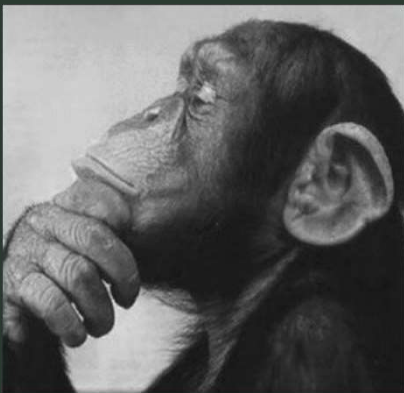


# Remote Workshop Salmon and Environmental Change



Pacific Salmon Commission  
CoTC -CSC

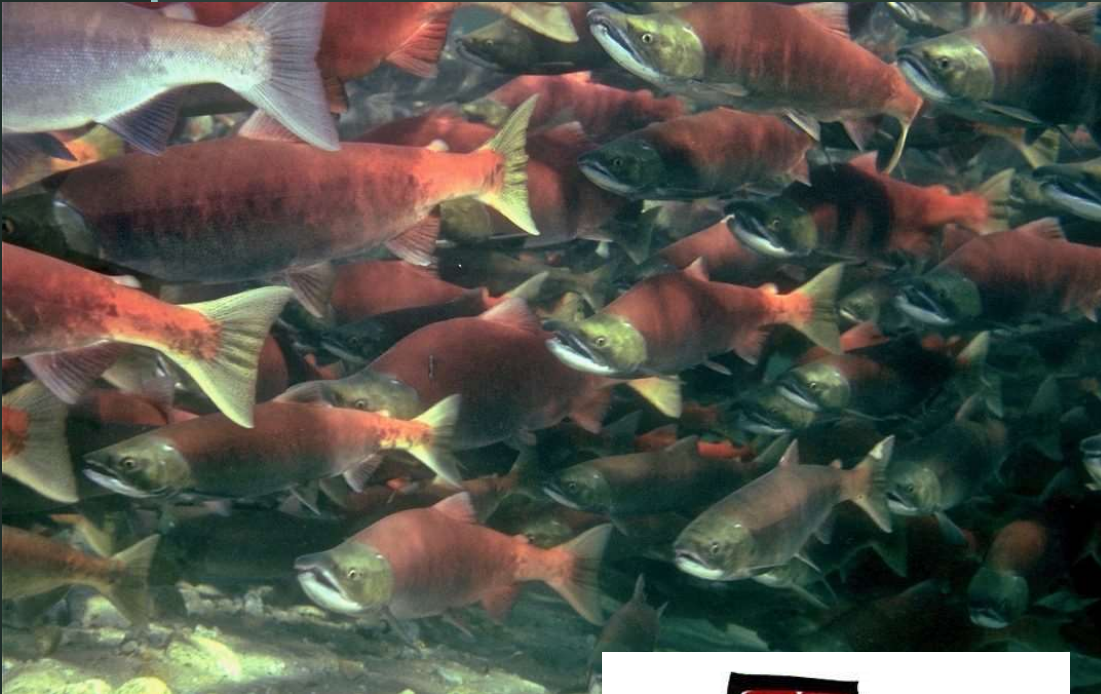
Introductory Comments  
Gary Morishima

May 11, 2021



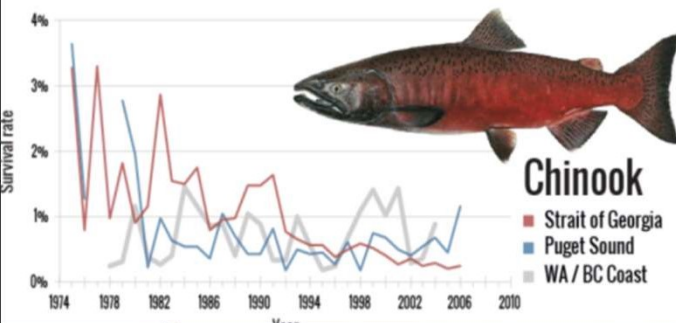
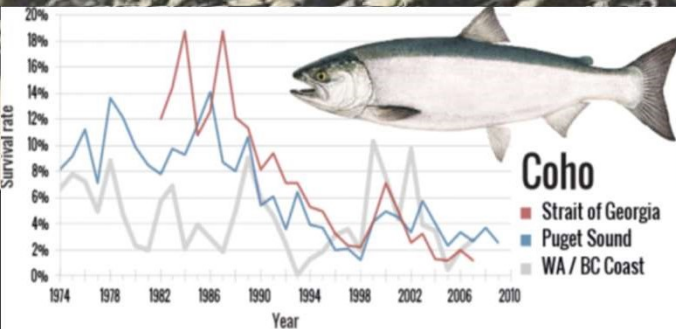
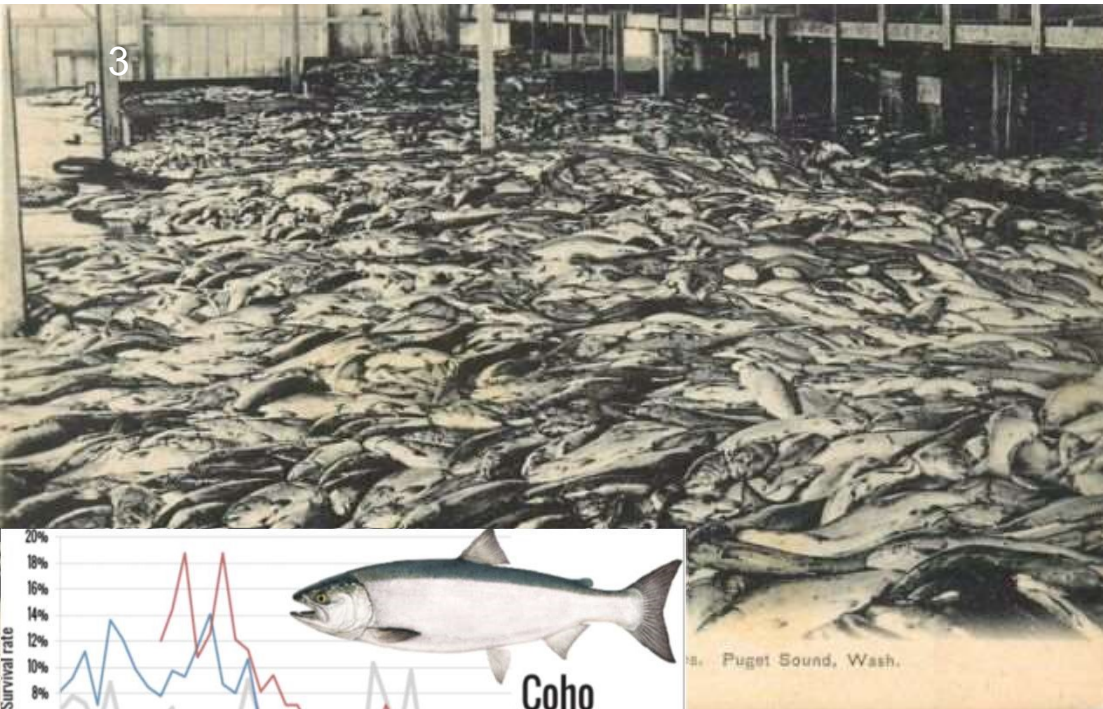
## NOT SO LONG AGO

Abundant salmon sustained communities, cultures, and economies for countless generations over thousands of years.

