Ecology of Alaska Chinook Salmon in the Open Ocean

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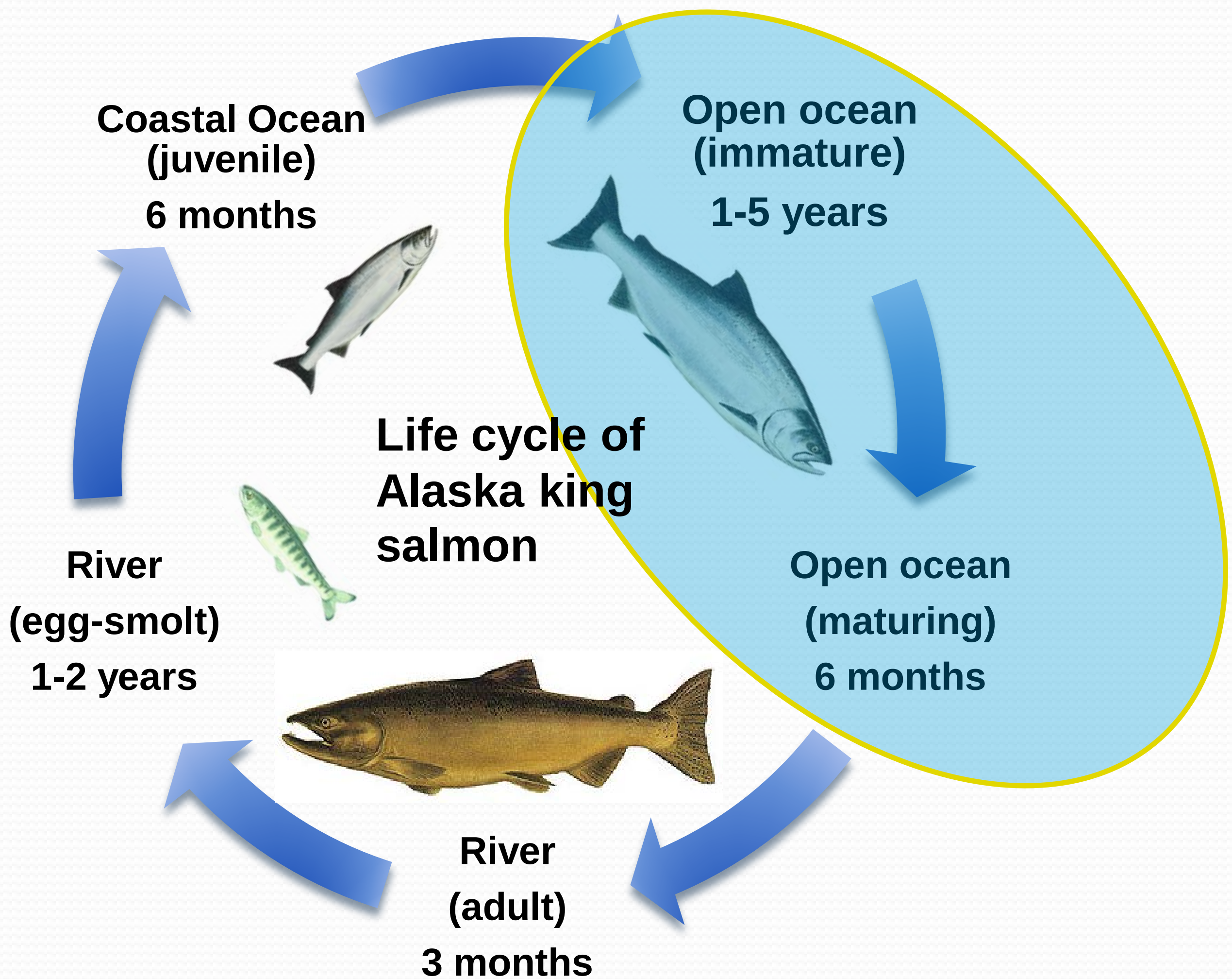
Why is the open ocean important to Alaska king salmon management?



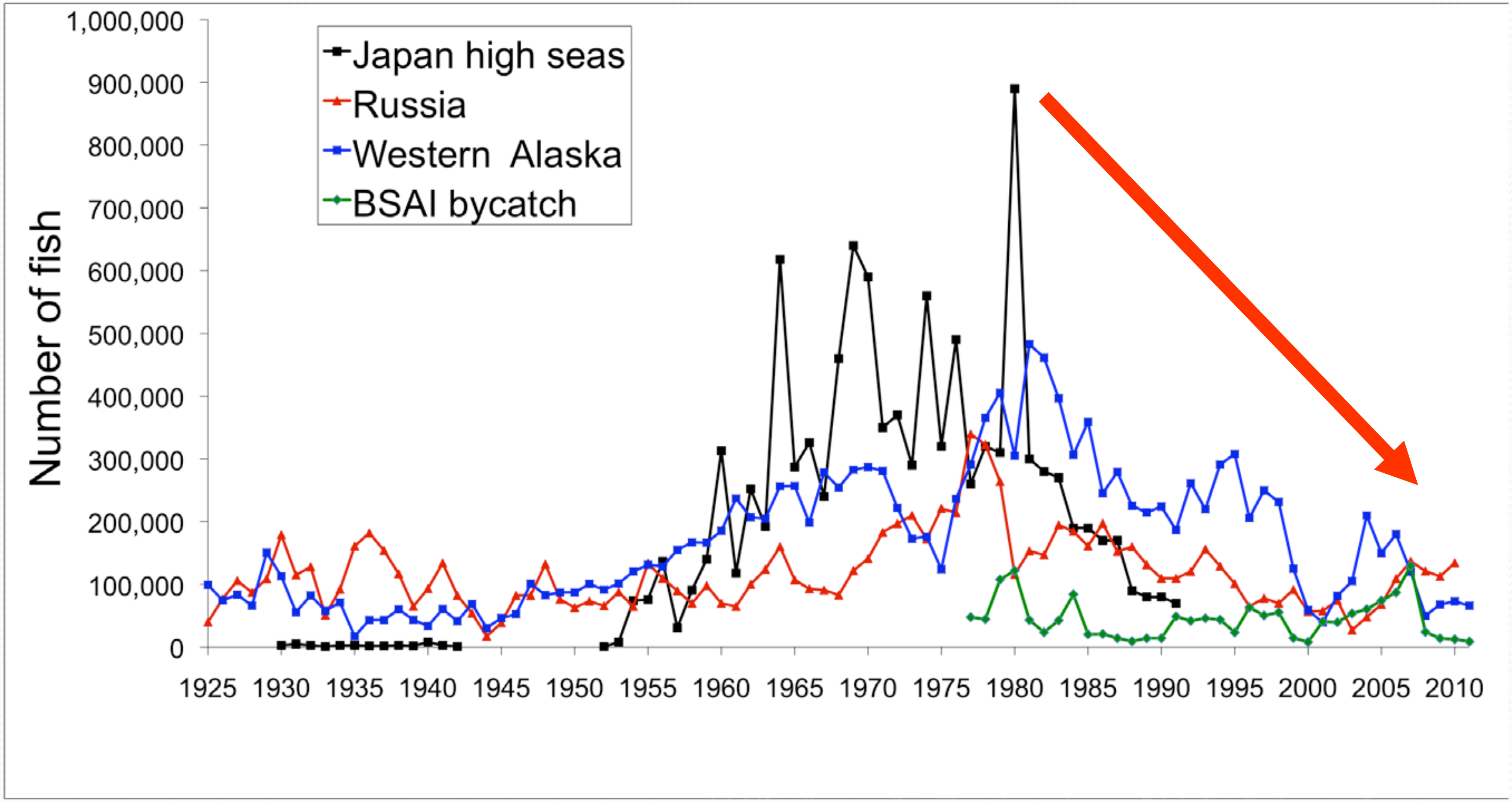
Local and traditional knowledge important to open ocean research, monitoring, & evaluation

- **<u>Salmon</u>: abundance, body size, diseases, parasites, and scars**
- **<u>Climate change</u>: wind, ice, temperature, algae, & jellyfish**
- **<u>Fishing</u>: harvests & bycatch**

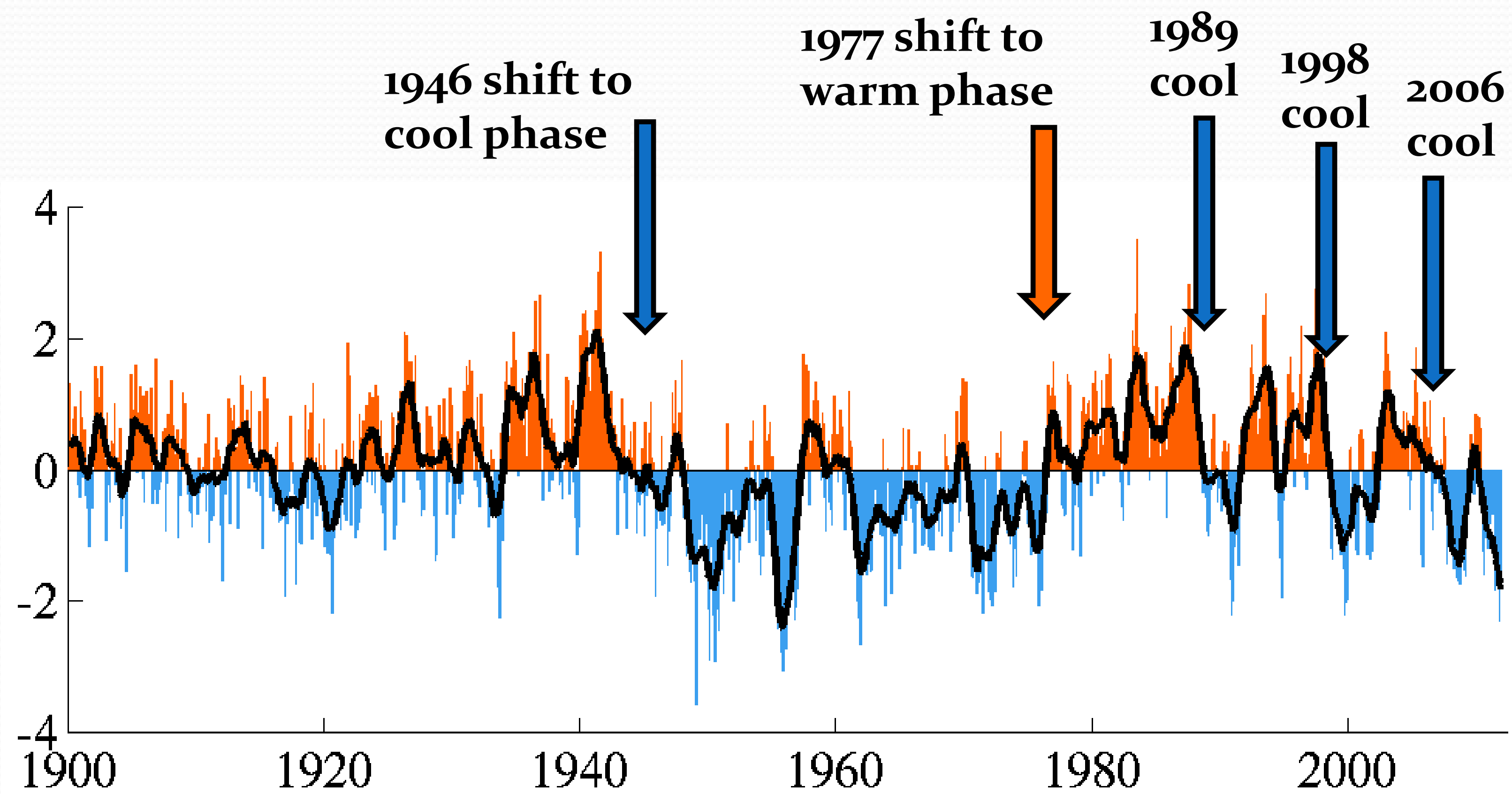
Data source: Julie Raymond-Yakoubian, Kawerak, Inc.

