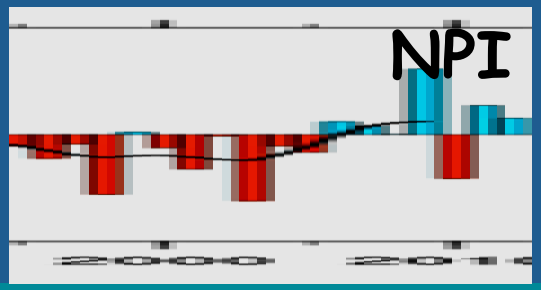
Winter ENSO (MEI) climate signal is related to Icy Strait temps from May to Aug



Correlations of physical/climate variables to regional pink harvest proportion to SEAK, 1998-2013

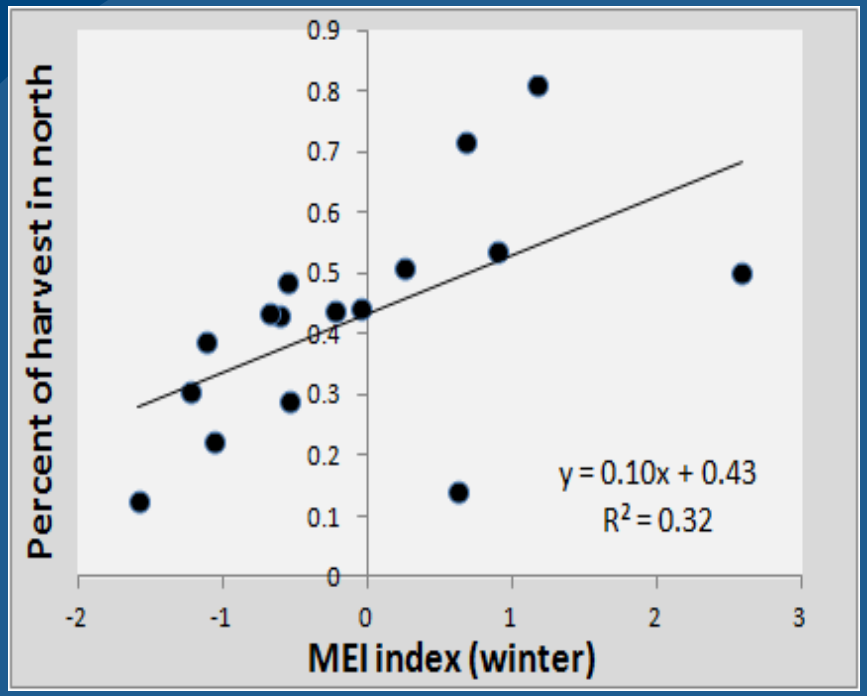


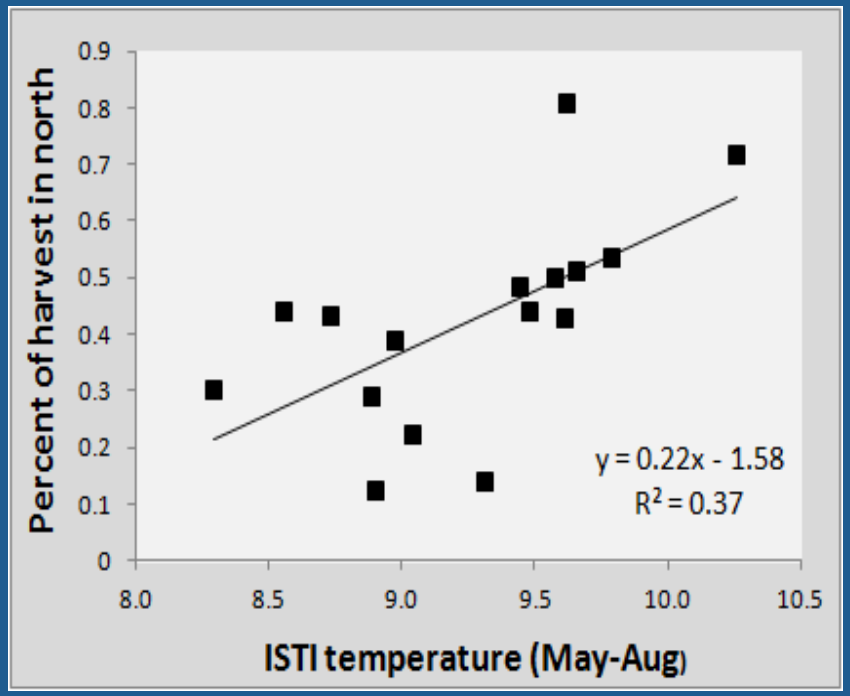




Physical	Pink return proportion	
Ocean metric	% N region	% S region
$MEI_{Nov\text{-}Mar\ yr\text{-}1}$	↑ **0.56**	↓ **-0.57**
$PDO_{Nov\text{-}Mar\ yr\text{-}1}$	→ 0.47	→ -0.48
$ISTI_{MJJA}$	↑ **0.60**	↓ **-0.61**
NPI_{JJA}	→ 0.20	→ -0.20

