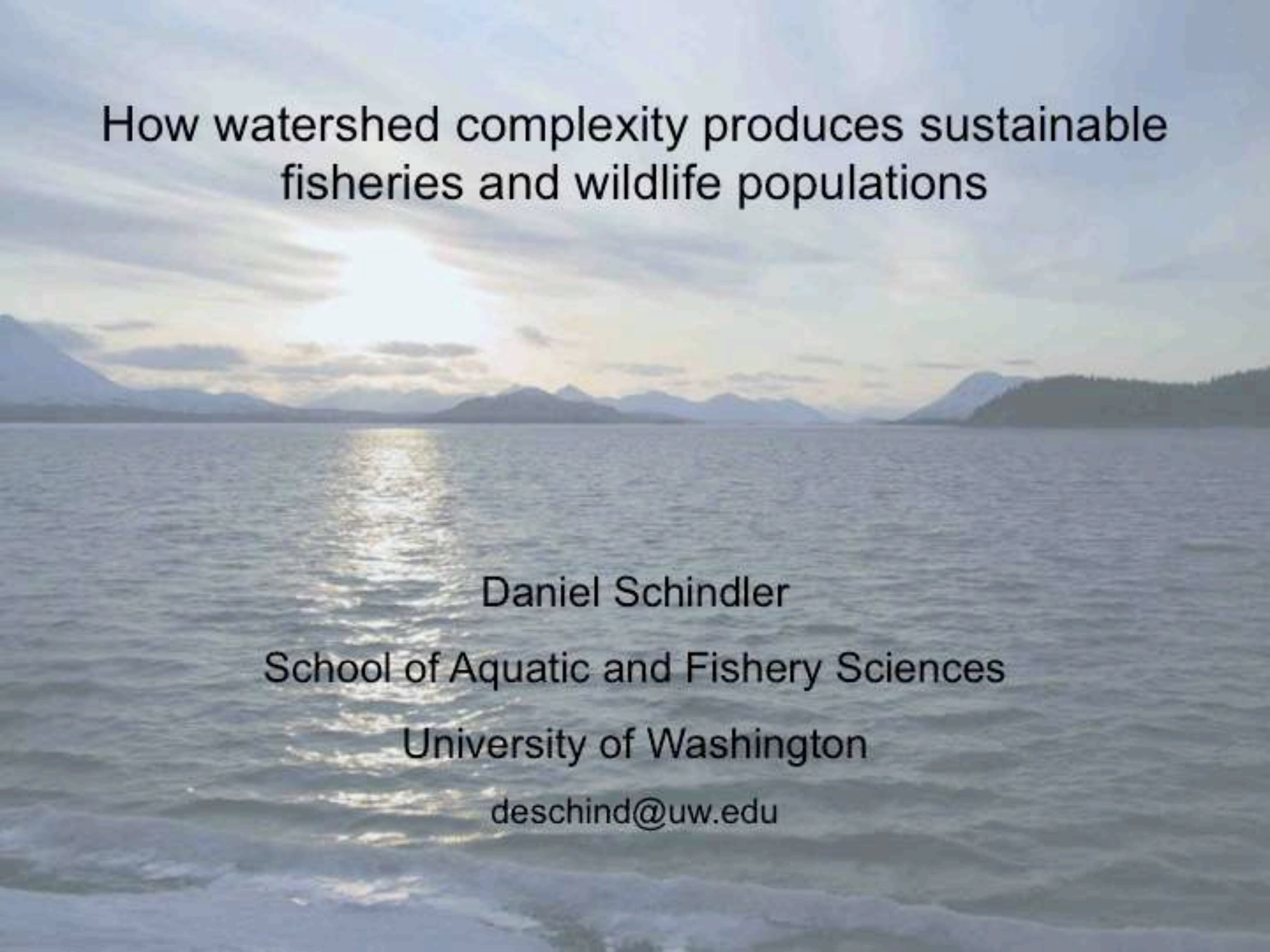


How watershed complexity produces sustainable fisheries and wildlife populations

Daniel Schindler

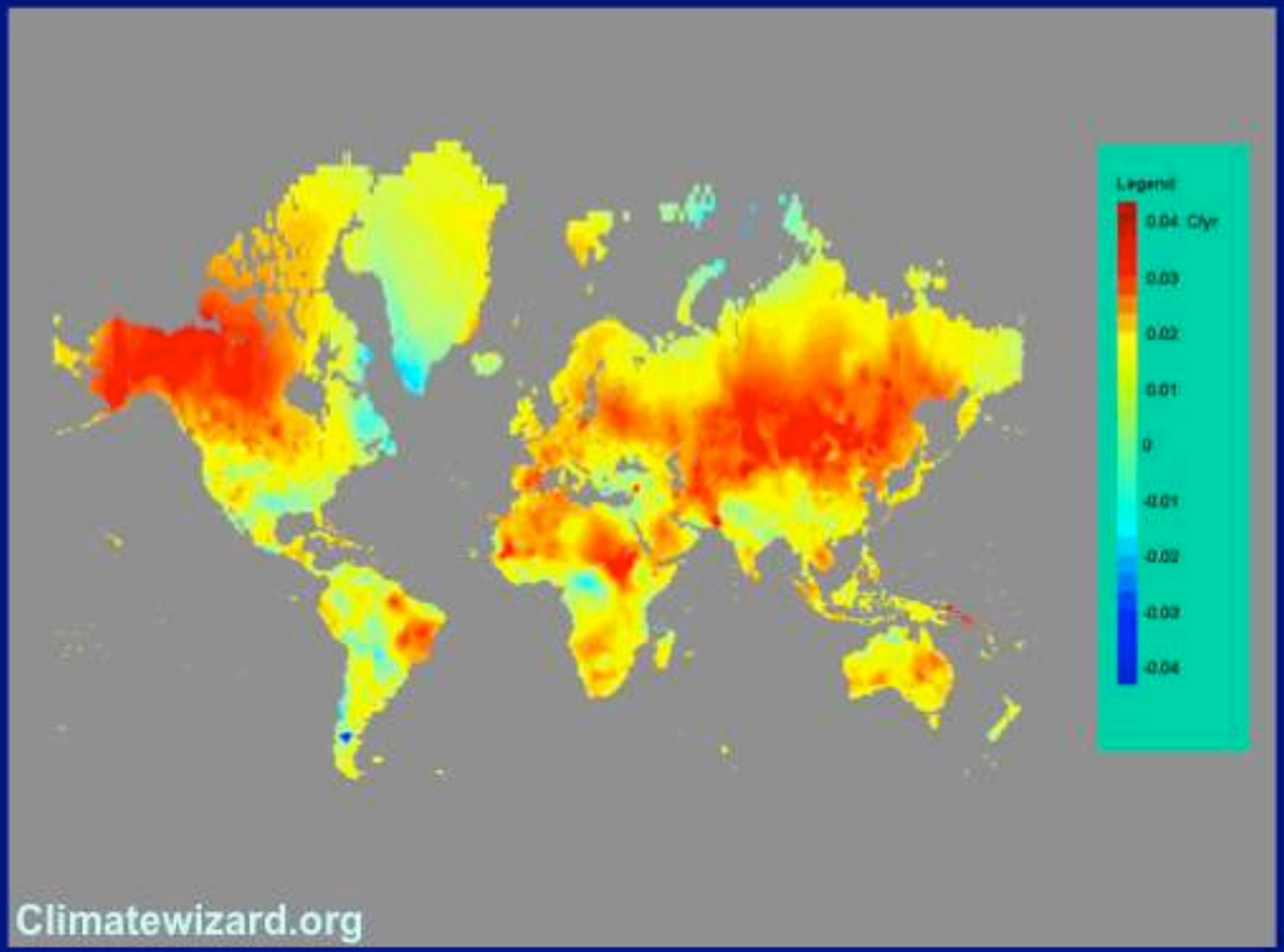
School of Aquatic and Fishery Sciences

University of Washington

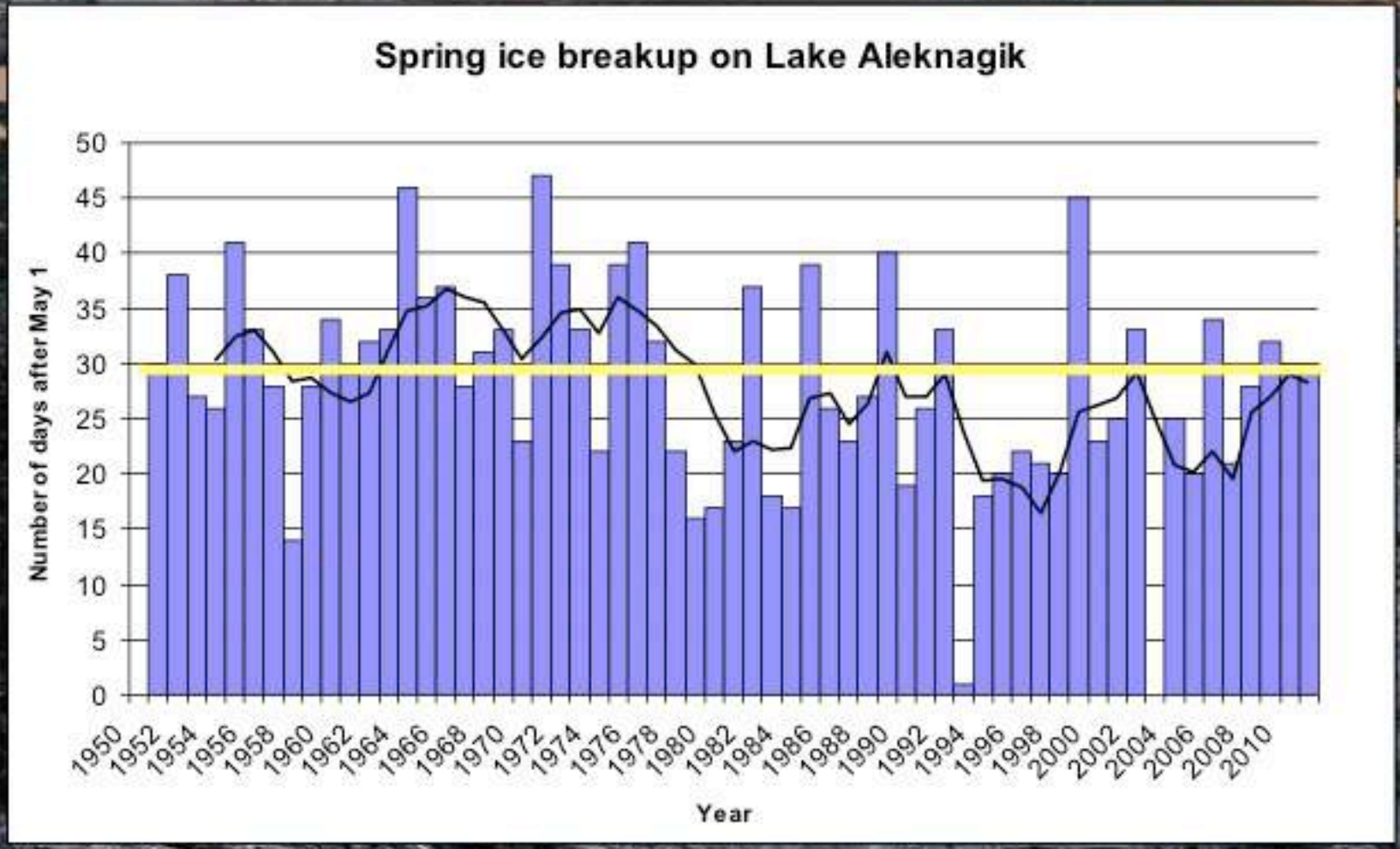
deschind@uw.edu

Bristol Bay, Alaska

Climate warming since 1950