How do Alaska king salmon respond to ocean fishing?

Long-term trends in commercial catch/bycatch of king salmon, 1925-2011



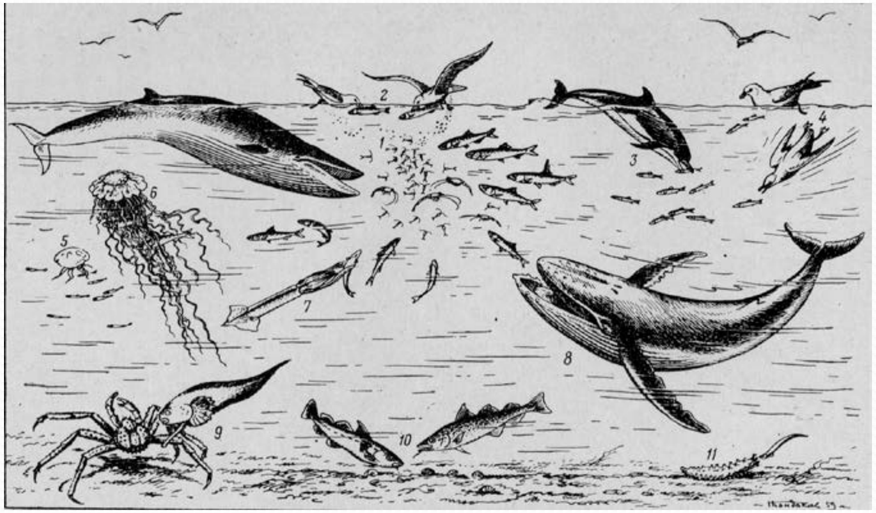
How do Alaska king salmon respond to climate change?



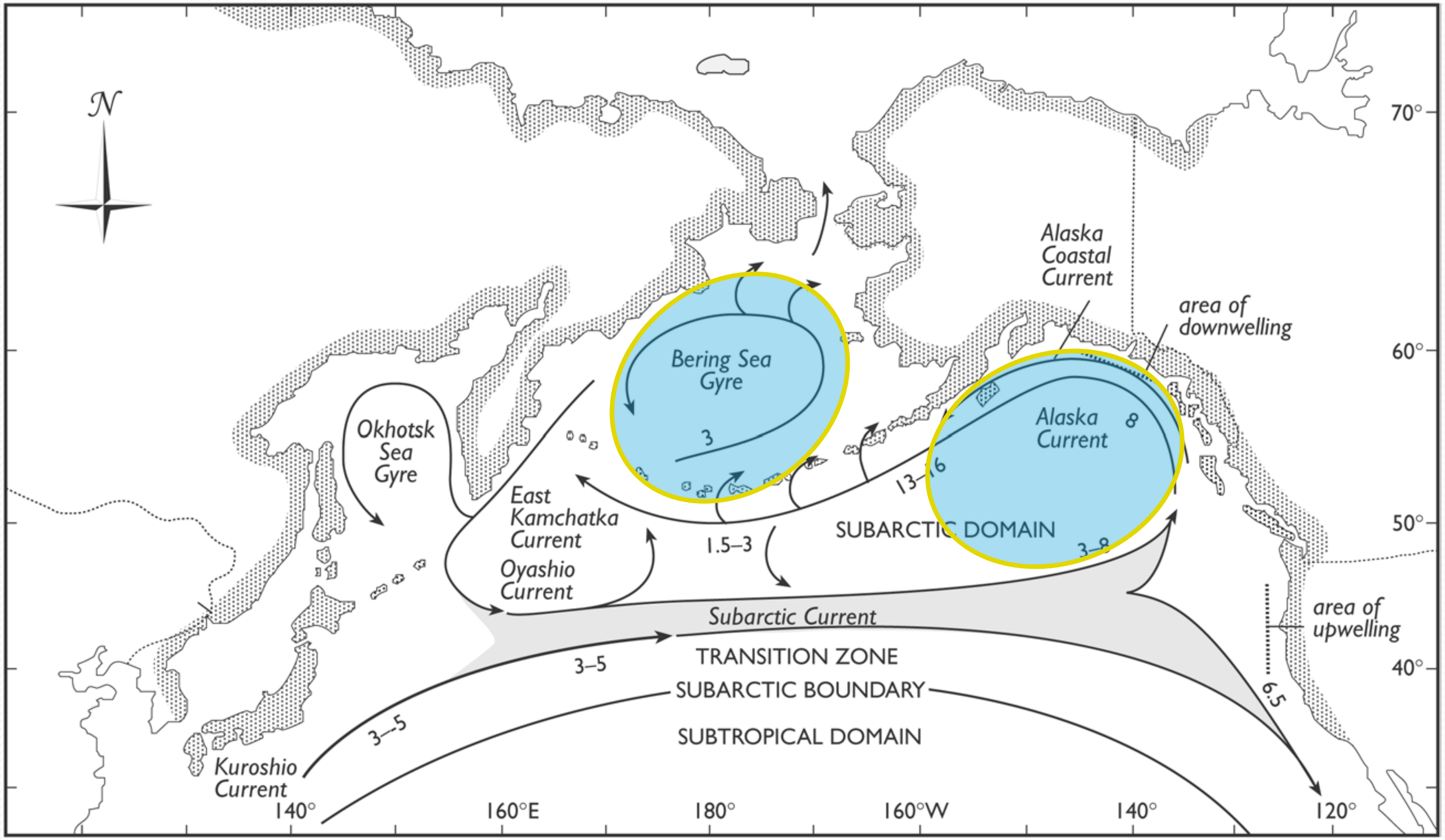
Monthly values for the Pacific Decadal Oscillation index (PDO): 1900-2011 (http://jisao.washington.edu/pdo/)

Ecological process studies and modeling to understand mechanisms of climate & fishing effects on Alaska kings

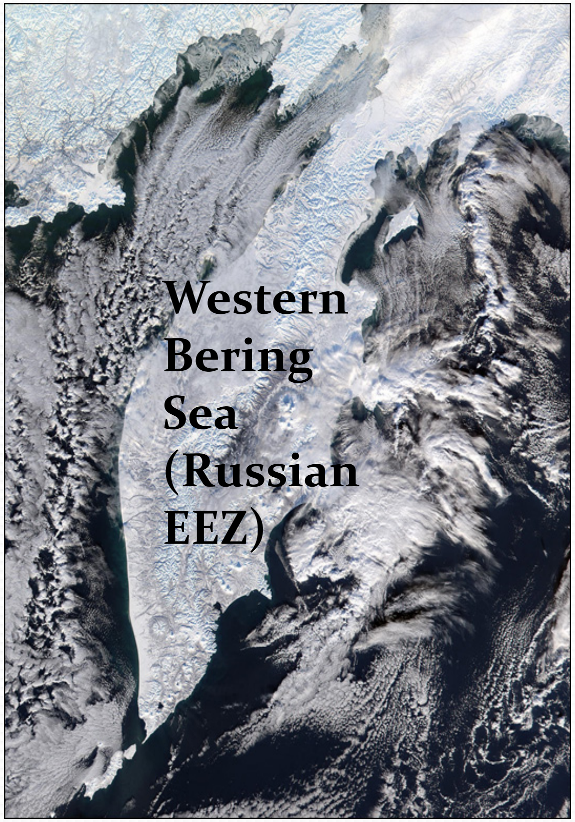
- **Salmon distribution (horizontal and vertical)**
- **Salmon food habits**
- **Salmon growth and bioenergetics**
- **Climate/ocean effects on salmon and their habitats**

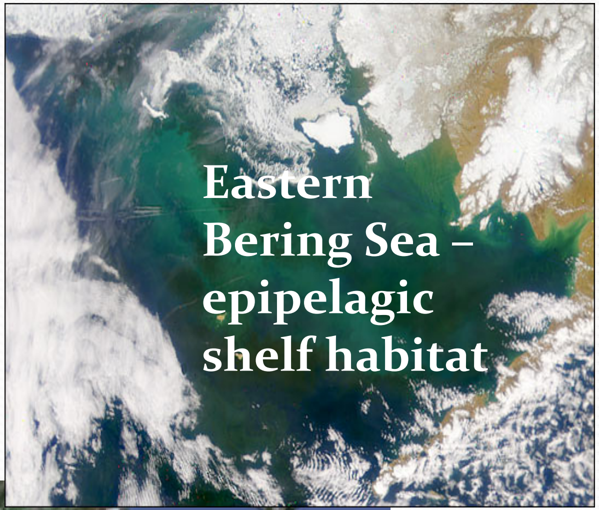


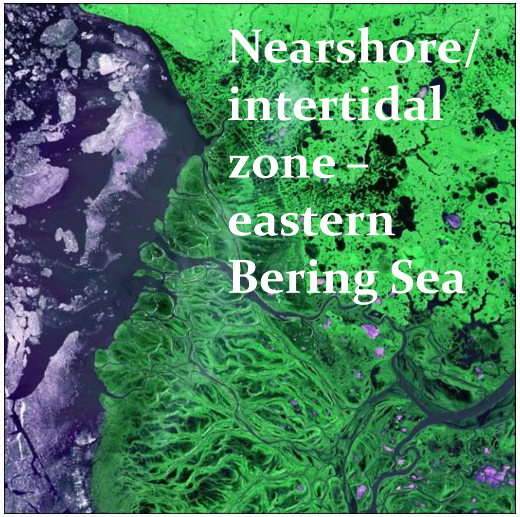
The Bering Sea and Gulf of Alaska are the most important open-ocean habitats of Alaska kings