Winter ENSO (MEI) & Icy Strait summer temp index (ISTI) data in relation to the proportion of pinks harvested in the northern region of SEAK





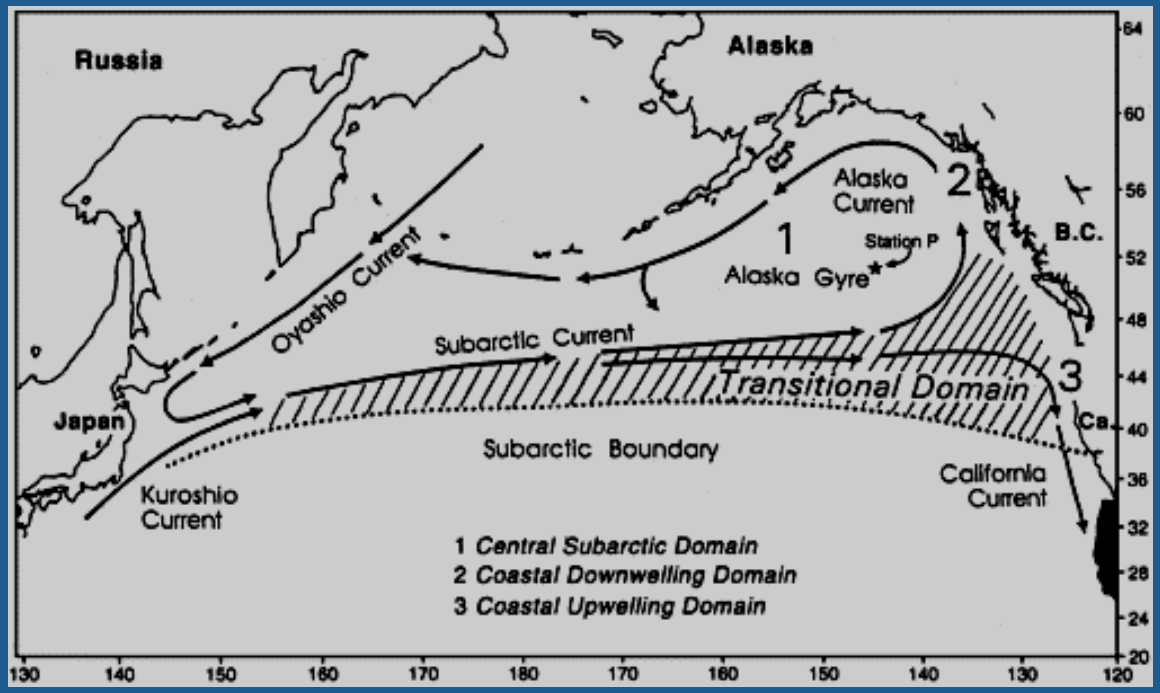
MEI 2013/4 = -0.01
2014 = (43% N harvest)

2013 ISTI = 9.2
2014 = (41% N harvest)

How might high MEI & ISTI values relate to regional pink survival and migration?

1) There may be higher early marine survival in the north vs. south when springs are anomalously warm?

2) Adults may make landfall to SEAK further north in years when ocean winters are warmer, as a result of fish not extending as far southward?