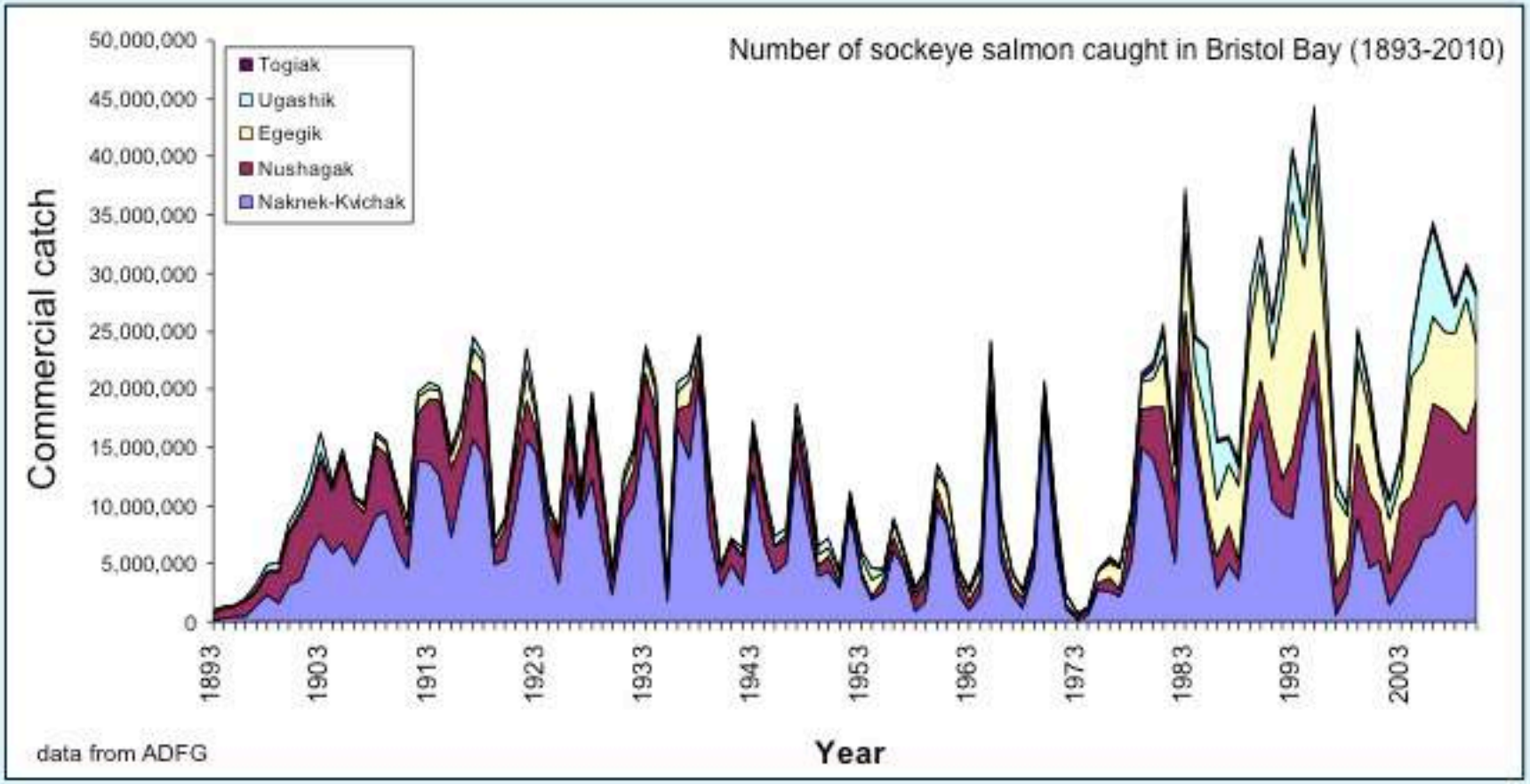


Changing climate in Western Alaska

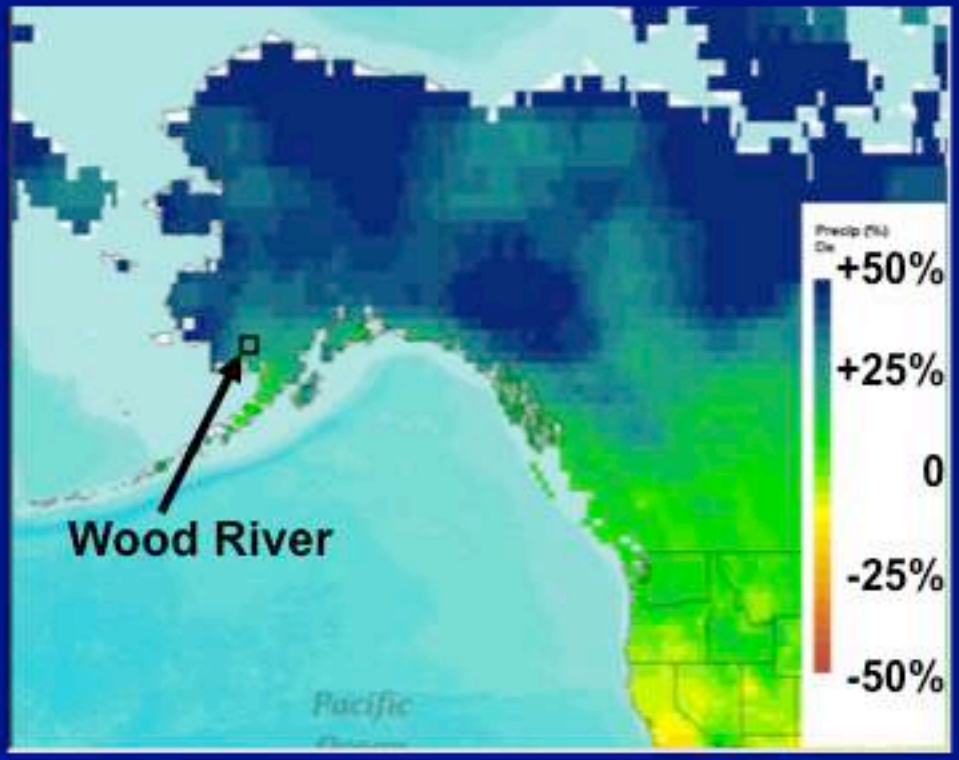


Commercial fisheries for sockeye salmon in Bristol Bay have been sustained for over 120 years

- record catches have occurred within the last 20 years -



Coastal watersheds in AK are predicted to have
2 to 3 degrees warmer air and 25 to 50% more precipitation

