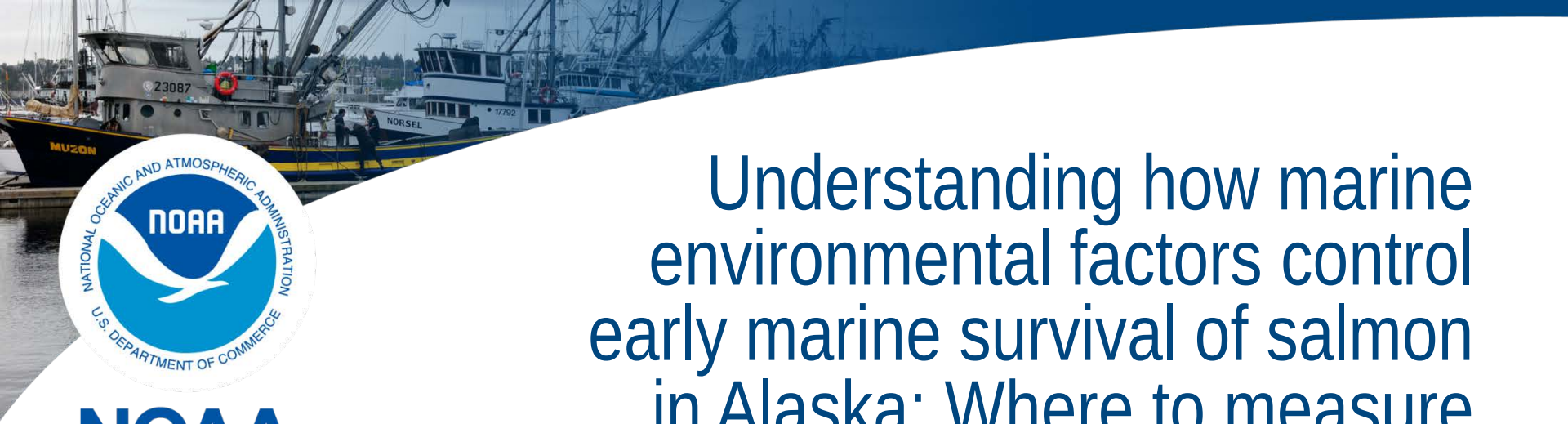


Understanding how marine environmental factors control early marine survival of salmon in Alaska: Where to measure what for stock assessment of Chinook salmon in the coastal waters of Alaska

NOAA FISHERIES
Alaska Fisheries Science Center

Phillip R. Mundy
Auke Bay Laboratories

Ted Stevens Marine Research Institute
17109 Pt Lena Loop Rd, Juneau, Alaska

October 23, 2012

Alaska Chinook Salmon Symposium: Understanding Abundance and Productivity Trends of Chinook Salmon in Alaska, Session 3: Ecology and Stock Assessment of Chinook Salmon In the Marine Environment. Egan Center, Anchorage, AK