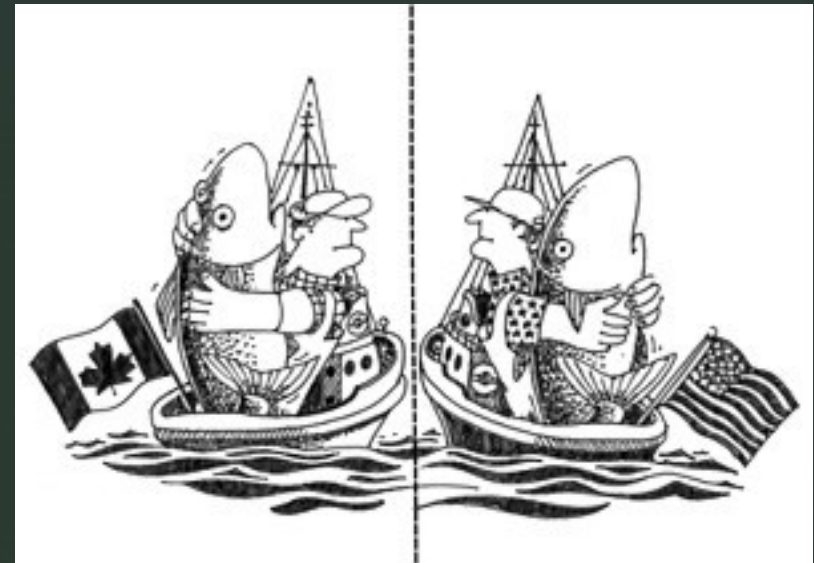




# Overfishing & Development Took Their Toll



**Alarms sounded  
over conservation  
and interceptions**



1914 Hell's Gate slide  
1930 Fraser Sockeye Convention  
1937 IPSFC Established  
1957 Fraser Pink Protocol  
Mid 1970's EEZs established



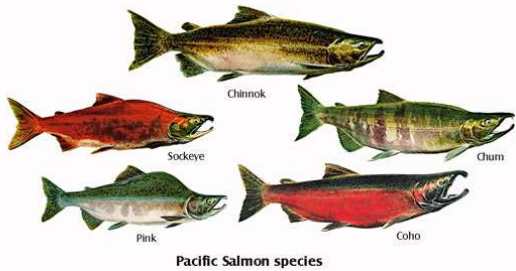


# PACIFIC SALMON TREATY



## PRINCIPLES: Article III

- 1(a) Prevent overfishing & provide for optimum production
- 1(b) Benefits equivalent to production
- 2 Cooperate in management, research & enhancement.
- 3(c) Account for annual variation



**5 Species + Hundreds of Populations  
+ Diverse Migration & Maturation**

=

**FORMIDABLE CHALLENGE  
IN 1985**





## **HUBRIS** Told Us We Could, BUT SALMON HAVE NOT FARED WELL

### ESA ESUs

- 14 Chinook
- 2 Chum
- 4 Coho
- 2 Sockeye

### SARA

- Interior Fraser Coho
- Fraser Sockeye
- Okanagan Chinook
- Southern BC Chinook (under review)

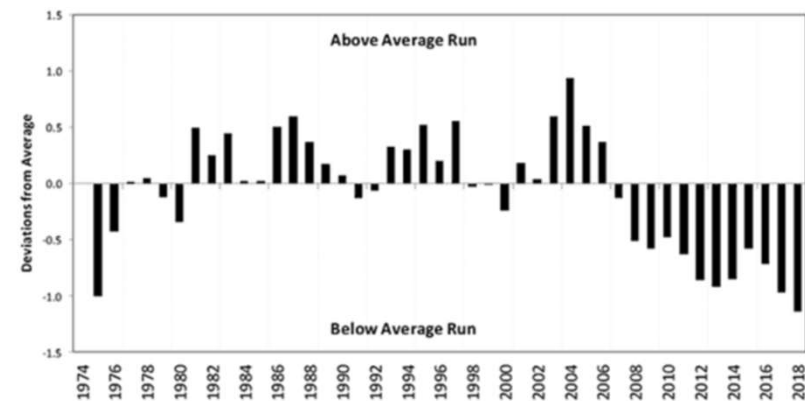
### MANY OTHERS OF CONCERN

## Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington

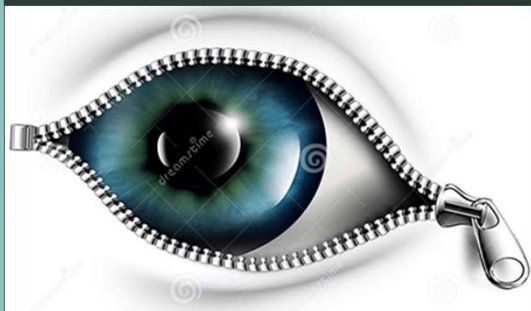
Willa Nehlsen, Jack E. Williams, and James A. Lichatowich

### What areas of Alaska were affected by low Chinook runs?

With few exceptions, since 2007, Chinook salmon runs across the state have been well below the long term average.



# What We're Doing Now Isn't Sustainable



Open our eye to begin to understand why & what we need to change

## Accept That It's Not Working



Think about  
tomorrow  
today





## “Hot” Topic

### Impacts of Climate Change on Salmon of the Pacific Northwest

*A review of the scientific literature published in 2015*

Lisa Crozier

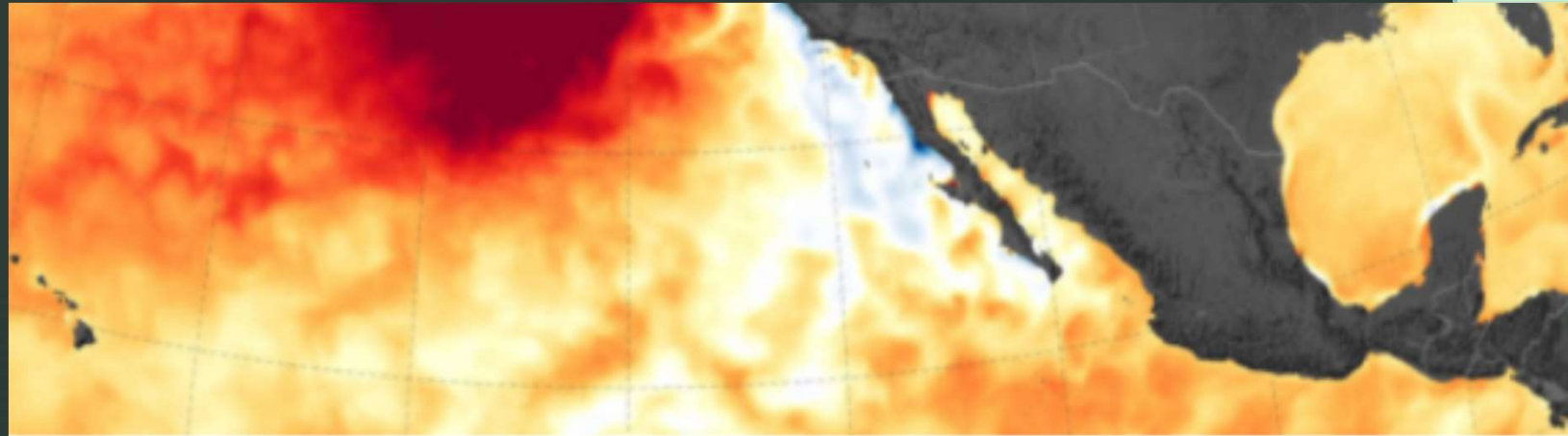
Fish Ecology Division  
Northwest Fisheries Science Center  
National Marine Fisheries Service, NOAA  
2725 Montlake Boulevard East  
Seattle, Washington 98102



### Global Warming Is Pushing Pacific Salmon to the Brink, Federal Scientists Warn

The fish, critical to local economies and the food chain, were already under pressure from human infrastructure like dams. Climate change is turning up the heat.