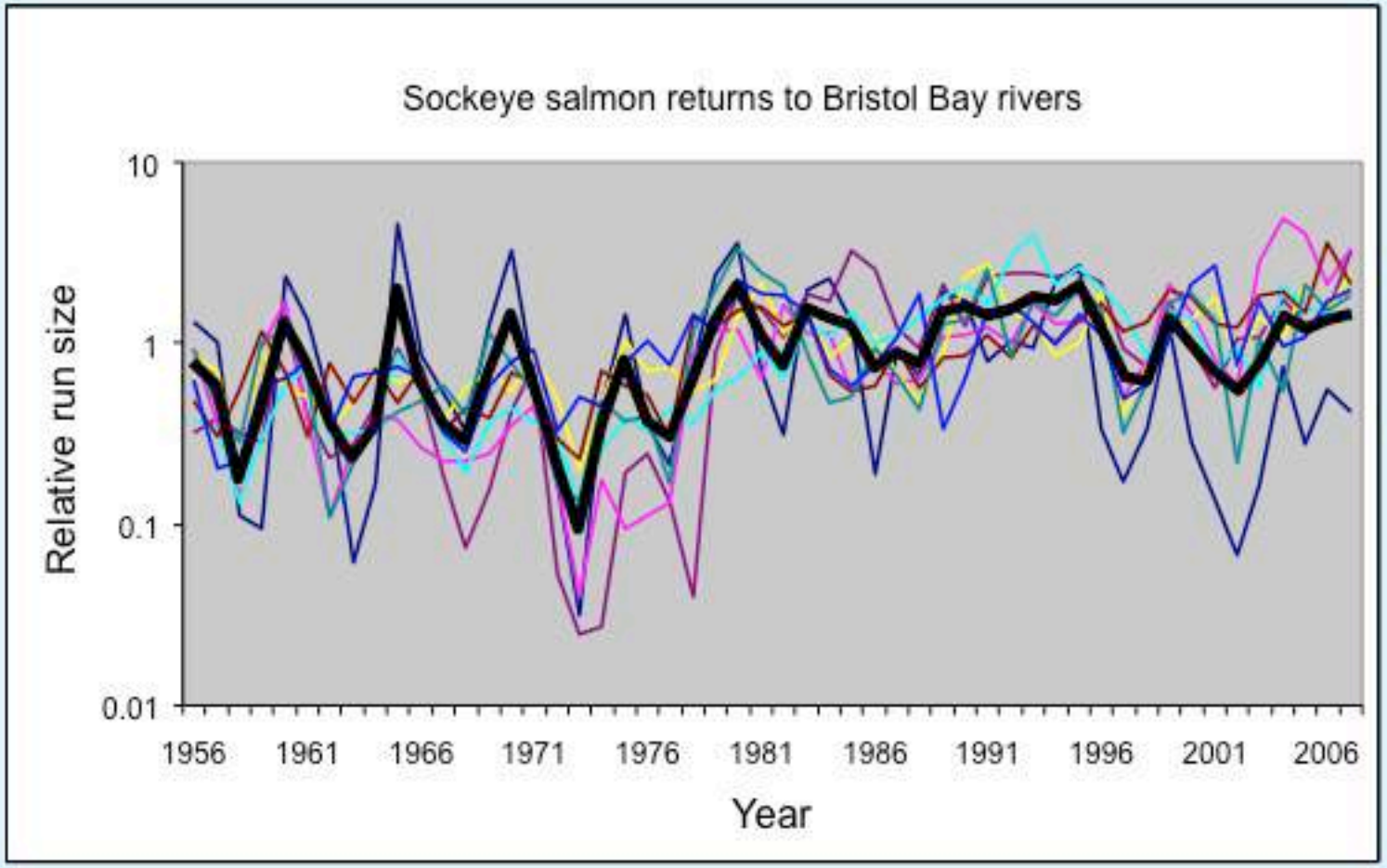


Predicted air and precipitation departures from today in 2079-2099

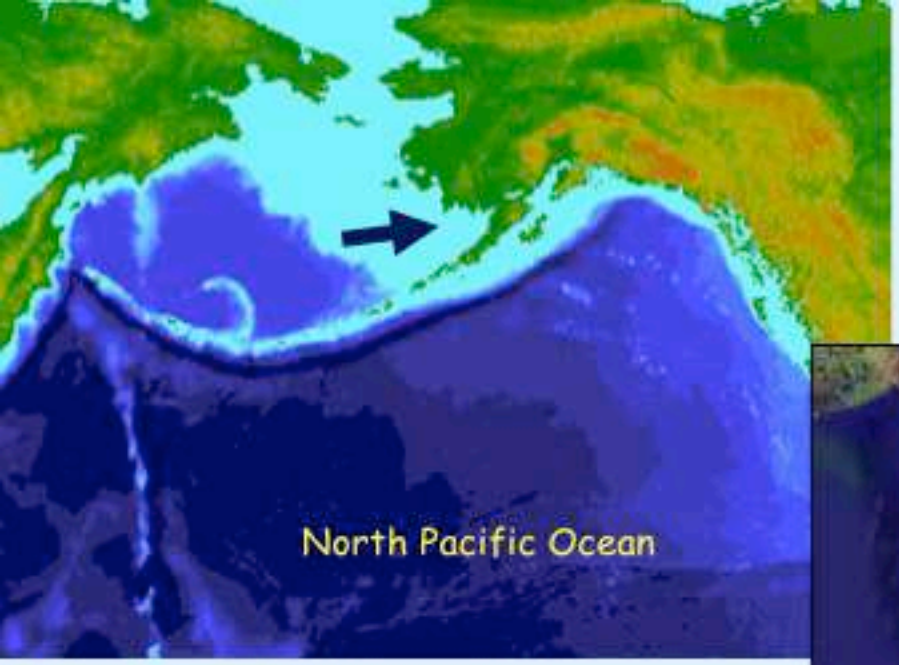
Maurer, et al (2007), Eos Trans. AGU, 88(47), 504


Changing climate and ecosystems?
Complexity makes prediction at small scales very difficult
- but at large scales, it produces stability -
Jeanelle Miller

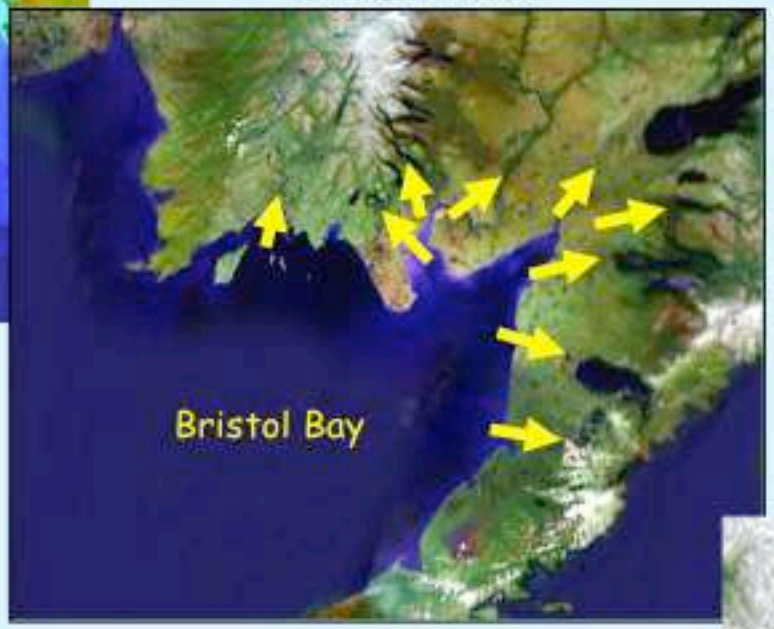
Complementary dynamics in stocks of Bristol Bay sockeye produce portfolio effects in fisheries



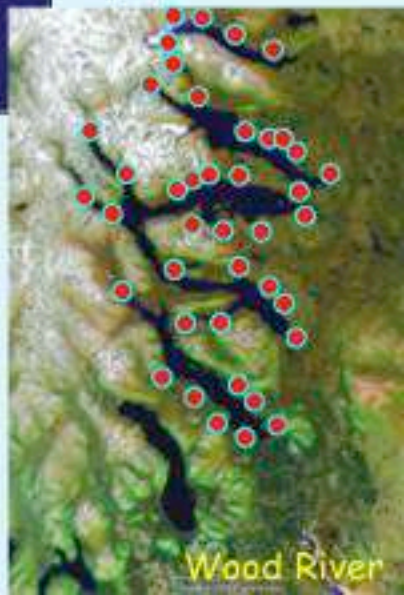
Salmon habitat in Bristol Bay



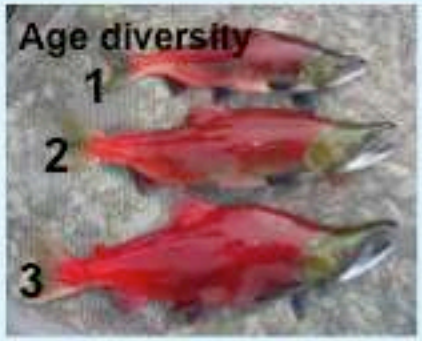
9 major rivers

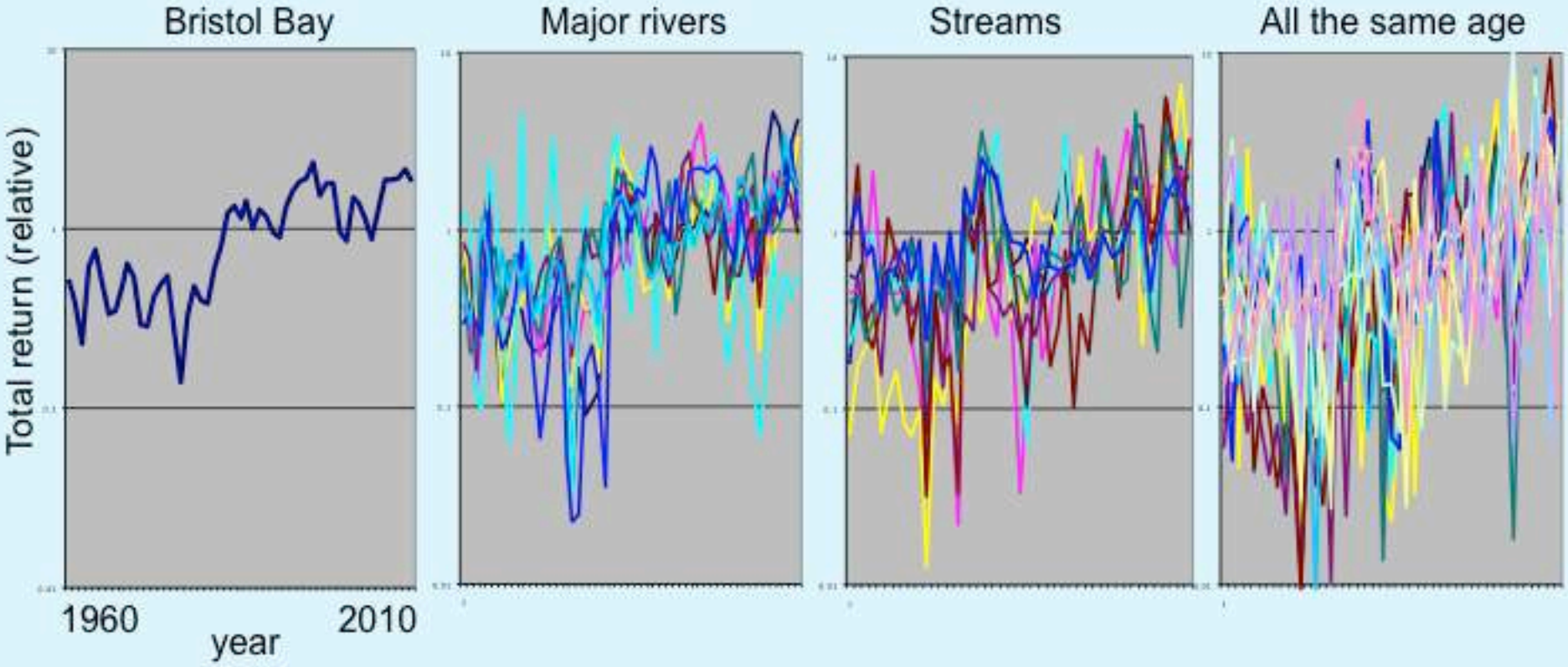


each with many populations



Salmon returns to Bristol Bay are two times more reliable than the individual components of the portfolio





Salmon biological features are adapted to local habitat conditions and how these 'filter' climate

