Climate Change in Southeast Alaska: Potential Effects on Fish

Gordie Reeves
US Forest Service
Pacific Northwest Research Station

Sheila Jacobson
US Forest Service
Tongass National Forest

Climate Change in Southeast Alaska: Potential Effects on Fish: Challenges to Moving Forward

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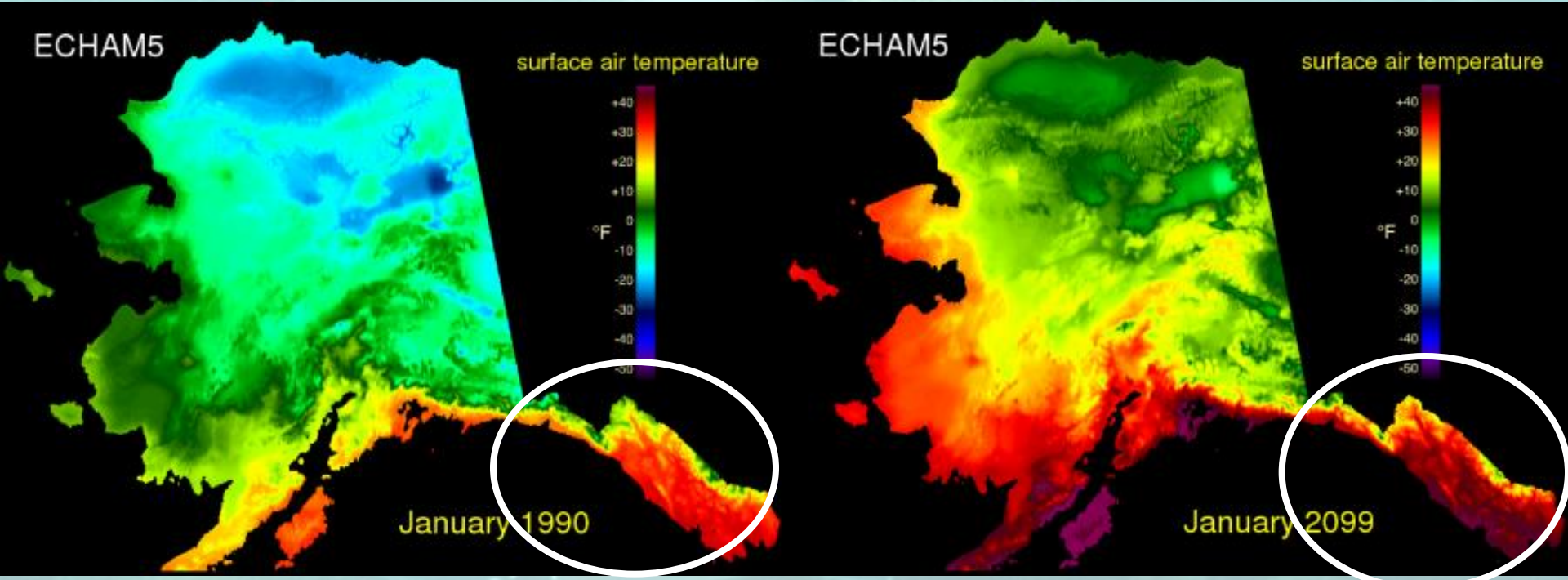
Expected Effects of Climate Change

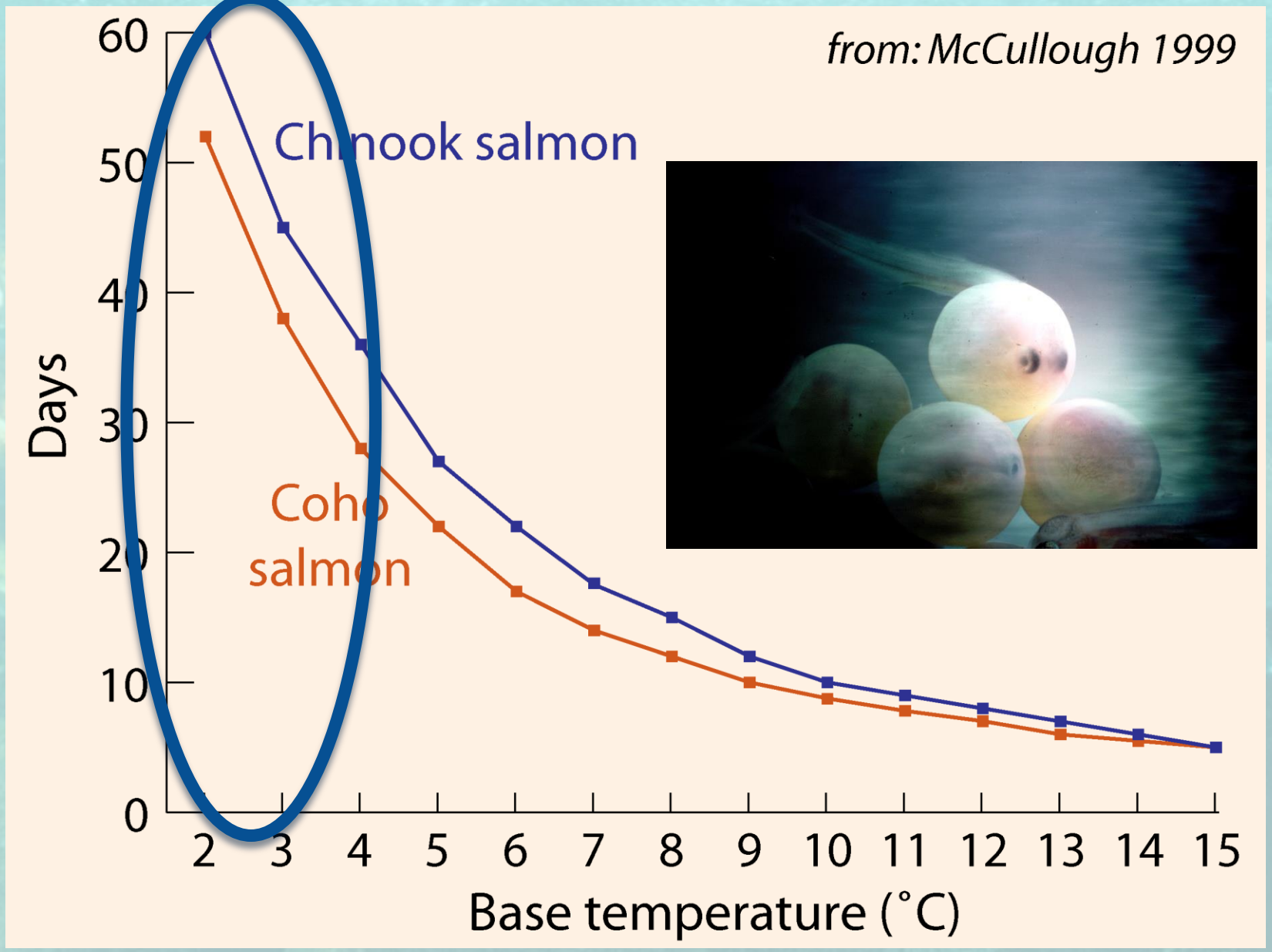
- Freshwater
  - Change in seasonal temperatures
  - Change in hydrograph

