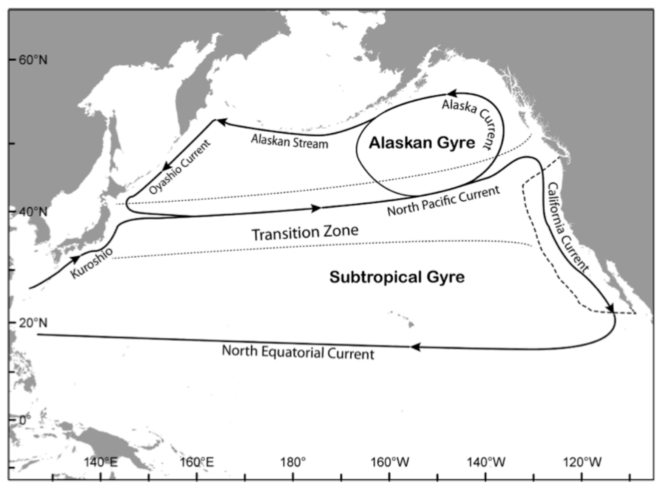
Lab 3: Exploring seasonal and interannual climate variation with NCEP Reanalysis

NCEP Reanalysis is a global view of daily atmospheric and sea surface conditions from 1948-present. It's constructed by using an atmospheric simulation model to "assimilate" (merge, smooth, and harmonize) lots of actual observations. There's an online interface that lets you make maps and extract time series at ***http://www.cdc.noaa.gov/Composites/*** .

As a group, go through Question 1, which will orient you, and then pick *one* of Questions 2–4. Post your results on the class discussion board (we started a discussion thread for this).

Question 1: Seasonal variations in West Coast upwelling

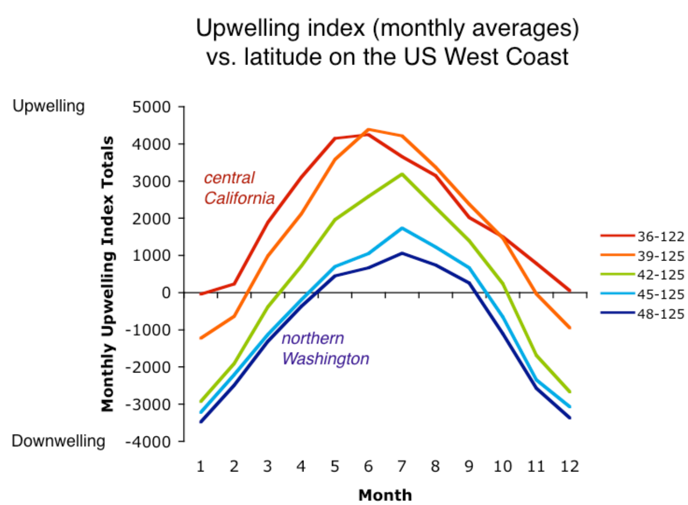
In class, we have looked at a *long-term mean* picture of North Pacific gyre circulation, which is compatible with coastal upwelling in the California Current System (Baja, CA, OR, WA) and downwelling in the Gulf of Alaska (BC north).