Lake beaches

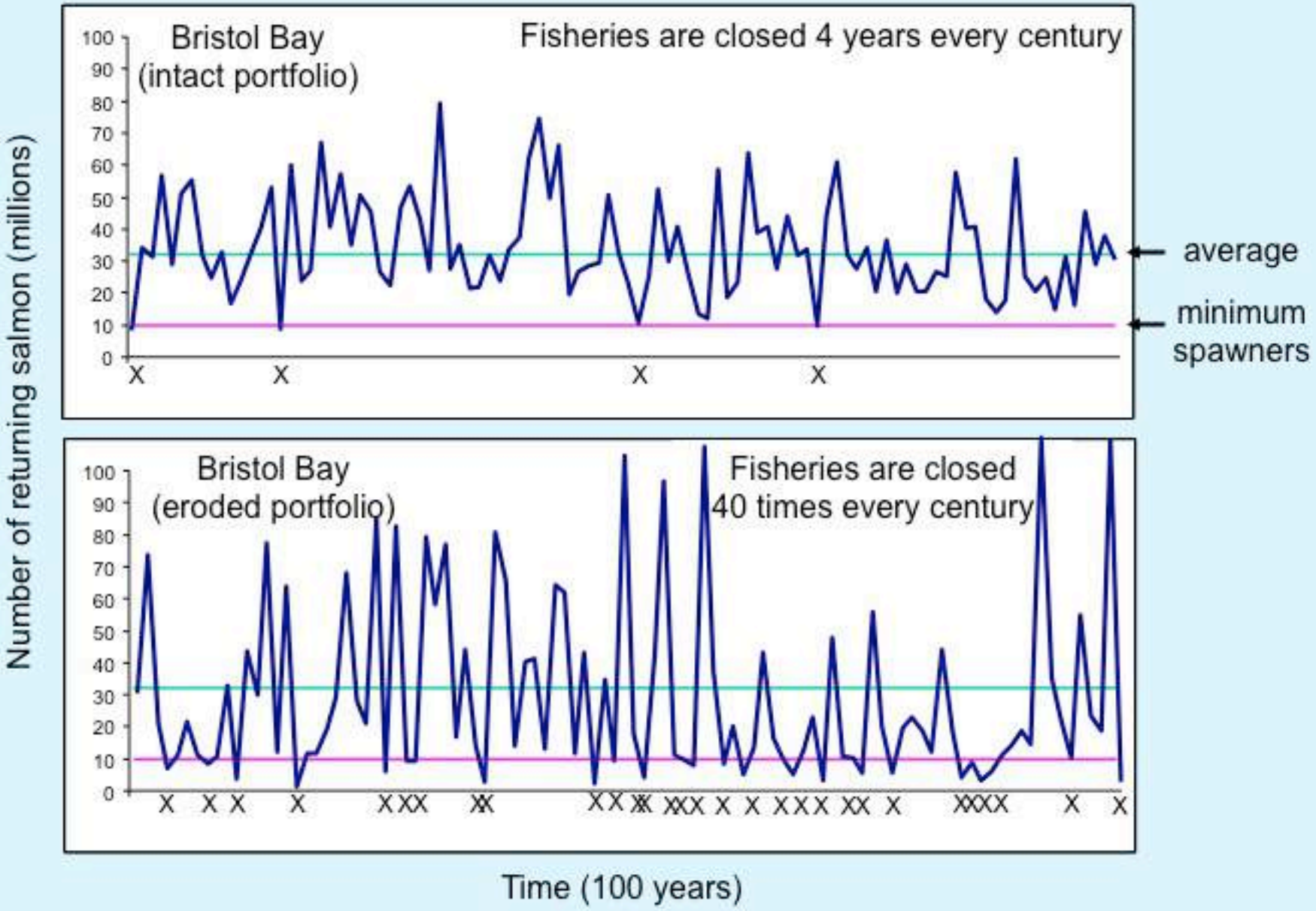
Small streams

Salmon landscapes are shifting mosaics of suitable habitat

(*sensu* Stanford 2005)

Does reliability affect people dependent on fisheries?

Variability in salmon increases the rate of fisheries closures



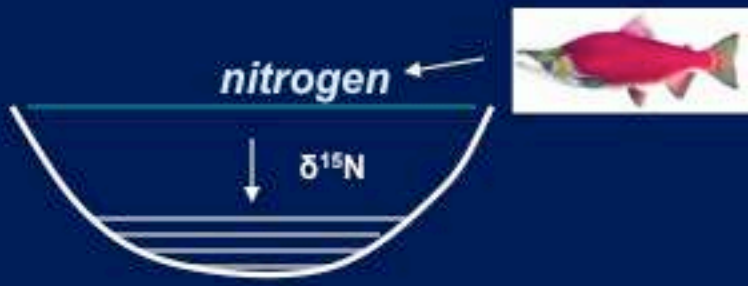

Sue Johnson

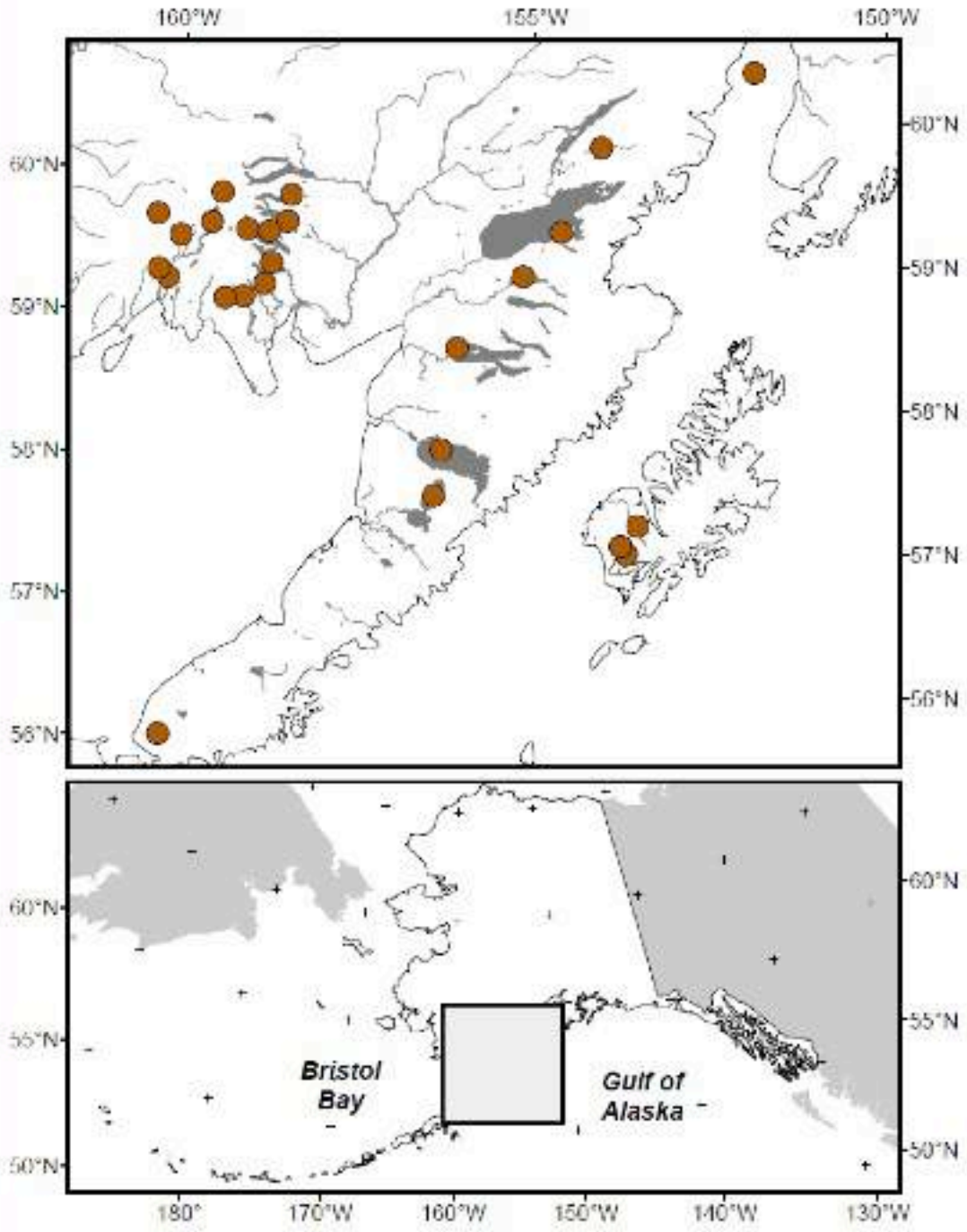

Jonny Armstrong


Does diversity play out over longer time scales (centuries)?

Paleolimnology

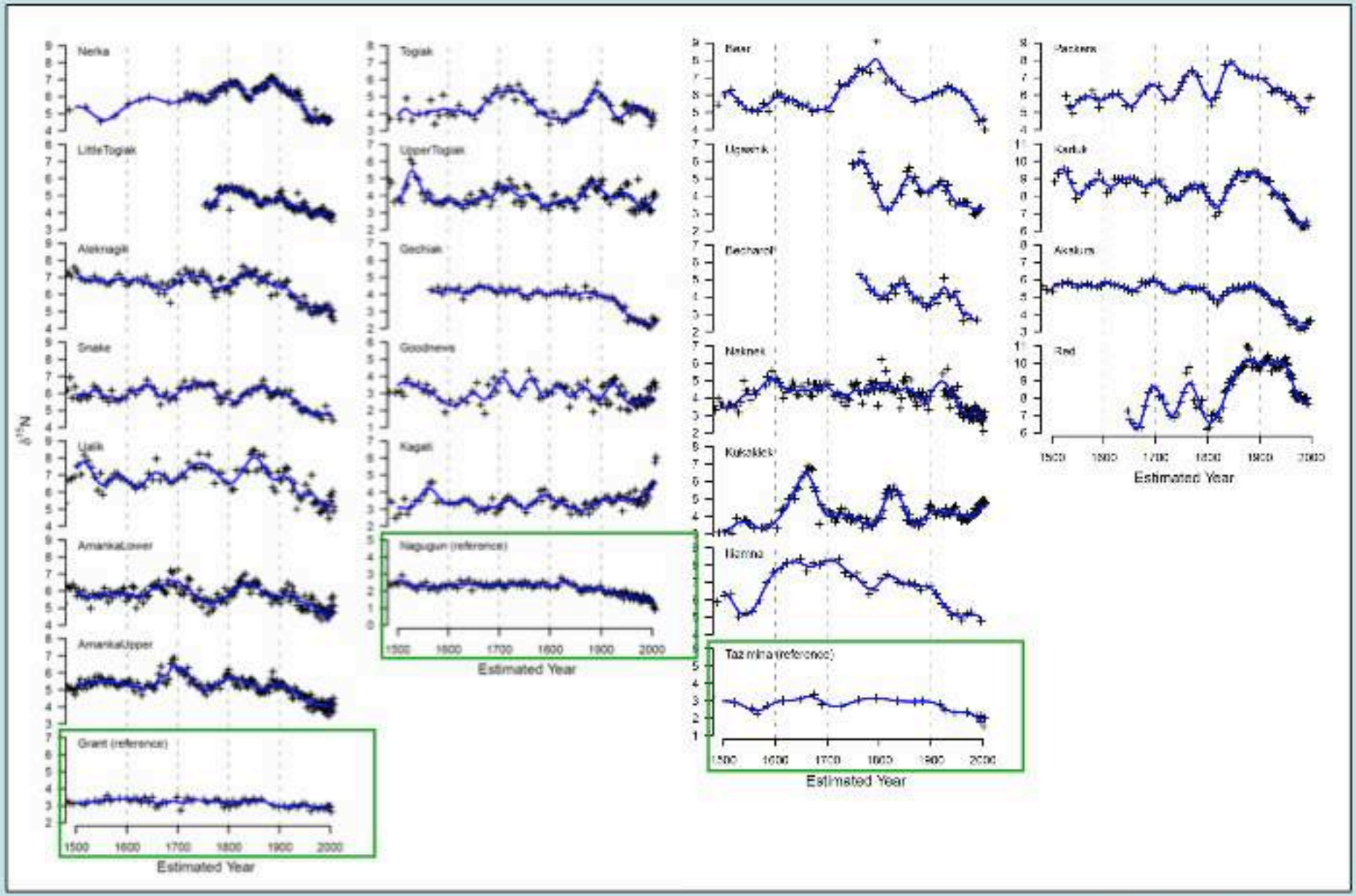
Lake sediments contain a biogeochemical archive that reflects salmon abundance