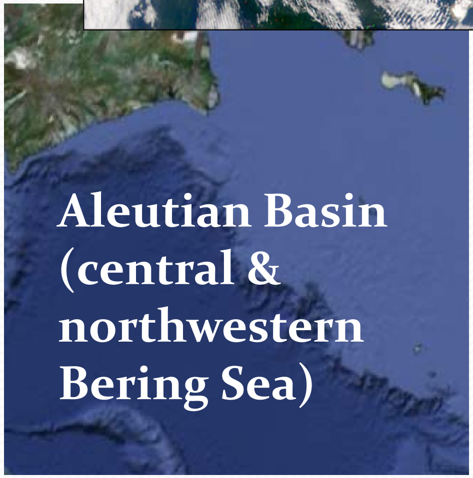


Critical habitats for Alaska kings in the Bering Sea

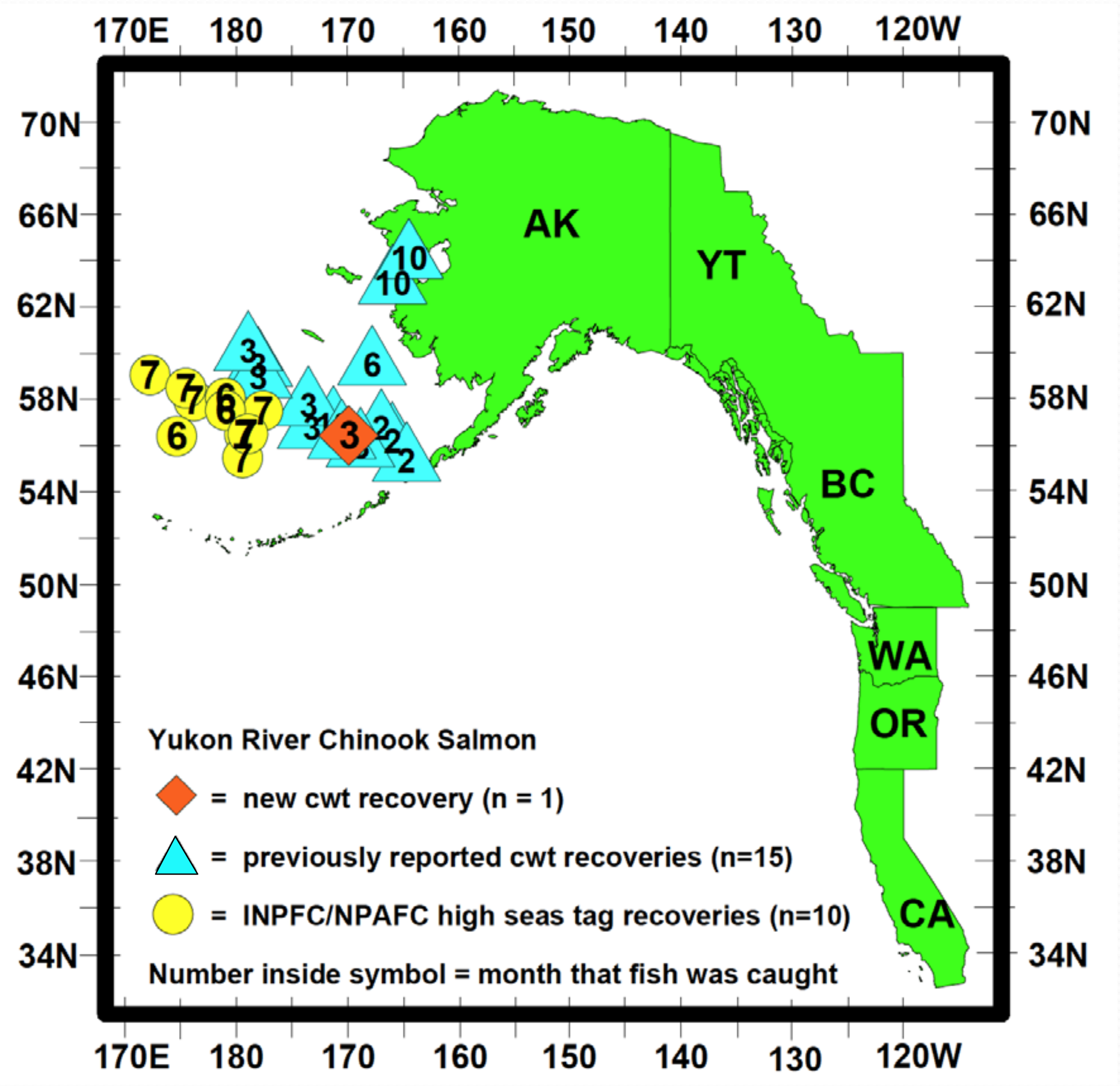




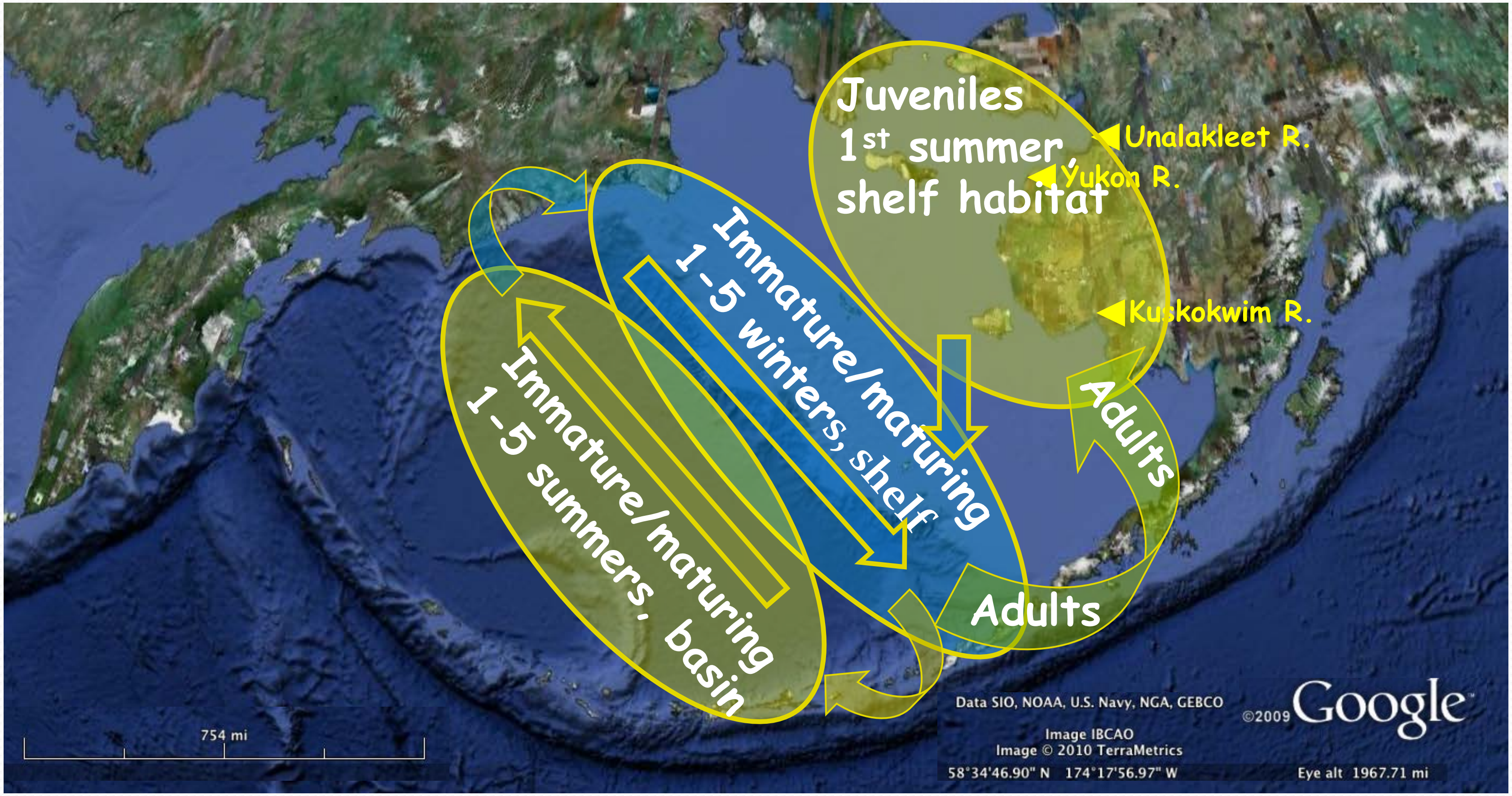




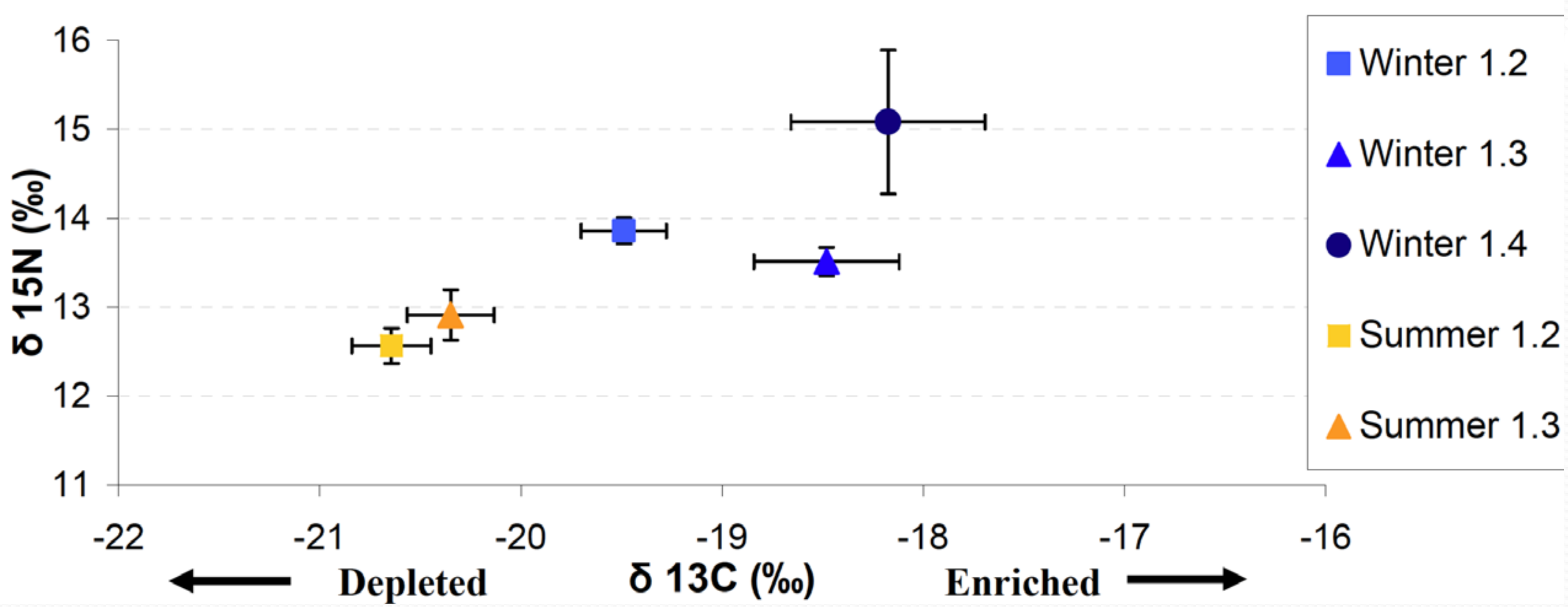
Ocean recoveries of tagged Yukon Kings, 1956-2004