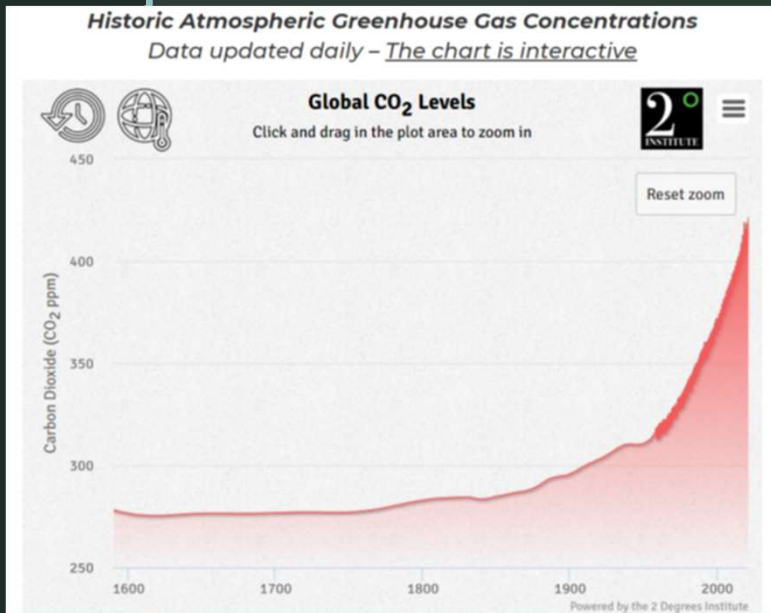
**The New  
Normal?**



**Marine heat wave  
'blobs' are becoming  
more severe as oceans  
warm**



# IS THERE ANY SUCH THING? UNIMAGINABLE CHANGES ARE HAPPENING



CO<sub>2</sub>  
concentrations  
are accelerating

## Receding glaciers causing rivers to suddenly disappear

Global phenomenon known as river piracy demands urgent adaptation from ecosystems and people who rely on their flow



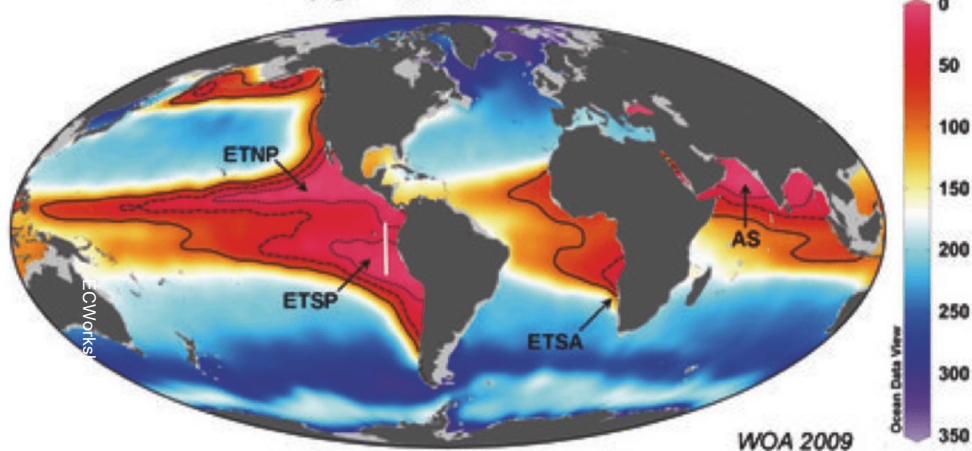
The mouth of the Alsek River is forecast to shift 20 miles south from its current location in Glacier Bay national park.

The Guardian, May 3, 2021, Photograph: NASA Earth Observatory





Oxygen ( $\mu\text{M}$ ) at 300 m



**Ecological: Harmful Algal Blooms & Dead Zones**



## Chemical: New Relationships – Food Chains



Changes in food availability – e.g., 2019 diet high in anchovy – tied to thiamine deficiency in salmon eggs and neurological symptoms – impact on naturally spawned fish uncertain

### Thiamine Deficiency Complex (TDC)

Thiamine is **Vitamin B<sub>1</sub>**

It is an essential vitamin (We all require)

Fish don't make it

Observed between hatch and first feeding and characterized by:

- Loss of equilibrium
- Swimming in a spiral pattern
- Lethargy
- Hyperexcitability
- Hemorrhage, etc.