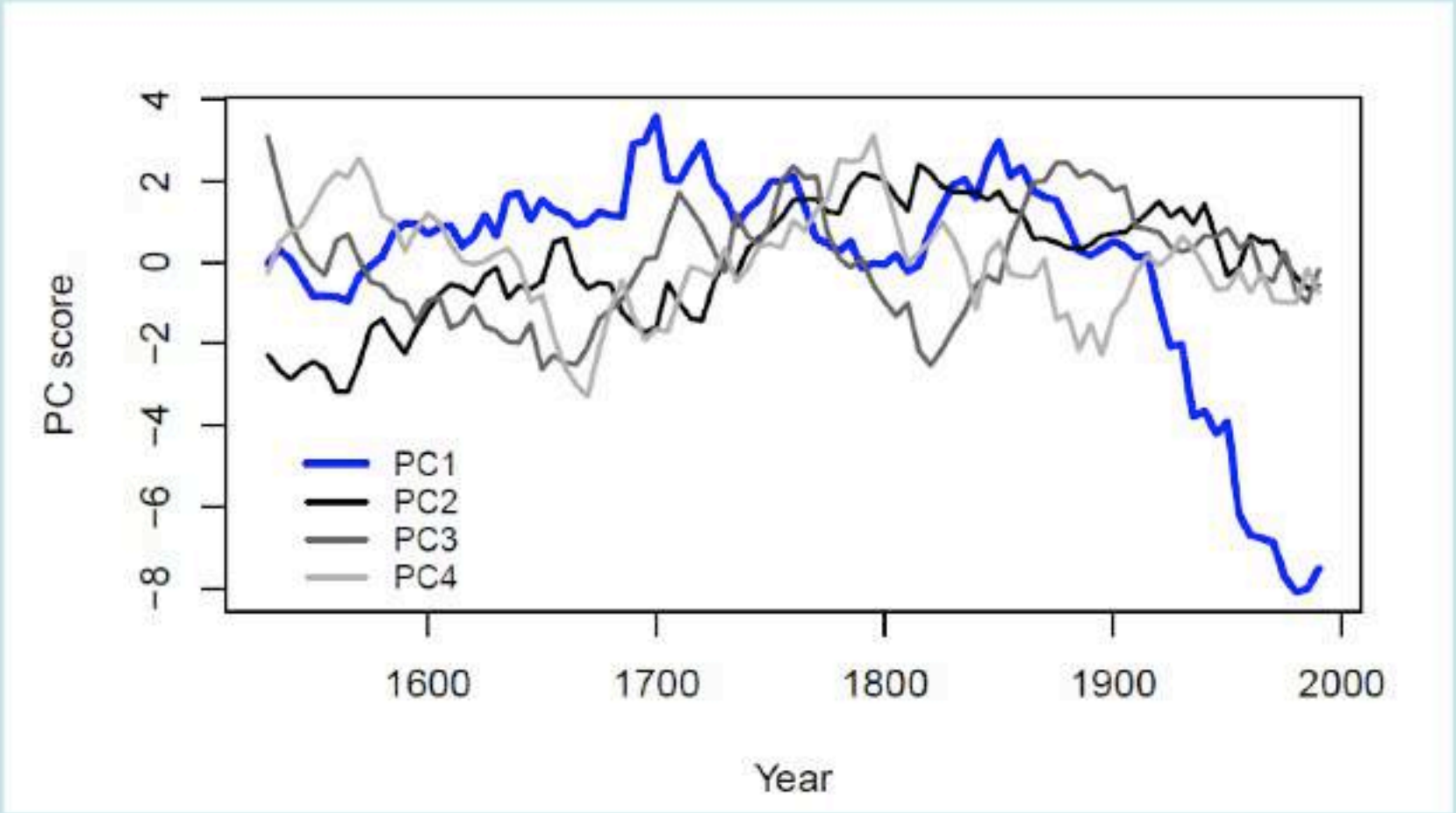
Daniel Schindler
Peter Lisi
Gordon Holtgrieve
Lauren Rogers
Peter Leavitt
Lynda Bunting
Pat Walsh
Mark Lisac
Bruce Finney
Irene Gregory-Eaves

Variation in salmon returns to Alaskan lakes 1500-2000



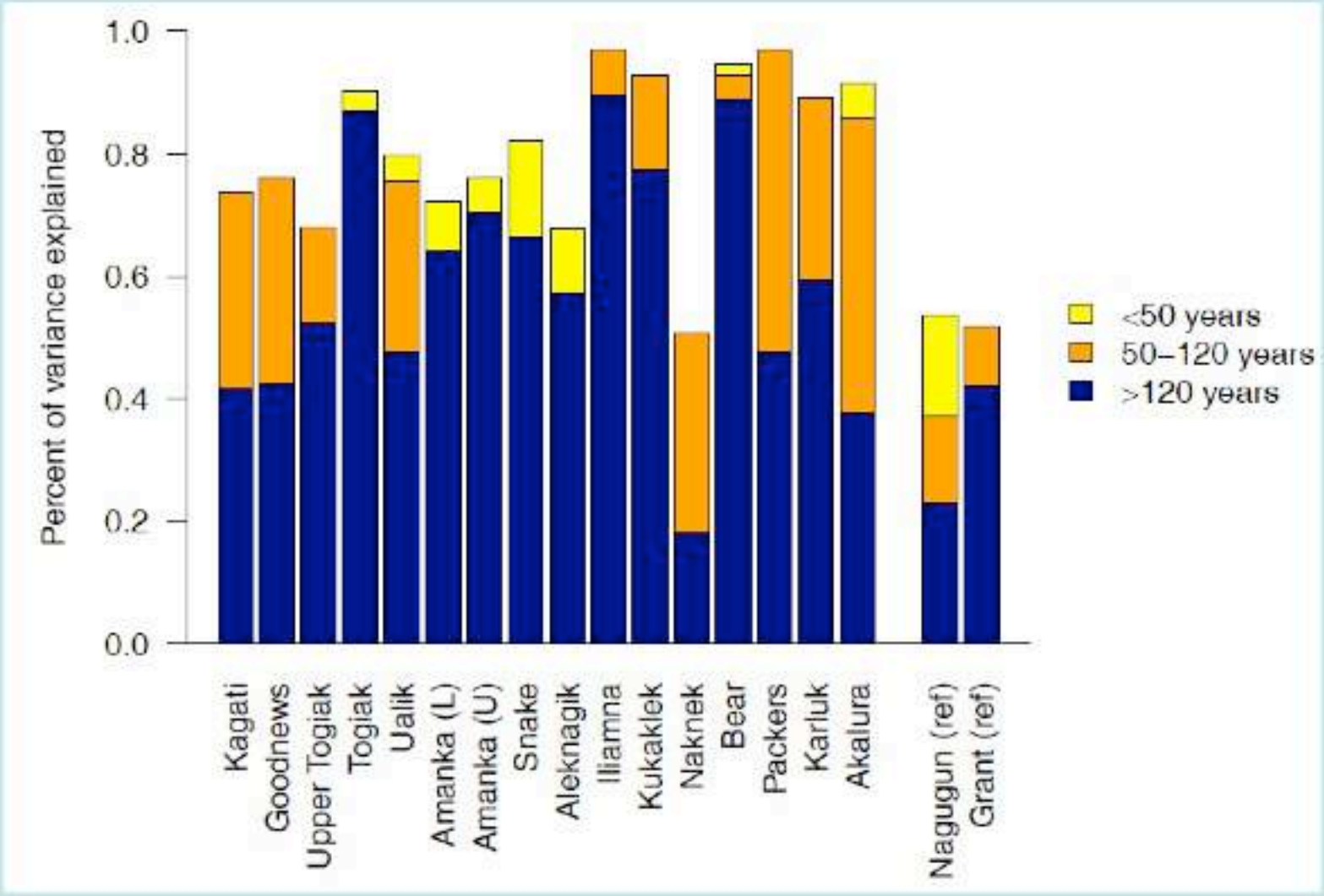
Rogers et al., in prep

Weak coherence in salmon population dynamics among stocks in western Alaska (1500-present)