Conceptual Model of Bering Sea Distribution of AYK Kings



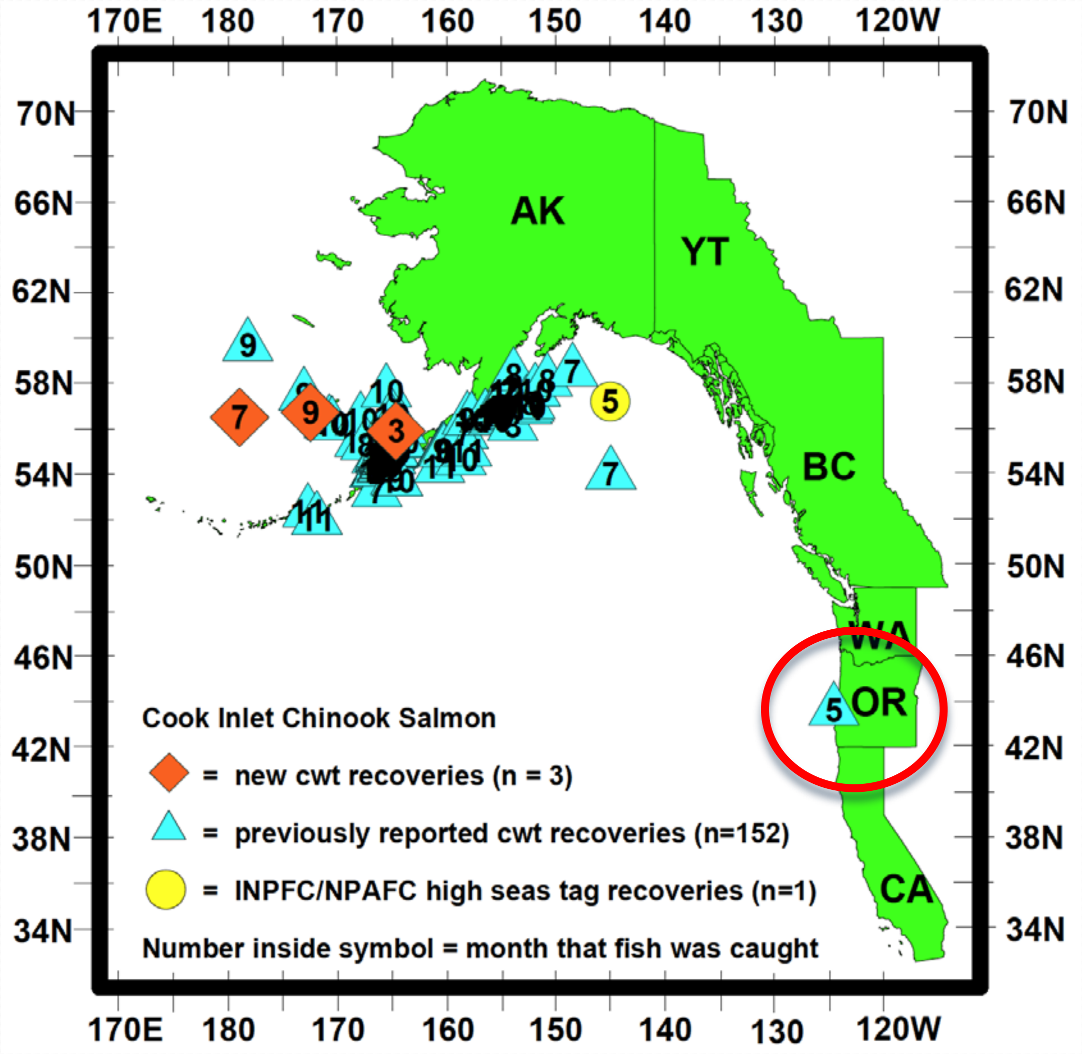
Stable isotope composition of kings in the BSAI bycatch supports seasonal distribution model



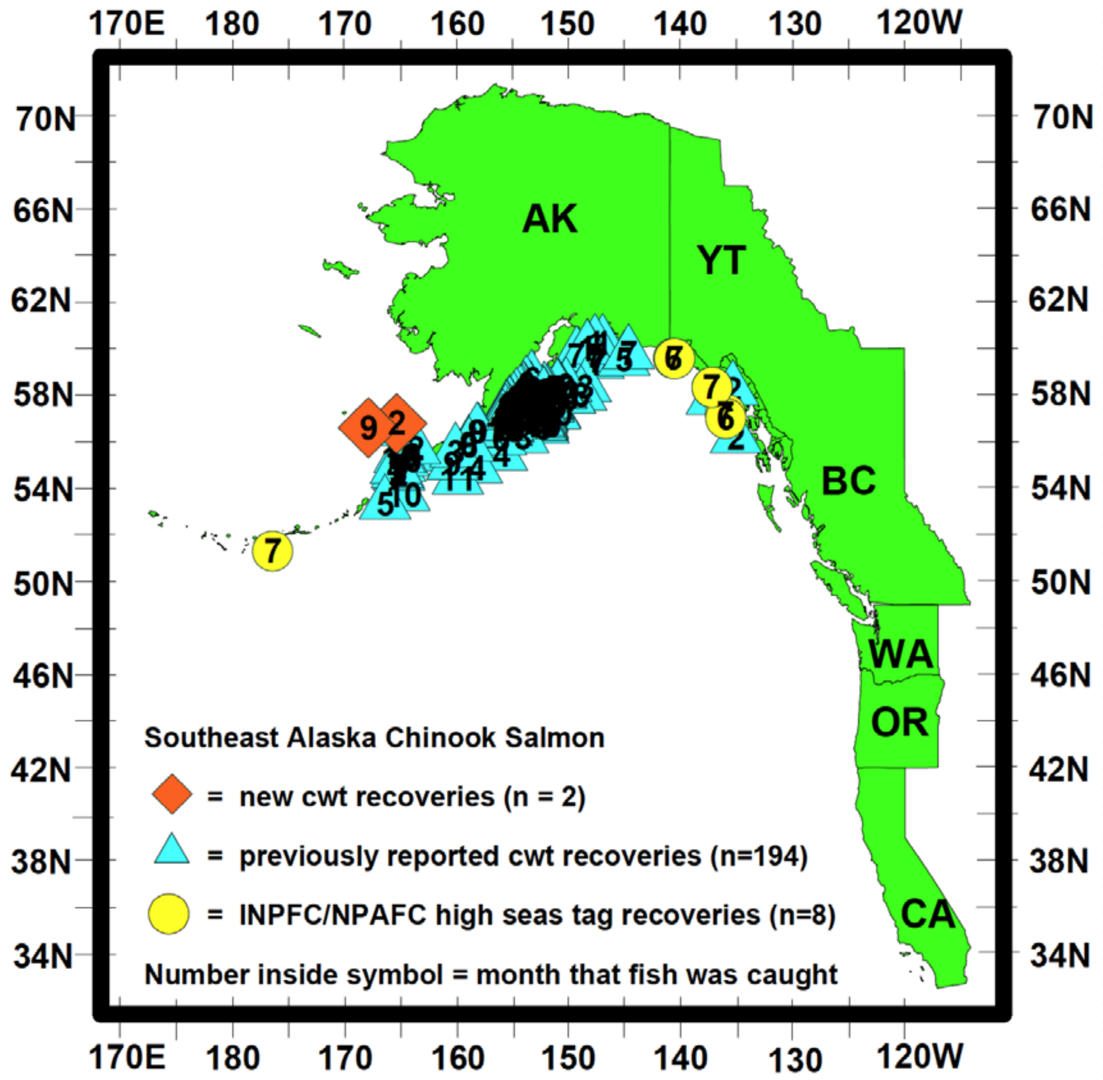
Depleted 13C = basin habitats, Enriched 13C= shelf/slope habitats

Data from Wyatt Fournier (2011)