**Neurological  
Symptoms**

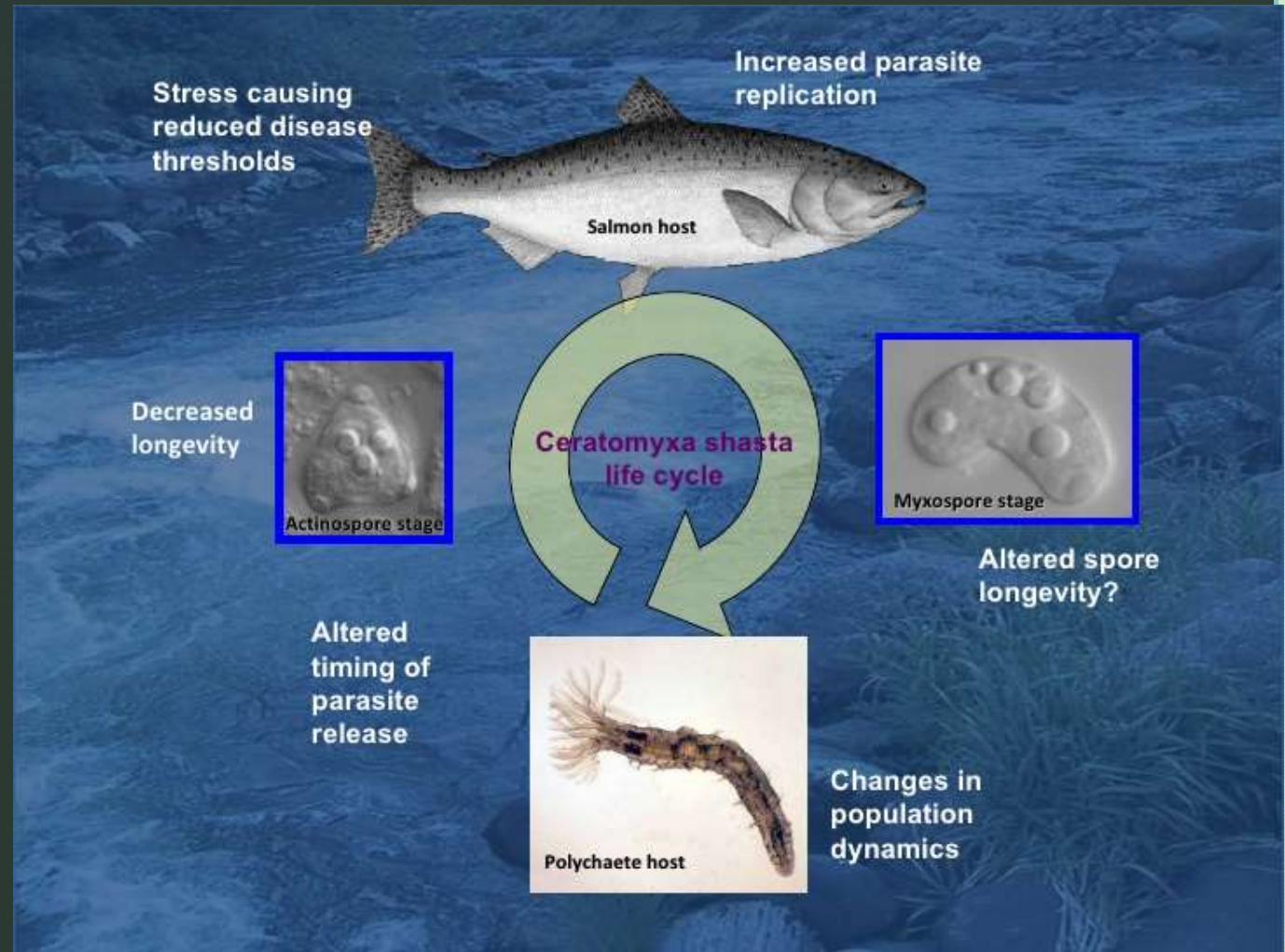


*Healthy*



*B1 deficient*

## Biological: Disease & Pathogens







## Food Webs: Predation By Marine Mammals and Birds



In the Strait of Georgia, a 2012-14 study estimated that seals consumed 40% of Chinook smolts and 47% of Coho smolts.

Chasco (2016) estimated that pinniped consumption of Chinook increased 10x since 1970.



In Alaska, humpback whales are reducing availability of prey species like herring and also eating salmon smolts.



**More than Global Warming: Other Things Have Changed Too**

**Habitats: Columbia River Dams**



Development AND fishing have affected the "June hogs"



## NOT ONLY ARE NUMBERS GETTING SMALLER, FISH ARE TOO

### The mystery of the shrinking fish: Alaska's salmon are getting smaller

A new study has found four species reduced in size, with climate change and competition from hatchery-raised cousins as possible factors



### Salmon have shrunk so much that Whole Foods redid its guidelines

April 27, 2021 at 5:15 pm | Updated April 27, 2021 at 6:13 pm



### Famed Seafood Chain Ivar's Raises Concerns Over Shrinking Salmon from Alaska

Smaller fish get sent back to the supplier, and the trend is alarming environmentalists

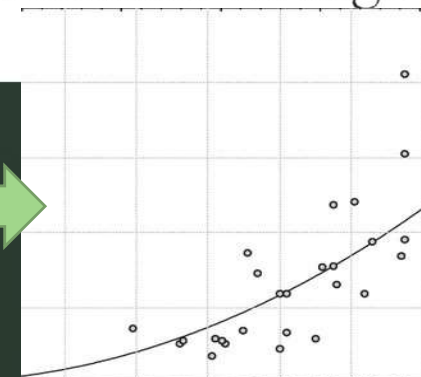
by Gabe Guarente | Apr 29, 2021, 2:00pm PDT

### Alaska's salmon are shrinking, and climate change may be to blame

Also affects reproductive potential & productivity – fecundity & length



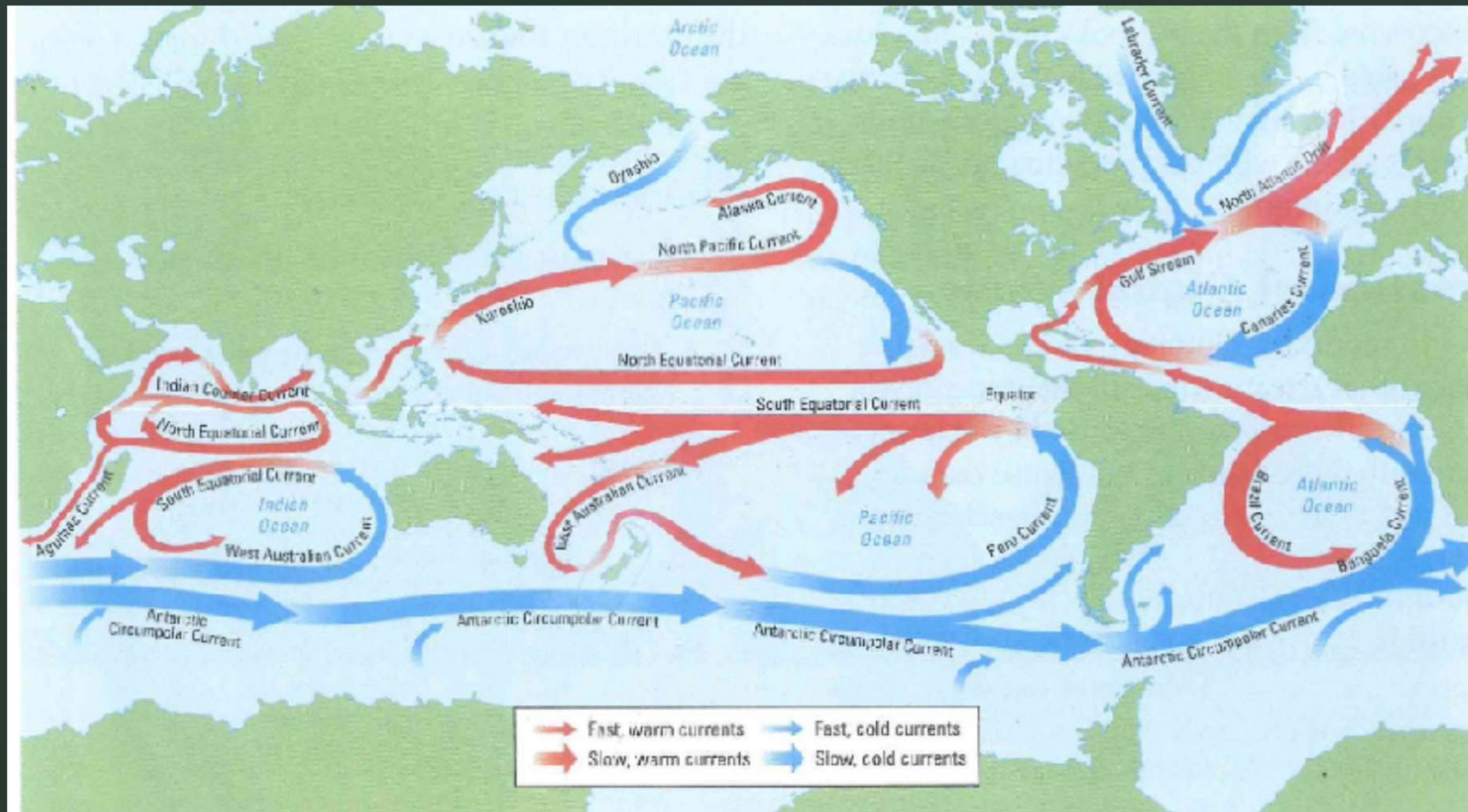
Maturation Rates & Schedules may also be affected?





# Coping With Environmental Change

## Physical: Ocean and Atmospheric Currents



# ENVIRONMENTAL INDICATORS: BIOPHYSICAL

## Ocean Indicators Summary for 2020

Summary of ocean ecosystem indicators used to characterize juvenile marine salmon survival in the Northern California Current.