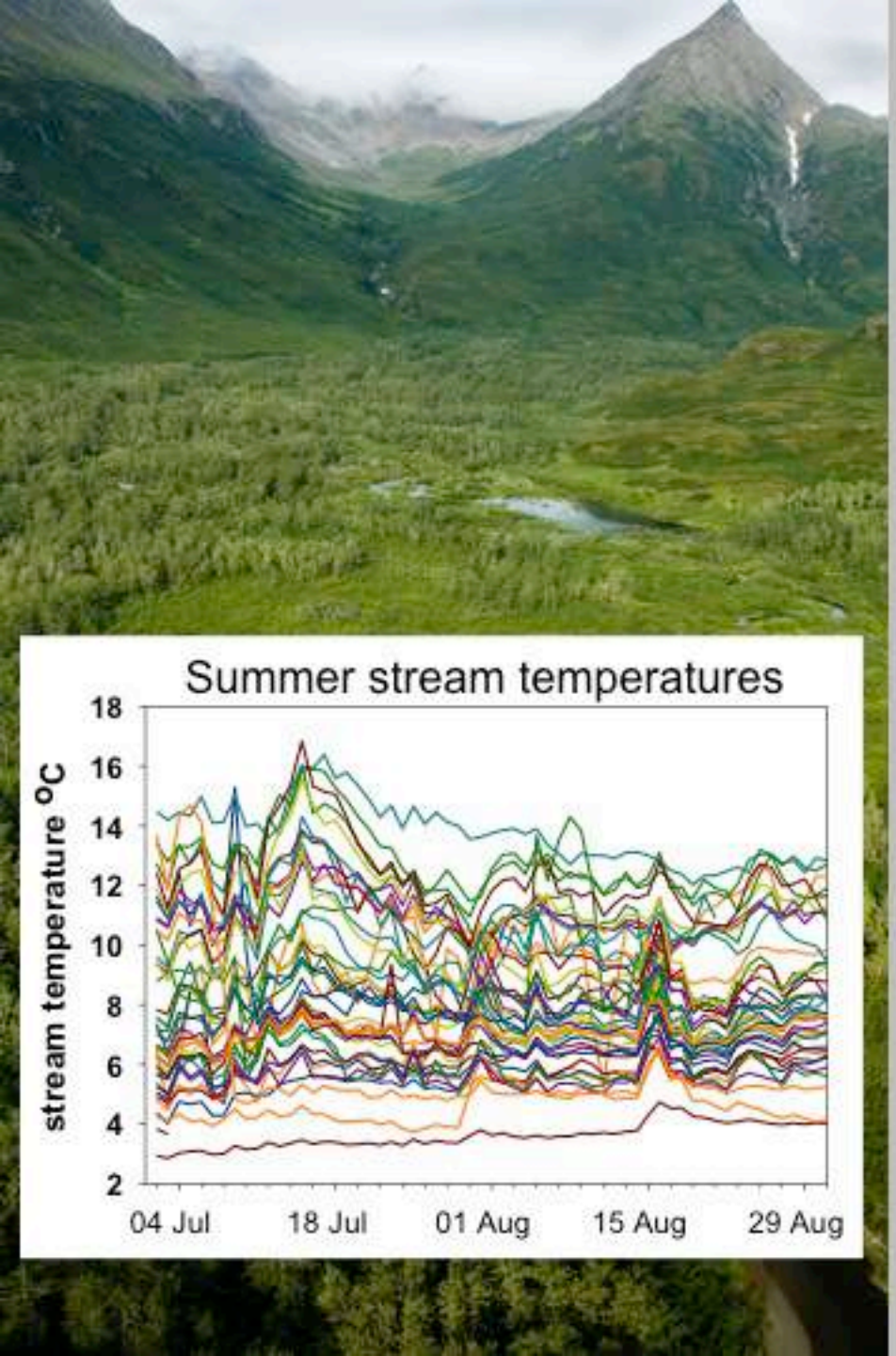


Lauren Rogers et al., in prep

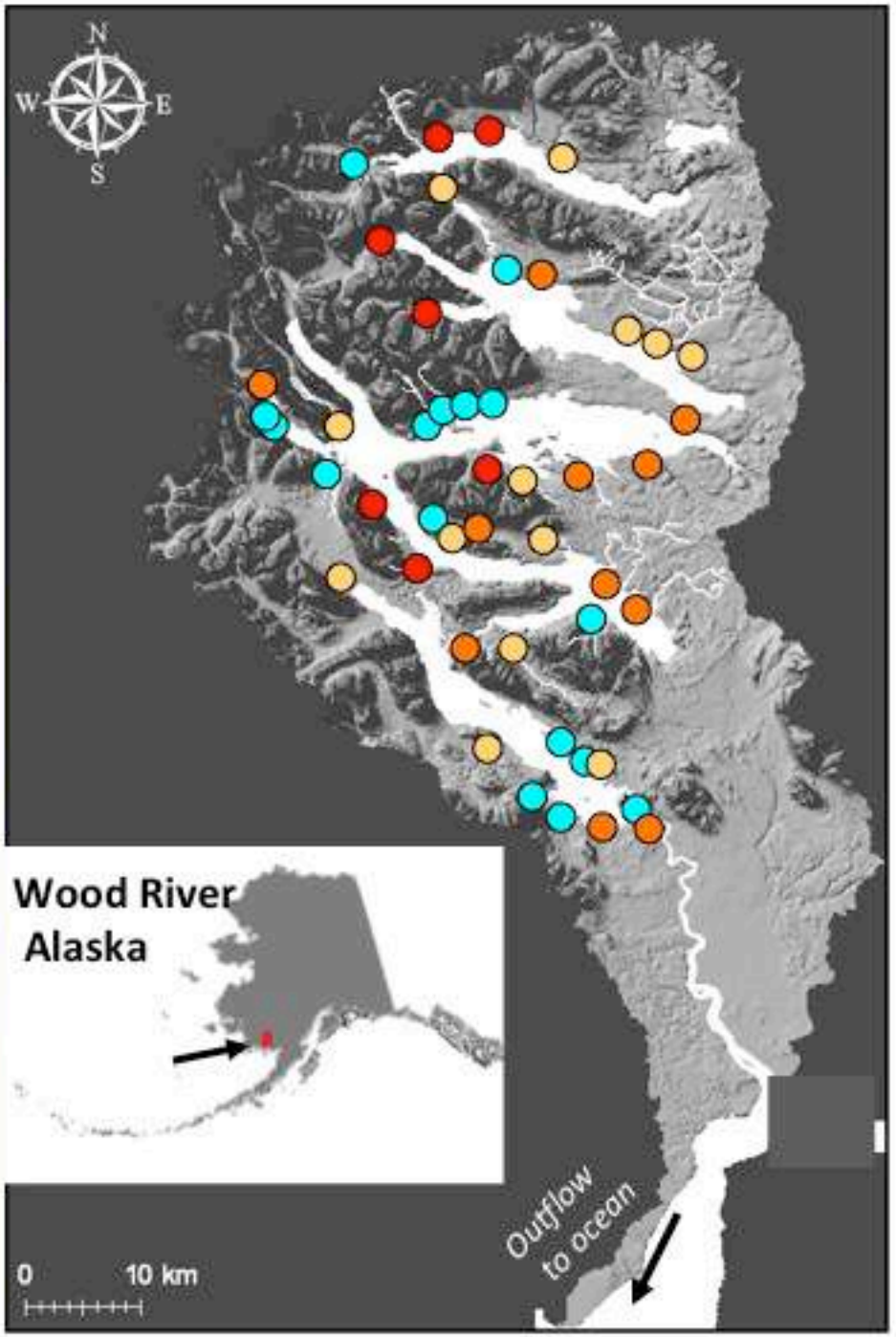
Temporal variation is dominated by >120 year periods

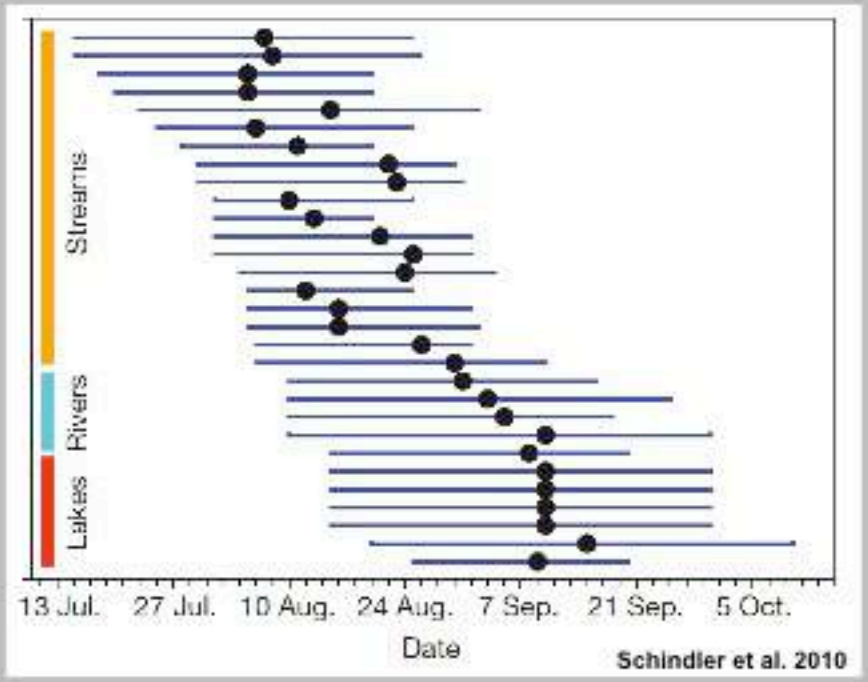


Sockeye salmon have a wide variety of biological attributes that represent local adaptations to habitat



Summer stream temperatures
stream temperature °C
18
16
14
12
10
8
6
4
2
04 Jul
18 Jul
01 Aug
15 Aug
29 Aug

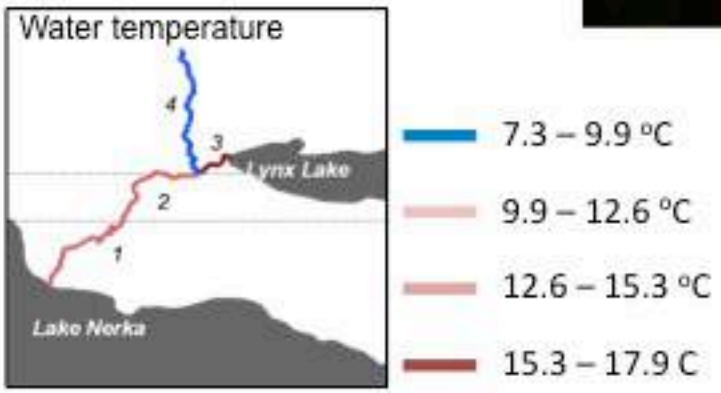

N
W
E
S
Wood River
Alaska
Outflow
to ocean
0
10 km

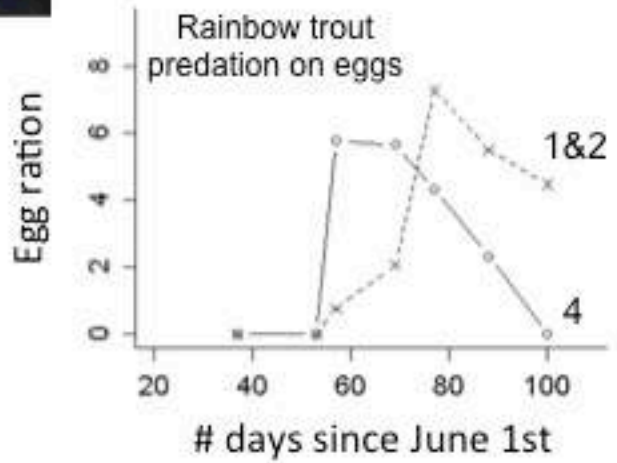

Streams
Rivers
Lakes
13 Jul.
27 Jul.
10 Aug.
24 Aug.
7 Sep.
21 Sep.
5 Oct.
Date
Schindler et al. 2010

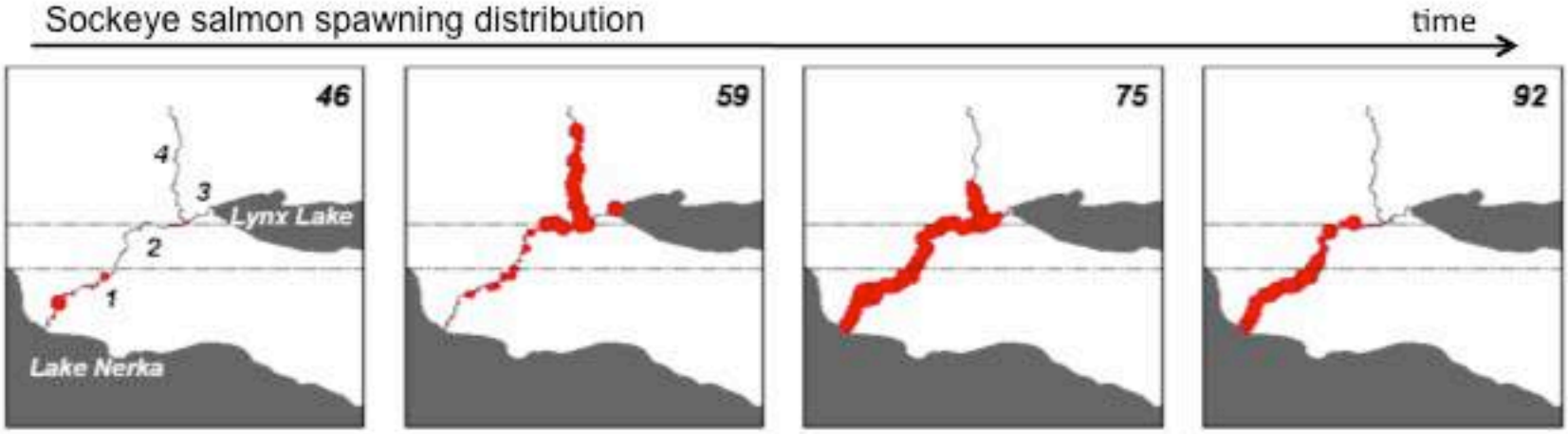

Photos by J. Armstrong

Do consumers track the seasonally shifting landscape of sockeye salmon resources?