Winter Temperatures

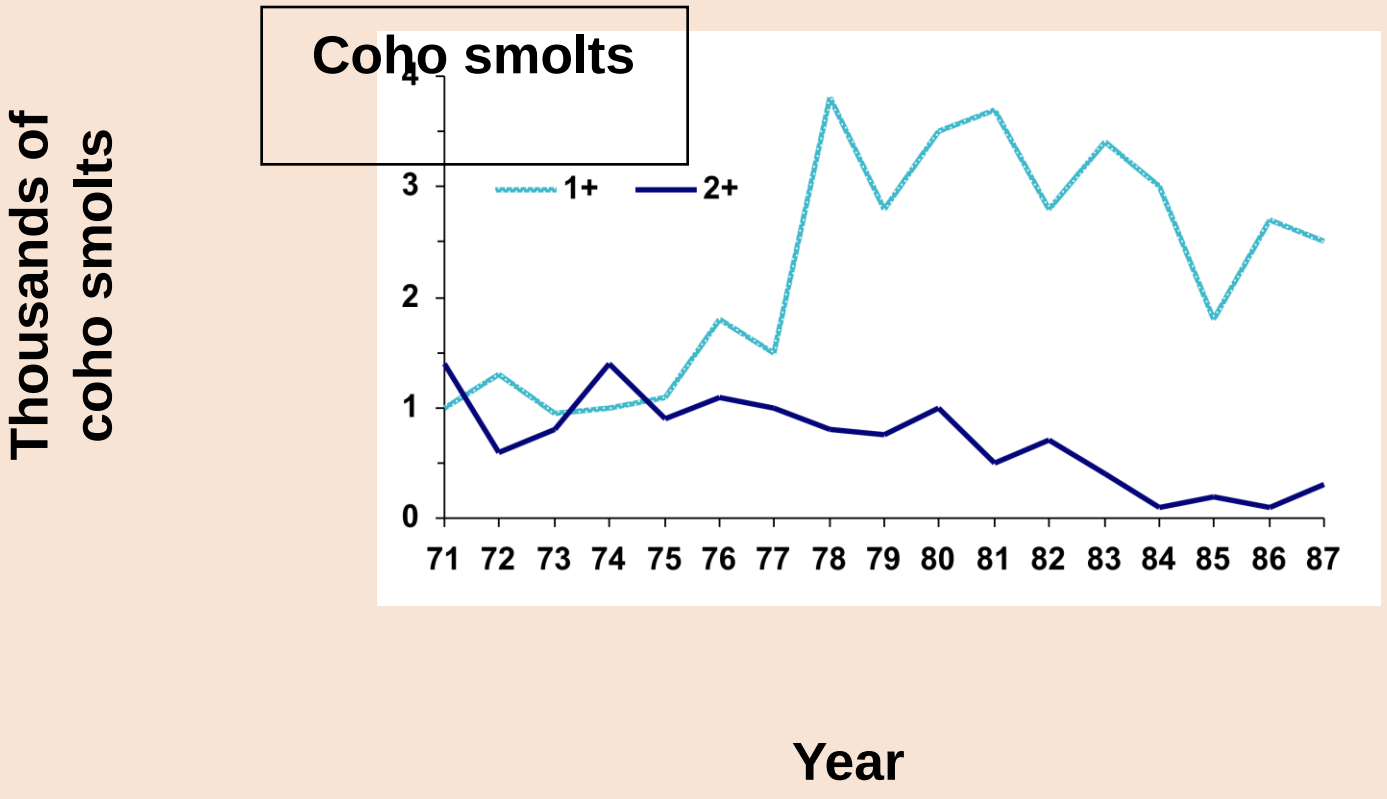


From: http://igloo.atmos.uiuc.edu/SNAP/

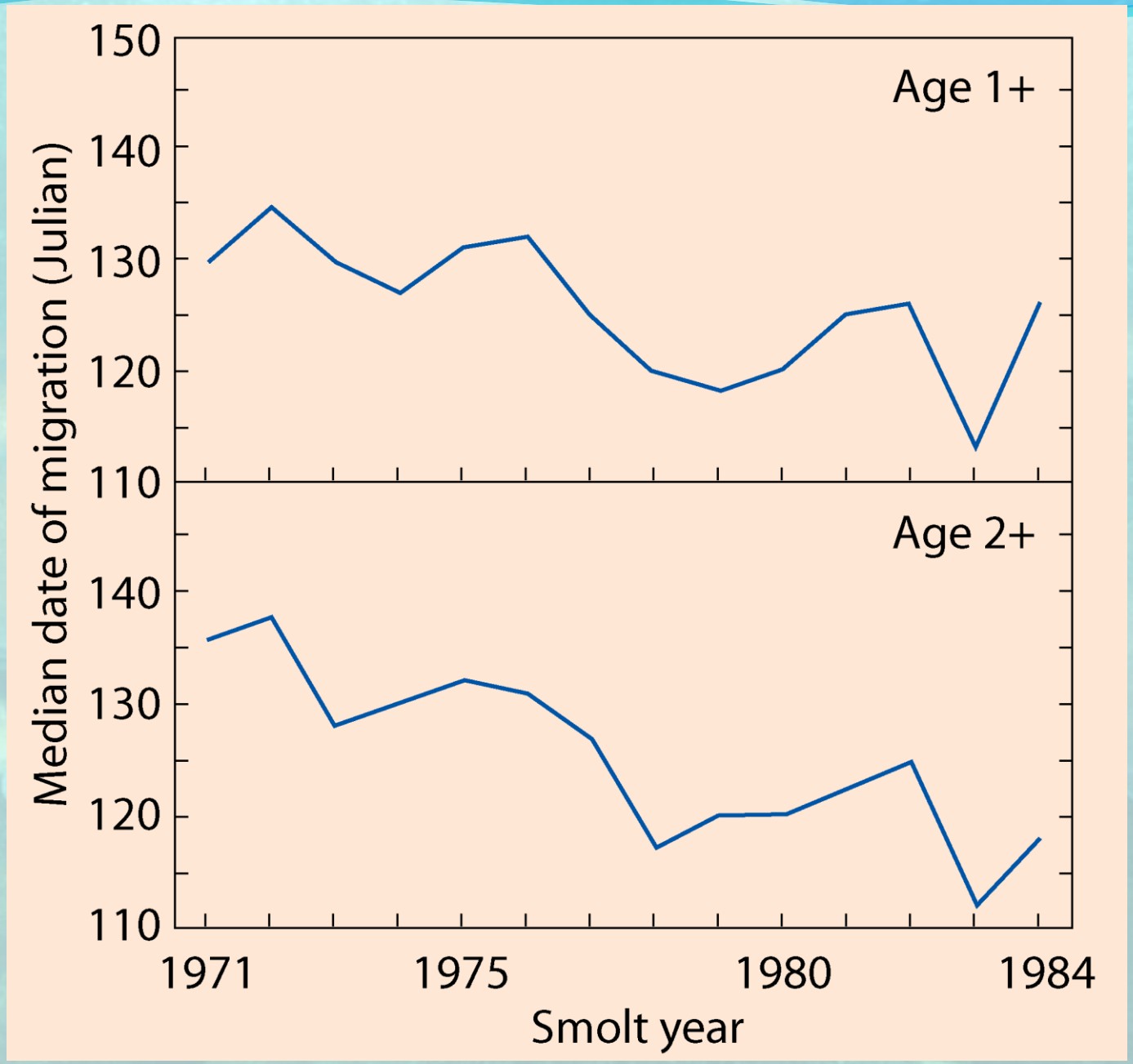
Reduced Number of Days to Emergence from Each 1°C Increase in Water Temperature from Base



Numbers of age 1+ and 2+ coho salmon smolts migrating from Carnation Creek, BC, 1971-1987



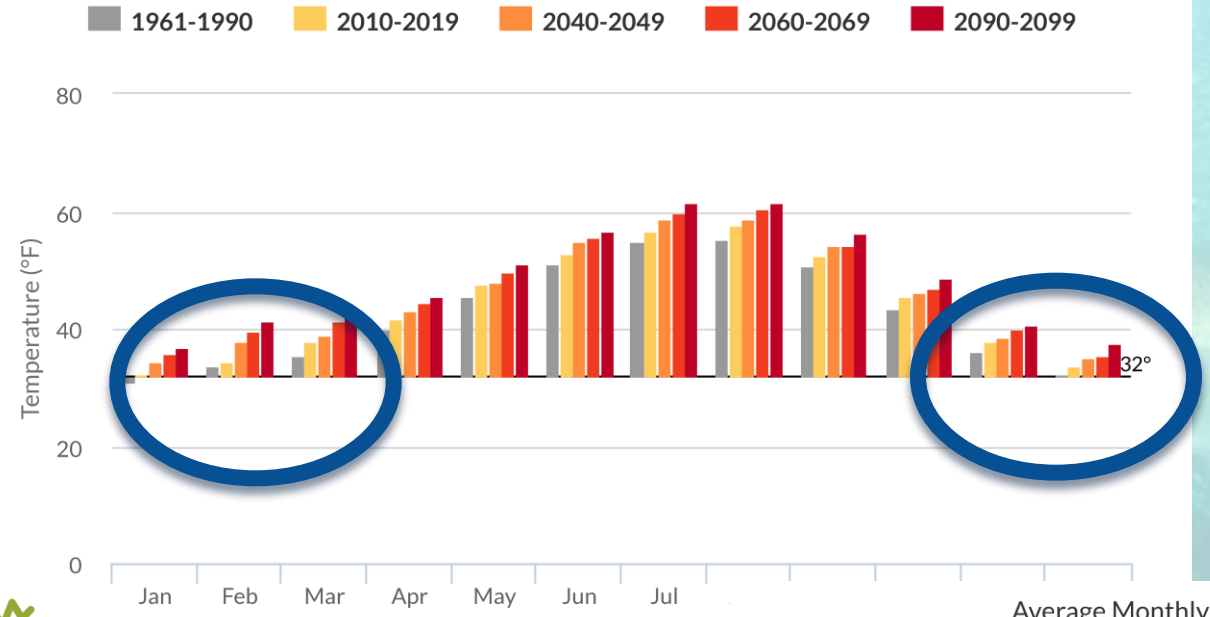
From: Hartman and Scrivener, 1990. Impacts of forestry practices on a coastal stream ecosystem, Carnation Creek, British Columbia. Canadian Bulletin of Fisheries and Aquatic Sciences 223



from LB Holtby (1988) Can. J. Fish. Aquat. Sci. 45: 502-515

Average Monthly Temperature for Ketchikan, Alaska

Historical CRU 3.2 and 5-Model Projected Average at 10min resolution, Mid-Range Emissions (RCP 6.0)

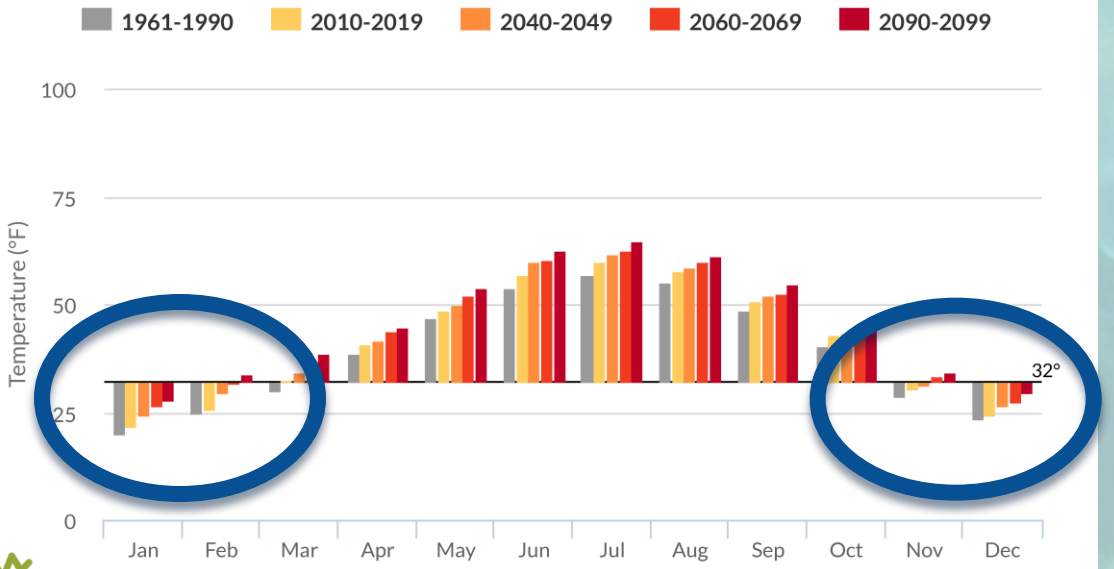


SNAP

Due to variability among climate models and among years in a natura
over time, rather than for precisely prec

Average Monthly Temperature for Haines, Alaska

Historical CRU 3.2 and 5-Model Projected Average at 10min resolution, Mid-Range Emissions (RCP 6.0)