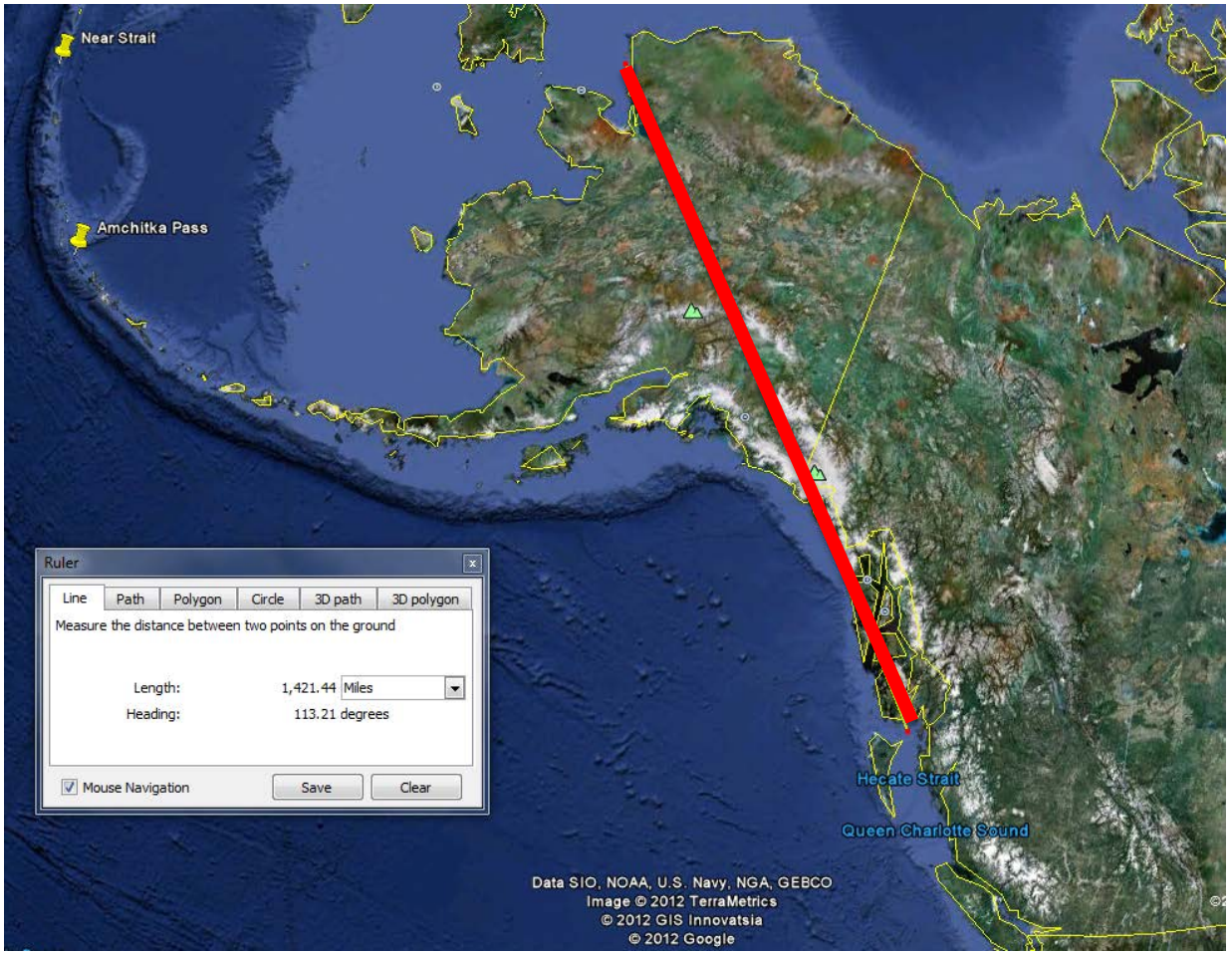
Coastal Marine Research Questions

- What are the marine environmental variables appropriate to 1) juvenile stock assessment in coastal Alaska 2) incorporate in marine process studies?

- What new techniques/projects could be brought to bear in estimating abundance of juvenile Chinook salmon in nearshore areas?

- How will nearshore surveys and process studies help in understanding the productivity and abundance trends?

Alaska is a very big place; no one set of answers



Answers depend on hydrography, bathymetry, productivity and food web structure at marine entry

Critical Size and Period Hypothesis CSP

Leigh Rubin's version of CSP

Salmon moms

Natural marine mortality is the major determinant of brood year strength. It occurs during two periods during the year of marine entry, the first happens in coastal waters (the spring and summer), and the second may happen farther offshore (late fall and winter). Salmon have to achieve a critical size by end of first summer to make it through the winter. Beamish and Mahnken 1999, 2001.

Evidence accumulates: Farley et al. 2007, Beamish et al. 2004, Karpenko 1998, Pearcy 1992 Parker 1968 … many more for other species

Where to measure what? The basic CSP formula

- Where: Migratory exit path first
    - Estuary, nearshore, coastal waters …
- What: Sources of mortality and growth
    - **Predators**: Abundance, distribution, size
    - **Food**: Availability, quality (prey species, lipids)
    - **Size at age** of juveniles

Physics, Plankton, Juvenile Salmon, Alaska
~ $82M 1990 – 2010 = $4M/YR

- Sound Ecosystem Assessment, SEA* (Pr. Wm Sound) – this talk
- Ocean Carrying Capacity, OCC (N. Gulf of Alaska) - FARLEY
- Southeast Coastal Monitoring, SECM (SE Alaska) - ORSI
- NEP GLOBEC (N. Gulf of Alaska) (Kline et al. not here)
- BASIS (Bering Sea) – FARLEY

All had the objective to understand factors responsible for marine salmon production, from physics up.

Other marine foundations

- High Seas Salmon Research - MYERS
- Bering Sea Integrated Ecosystem Research Program BSIERP, physics to fish, birds & mammals (and precursors PROBES et al.) – this talk
- Gulf of Alaska IERP – now ongoing – more later

Sound Ecosystem Assessment 1993 – 1997

2001 Blackwell Science Ltd., *Fish. Oceanogr*.,10 (Suppl. 1)

- Mark Willette: **Foraging behaviour of juvenile pink salmon and size-dependent predation risk**

  Fish. Oceanogr. 10 (Suppl. 1), 110–131, 2001

  - *Low zooplankton density inshore takes juvenile pink salmon offshore where predation is 5 times higher*
  - *Size dependent predation on salmon depends on both predator and prey sizes*

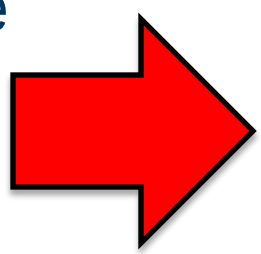
Sound Ecosystem Assessment 1993 – 1997

- $25M+ , five years, physics, biological oceanography, all directed to understanding mechanisms of salmon and herring production in PWS
- Major salmon findings *in addition to Willette et al.* – Seasonal patterns of wind drive distribution of zooplankton, driving distribution of salmon and predators. Atmospheric + ocean processes can influence juvenile salmon survival via CSP mechanisms … Wang, Jin, Eslinger, Patrick, Allen, Cooney, and others;
- See *2001 Fish. Oceanogr*.,10 (Suppl. 1)

Coastal Marine Research Questions

•What are the marine environmental variables appropriate to 1) juvenile stock assessment in coastal Alaska 2) incorporate in marine process studies?