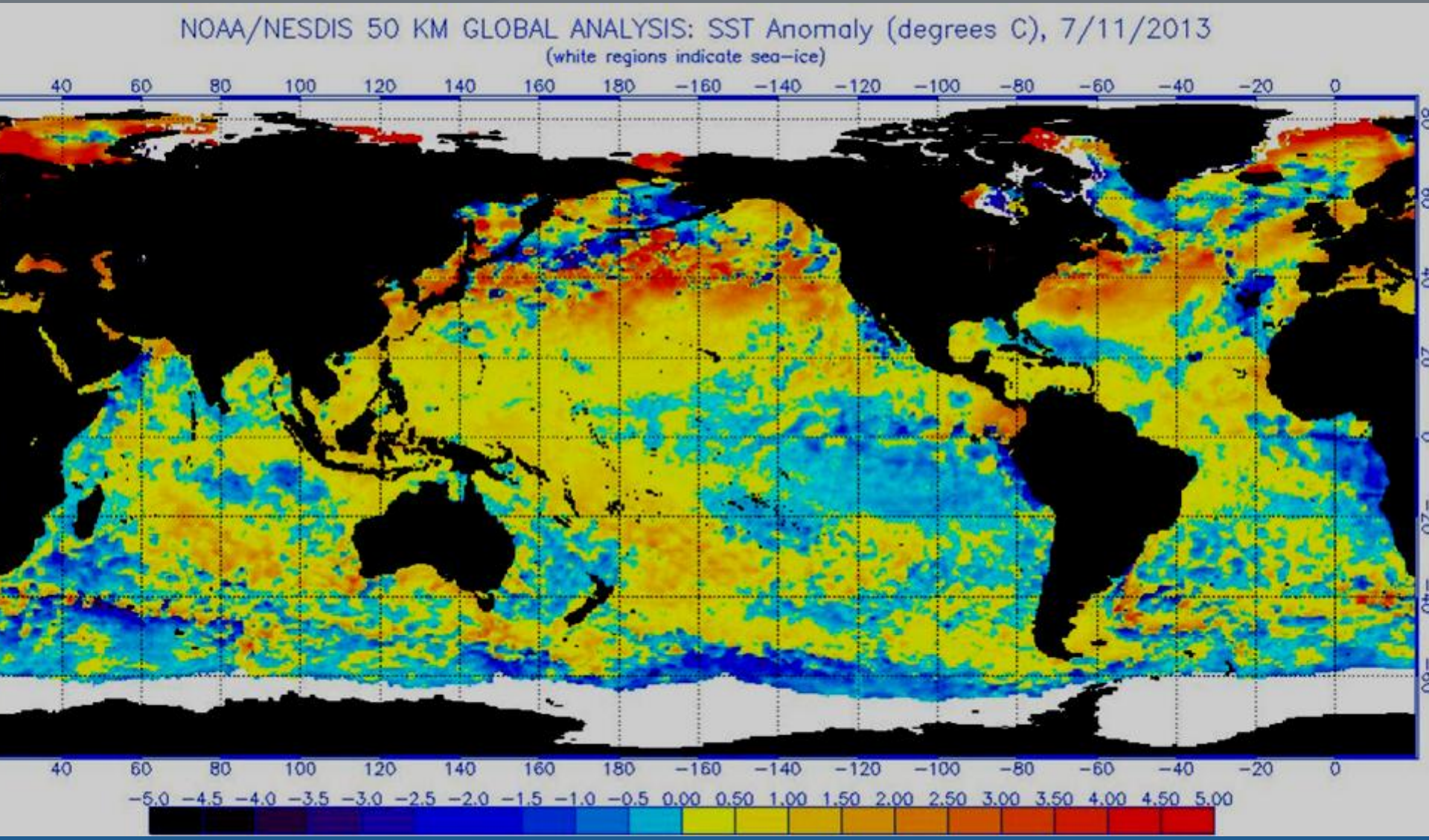
http://www.esrl.noaa.gov/psd/map/clim/sst.anim.year.html

Conclusions:

- 26-38 M pink salmon harvest forecast in 2014
- Developed multiple new forecast tools:

1. "$CPUE_{ttd}$" method for use when CPUE is high to better forecast large return years
2. An adult coho predation impact as a new metric
3. Use of annual ranked scores across significant ecosystem metrics (6): future forecast method?
4. Climate (MEI and ISTI) signals may detect shifts in regional SEAK pink returns (42% N in 2014?)

Intermediate summer conditions in eastern GOA in 2013



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

When might we be riding the next big wave of pink salmon? ~~2014~~ 2015?

Thanks for collaborative survey support!

ADFG, UofAK, NWFSC, & SSRAA