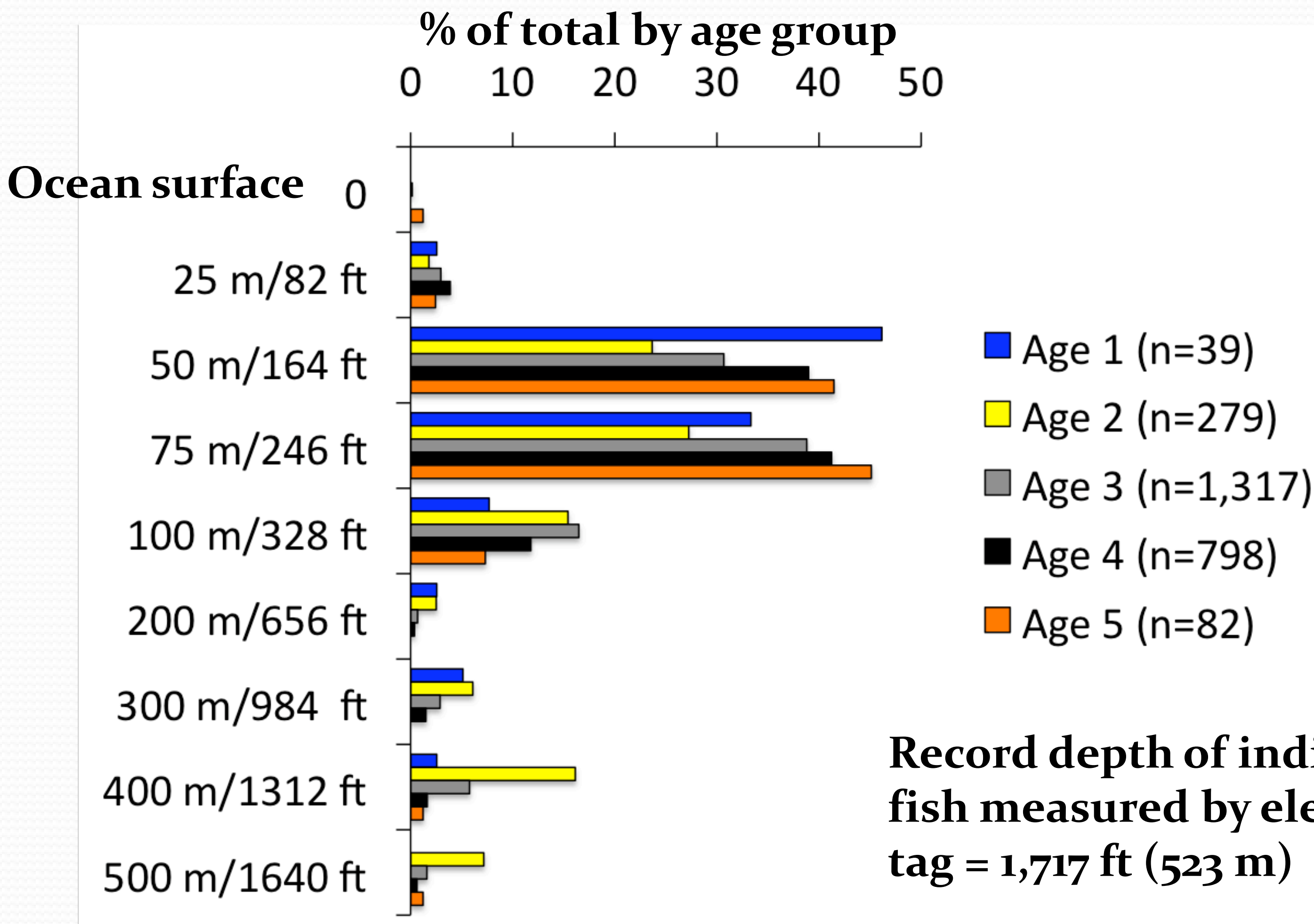
Ocean recoveries of tagged Cook Inlet Kings, 1956-2004



Ocean recoveries of tagged SE Alaska Kings, 1956-2004



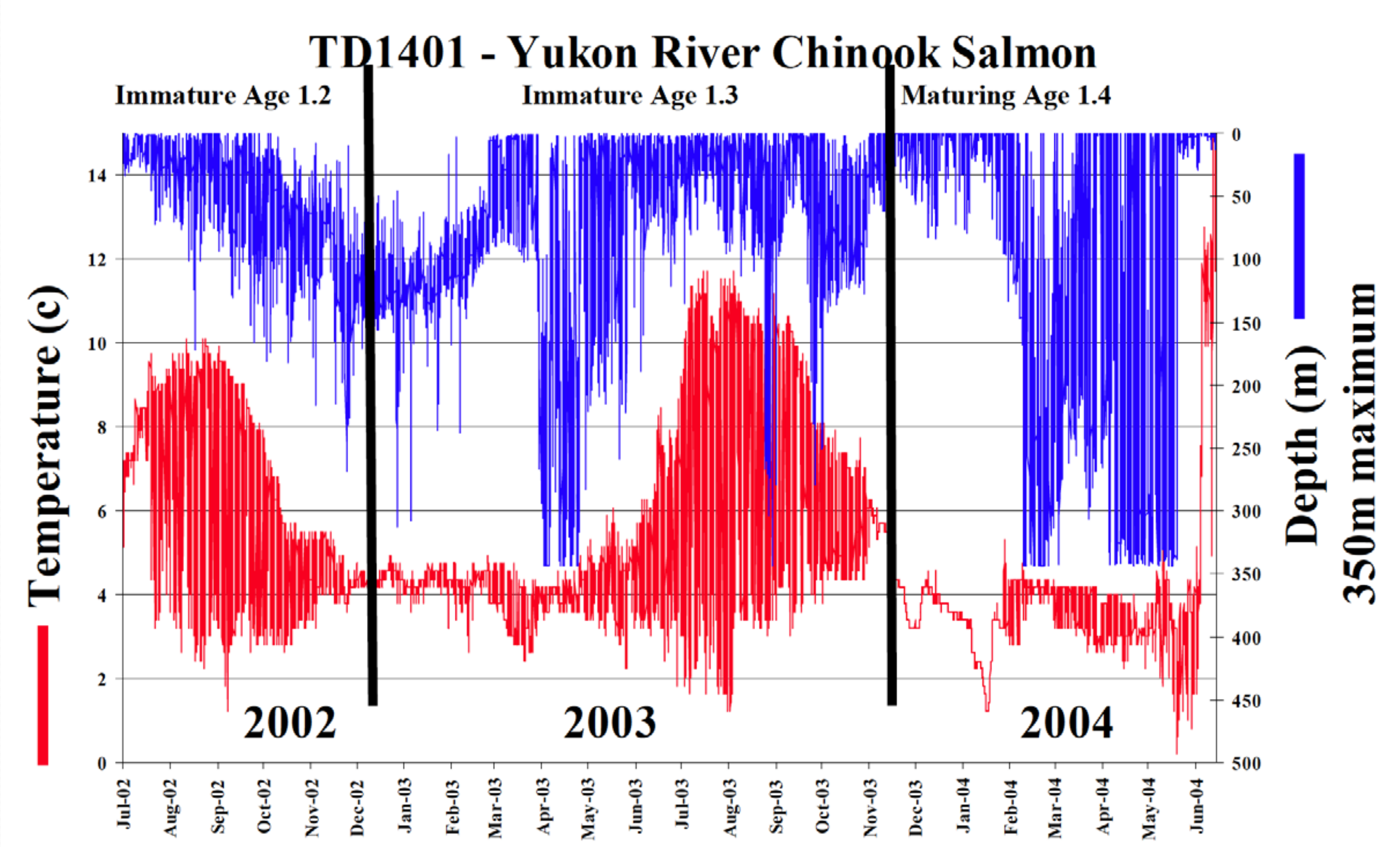
Vertical distribution of trawl bycatch of kings by ocean age group in winter



Record depth of individual fish measured by electronic tag = 1,717 ft (523 m)

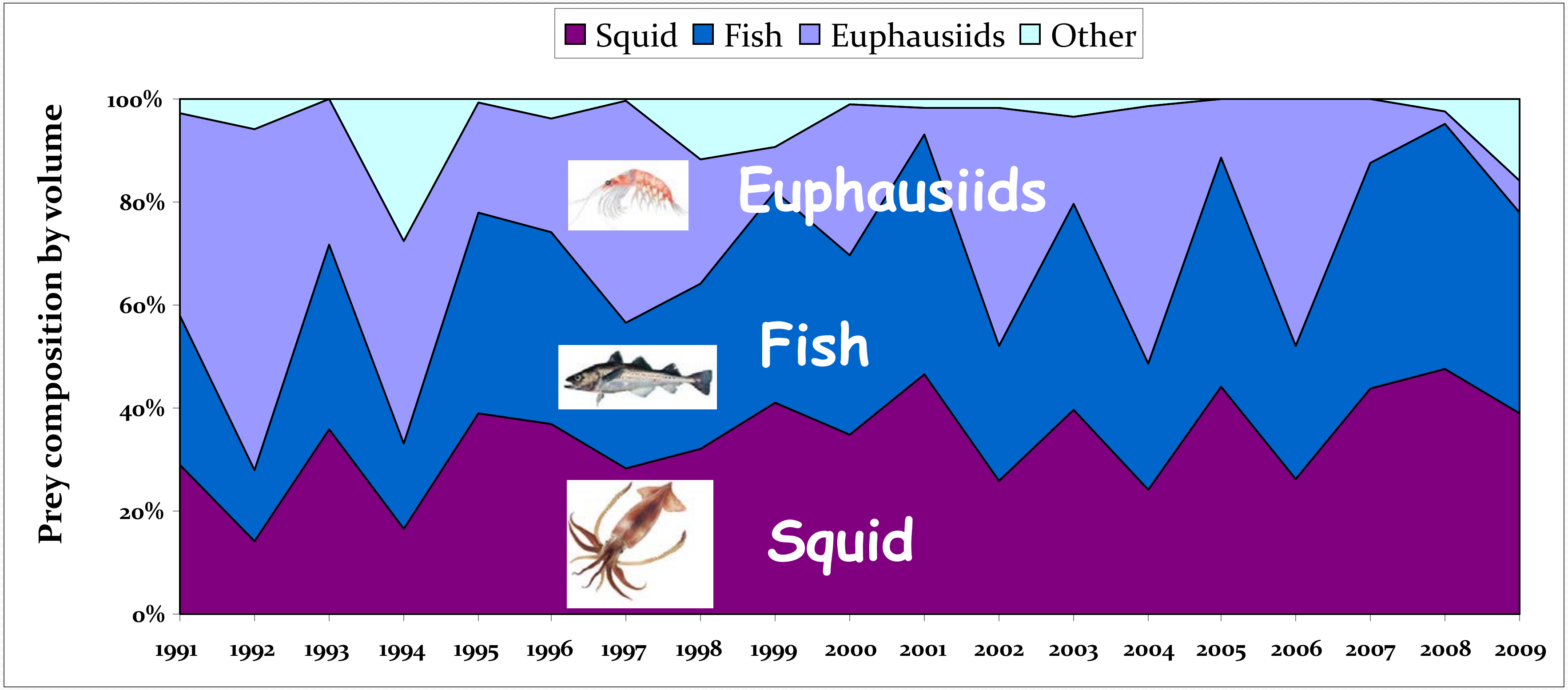
Data are from 1997-1999

Temperature (red) & Depth (blue) data storage tag record (16,246 data points) for an individual fish