Juvenile Growth & Abundance
Food, Distribution, Quality
Prey Species
Predators Species Size



COASTAL MARINE SURVEYS

SECM – ORSI

BASIS - FARLEY

OR …

Physical proxies of same

Wind Drives Circulation in the Bering Sea

DANIELSON ET AL.: BERING SHELF CIRCULATION 2012

Same area as Cooper et al. 2012

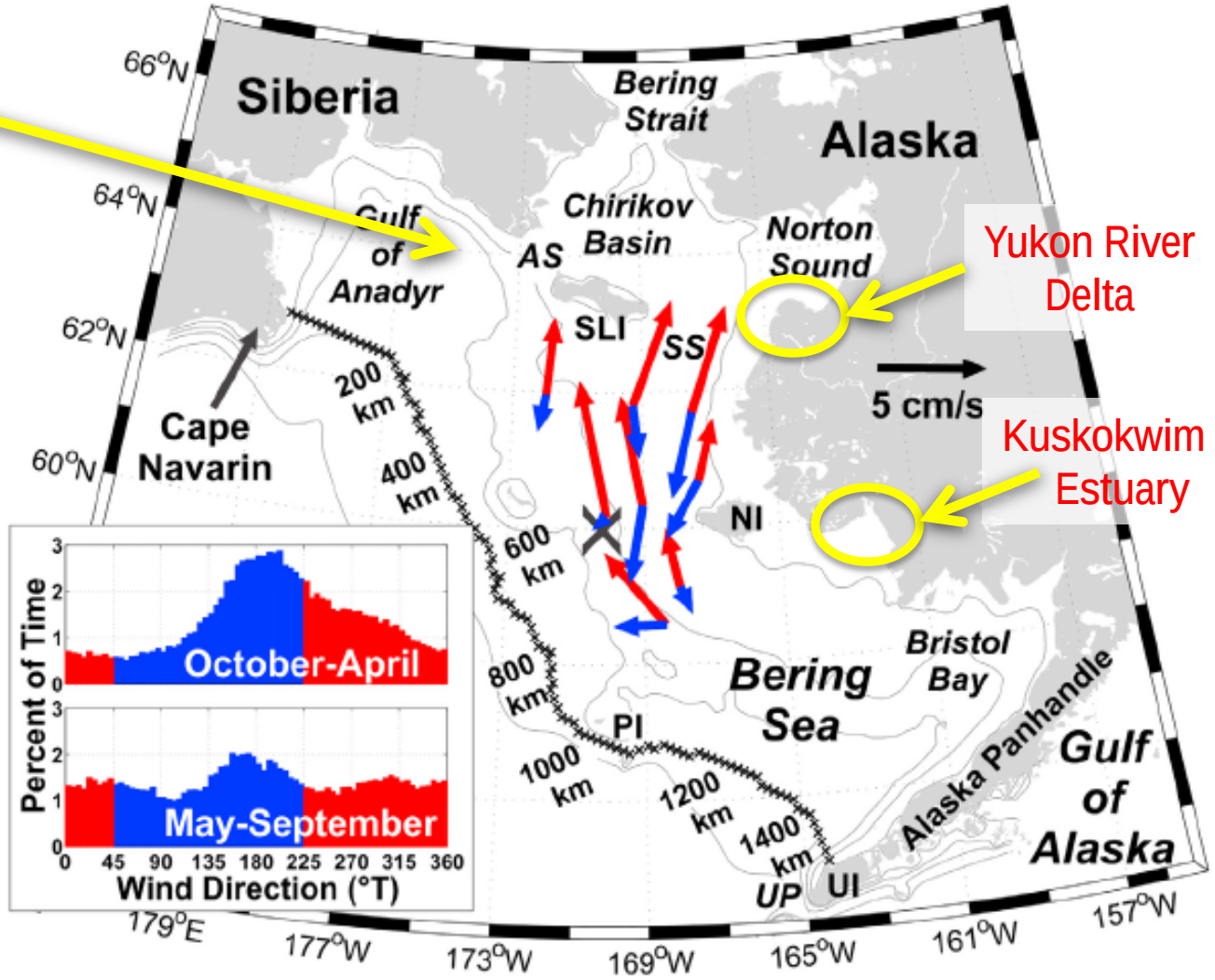
July 2008–July 2010

Mean vertically averaged currents

Wind direction from:

SE

NW



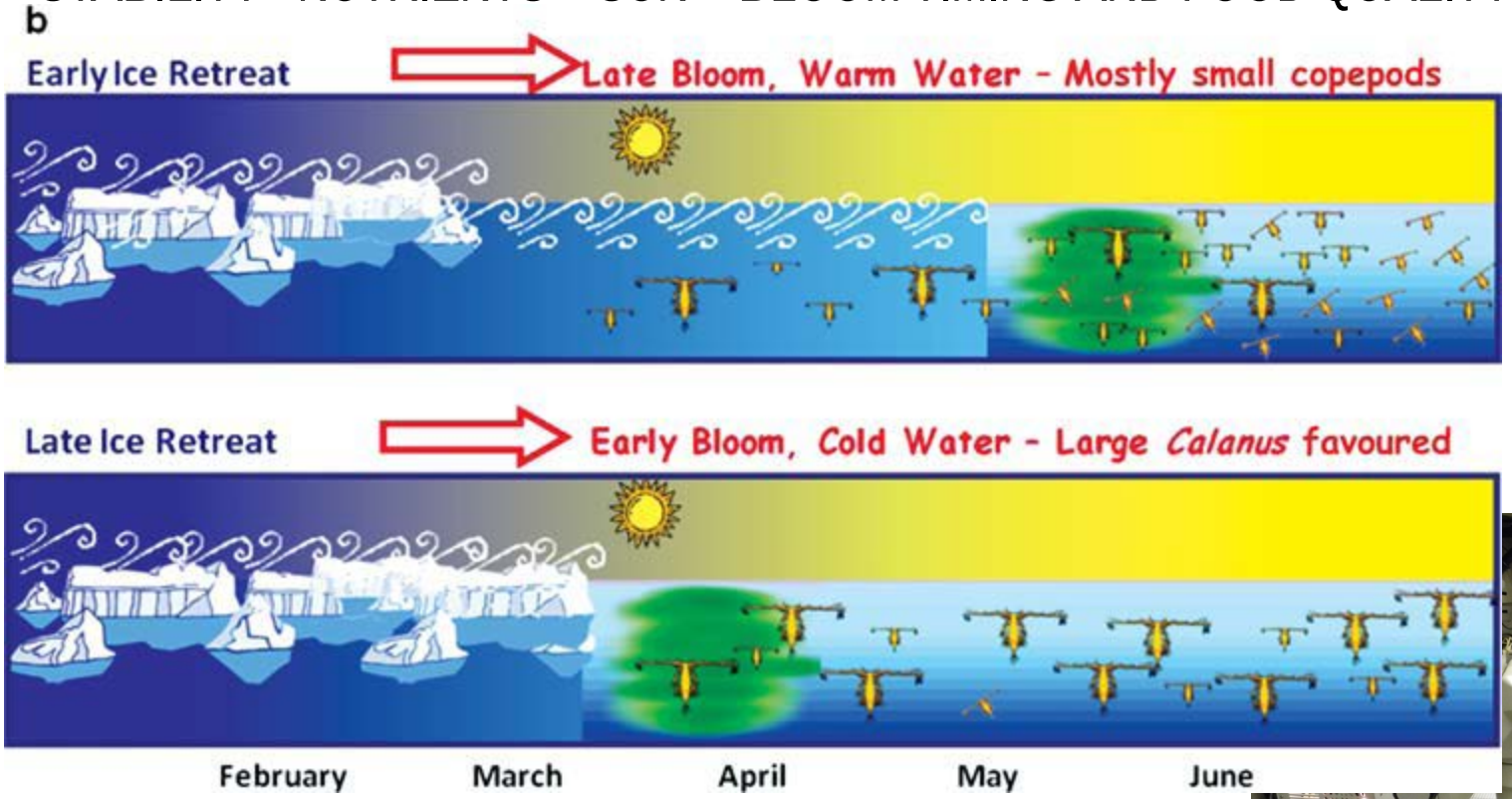
Physical proxies for CSP variables

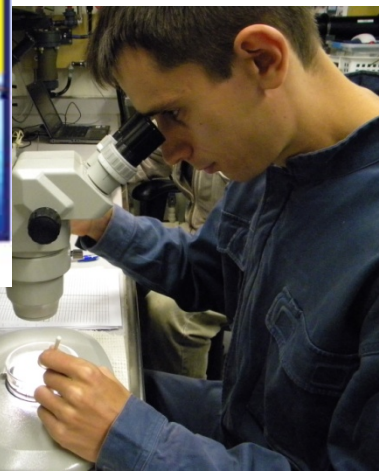
- L.W. Cooper et al. 2012. The relationship between sea-ice break-up, water mass variation, chlorophyll biomass, and sedimentation in the Northern Bering Sea. Deep Sea Research II. BSIERP – Not salmon but CSP variables in coastal waters
  - Satellite measurements: productivity, wind, ice cover, surface air temperatures
  - Real time sensors – buoys and coastal land stations

Ecosystem Processes affecting Fish Growth/Energetics

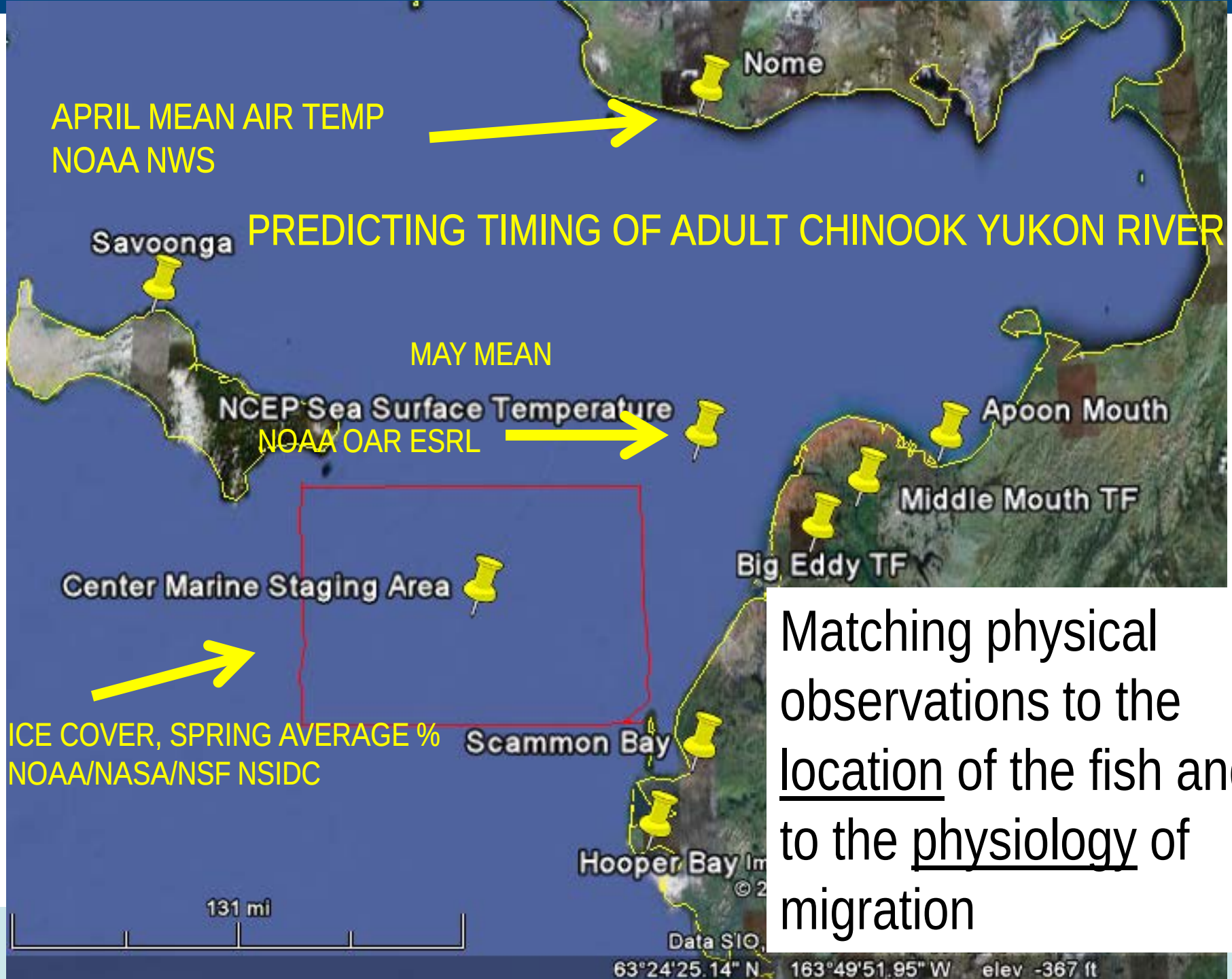
ICE + WIND → WATER COLUMN STABILITY (OR NOT)