Lynx Creek







Ruff et al., *Ecology*, 2011

-Visual counts at 23 stream mouths and along 2 major rivers

(June 1 – Sept 14)

- Camera traps on 4 streams and 2 lake beaches, ~June 15 – Sept. 13

- Park ranger observations at Agulukpak River cabin ~ June 5 – Oct 1 (2010-11)

(Gene Shepherd and Bill Berkhahn, WTSP)

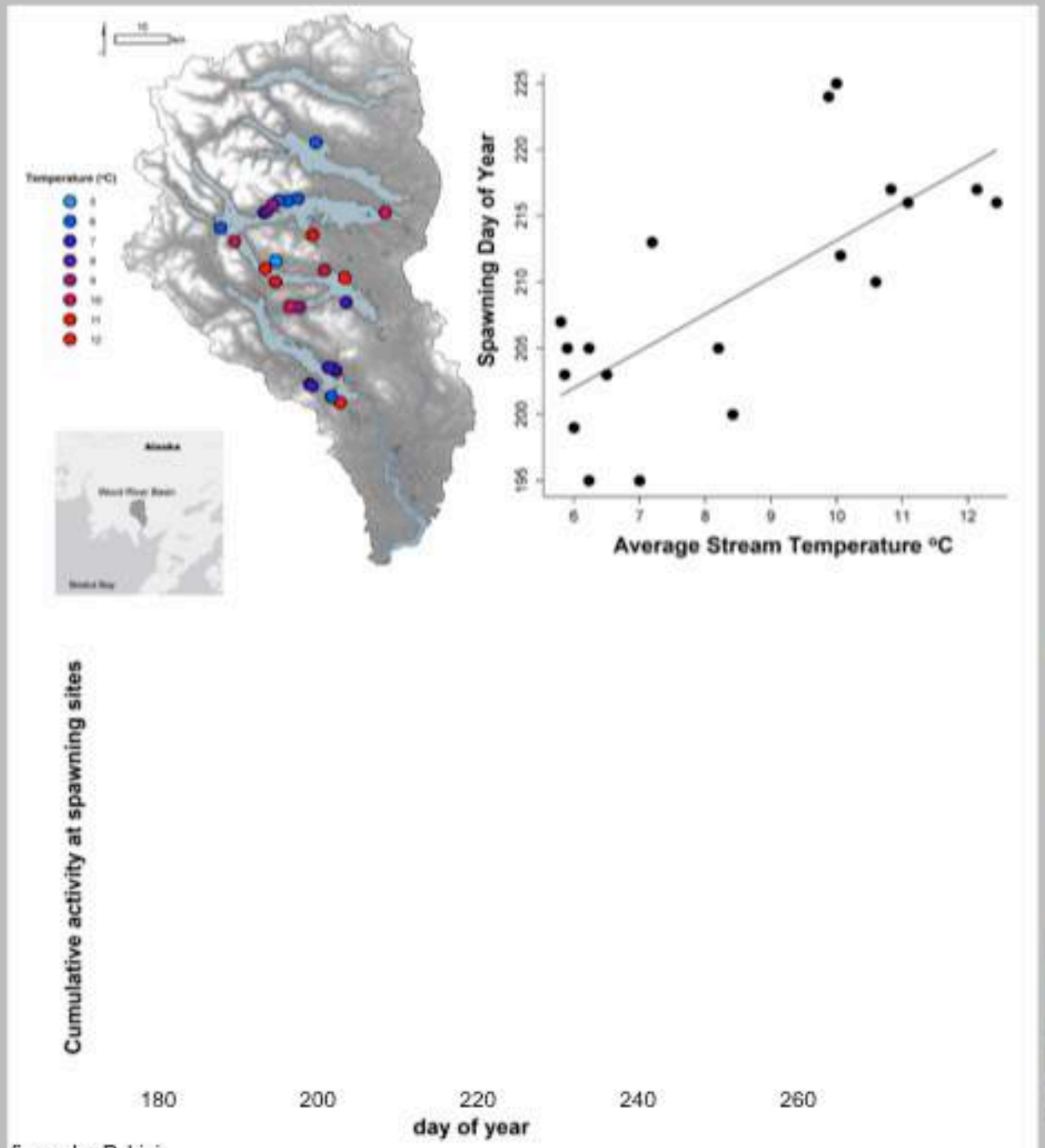
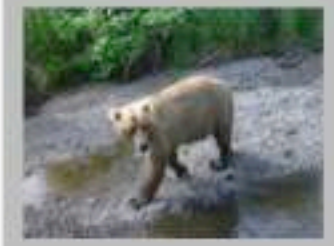
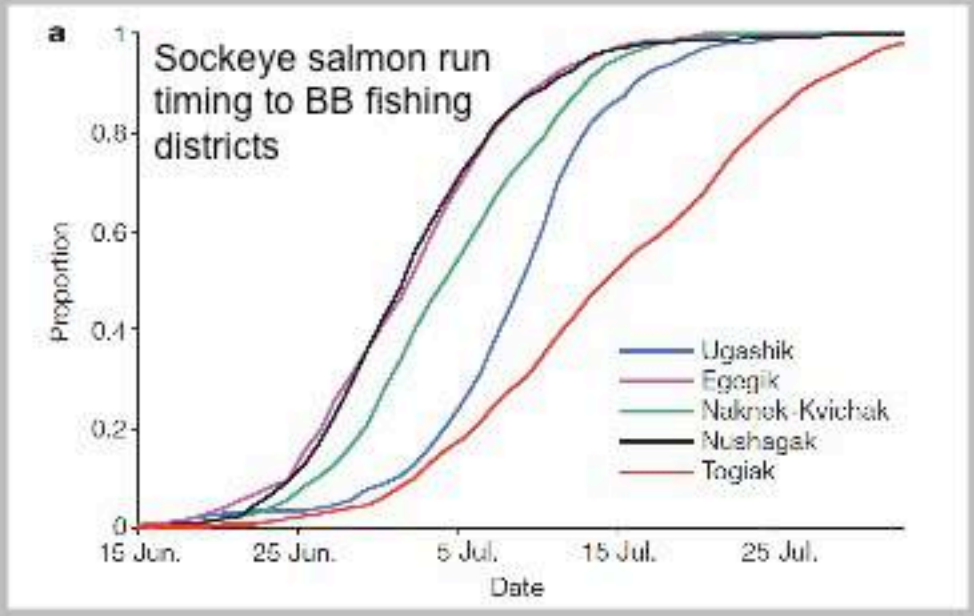
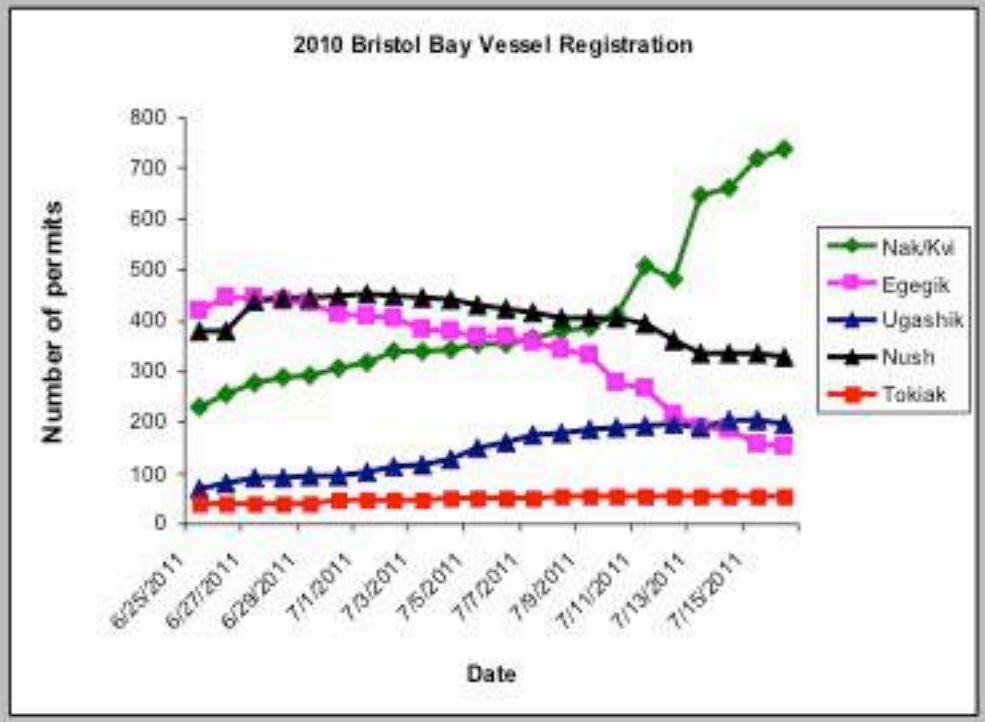