West Coast

### Table of Contents

Summary of Ocean Indicators for 2020
Pacific Decadal Oscillation and Ocean Nino Index
Upwelling Index at 45°N
Sea Surface Temperatures from NOAA Buoys
Water Temperatures on the Shelf and Slope
Hypoxia
Zooplankton
Pyrosomes
Winter Ichthyoplankton

### Summary of Ocean Indicators for 2020

The early onset of upwelling led to cool ocean conditions during the winter and early spring. This winter, 'pre-conditioning' was likely the cause of the highest annual biomass of northern copepods observed in our 24-year time series. The nearshore winter ichthyoplankton index also pointed towards productive ocean conditions, likely for the same reason.

Therefore, although summer temperatures were warmer than average, our biological indices point towards a productive year for higher trophic levels.

### Pacific Decadal Oscillation and Ocean Nino Index

The PDO turned negative (cool phase) in January 2020 and remained negative throughout 2020. This trend was the longest stretch of negative PDO values since 2013. The Ocean Niño Index turned negative in May 2020 and has been in La Niña conditions (values less than or equal to -0.5 °C) for four consecutive months, one month shy of being declared a La Niña event from the National Weather Service [Climate](#)



## MARINE BIRDS - BIOLOGICAL INDICATORS?



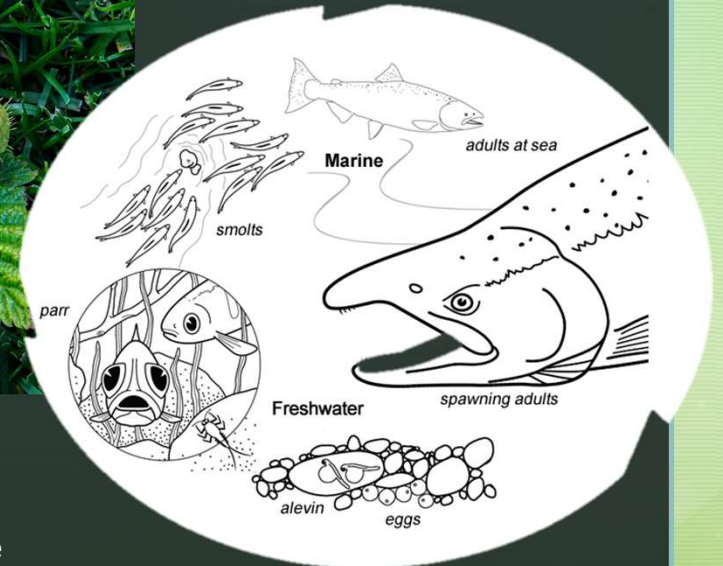
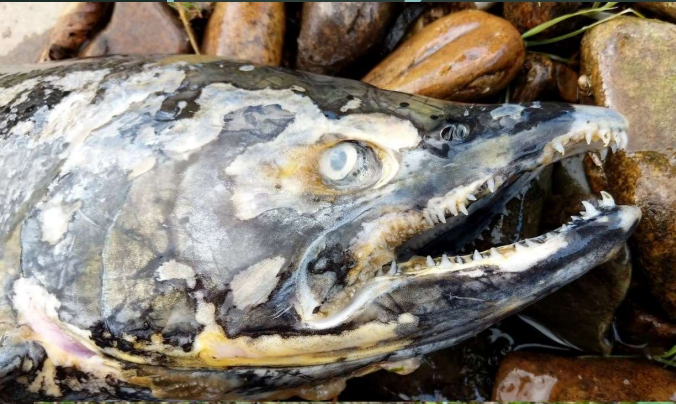
Cassin's Auklet chicks feed on the same copepods that coho feed on - growth of chicks could be a surrogate for early coho survival?



Rhino Auklets feed on small forage fish - a surrogate indicator for early growth stages of salmon?

Some ideas from Roger Dunlop

## TRADITIONAL KNOWLEDGE indicators of salmon abundance



Salmon fertilize the forest. Salmon berry abundance is an indicator. Lantz et.al. J. Ethnobiology 2003. Siemens et.al. Ecosphere 2020.

**TENETS: RESPECT, RECIPROCITY,  
RELATIONSHIPS, & RESPONSIBILITY**

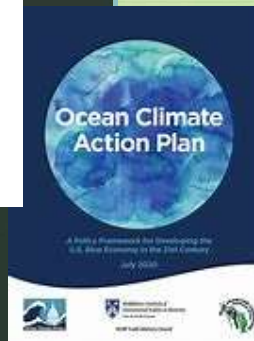


## Salmon & Water: Environments & Habitats Are Changing





## And The World Is Too

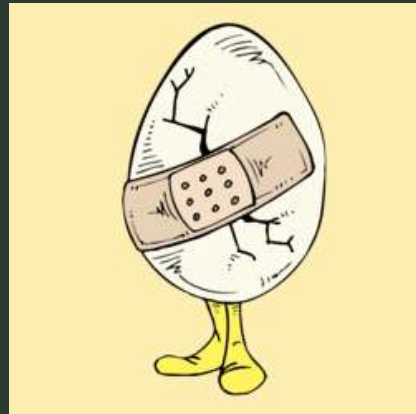
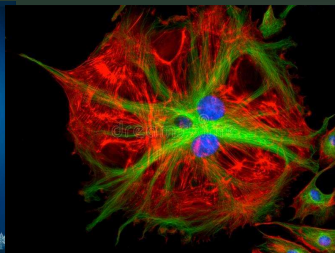






## SUSTAINING & RESTORING SALMON IN THE FACE OF ENVIRONMENTAL CHANGE

Understanding what's broken, how to untangle the web of interconnect forces, and remedy complex and uncertain causal factors is a formidable challenge



Like Humpty Dumpty. Can all the King's Horses & All the King's Men put a broken cycle of life together again? Will it ever be the same?

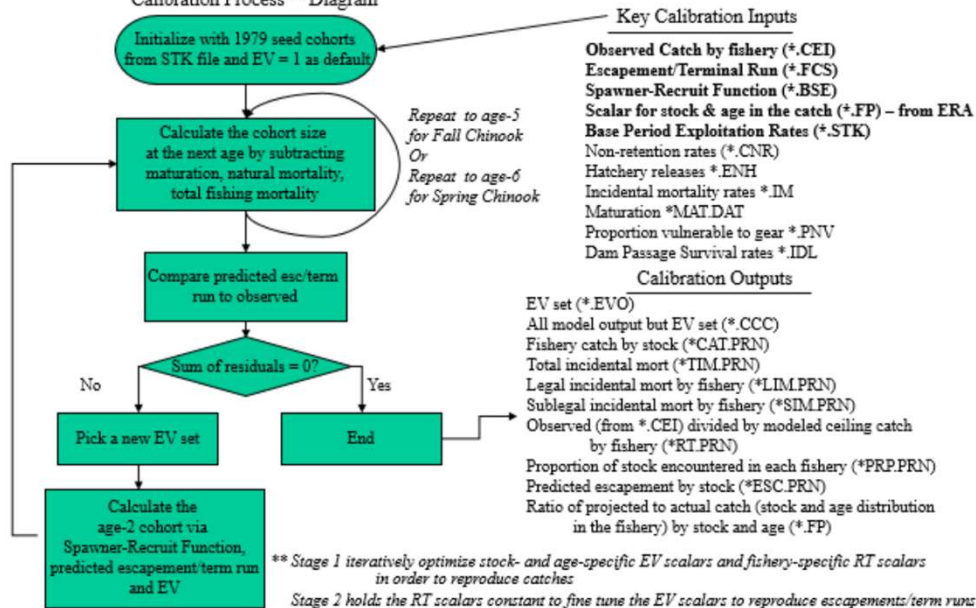


# The Environment Is Changing. Are We? Will Our Aging Methods and Models Serve Us In an Increasingly Uncertain Future?

## CTC Chinook Model Calibration

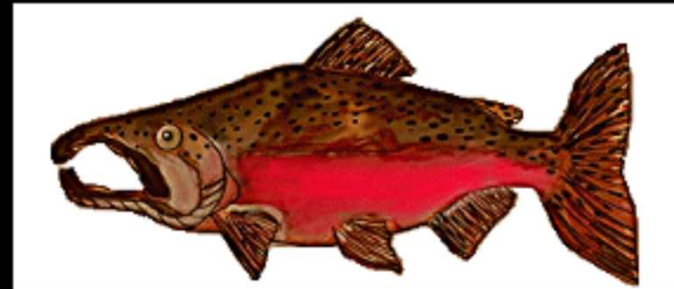
**Calibration Objective:** Estimate the set of stock and brood specific EVs that produce an identical set of Escapement/terminal runs compared to the observed escapement/terminal runs for 30 CTC stocks.