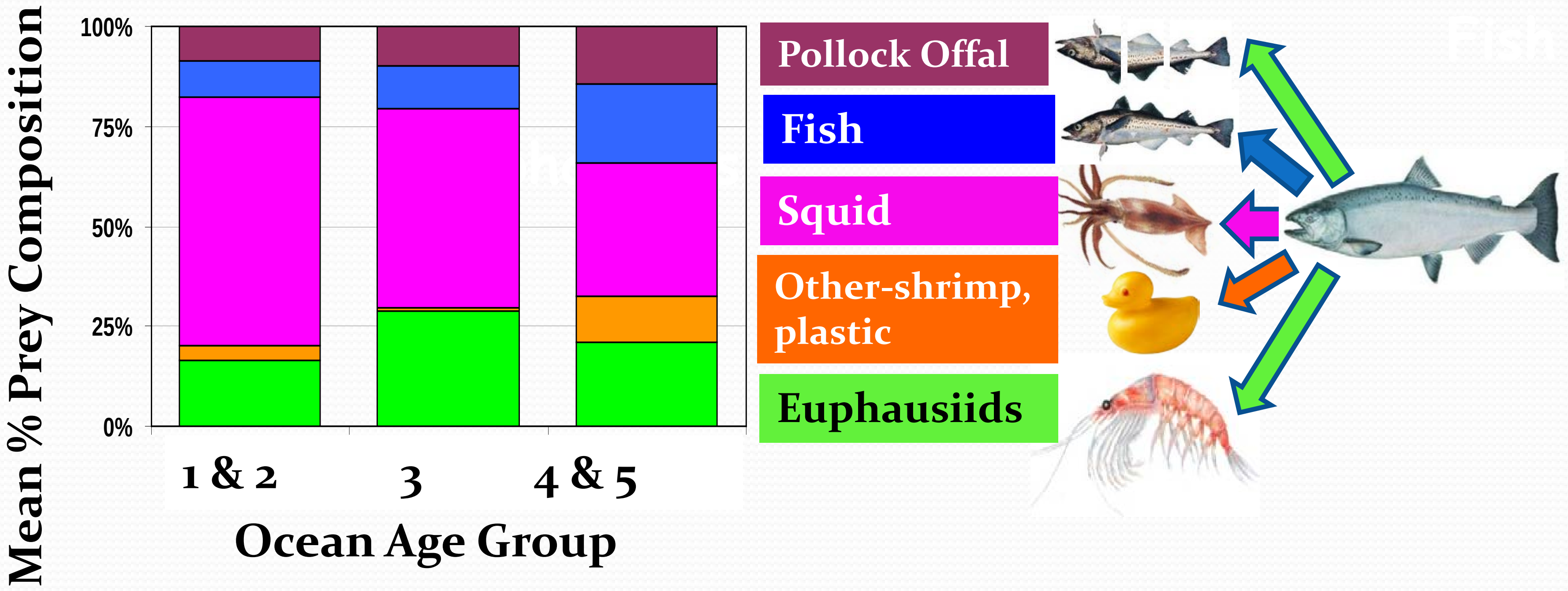


Chinook salmon tagged at 56°30´N, 179°00´W in the Bering Sea on 8 July 2002 and recovered at age 1.4 near Kotlik, Alaska, in the Yukon River on 21 June 2004.

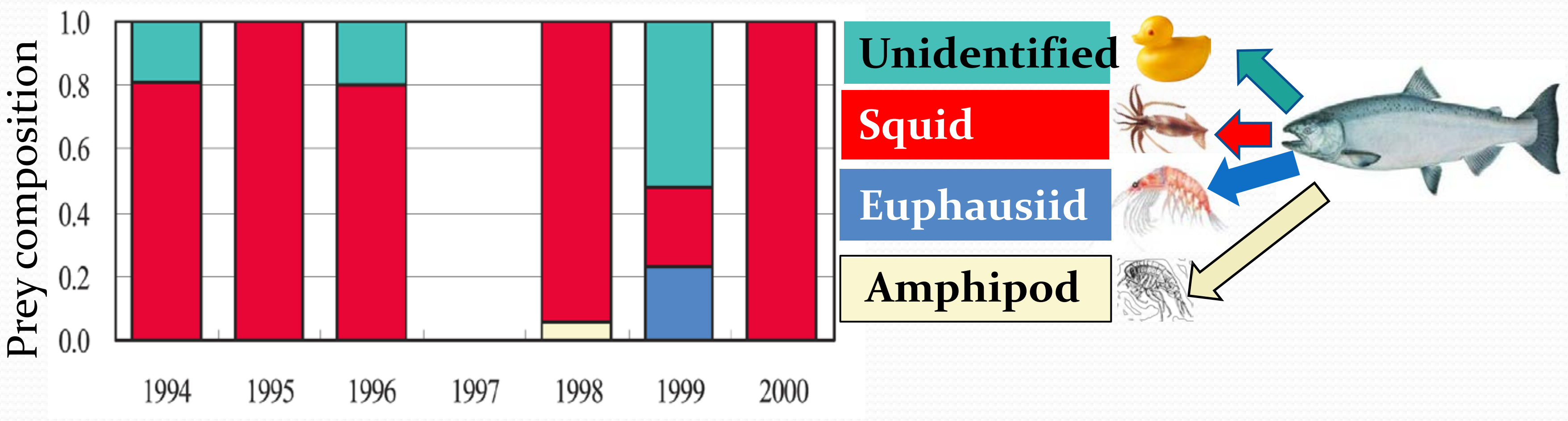
Summer diets of immature kings in Bering Sea basin habitats



Winter diets of kings in Bering Sea shelf habitats – BSAI bycatch 2007

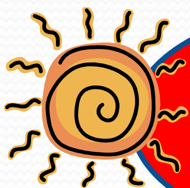


Summer diets of immature kings in the Central Gulf of Alaska (50-56°N, 145°W)



Data from Kaeriyama et al. 2004

Life-stage specific responses of Bering Sea kings to natural climate change



Warm climate

↓

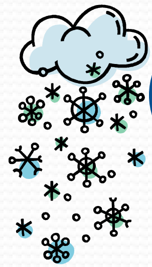
High survival & abundance

↓

High growth rate if prey not limited

↓

Early maturation; early return; adults younger, smaller at return



Cool climate

↓

Low survival & abundance

↓

Low growth rate if prey limited

↓

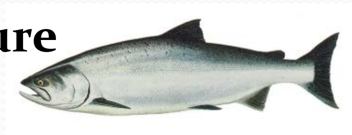
Late maturation; late return; adults older & larger at return

Open ocean life stage:

1st Ocean winter

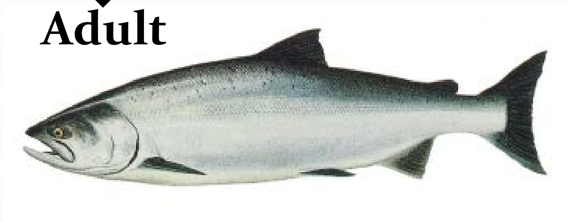
↓

Immature



↓

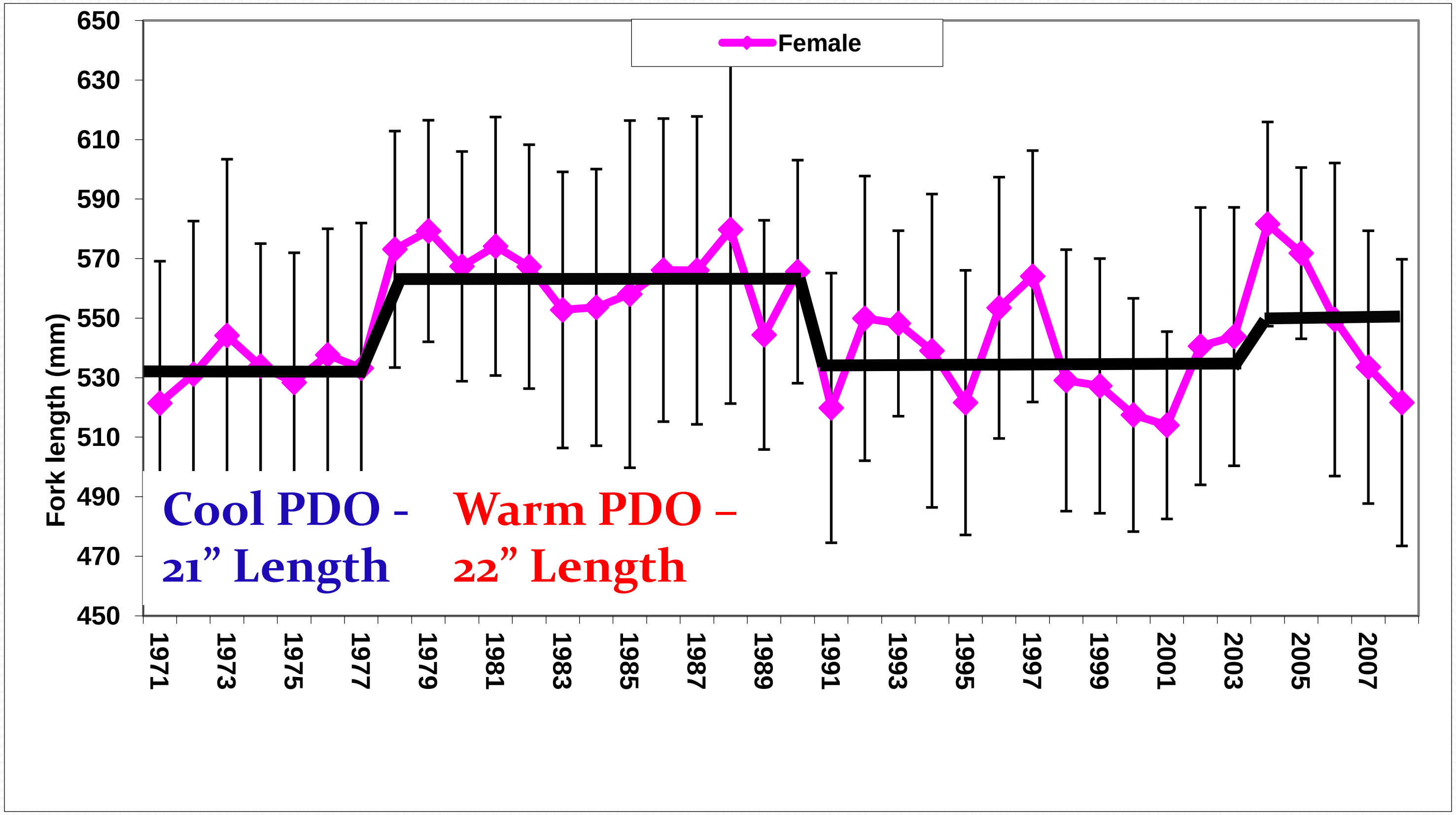
Adult



Bioenergetics and growth results for Bering Sea stocks

- **Immature kings respond to cool vs. warm climate regimes by changes in body size**
- **1st winter at sea most critical growth period affected by warm vs. cold climate change**
- **Female Yukon kings showed a positive shift in growth around 2000**
- **Climate/ocean variables correlated to increased high seas growth: low sea ice cover and warm temperatures**