SNAP

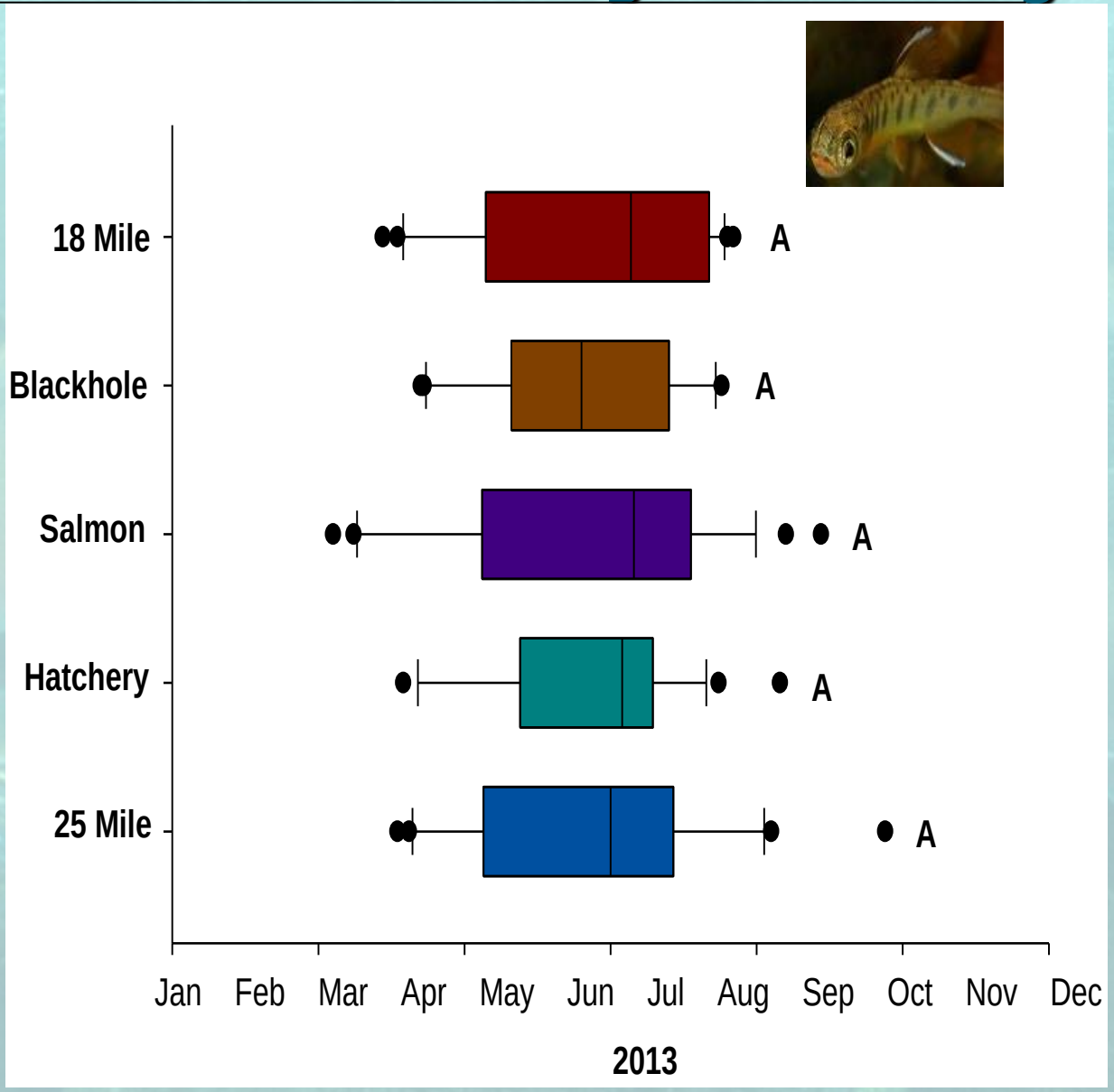
Due to variability among climate models and among years in a natural climate system, these graphs are useful for examining trends over time, rather than for precisely predicting monthly or yearly values.