STABILITY+ NUTRIENTS + SUN = BLOOM TIMING AND FOOD QUALITY





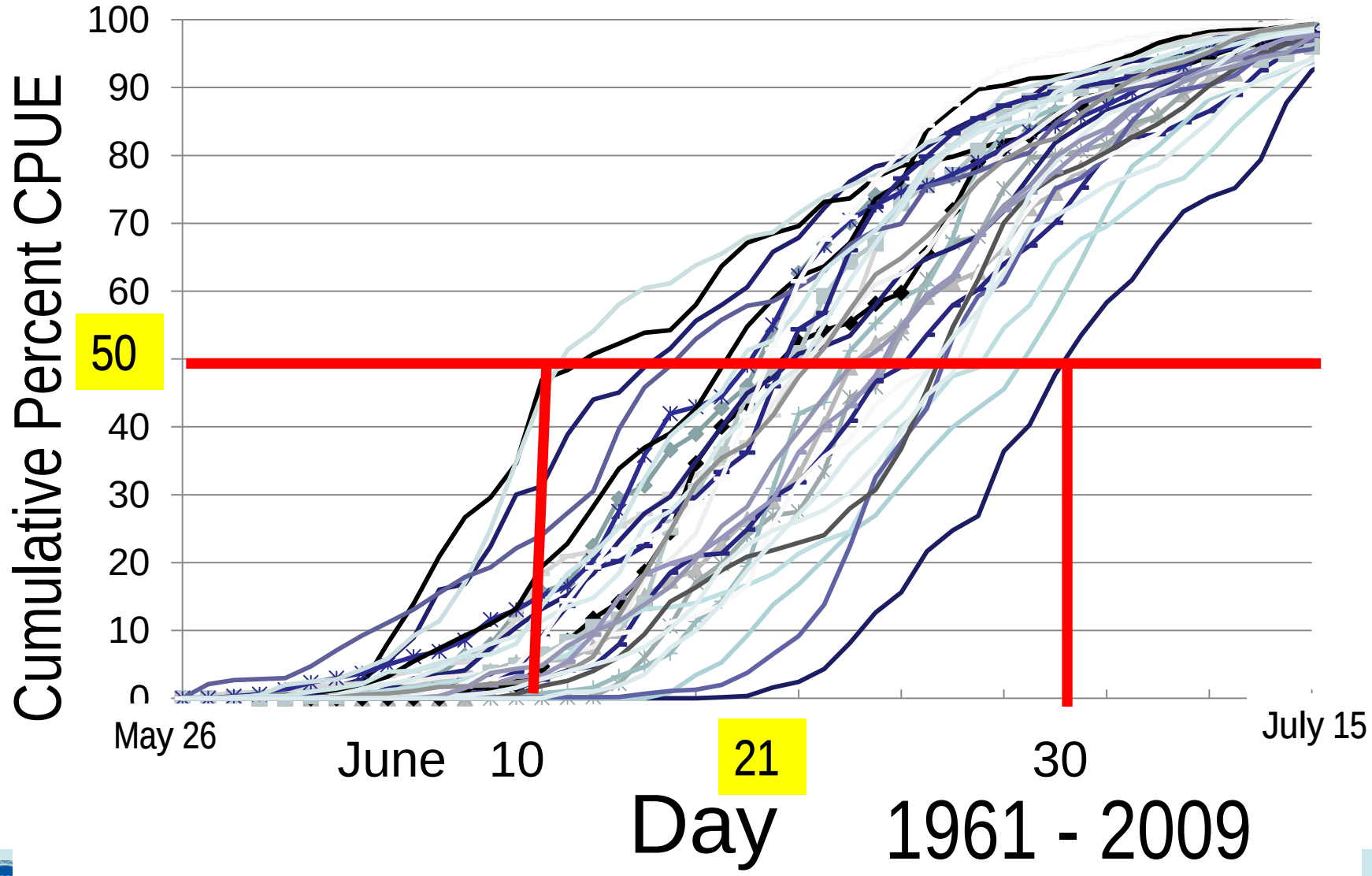
OSCILLATORY CONTROL HYPOTHESIS Hunt et al. 2011 Modified by Coyle et al. 2011