Body size response of immature kings to cool & warm climate shifts



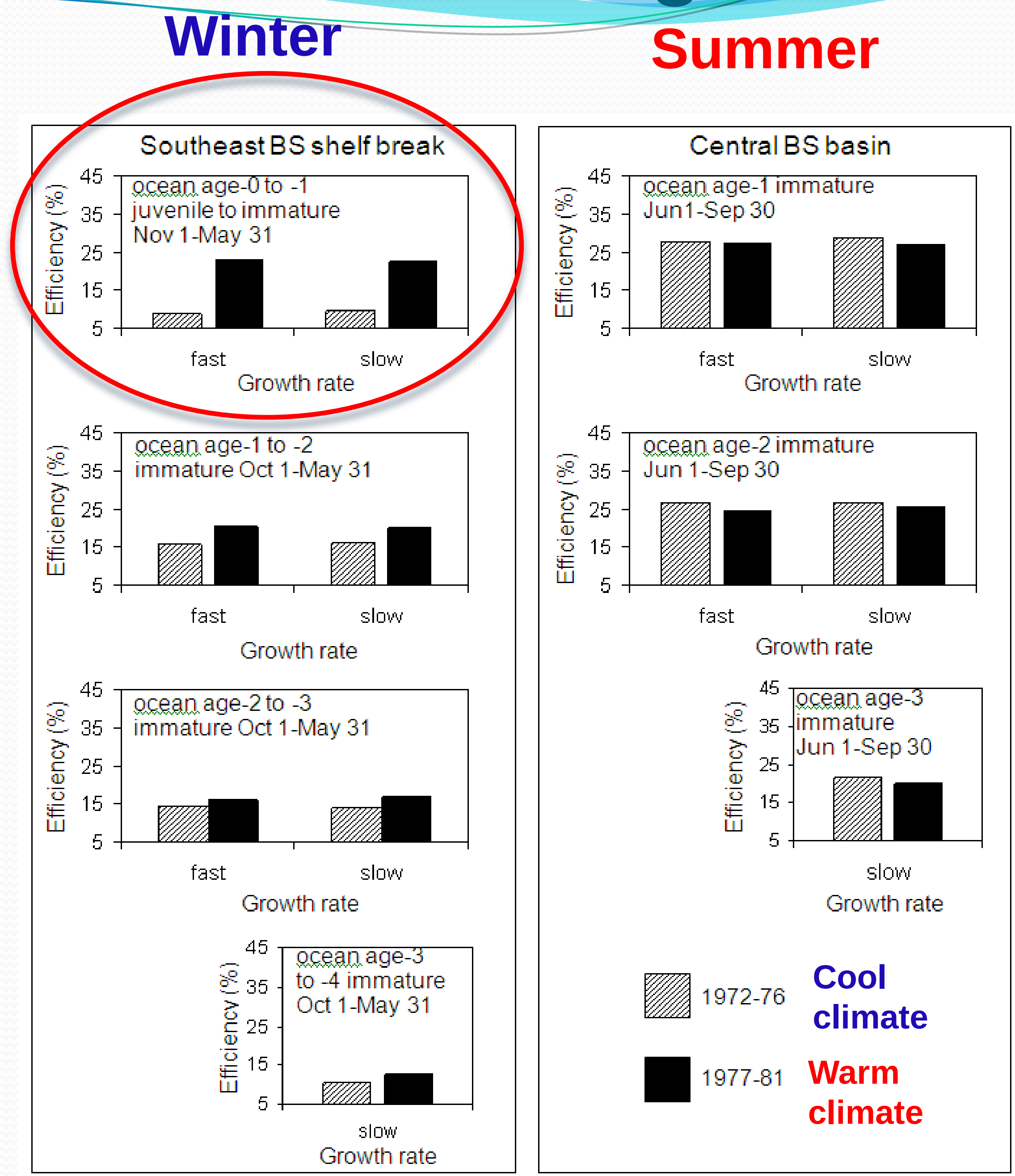
Sequential t-test analysis of regime shifts (Rodinov 2005) using Japanese salmon research vessel data (1971-2008) - significant shifts in 1978 and 1991. Immature age 1.2 female kings in Bering Sea.

1st winter at sea -most critical growth period

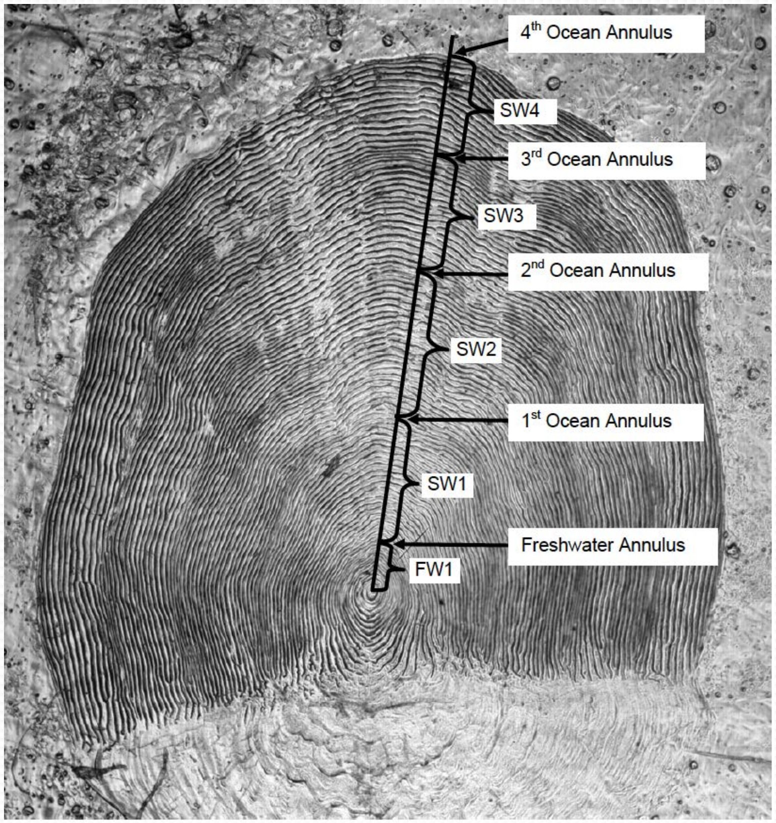
Estimated conversion efficiency (%) = net growth/total prey consumption

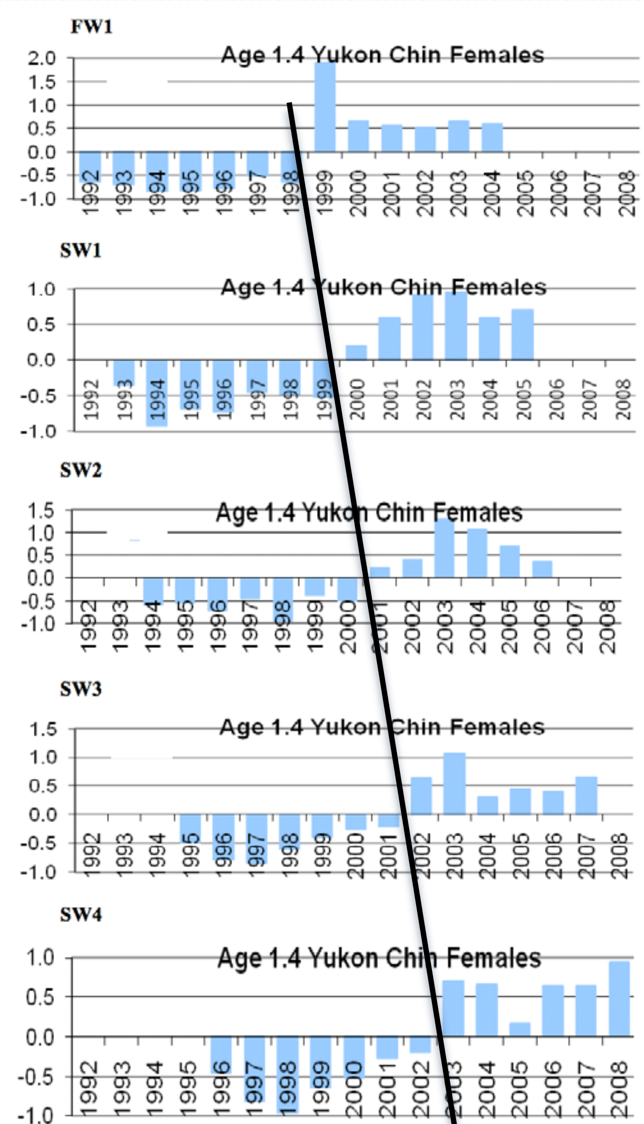
Bioenergetics Model

C = M + W + G



Positive shift in growth of Yukon kings around 1999-2000



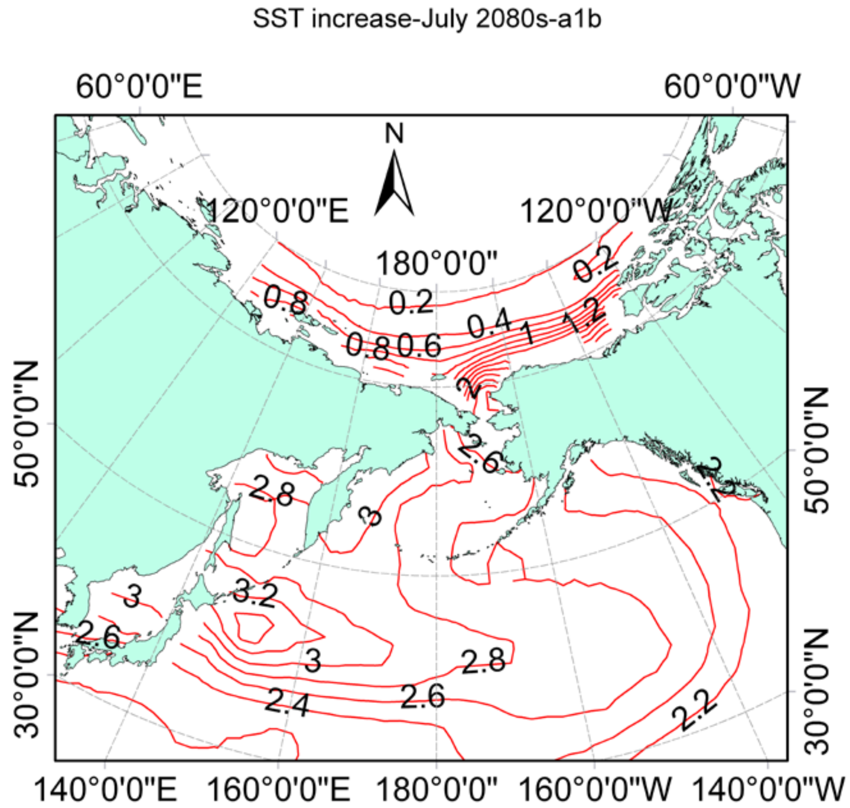


Age 1.4 Yukon King Scale

Data sources: G. Ruggerone & Bev Agler; UW High Seas Project

How will kings respond to changes in thermal habits given projected changes due to greenhouse gas emissions?