Results: Coho Salmon Emergence Timing

High

Thermal Variability

Low

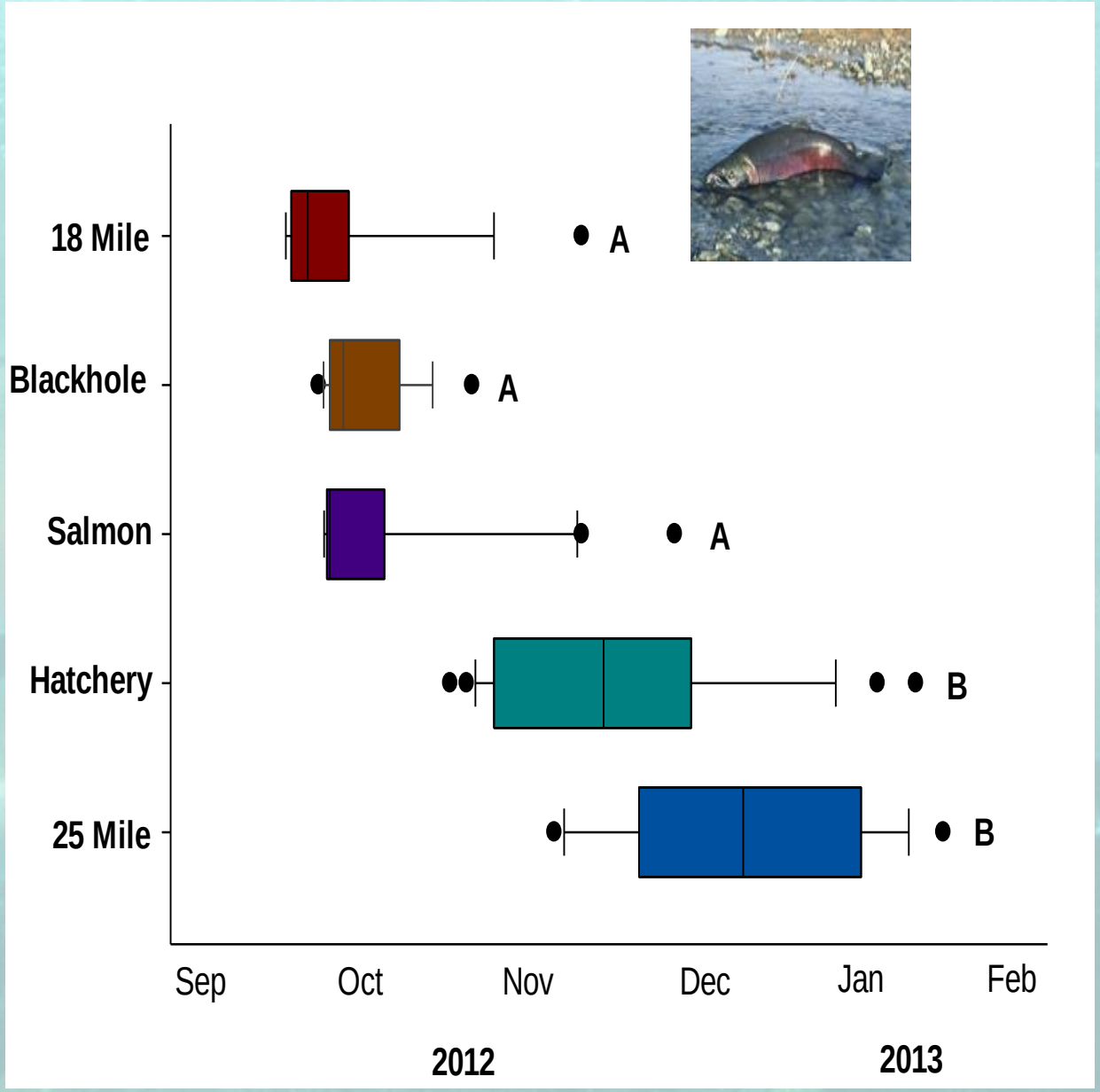


Coho Salmon Spawn Timing

High

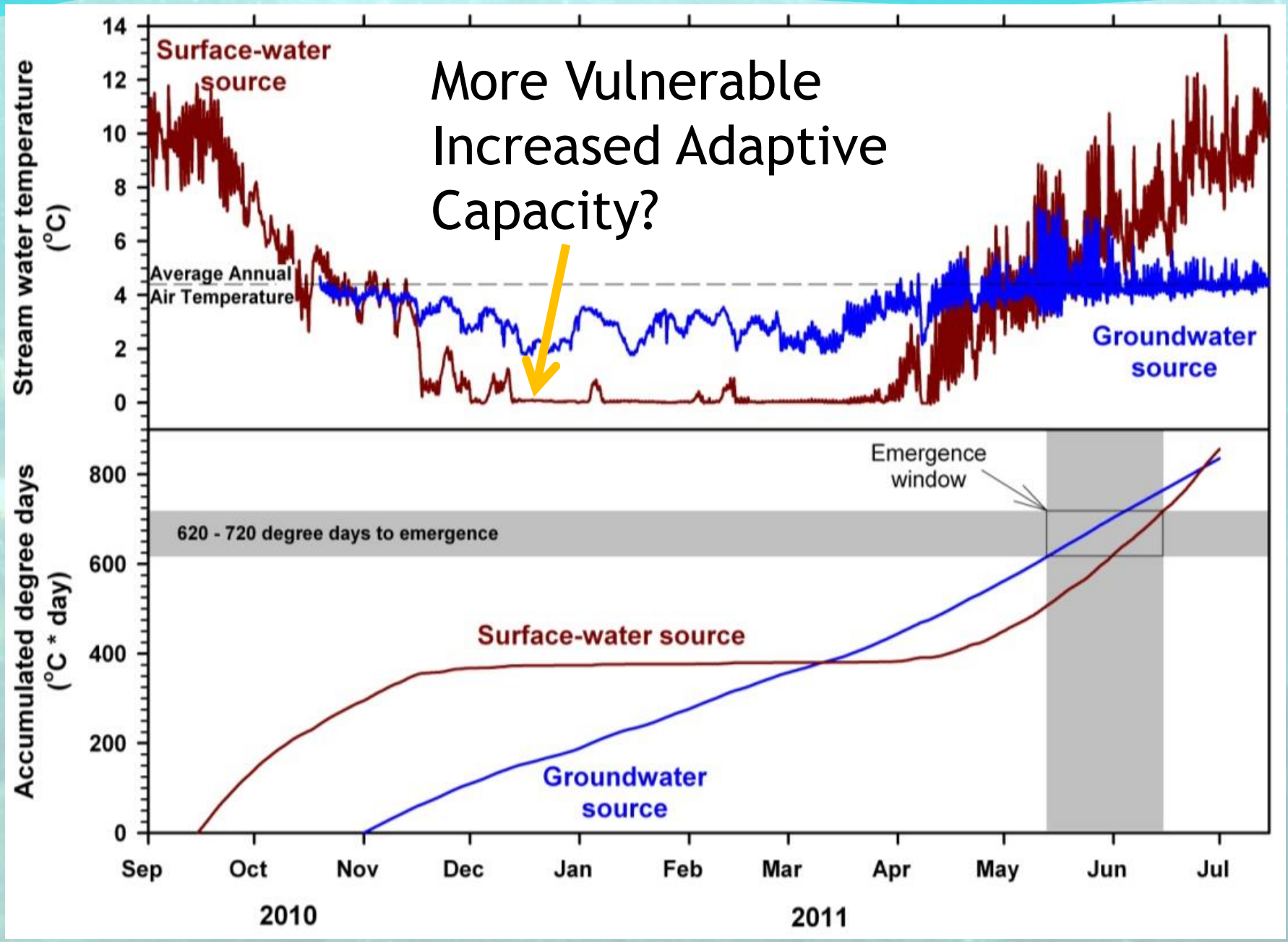
Thermal Variability

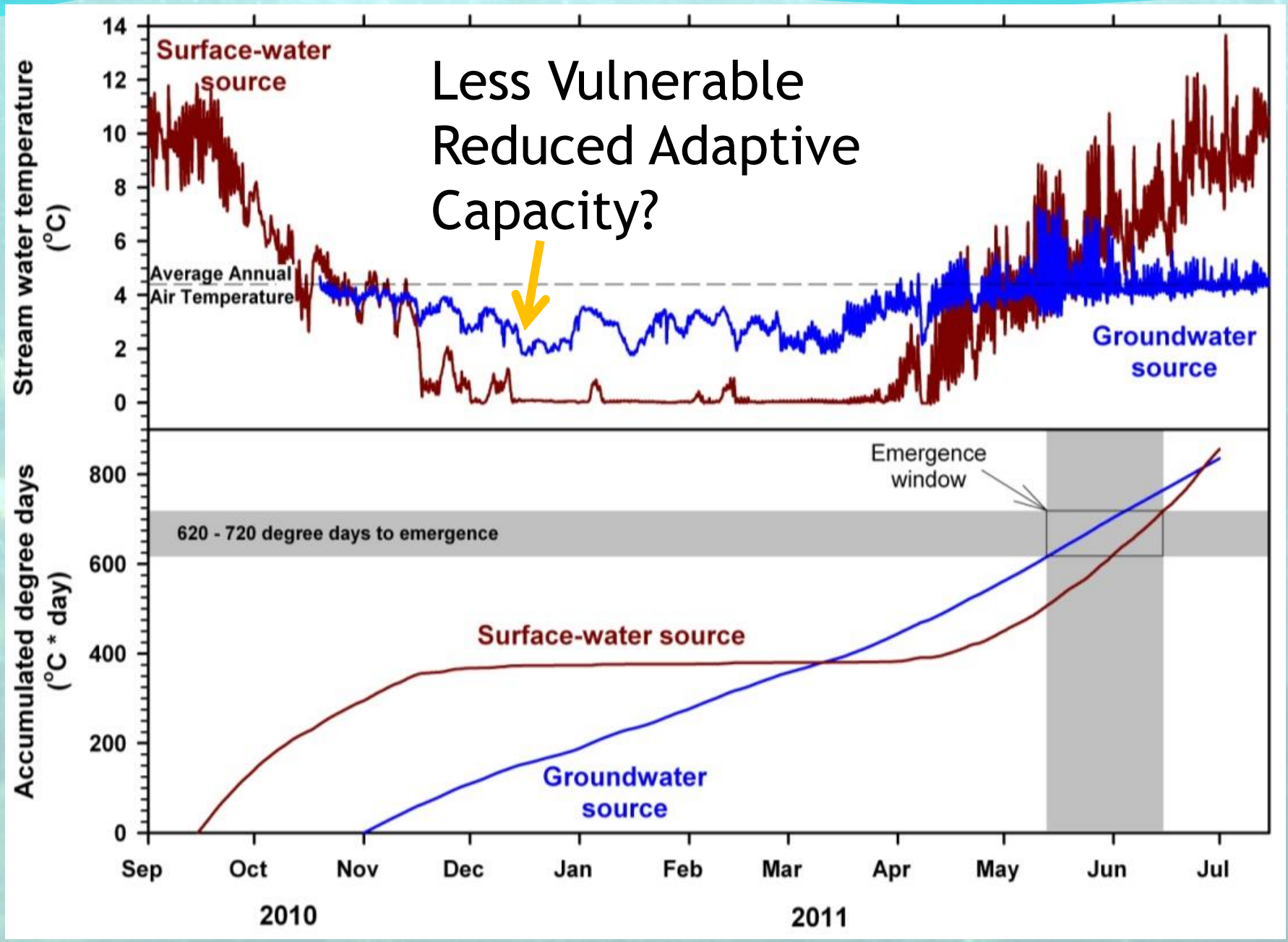
Low



Adaptations

- Shift in time of spawning
- Change in egg size/yolk content


More Vulnerable
Increased Adaptive
Capacity?
Surface-water source
Groundwater source
Average Annual Air Temperature
Stream water temperature (°C)
Accumulated degree days (°C * day)
620 - 720 degree days to emergence
Emergence window
Surface-water source
Groundwater source
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
2010
2011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Capacity?
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Accumulated degree days (°C * day)
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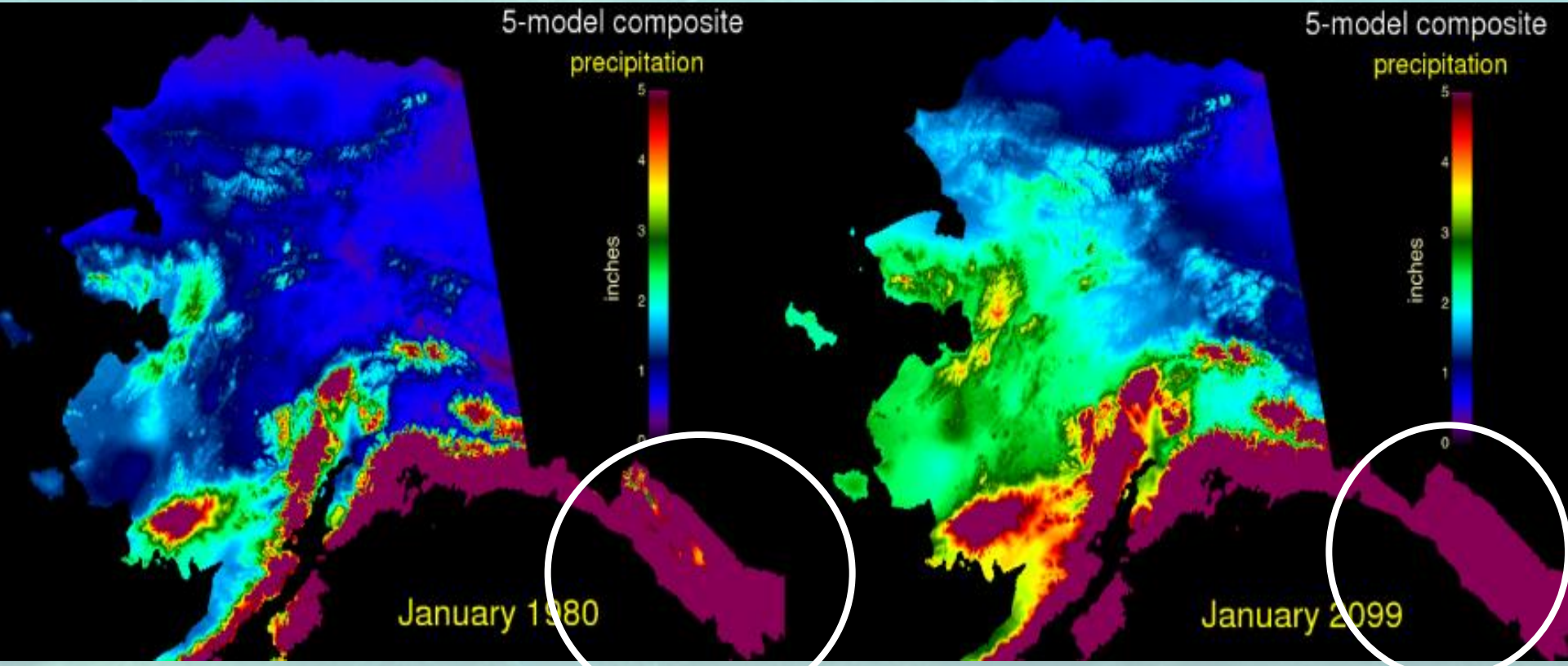
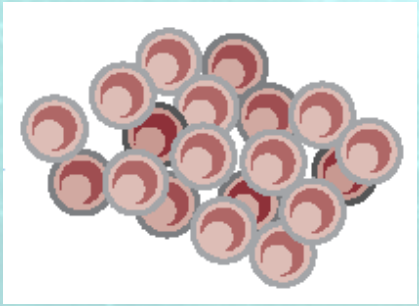
Surface-water source
Groundwater source
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
2010
2011

Changes in Precipitation



From: http://igloo.atmos.uiuc.edu/SNAP/



Eggs & Developing Embryos

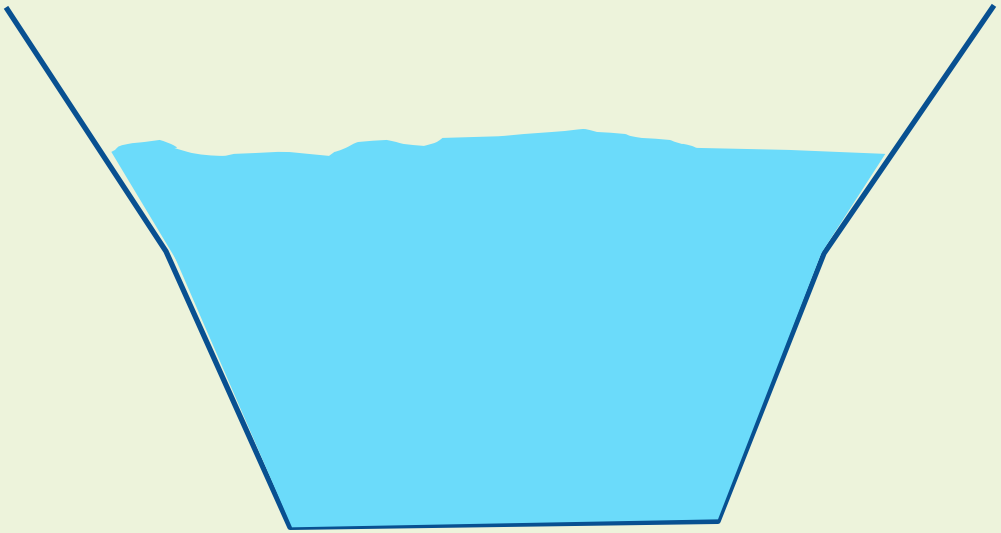
- Water temp ⇧
- Flows ⇧

⇨

- Increased rate of development
- Increased susceptibility to scour - ?