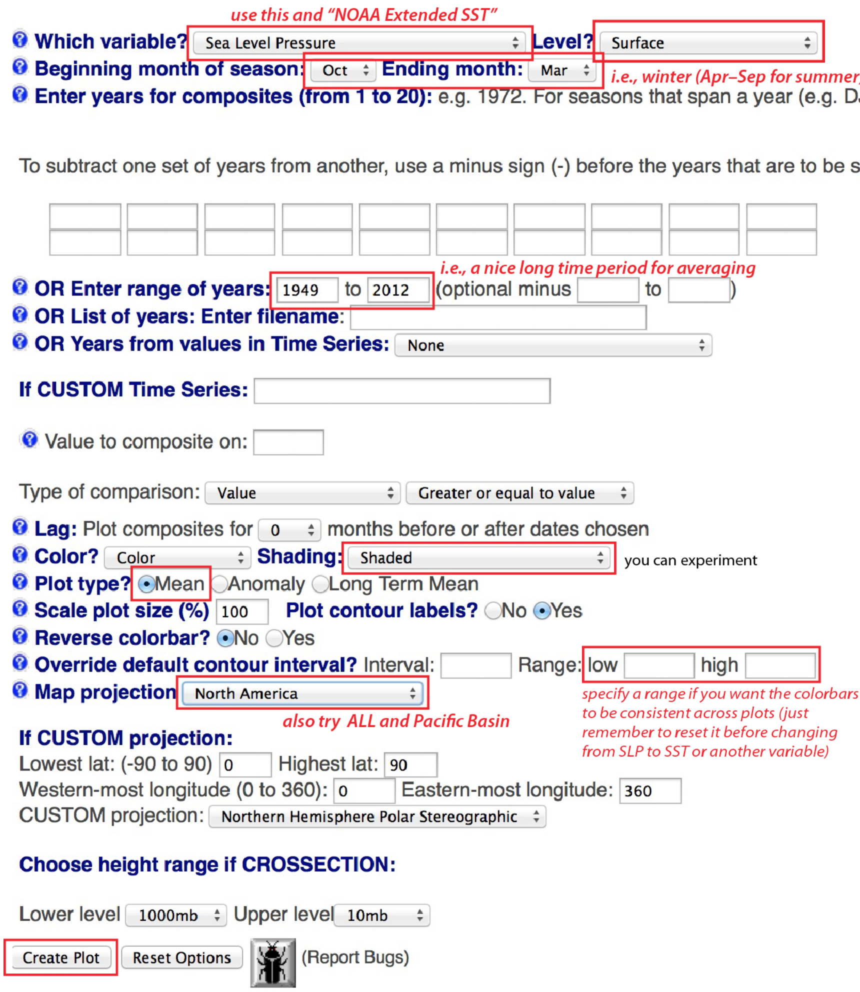
Supplementary Figure 1: Schematic of dominant ocean current features in the north Pacific Ocean. The California Current Large Marine Ecosystem is outlined (dashed line). The north Pacific Transition Zone is delineated by the dotted lines.

Block et al. 2011, supplemental

But we've also looked at latitudinal variation in upwelling/downwelling—which shows *seasonal reversals* over most of this range. How do these pictures fit together? **What is the mechanism behind the seasonal oscillation from upwelling to downwelling and back?**



To answer this, make maps of sea-level pressure (SLP), which tells you about the surface winds, and sea surface temperature (SST—use "NOAA Extended SST"), which tells you about the upwelling response. Here is a recipe for a plot of winter SLP.



use this and "NOAA Extended SST"

Which variable? Sea Level Pressure **Level?** Surface

Beginning month of season: Oct **Ending month:** Mar *i.e., winter (Apr–Sep for summer)*

Enter years for composites (from 1 to 20): e.g. 1972. For seasons that span a year (e.g. DJF), please enter year of the **LAST** month.

To subtract one set of years from another, use a minus sign (-) before the years that are to be subtracted.

i.e., a nice long time period for averaging

OR Enter range of years: 1949 to 2012 (optional minus to)

OR List of years: Enter filename:

OR Years from values in Time Series: None

If CUSTOM Time Series:

Value to composite on:

Type of comparison: Value Greater or equal to value

Lag: Plot composites for 0 months before or after dates chosen

Color? Color **Shading:** Shaded you can experiment

Plot type? Mean Anomaly Long Term Mean

Scale plot size (%) 100 **Plot contour labels?** No Yes

Reverse colorbar? No Yes

Override default contour interval? Interval: Range: low high

Map projection North America

also try ALL and Pacific Basin

specify a range if you want the colorbars to be consistent across plots (just remember to reset it before changing from SLP to SST or another variable)

If CUSTOM projection:

Lowest lat: (-90 to 90) 0 Highest lat: 90

Western-most longitude (0 to 360): 0 Eastern-most longitude: 360

CUSTOM projection: Northern Hemisphere Polar Stereographic

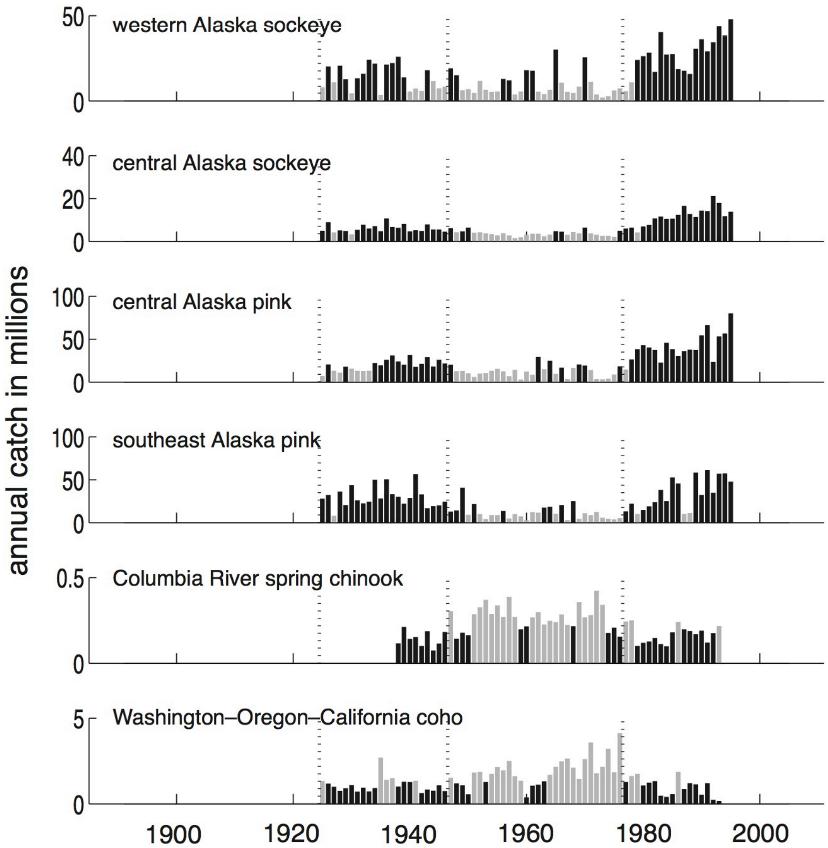
Choose height range if CROSSECTION:

Lower level 1000mb Upper level 10mb

Create Plot Reset Options (Report Bugs)

Question 2: Inverse production regimes in West Coast salmon

It is generally the case that good historical periods for Alaska salmon have been bad for California-to-Washington salmon and vice versa. In the time series of annual catch below, dotted lines mark major reversals (1925, 1947, 1977): Alaska high, then CA-to-WA high, then back again…. **Why does this happen?**



Gray bars = *below* the median for Alaska time series and *above* the median for Columbia River and WA-OR-CA time series. *(Mantua et al. 1997)*

We have discussed coastal and gyre-scale patterns that leave signatures in sea surface temperature (SST) and sea level pressure (SLP). Go to ***http://www.cdc.noaa.gov/Composites*** and look at annual averages of these fields in the North Pacific for **composites** of years representing the two production regimes, and look for what's anomalous. Make plots of both mean fields and anomalies (under "Plot Type") to help visualize what's going on.

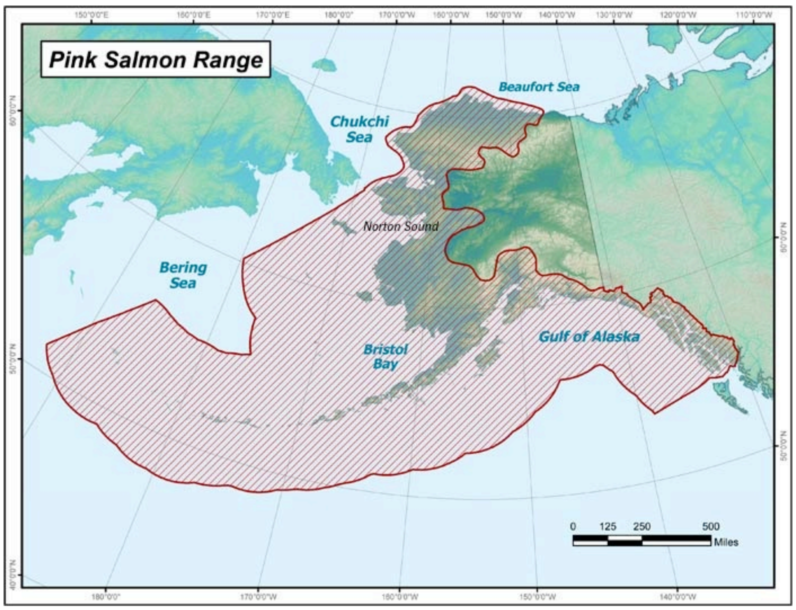
Question 3: climate impacts on Alaskan pink salmon from a life-history perspective

Here are two plausible mechanisms by which North Pacific climate could generate the observed year-to-year variation in productivity of Alaskan pink salmon.