Matching physical observations to the location of the fish and to the physiology of migration

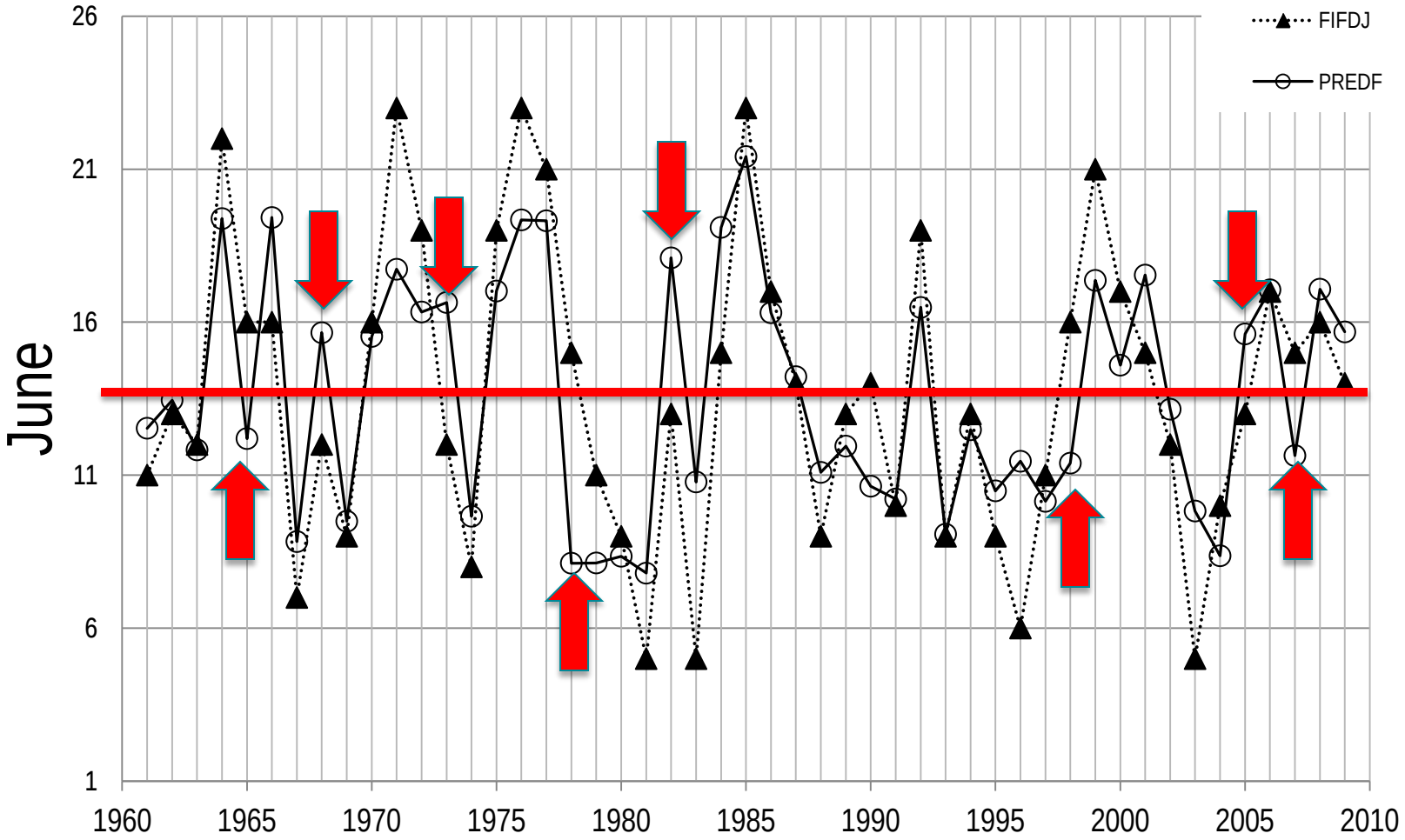
Chinook salmon timing lower Yukon River

Looking for the Needle in the Haystack



NEEDLE FOUND … NOW USED IN ANNUAL OPERATIONAL FORECAST

YUKON RIVER DELTA ADULT CHINOOK TIMING 15% POINT
PREDICTED V. OBSERVED USING ICE, SST AND SAT 1961 - 2009