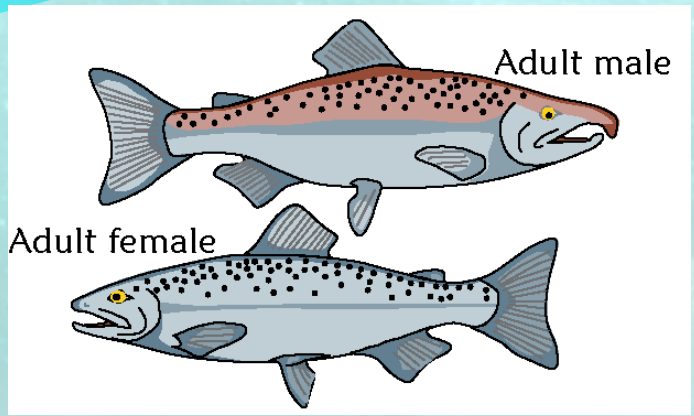
Static channel morphology
Unconfined channels

Static channel morphology
Confined channels



Expected Effects of Climate Change

- Freshwater
  - Change in seasonal temperatures
  - Change in hydrograph
- Marine
  - Increased water temperatures
  - Change in pH

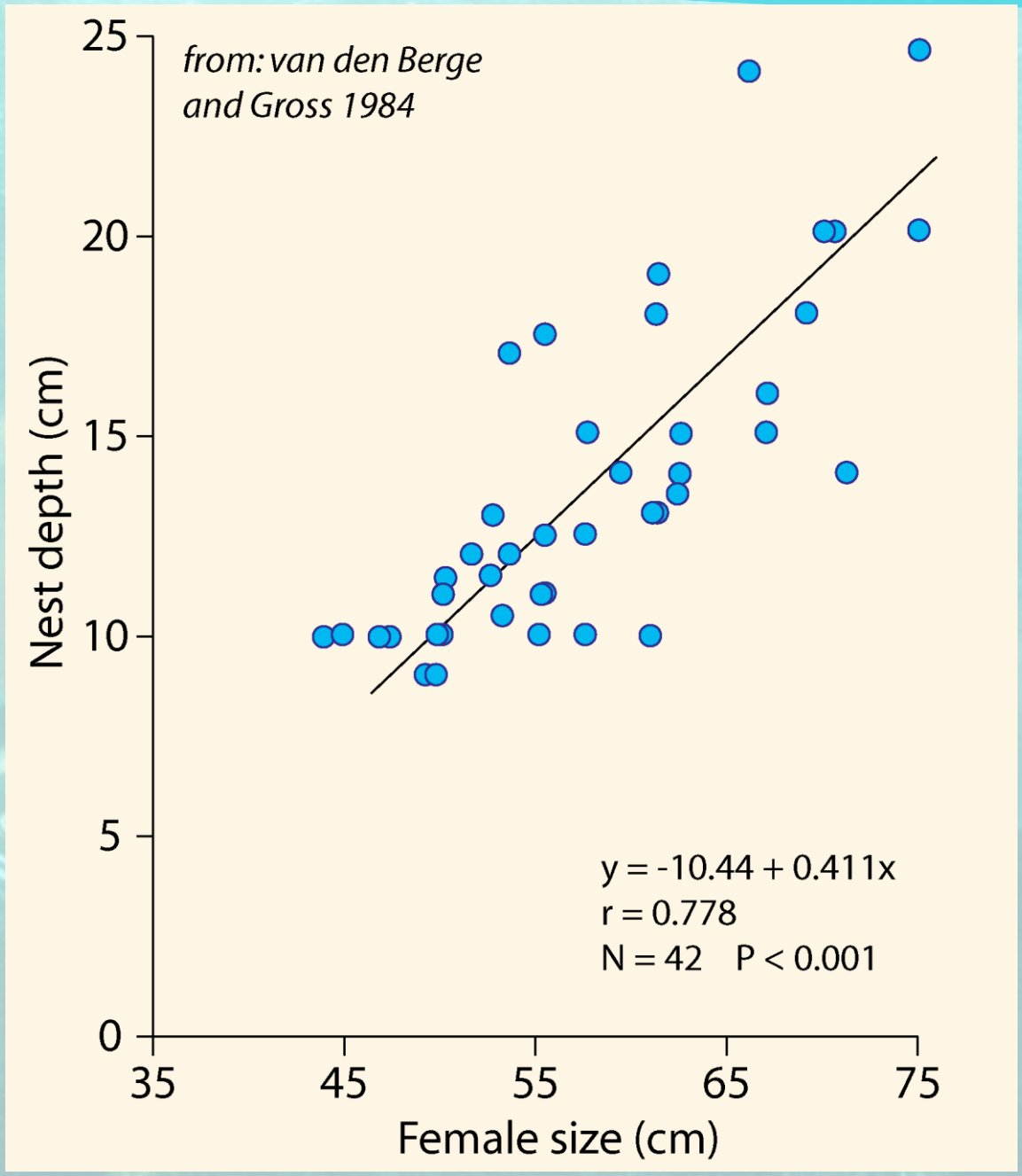


Adults: Ocean

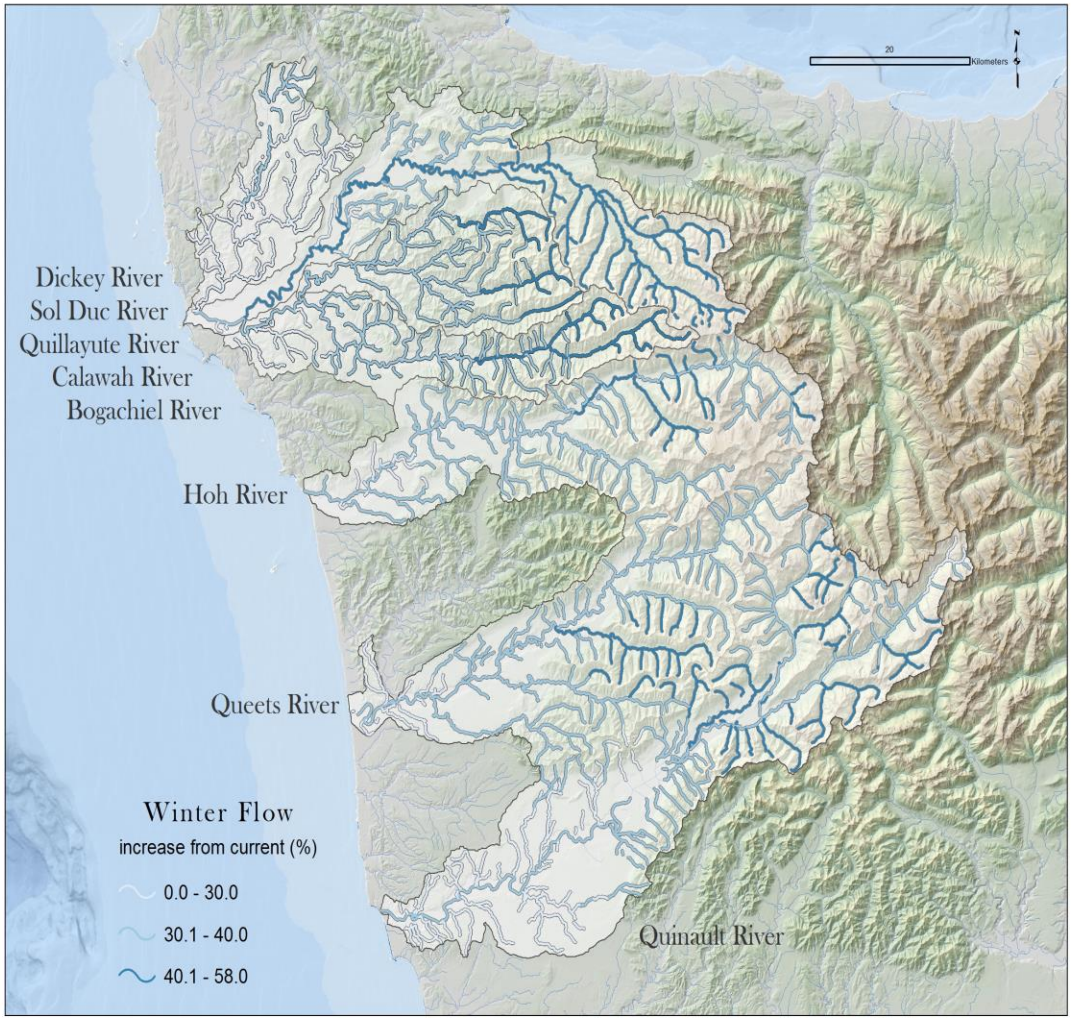
- Water temp ↑
- pH ↓

→

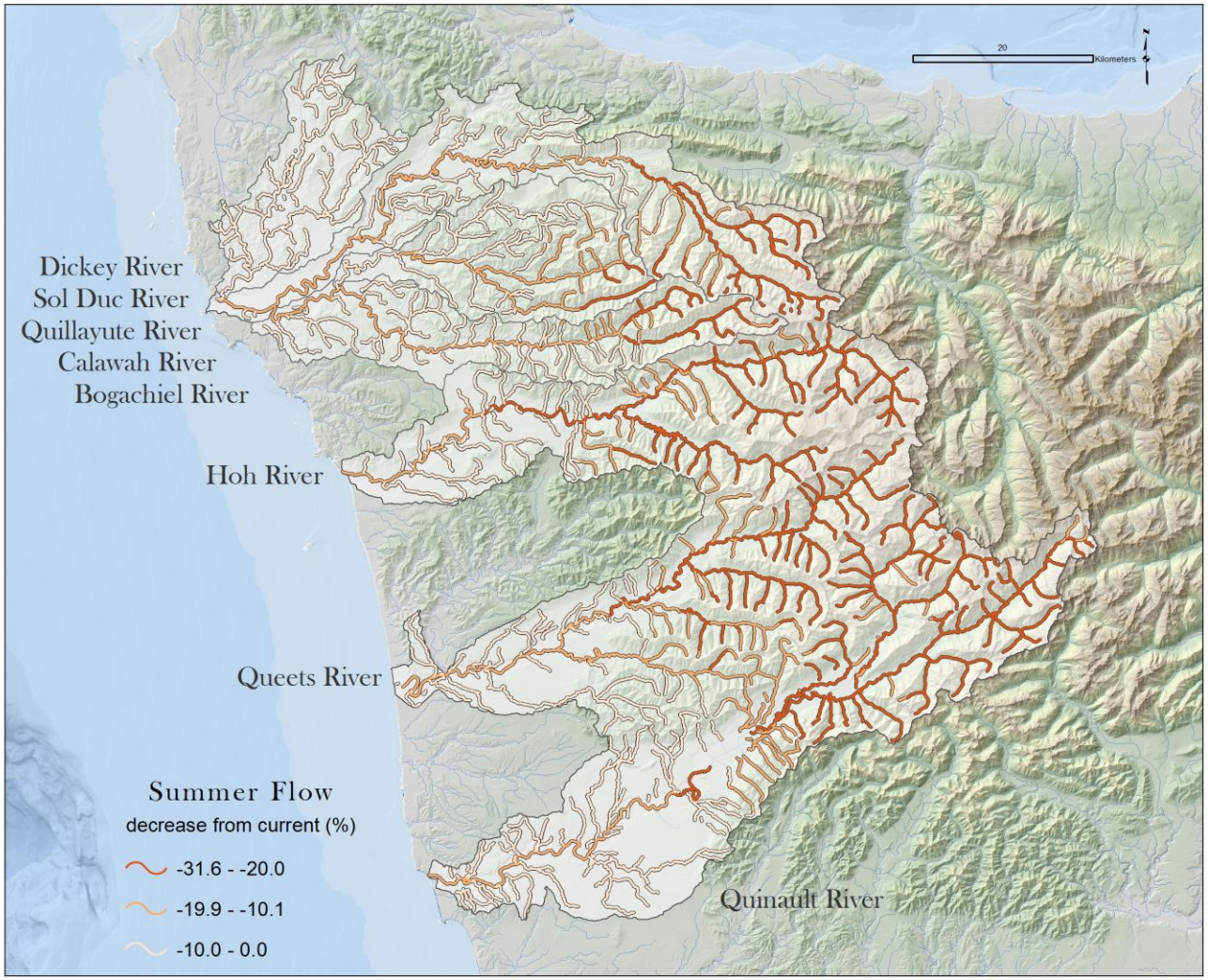