### Calibration Process\*\* Diagram



## Coho FRAM

### Fisheries Regulatory Assessment Model



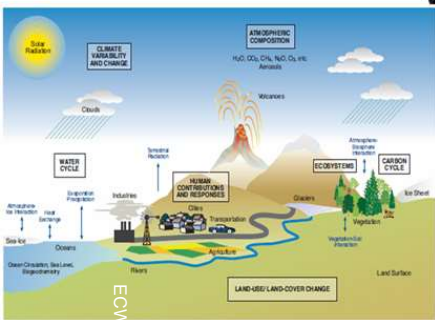
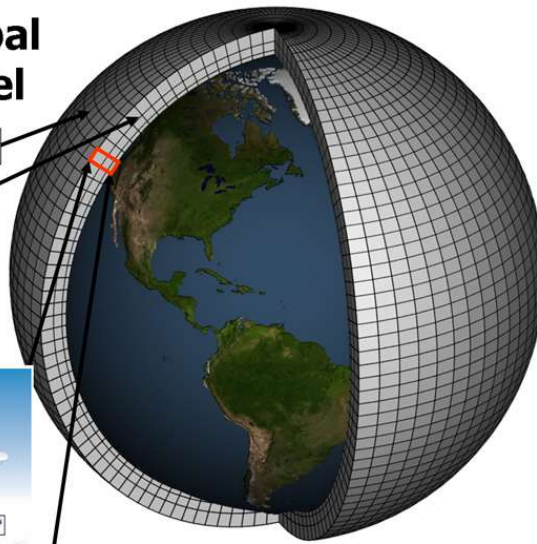
Deterministic – Base Periods, & Assumption-Based. Little consideration for uncertainty

# WHAT DOES THE FUTURE HOLD? GLOBAL CLIMATE MODELS AND LOCAL ENVIRONMENTAL IMPACTS

## Schematic for Global Atmospheric Model

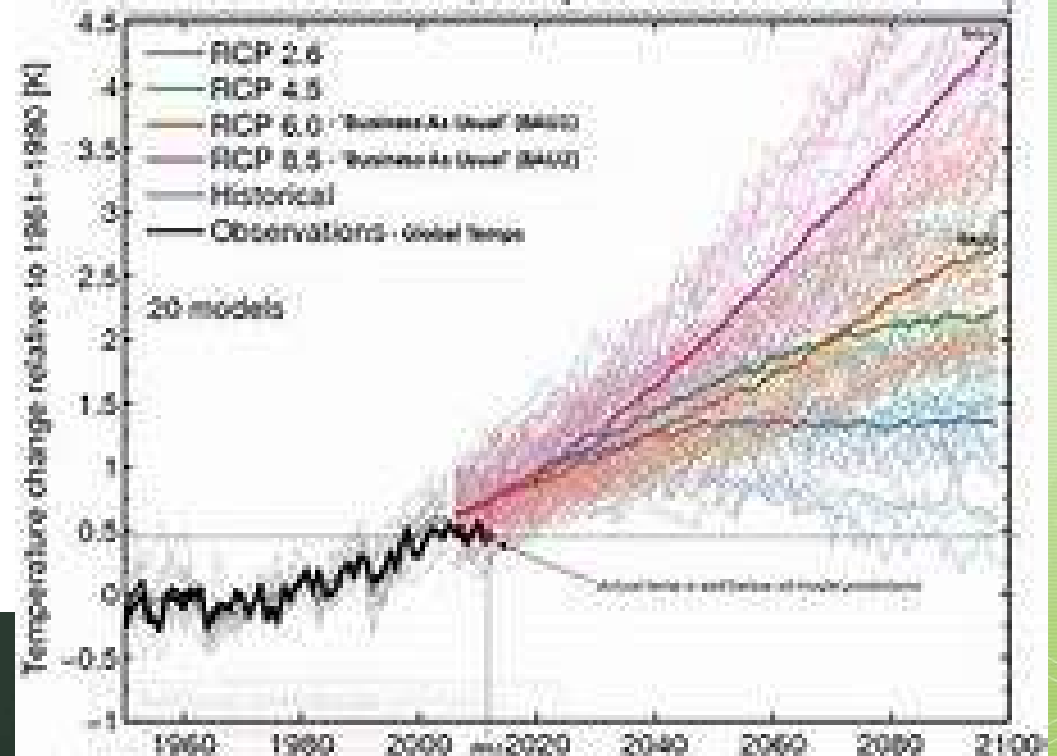
Horizontal Grid (Latitude-Longitude)

Vertical Grid (Height or Pressure)



## Newest IPCC Climate Models Vs. Climate Reality

Similar to older models, the fully-featured CMIP5 versions fail also





# ABRUPT CHANGE

## Climate Tipping Points

Thresholds that, when exceeded, can lead to rapid, large environmental changes

### Climate tipping points – too risky to bet against

The growing threat of abrupt and irreversible climate changes must compel political and economic action on emissions.

### RAISING THE ALARM

Evidence that tipping points are under way has mounted in the past decade. Domino effects have also been proposed.