16%

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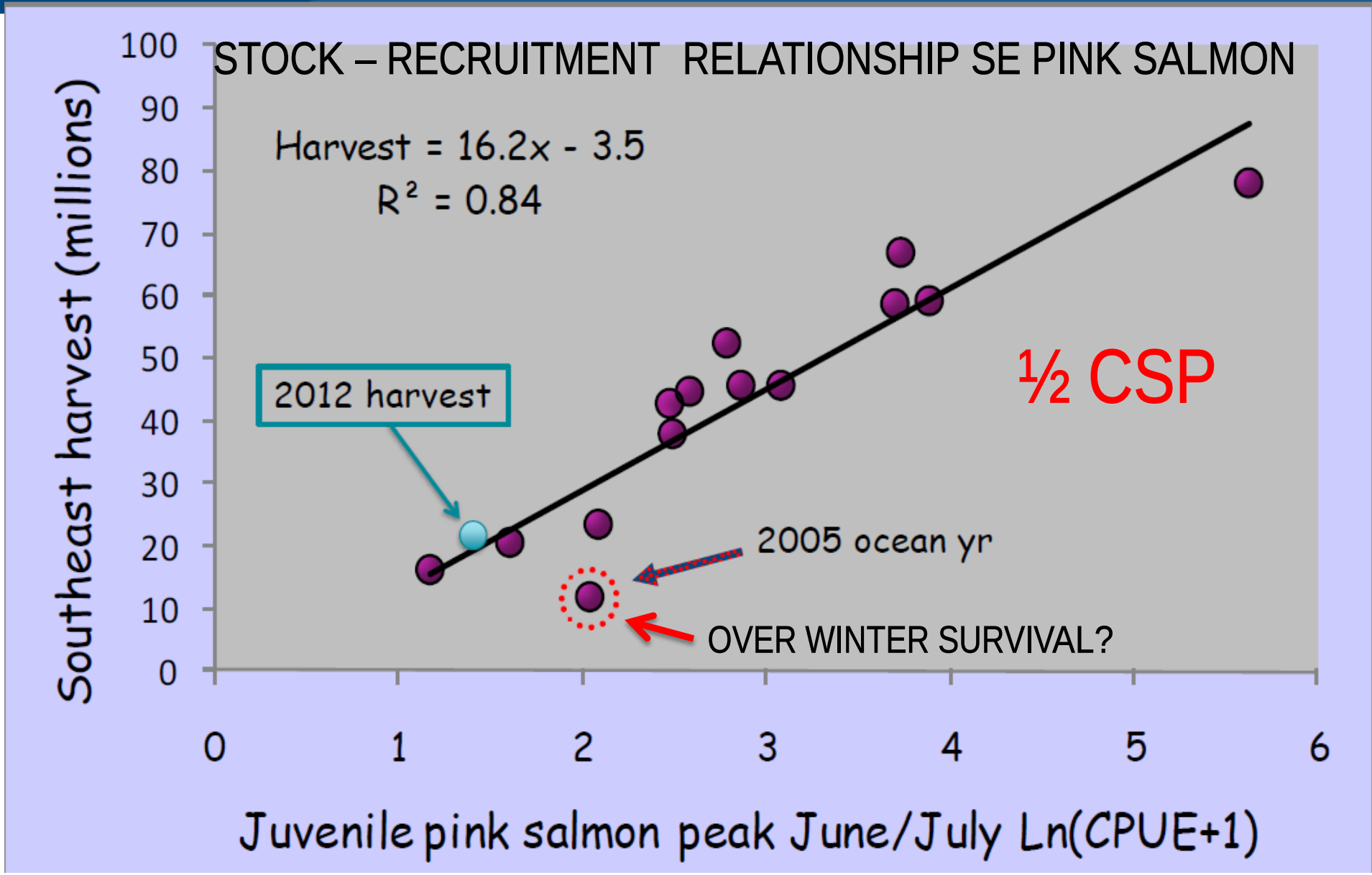
OR FIND A GOOD COASTAL MARINE LOCATION

…



Auke Bay Labs: Orsi, Fergusson, Sturdevant, Wertheimer, Heard and others

Research Questions

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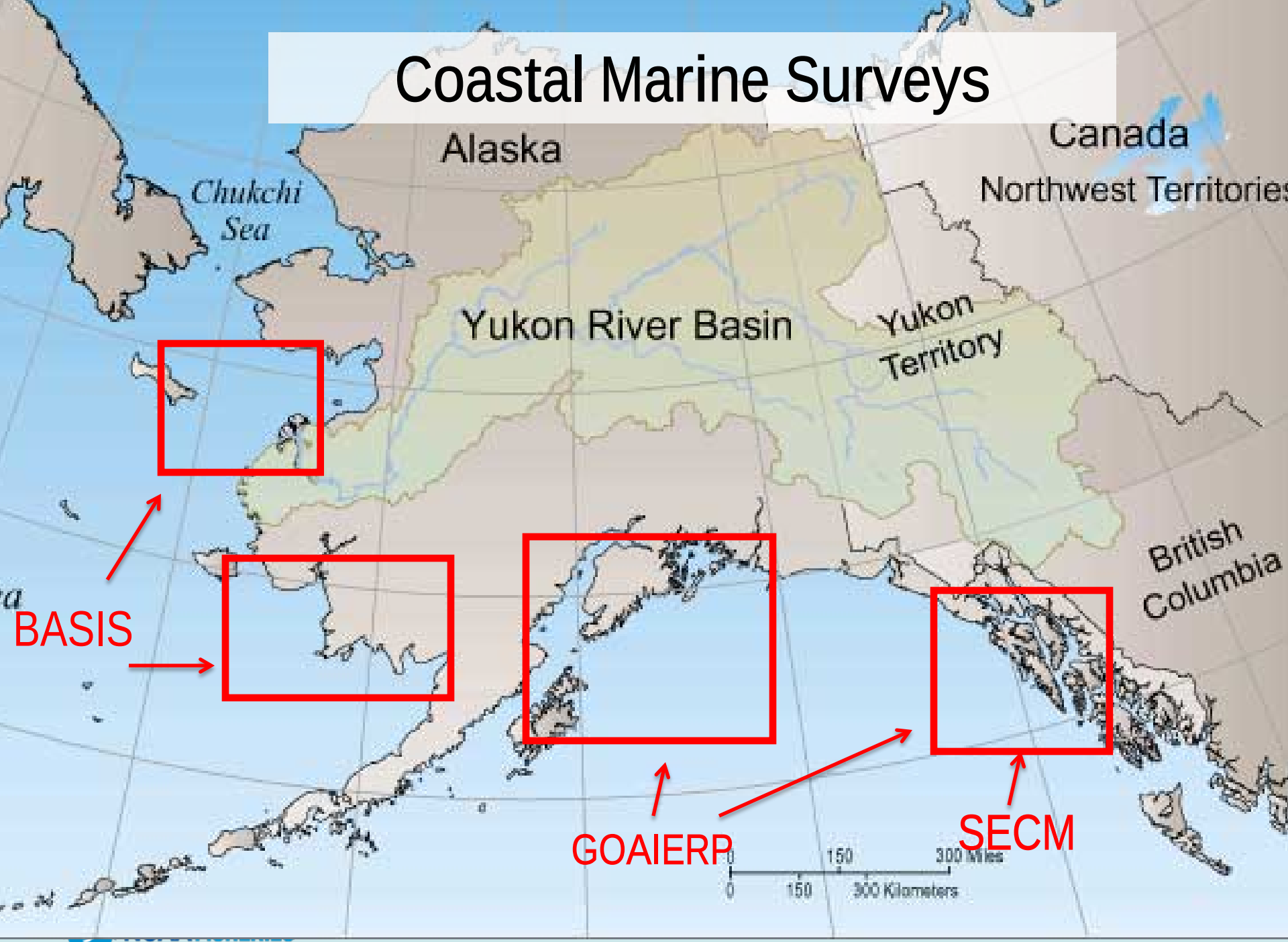
Coastal Marine Surveys