- decreased food supplies
- decreased growth and survival in marine environment


from: van den Berge
and Gross 1984
Nest depth (cm)
25
20
15
10
5
0
35
45
55
65
75
Female size (cm)
y = -10.44 + 0.411x
r = 0.778
N = 42 P < 0.001

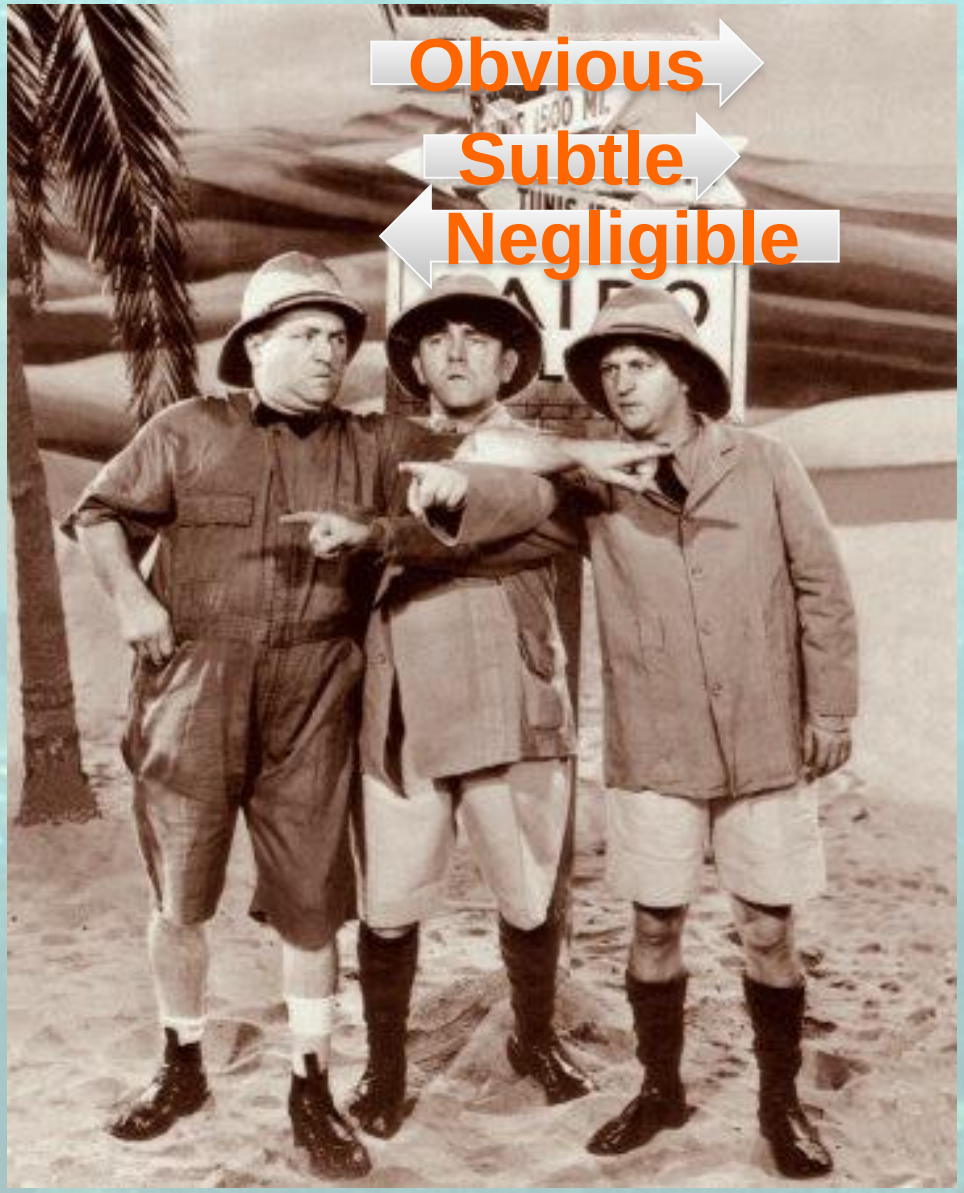
Increase in Winter Flows (%)



Decrease in Summer Flows (%)

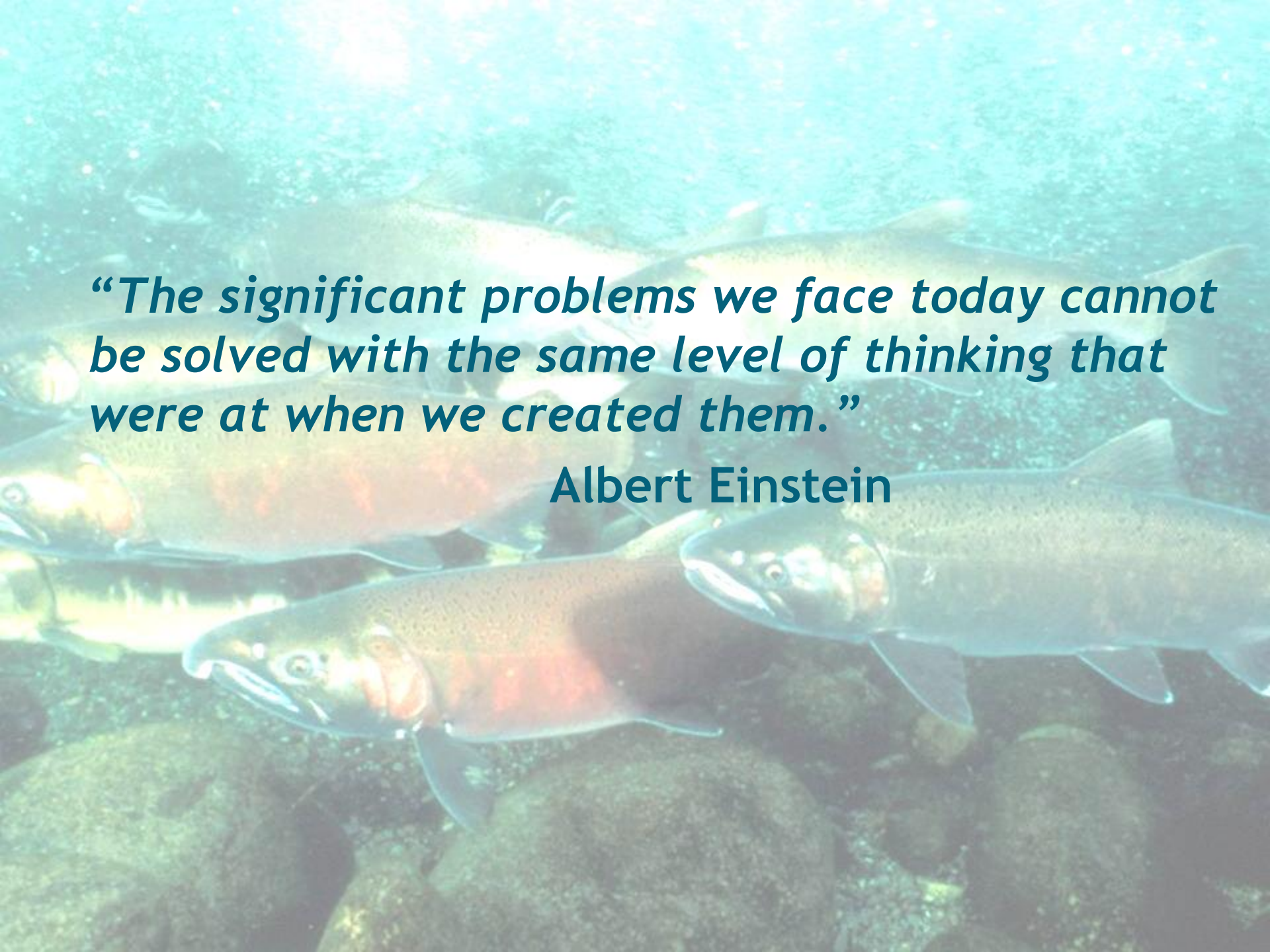


Effects of Climate Change



“There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.”