H1) years with warmer air and/or sea surface temperatures are good for egg and/or juvenile development

H2) years with more upwelling along the Gulf of Alaska coast are good for growth and productivity of juveniles and/or adults once they reach the sea

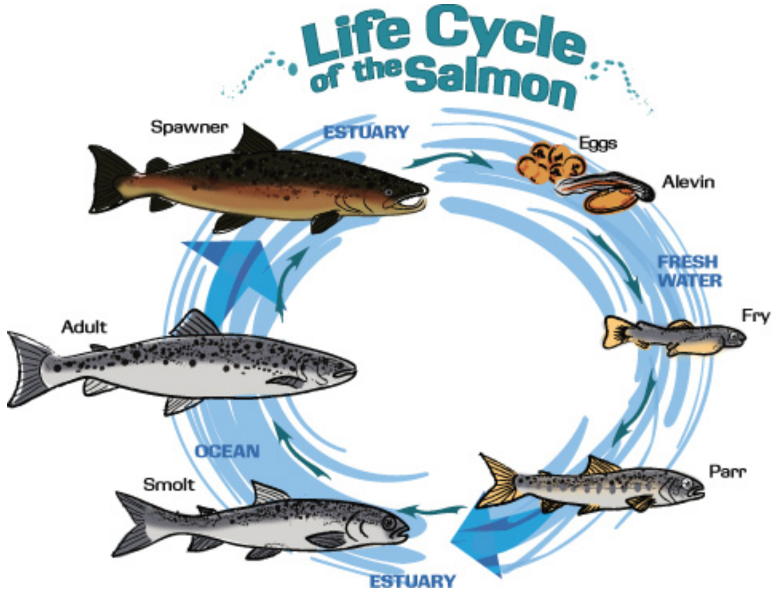
Either, both, or neither may be correct. Which is it? Also: which life stages are the weak links for this population—that is, most sensitive to climate forcing?



Here are lists of the good and bad years for Norton Sound pinks over recent decades.

Highest Productivity Years	Lowest Productivity Years	Medium Productivity Years
1978	1963	1996
1969	1984	1975
1981	1986	1990
1967	1970	1987
1977	1994	1974
1983	1976	1973
1979	1971	1989
1993	1992	1995
1991	1964	1980
1988	1985	1982
		1972

Note: years are given as **Fry Ocean Entry** years
For example: egg is buried in Fall 1968, Emerges from gravel in Spring 1969,
Enters the ocean as a fry in Spring/Summer 1969,
Migrates to the Gulf of Alaska for Winter 1969/70,
Migrates back to Norton Sound rivers in Spring/Summer 1970 to spawn.



Here is a recipe for a sea-surface temperature anomaly map for a composite of the high-productivity years.