**A. Amazon rainforest**  
Frequent droughts

**B. Arctic sea ice**  
Reduction in area

**C. Atlantic circulation**  
In slowdown since 1950s

**D. Boreal forest**  
Fires and pests changing

**F. Coral reefs**  
Large-scale die-offs

**G. Greenland ice sheet**  
Ice loss accelerating

**H. Permafrost**  
Thawing

**I. West Antarctic ice sheet**  
Ice loss accelerating

**J. Wilkes Basin, East Antarctica**  
Ice loss accelerating

©nature

# Coming Our Way

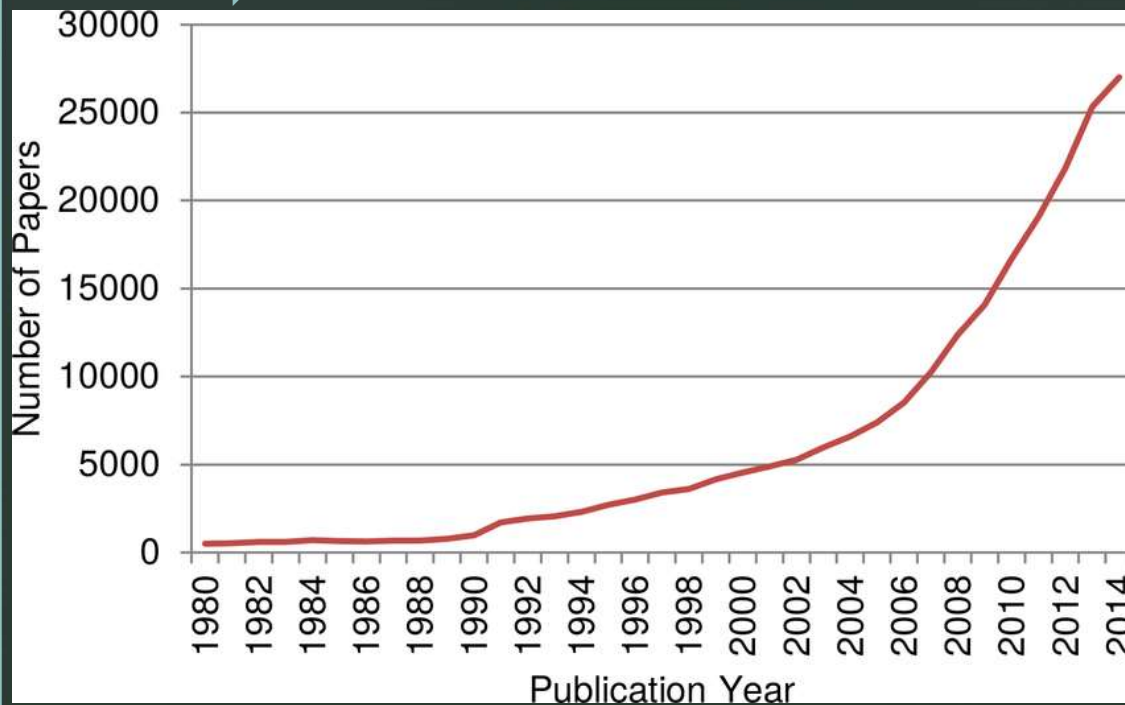
## Tidal Wave

New information and observations



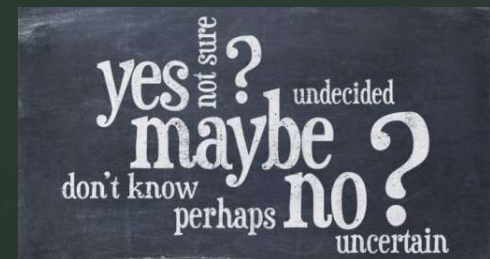


# Number of Climate-Related Publications



**No wonder it's hard to keep up!**

Paralysis By Analysis?



# Uncertainty *Is* CERTAIN

**IGNORE IT?**



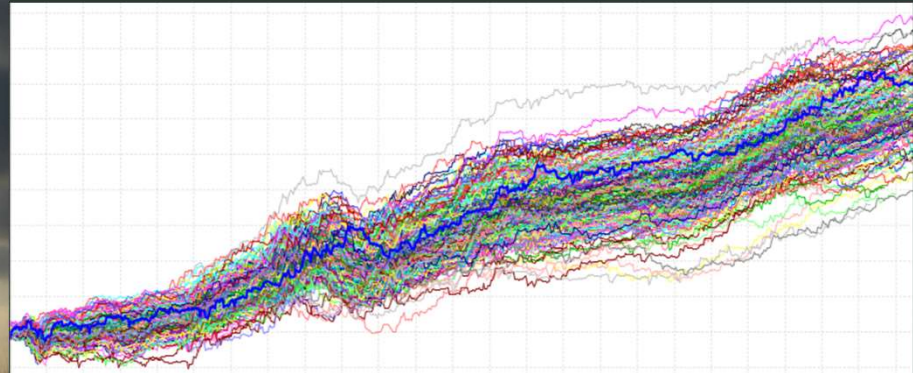
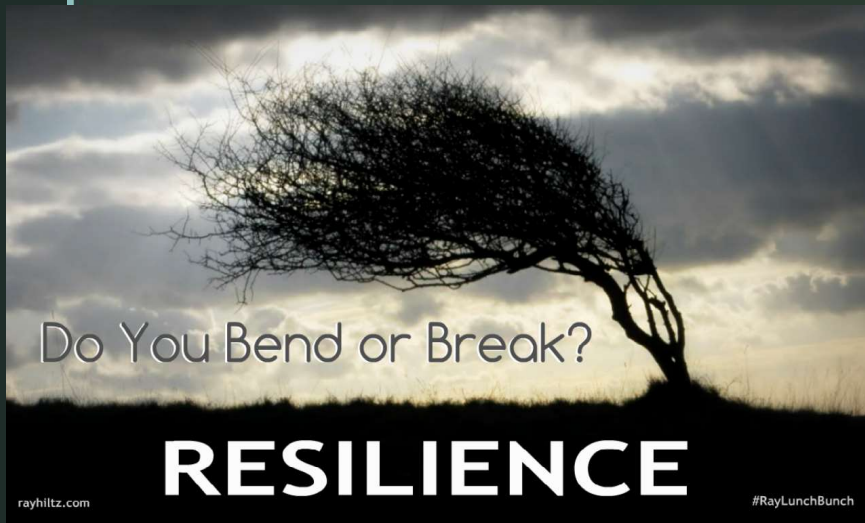




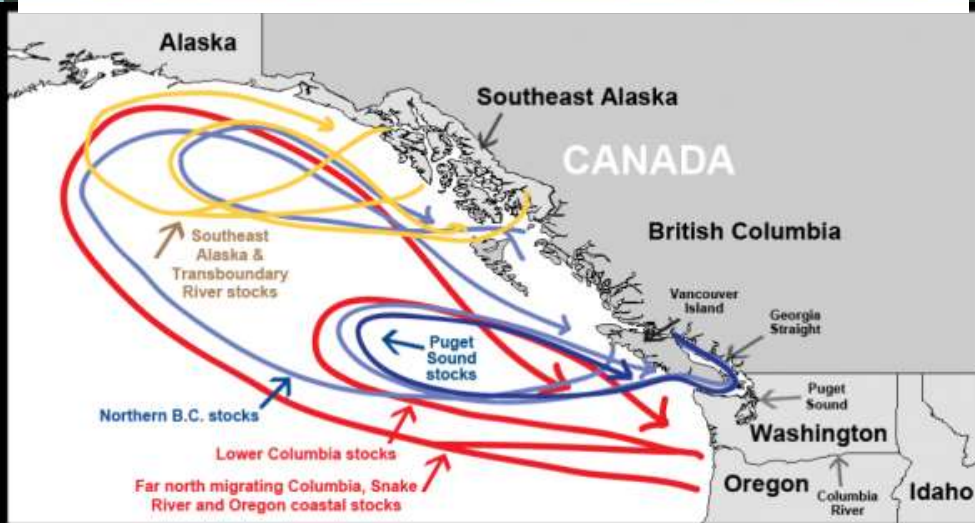
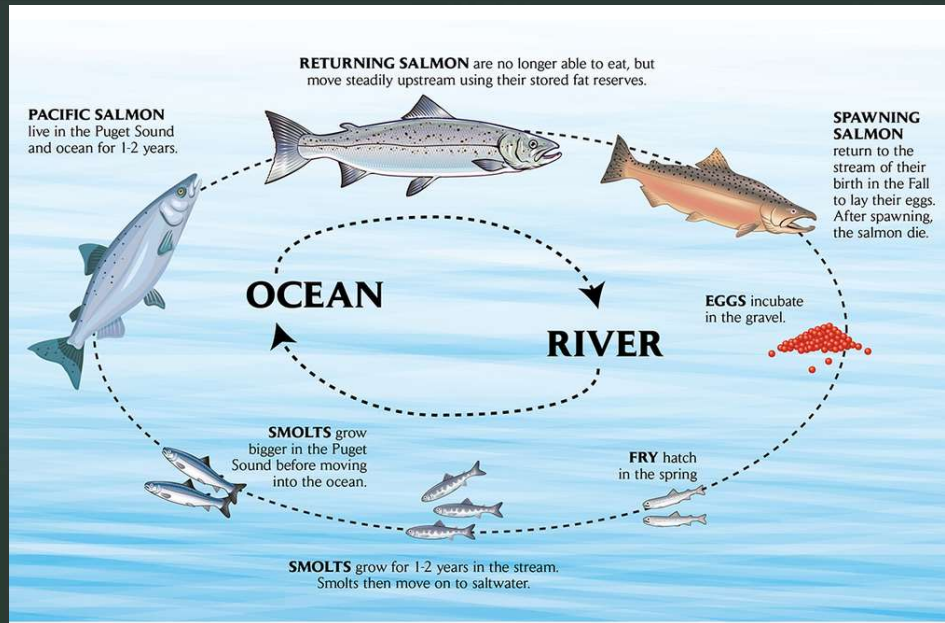
# STUDY IT?