New Projects:

- Every salmon is a low cost biological autonomous underwater vehicle that collect data throughout marine life. There are many millions of them. We need to learn how to download the data when they return to spawn.

  - **Lipids** – What do they eat?
  - **Stable isotopes** – trophic level, location of food
  - **Scale pattern analysis** – growth - when and how fast
  - **Otolith mass marks hatcheries** – billions of marks; sample in the coastal areas and offshore

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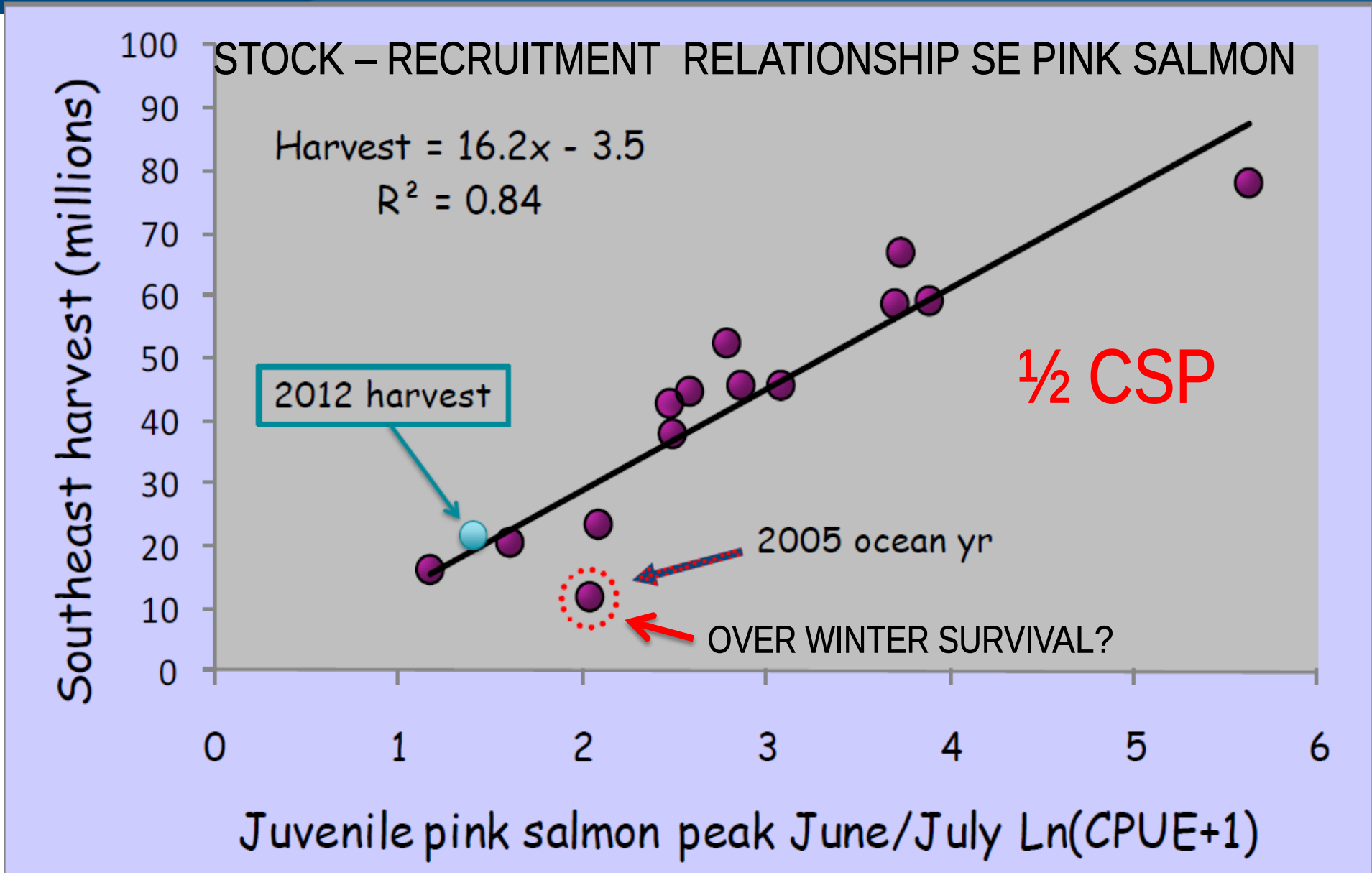

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NOAA FISHERIES

The End

QUESTIONS?