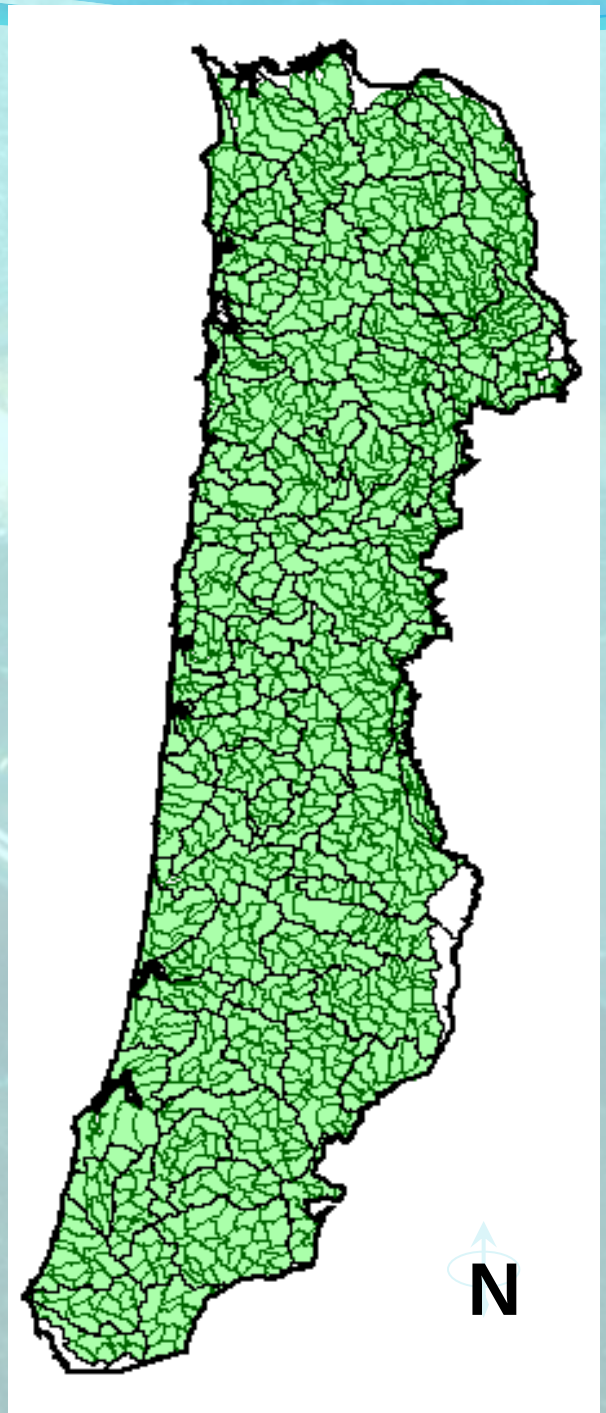
Donald Rumsfeld

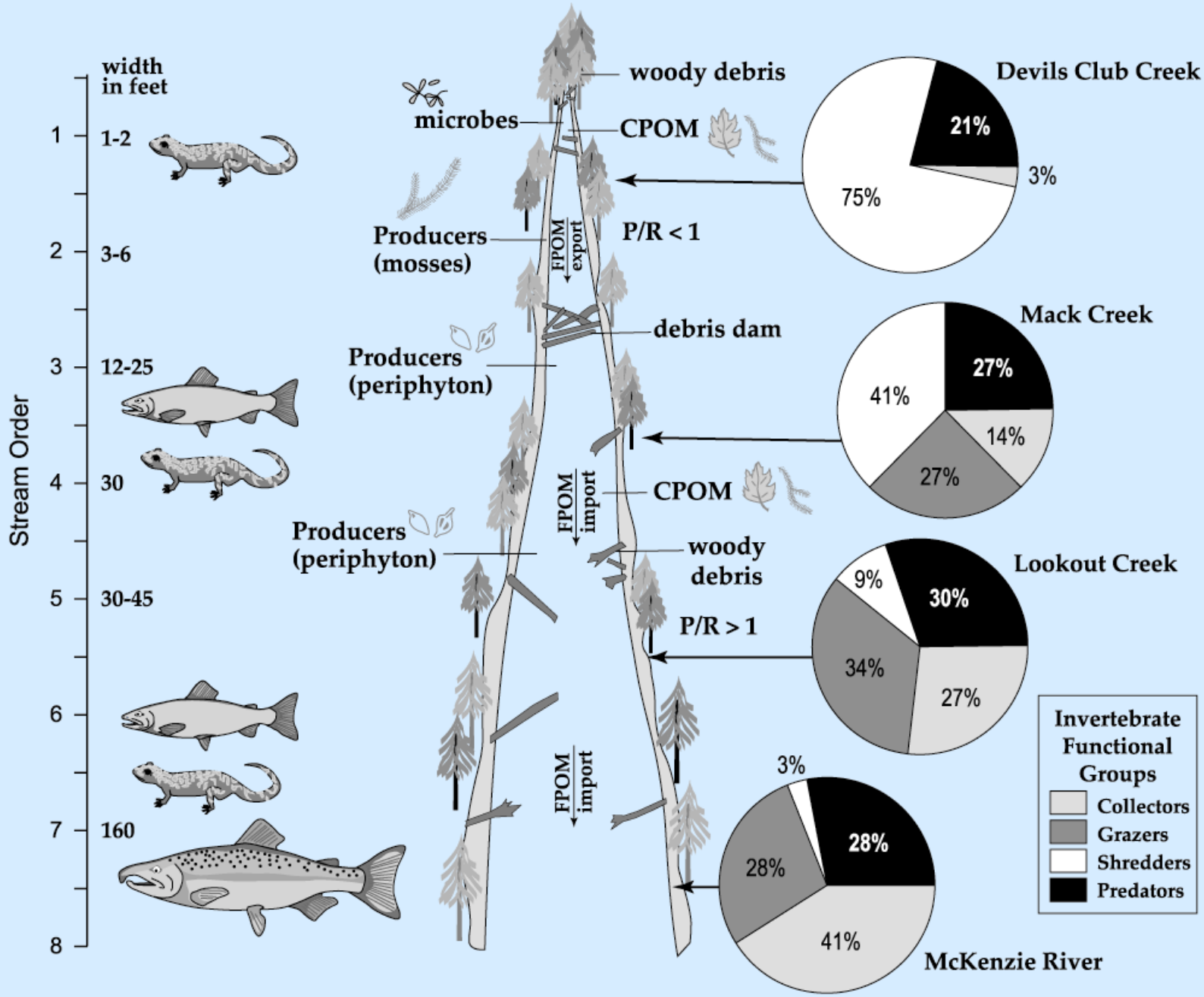


“The significant problems we face today cannot be solved with the same level of thinking that were at when we created them.”