# OR TRY TO OWN IT?

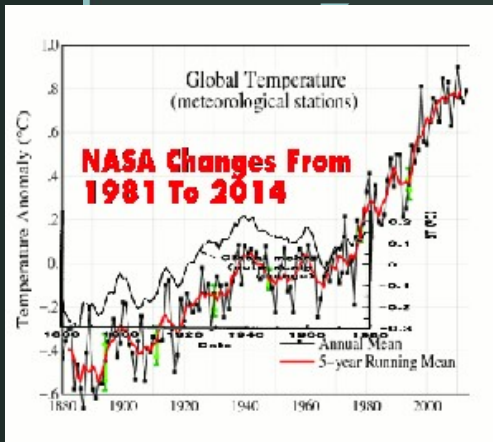






**PACIFIC SALMON ARE SUSTAINED BY REPEATING CYCLES OF LIFE**

**Anadromy**  
 +  
**Semelparity**  
 +  
**Homing Fidelity**  
 +  
**Short-Lived**  
 +  
**Highly Migratory**  
 =  
**Unique Stresses From Many Ecological, Social, Economic & Political Forces**



## ADD ENVIRONMENTAL CHANGE

**Environmental Trends + Increasing Instability**

=

**Novel Conditions & High Uncertainty**

## NEEDS

**Be Nimble & Adapt**

+

**Maintain Biological, Spatial, and Life History DIVERSITY**

+

**PRECAUTIONARY MANAGEMENT Tied To The Productivity & Abundance of Individual Populations**

+

**ACTIONABLE Options & Ability to Communicate Likelihood of Outcomes and Risks**





# The Road Ahead

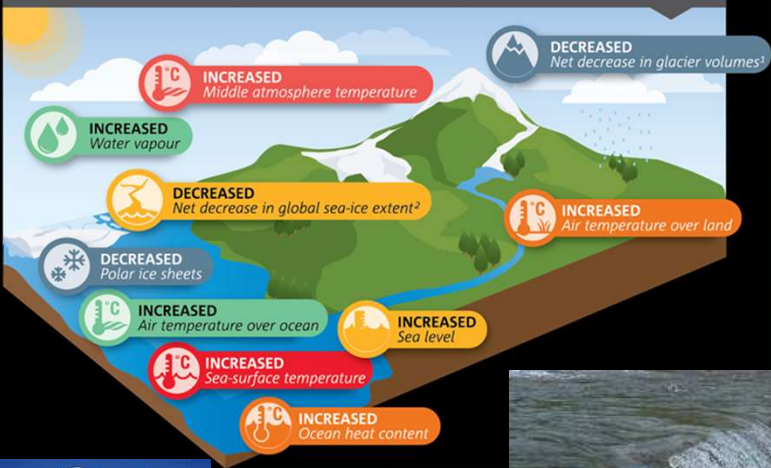


Where there is no  
road, blaze a path



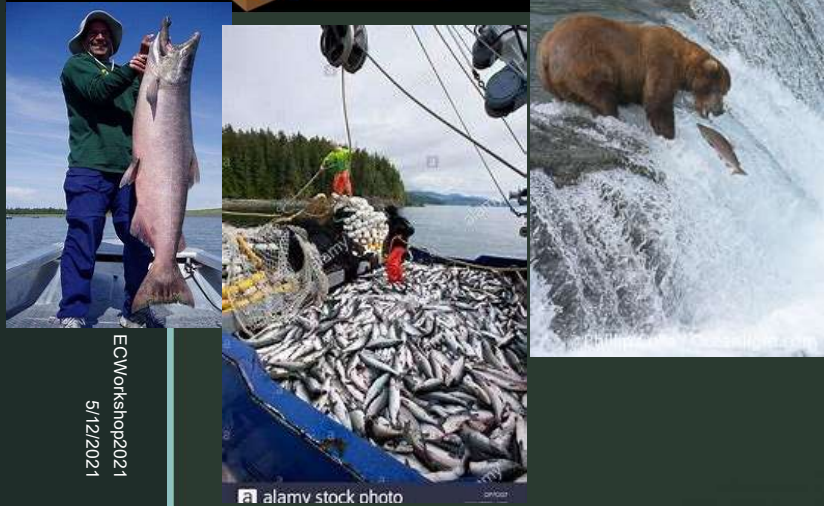
# TO SUSTAIN SALMON UNDER ENVIRONMENTAL CHANGE, DIFFICULT CHALLENGES MUST BE OVERCOME

Changes in the global climate system



## Wicked Problems

- Many interdependencies
- Multi-causal
- Unintended consequences to solutions
- Moving target, unstable
- Socially complex
- Rarely the responsibility of one organization
- Involve changing peoples' behavior



alamv stock photo





Look beyond your nose

EXPAND  
YOUR VISION



*Some see  
a weed.  
Some see  
a wish.*

[facebook.com/ABetterYouWithPlexus](https://facebook.com/ABetterYouWithPlexus)



# INTERDEPENDENCIES



Salmon are ecological integrators of the land, water, oceans, & their creatures, **AND** integrators of fragmented institutions of agency and political governance.

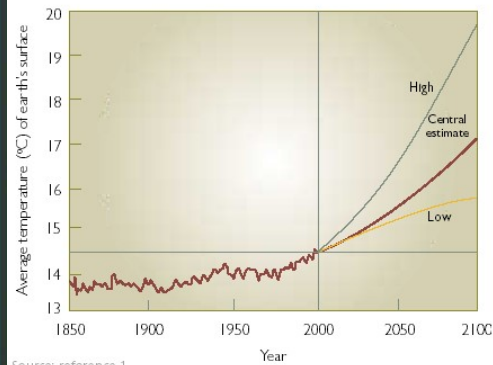
The World is alive. Everything is Connected  
By Place, Space, Time, Relationships.





# THE NEED IS URGENT

Figure 1.2 Global temperature record, since instrumental recording began in 1860, and projection to 2100, according to the IPCC



The pace of change is accelerating



Climate Countdown Clock



GSM1

We're running out of time. We don't have the luxury of waiting until we know it all.





## STAKES ARE HIGH

The Future of  
Salmon and  
the Salmon  
People are at  
GREAT RISK





## IT'S NOT JUST ABOUT FISH



Salmon are our miner's canary  
of what's happening to our  
environment



If we can find the will  
and the means to  
sustain abundant,  
productive salmon  
stocks,



THEN, there'll be

# HOPE

for us as well

MAY THE FORCE

BE WITH YOU