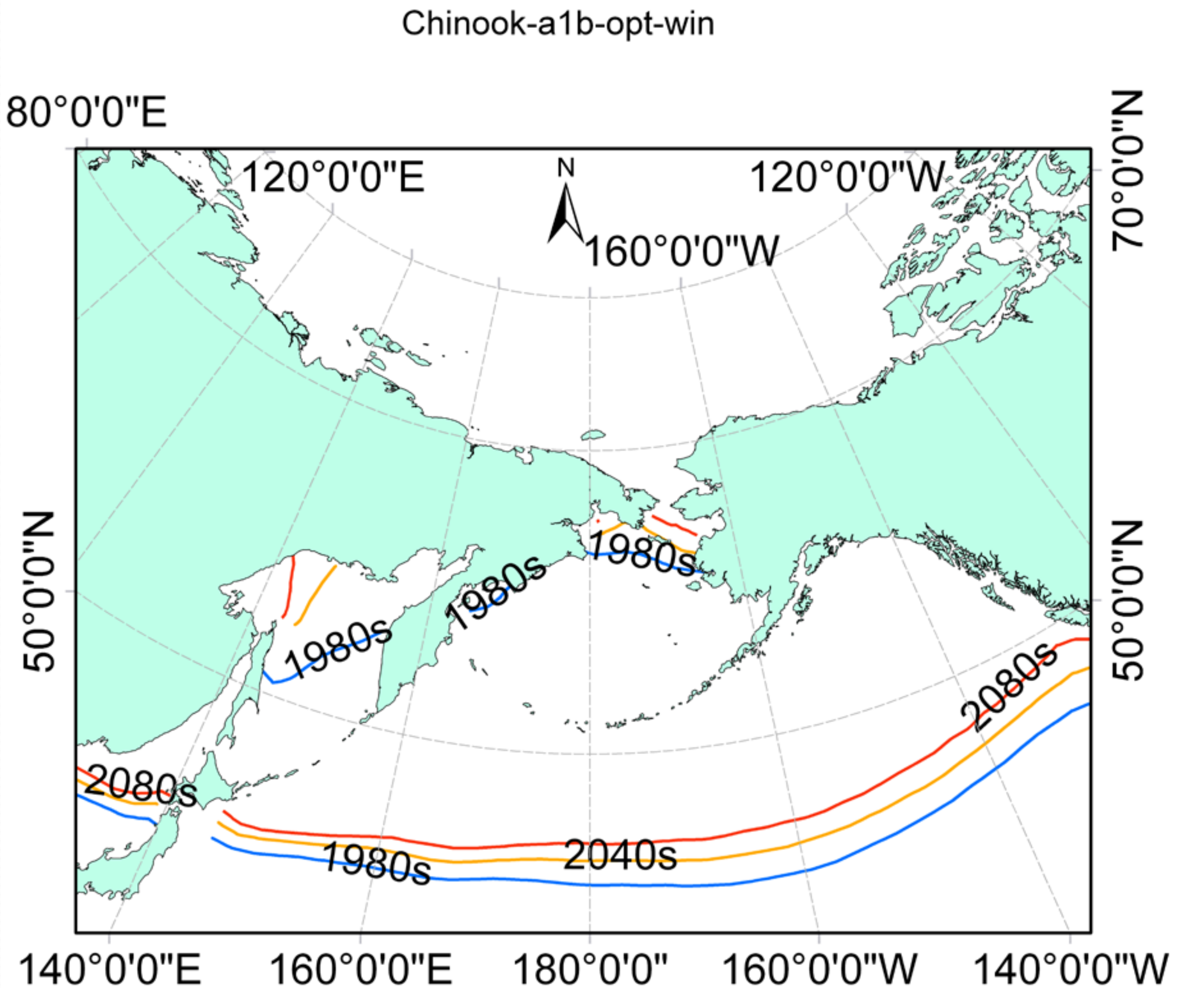
- Multimodel averages for A1B emissions scenario (18 different Global Climate Models)
- 2080s: SST warms by 2-3°C, with greatest warming in the western North Pacific and least in the northeast Pacific



Projected change in summer (July) sea surface temp. habitat- under medium greenhouse gas emission scenario

Data from Abdul-Aziz et al. 2011

Projected changes in open ocean thermal habitats of king salmon - winter

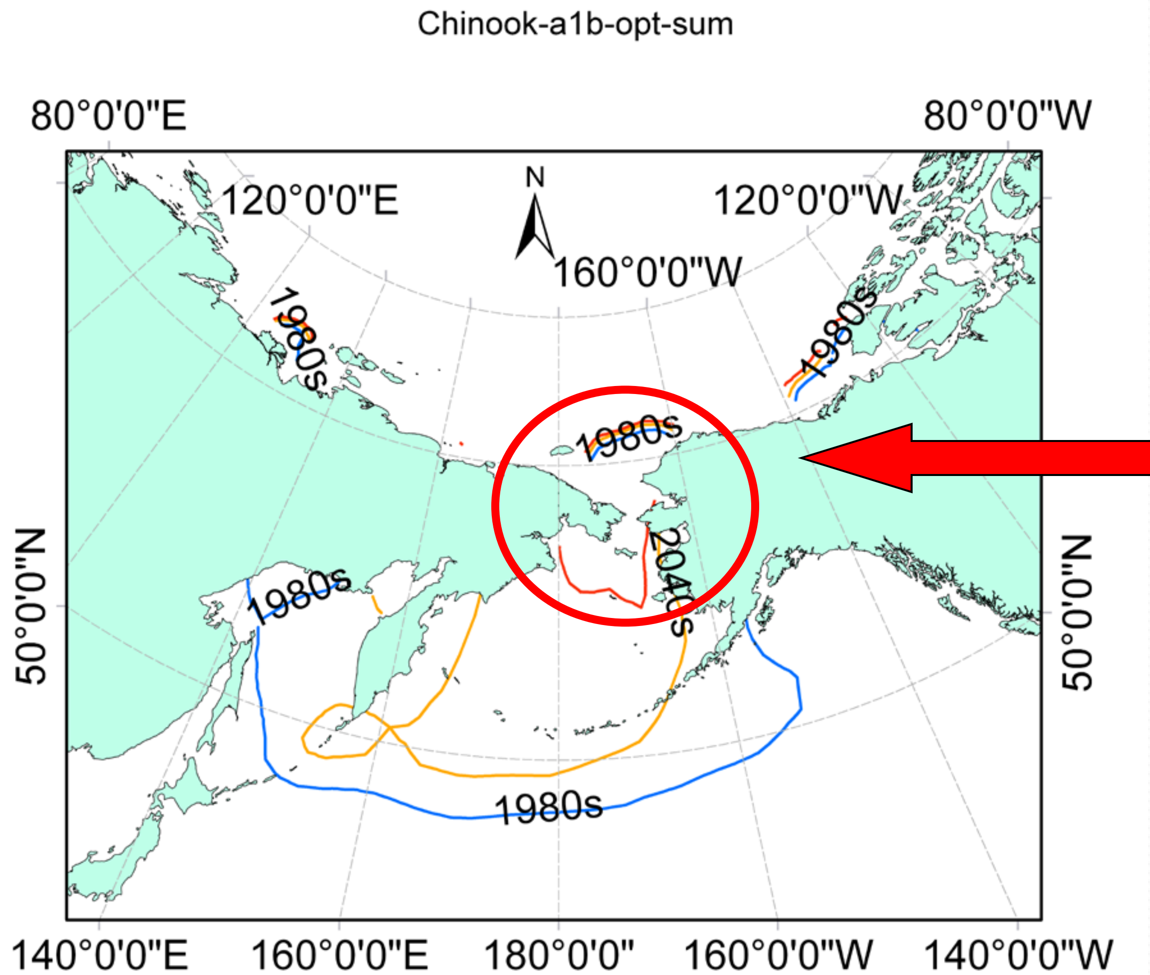


1980s
2040s
2080s

10% loss of 1.5-12°C (35-54°F) habitat by 2080s

Data from Abdul-Aziz et al. 2011

Projected changes in open-ocean thermal habitats of king Salmon - summer



1980s

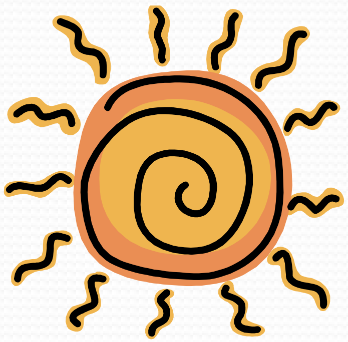
2040s

2080s

86% loss of 1-10°C (34-50°F) habitat by 2080s

Data from Abdul-Aziz et al. 2011

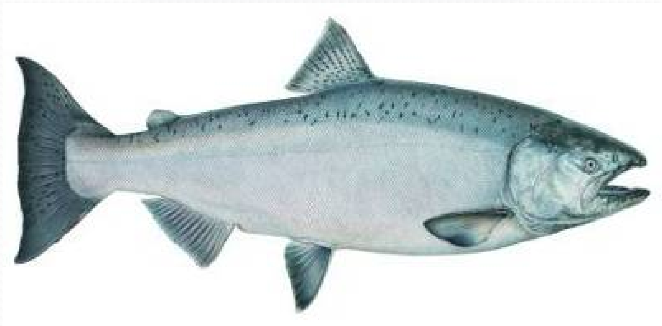
Hypothesis: Human forcing of open-ocean ecological processes is contributing to long-term declines in productivity of Alaska Chinook salmon



Climate

Fishing

Salmon



Important research areas and questions

1. **Climate-Change/Ocean Acidification (CCOA)**: What are the past, current, and projected effects of CCOA on salmon productivity?
2. **Industrial-Scale Fisheries (ISF)**: Are ISF both predators and competitors of salmon? Is there a threshold of maximum salmon biomass or minimal prey biomass or density needed in open-ocean ecosystems to sustain long-term salmon productivity? Are discarded fish processing wastes a vector for spreading disease and parasites?
3. **Hatchery-wild interactions (HWI)**: Do HWI in the open ocean affect the productivity of wild Alaska salmon?
4. **Marine pollution (MP):** Does open-ocean MP affect salmon productivity?
5. **Multiple Human Stressors (MHS)**: What are the cumulative effects of open-ocean MHS (climate change, fishing, hatchery production, and pollution) on salmon productivity?

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- **The statements, findings, conclusions, and recommendations are those of the author and do not necessarily reflect the views of NOAA, the U.S. Department of Commerce, or ADFG.**

Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK SSI) Chinook Salmon Outreach Workshop

December 11-12, 2012
Anchorage, Alaska

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