figure by P. Lisi



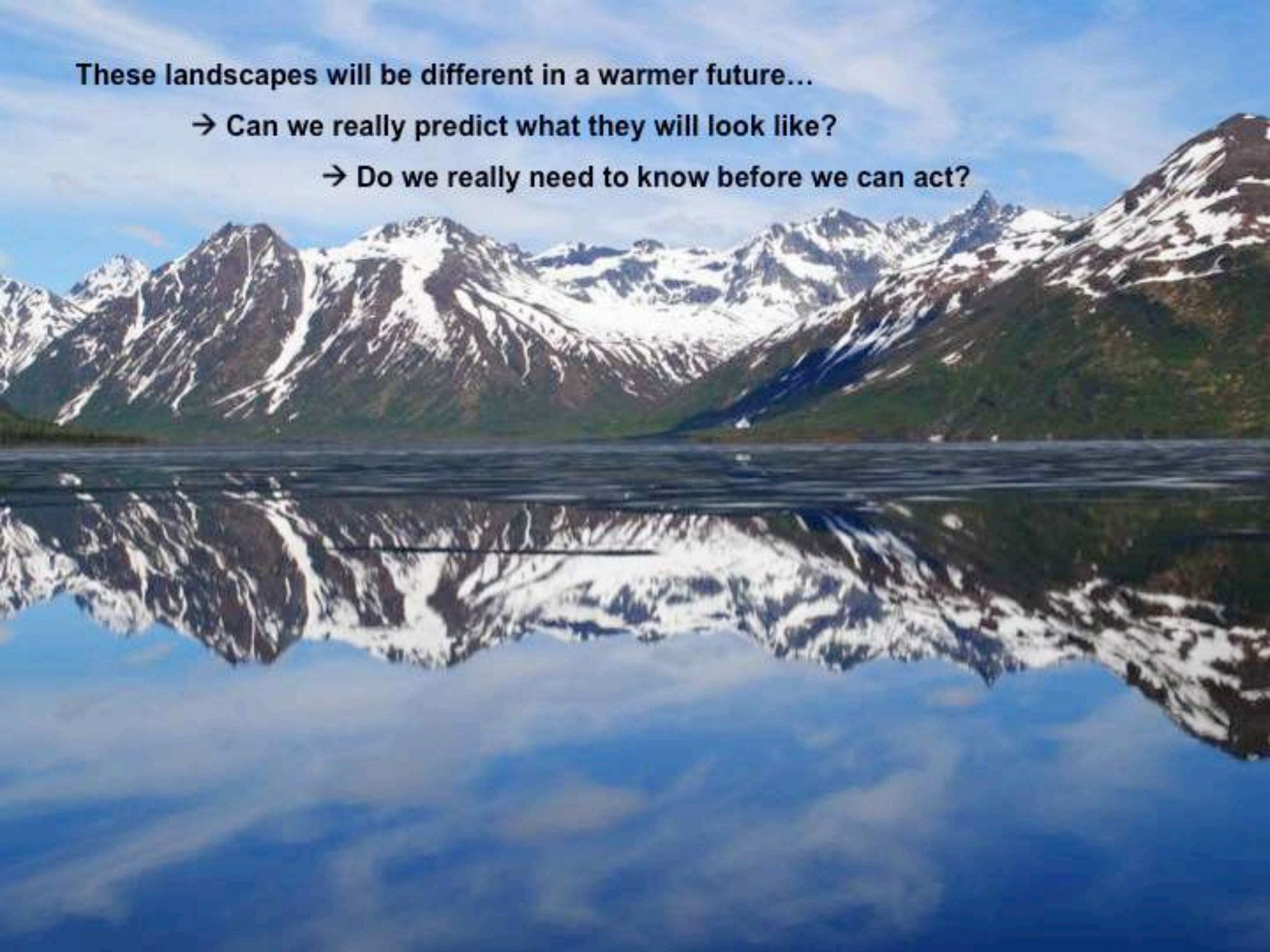

a
Sockeye salmon run timing to BB fishing districts
Proportion
0
0.2
0.4
0.6
0.8
1
15 Jun.
25 Jun.
5 Jul.
15 Jul.
25 Jul.
Date
Ugashik
Egegik
Naknek-Kvichak
Nushagak
Togiak


2010 Bristol Bay Vessel Registration
Number of permits
0
100
200
300
400
500
600
700
800
6/25/2011
6/27/2011
6/29/2011
7/1/2011
7/3/2011
7/5/2011
7/7/2011
7/9/2011
7/11/2011
7/13/2011
7/15/2011
Date
Nak/Kvi
Egegik
Ugashik
Nush
Tokiak

Salmon resources in ecosystems:

Ephemeral pulse of high quality, vulnerable food

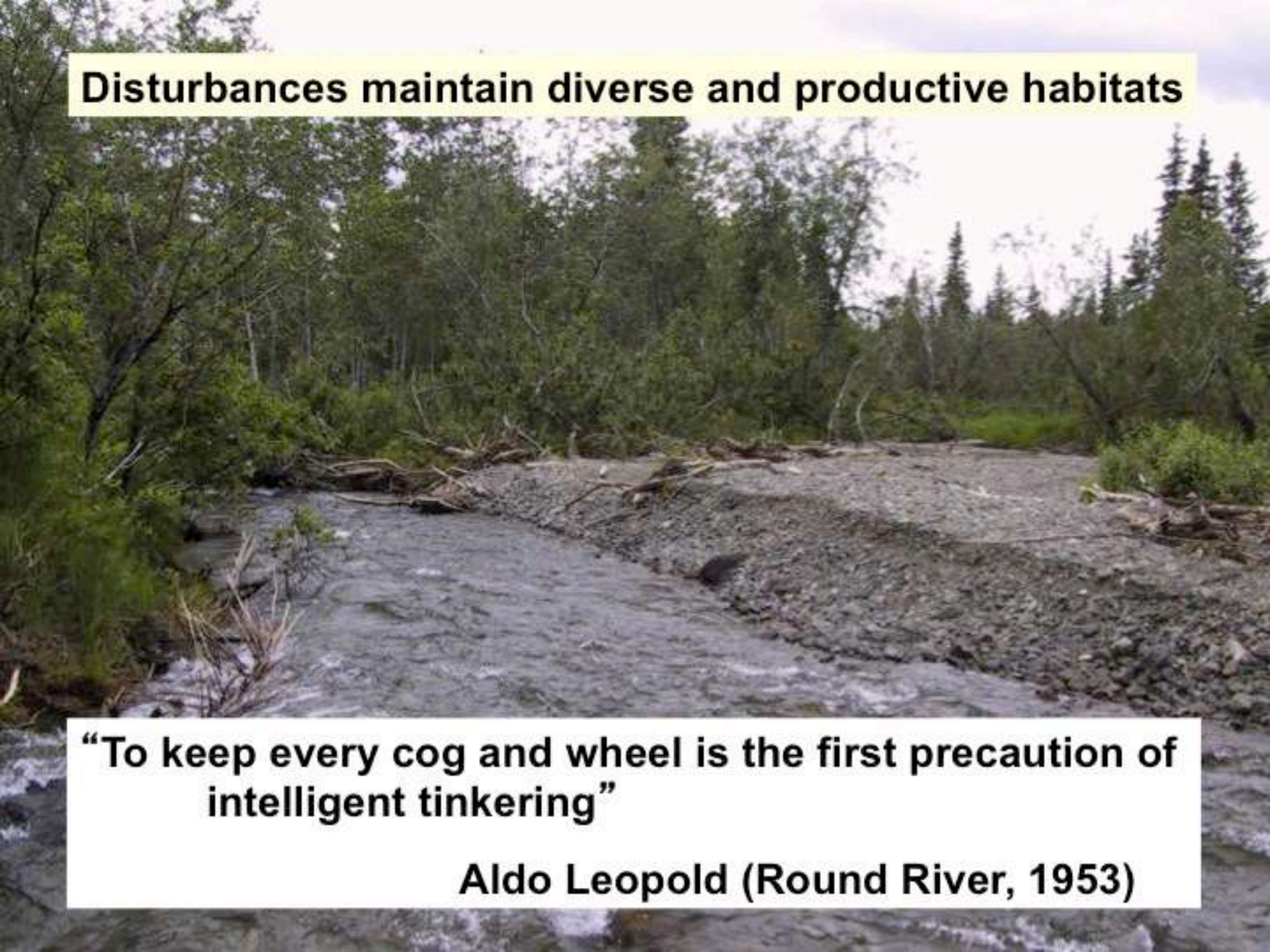
Photos by J. Armstrong


These landscapes will be different in a warmer future…
→ Can we really predict what they will look like?
→ Do we really need to know before we can act?

require scaling from modules to entire food webs. Accurate predictions of responses to climate change are crucial for conserving and protecting natural and human-influenced ecosystems, and cannot be considered complete without a deep understanding and recognition of the pervasive importance of species interactions.

Gilman et al. TREE (2010)

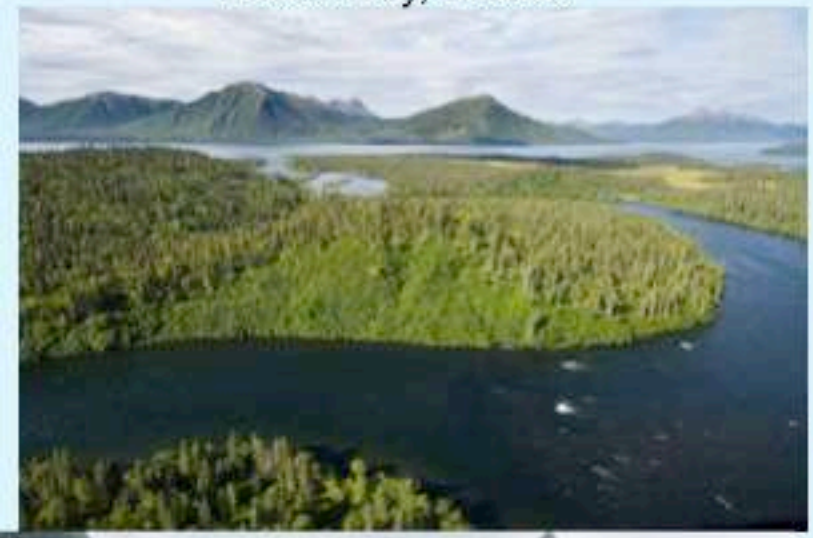

Maintaining diversity in landscapes is a tangible way to manage the risks of ongoing climate warming

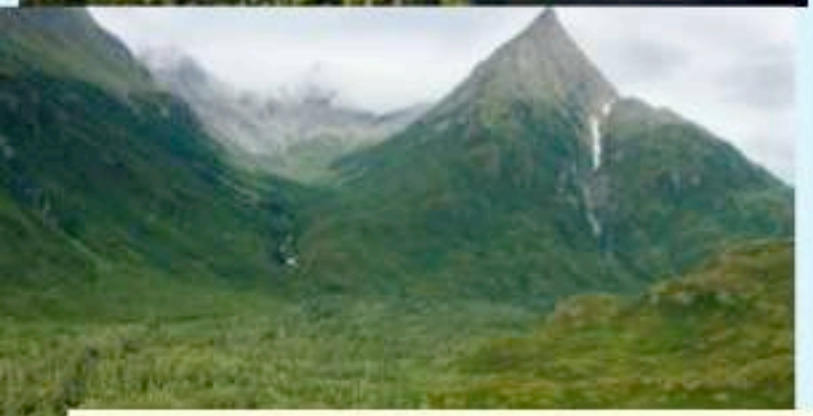

Disturbances maintain diverse and productive habitats
"To keep every cog and wheel is the first precaution of intelligent tinkering"
Aldo Leopold (Round River, 1953)

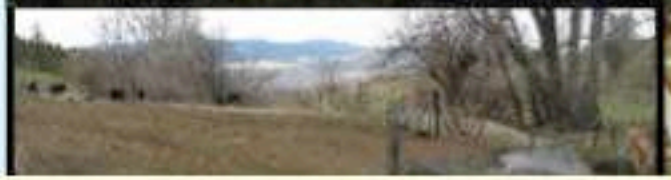
Stability and productivity derive from diverse and changing habitat

Bristol Bay, Alaska

Pacific Northwest







Thanks to: National Science Foundation, Gordon and Betty Moore Foundation, Alaska Salmon Processors, Bristol Bay RSDA, Alaska Dept. of Fish & Game, US Fish & Wildlife Service (LCC), Wood-Tikchik SP, Katmai NPP

University of Washington