CLIMATE CHANGE IN THE FRASER RIVER AND SOCKEYE SALMON

Fraser River

- This river system is the biggest BC watershed
    - ~ 1400 km long
    - 25% of BC
    - ~ as big as California
    - Each year, discharges:
        - 112 km3 of water
        - 20 million tons of sediment

- There are no hydro dams on the mainstem

- Low densities of people except for lower Fraser

- Increased water temperature about 0.5 degrees C in the last 20 years

And their Sockeye salmon. . .

- The dominant year class is four year old (2 years in lakes, and 2 years in the ocean).
    - Four year cycle
- Harvest (from 2000-2009)
    - First Nations 35%
    - Canadian Commercial 42%
    - Canadian recreational 3%
    - US interception 15%
    - Test Fishery 4%
- Commercial fishery
    - This is a massive and economically important fishery. Like most salmon fishery, this occurs in the marine ecosystem near the mouth of the river. The fishery is managed by opening and closing the fishery, depending on the predicted number of fish.

- Productivity has declined over the last two decades for unknown reasons (fish farms? ocean conditions?)

Figure 1: Ratio of aggregate (all stocks) sockeye salmon returns to the Fraser River to aggregate female spawners. Source: Pacific Salmon Commission.

- And then for something completely different . . .
  - 2007—1.4 million
  - 2008—1.6 million
  - 2009—1.37 million (predicted 10.5 million)
  - 2010—34.5 million (predicted 11.4 million)

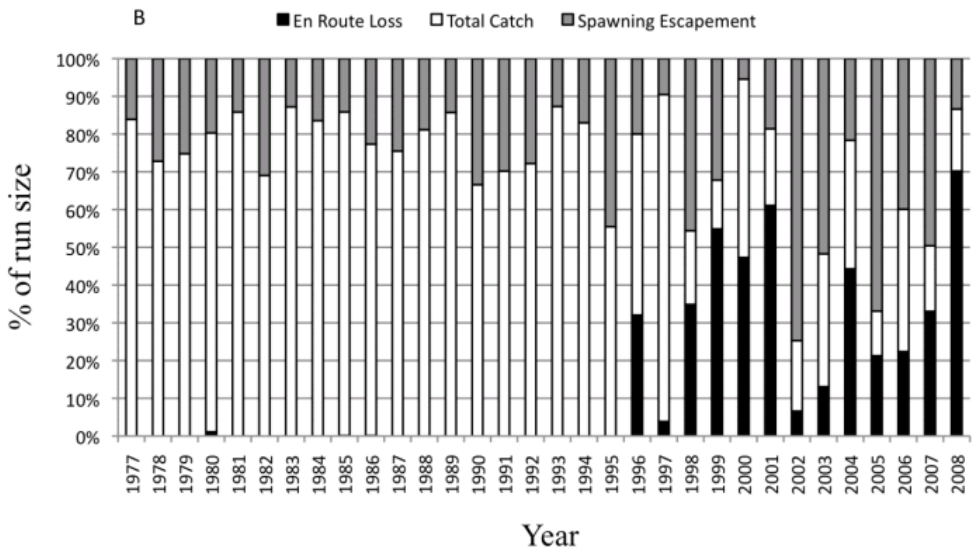
The case of the missing fish

- Scientists estimated the number of returning sockeye entering the Fraser, and then would count them again on their spawning grounds.

- They started to realize there was a large number of "missing fish" that seemed to have disappeared on their way upstream.

- Where did they go?
  - Most evidence indicates that these missing fish die on their way up the river and their bodies likely sink or are eaten (such as by sturgeon).

- What are patterns of mortality?
  - Different proportions from year to year.
  - Different mortality rates for different stocks that enter the river at different times.



Climate change and mortality

- During years with warmer water temperature, more fish die on migration upriver

1995-present—Early migration phenomenon

- Late run fish now are migrating earlier
- They are now exposed to higher temperatures
- Why? This might be an evolutionary trap—where past evolutionary forces no longer apply today

Local adaptation in Fraser sockeye

- There are numerous locally adapted sockeye populations in the Fraser
- Eliason et al. 2011 did a physiological study of sockeye populations
- Local physiological adaptations to migrations and water temperature

Future adaptation to climate change

Adaptive potential will depend on:

1. Strong directional selection
2. Genetic variation
3. Heritability of traits
4. Plus, whether traits will evolve or come up to hard physiological blocks. . .

- Study by Reed et al. 2011 predicted evolution of migration of sockeye from now until 2100
- This study used a model to make a prediction on evolution and population consequences
- Predicted that evolution may be able to keep up with climate change
    - But great uncertainty
    - And depends on above conditions