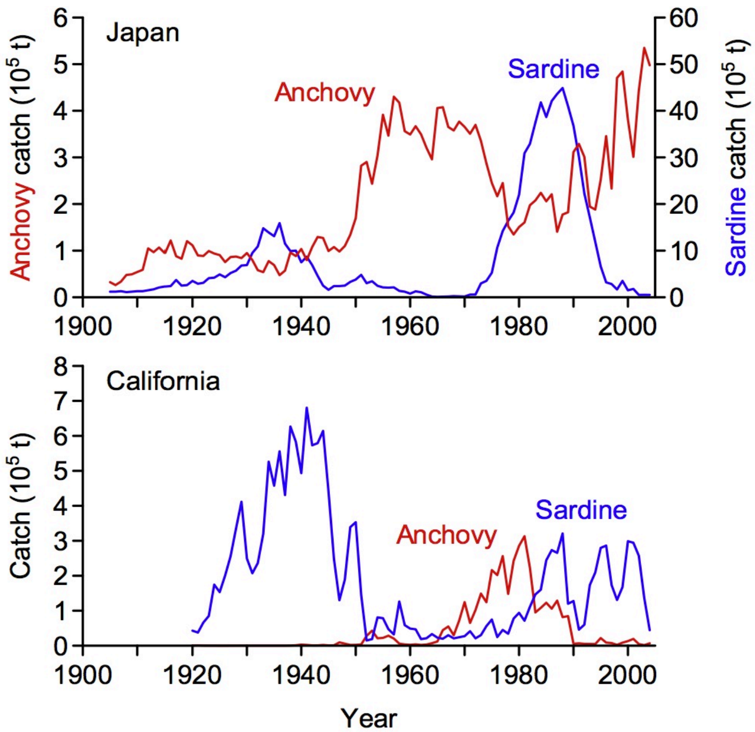
- For ***variable,*** choose ***NOAA Extended SST***
- For ***level***, choose ***surface***
- For **beginning month,** choose **May;** for **ending month,** choose **August**
- Enter each of the ***10 fry ocean entry years*** from column 1 of the data table. This will fill the top row of the boxes, and leave the 2nd row blank.
- Set the ***Lag*** to ***zero***
- For ***Shading,*** choose ***Shaded w/ overlying contours***
- For ***Plot type***, choose ***Anomaly***
- For ***Override default contour interval***, enter 0.1 for interval; for **Range**, enter **-1** for **low**, and **+1** for **high**
- For **Map projection,** choose **Custom**
- Enter **50** for **lowest lat,** and **75** for **highest lat**
- Enter **140** for **western-most longitude**, and **240** for **eastern-most longitude**
- Choose **Northern Hemisphere Polar Stereographic** for the **custom projection**

To make analogous maps for other life stages, you don't have to adjust or retype the years: for example, use a **Lag** of 6 mos for the winter that follows this summer, or a Lag of –12 mos for the previous summer (when eggs are being incubated before spawning).

For surface air temperature (which affects stream temperature), use the **variable** "air temperature (udel)."

Question 4: Sardine and anchovy production regimes

Here are the catch histories for sardines and anchovies from both sides of the subtropical pacific: the coast of California and the coast of Japan.



These patterns aren't entirely controlled by climate—overfishing and fishery regulation play a role too—but **how much of this historical variation *can* we explain using large scale climate (SLP and SST) patterns?**

First question: what is different, in climate terms, between the periods that are or aren't good for sardines, or the periods that are or aren't good for anchovies? Look at composite SST and SLP anomalies (you can also use *mean* SST and SLP fields for context).

Second: can we identify a *mechanistic link* between those climate patterns and the fish population response?

Takasuka et al. 2008 (*Prog. Oceanogr.* 77:225-232), from which these figures are taken, think the explanation has to do with *preferred spawning temperature*. Here are their optimal temperature ranges. *E.* = *Engraulis* = anchovy, *S.* = *Sardinops* = sardines; there are Eastern (California) and Western (Japanese) species of each. Spawning takes place during winter.

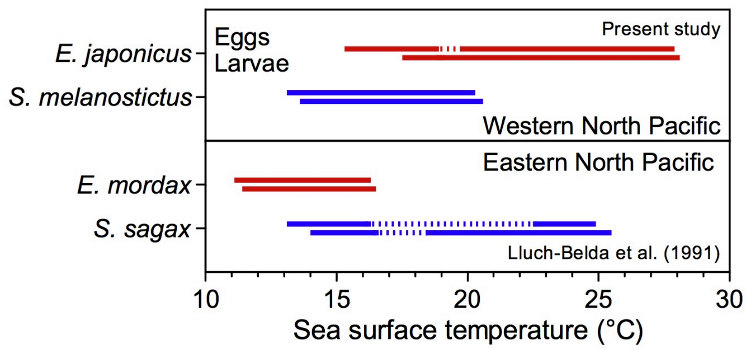


Fig. 5. Spawning temperature optimum ranges compared between anchovy and sardine and between the western and eastern sides of the North Pacific. Solid line segments are the spawning temperature index ⩾1.0, that is, the optimum ranges. Broken line segments are the spawning temperature index < 1.0 between the minimum and maximum of the optimum SST ranges.

However, many other studies have suggested (or assumed) the mechanism is prey productivity, which in California at least means *spring-summer upwelling*. Given your analysis of SST patterns, what do you think of the relative merits of these two explanations (upwelling intensity, spawning temperature)?