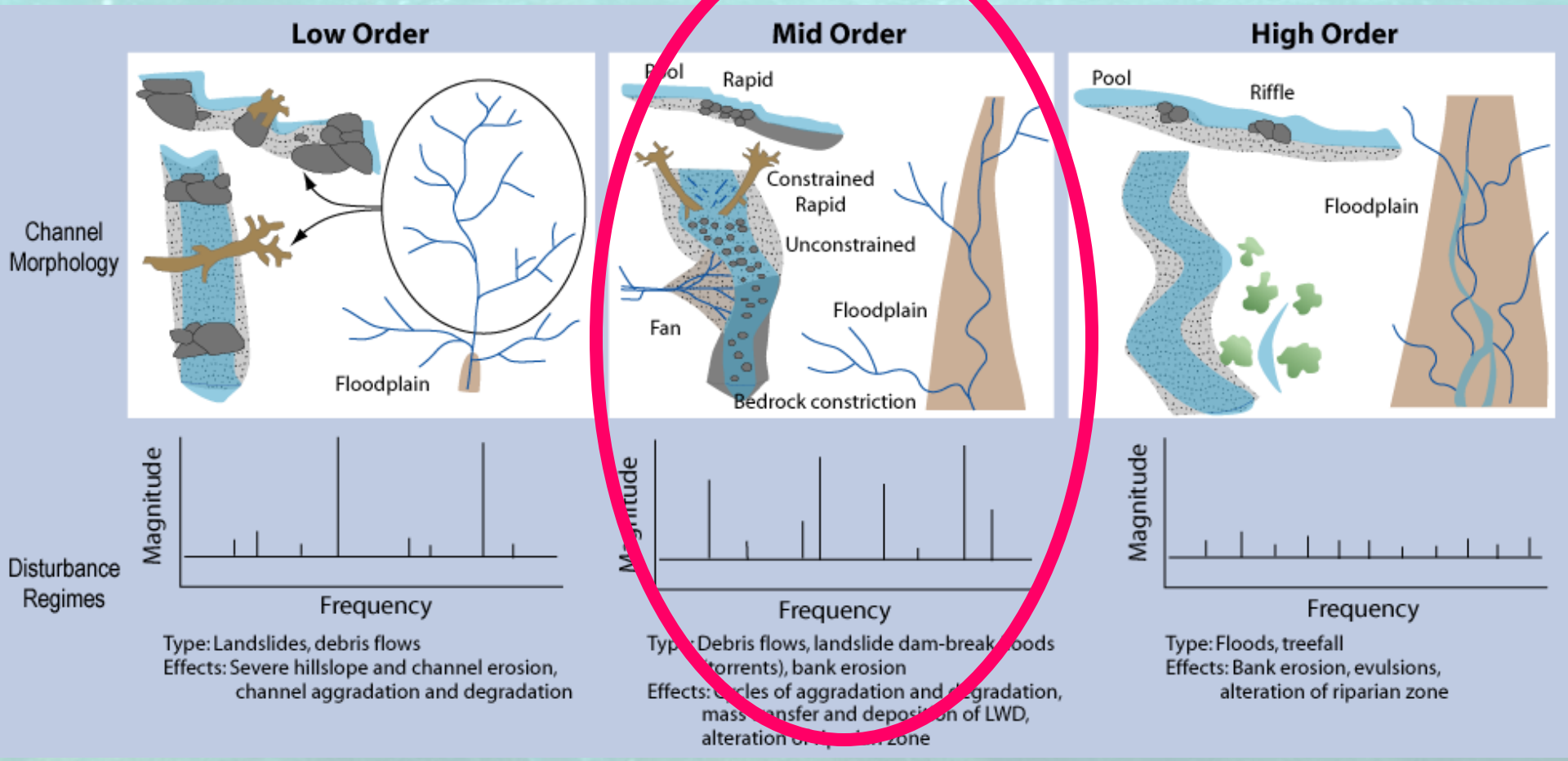
Albert Einstein

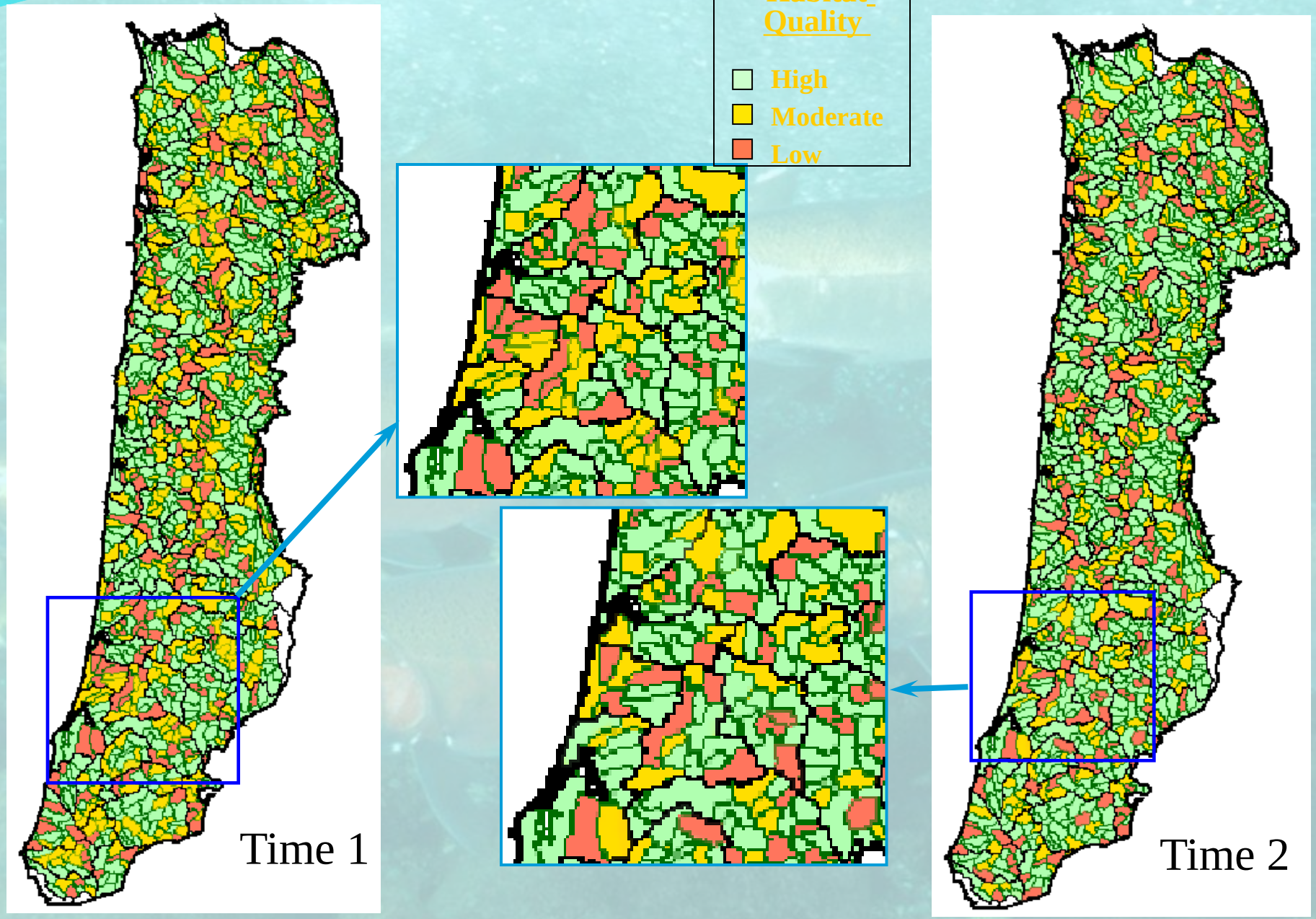
The Aquatic View of Large-scale Habitat Conditions?



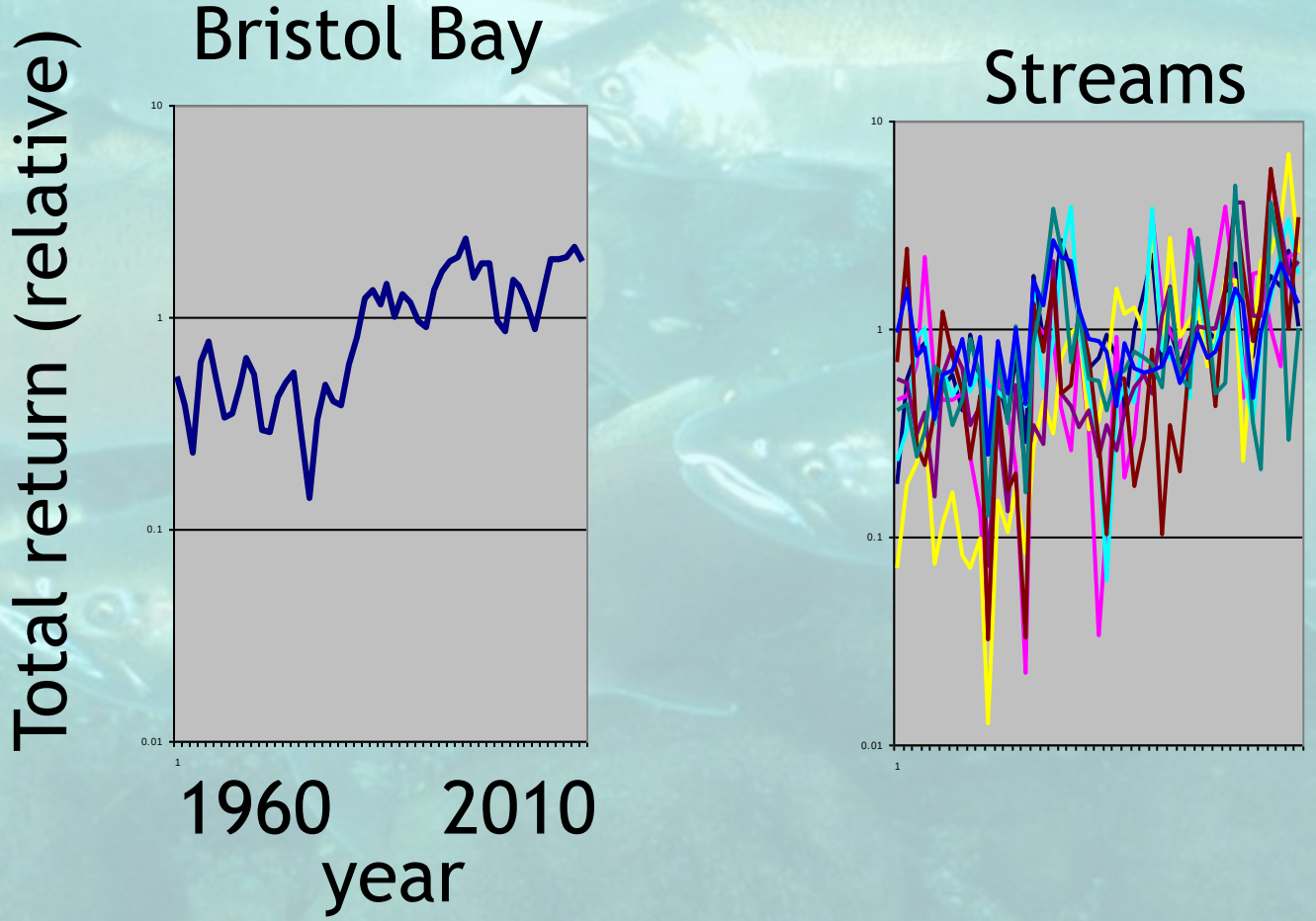


FPOM is fine particulate organic matter; CPOM is coarse particulate organic matter; P/R is the production/respiration


Low Order
Mid Order
High Order
Channel Morphology
Floodplain
Pool
Rapid
Constrained Rapid
Unconstrained
Floodplain
Fan
Bedrock constriction
Pool
Riffle
Floodplain
Disturbance Regimes
Magnitude
Frequency
Type: Landslides, debris flows
Effects: Severe hillslope and channel erosion, channel aggradation and degradation
Frequency
Effects: mass transfer and deposition of LWD,
Magnitude
Frequency
Type: Floods, treefall
Effects: Bank erosion, evulsions, alteration of riparian zone


Habitat_ Quality
High
Moderate
Low
Time 1
Time 2

Salmon returns to Bristol Bay, AK



From: D. Schindler

SATURDAY

The Oregonian

THE FLOOD OF '96

WRATH AND AFTERMATH

PORTLAND

The Willamette River crests, and OMSI and the harbor wall escape the worst

THE SUBURBS

Clackamas and Washington counties see major trouble along the Tualatin River

THE REGION

Some Oregon evacuees return, but problems plague Southwest Washington

TODAY'S DEVELOPMENTS

Floodwaters may stage slow retreat

The Tualatin River basin becomes a major concern

By STEVE MAYES and ERIN HOOVER

The Sunday Oregonian

NOVEMBER 3, 2002 — 2001 PULITZER PRIZE WINNER FOR PUBLIC SERVICE ★ FIRST EDITION — PORTLAND, OREGON $1.50

First of a three-part series

THE MONSTER IN THE WOODS

Decades of misguided forest management policy set the stage for an inferno that challenged the old rules of fighting wildfires

The Florence fire surges through the Siskiyou National Forest in Southwest Oregon this

ANALYSIS

Hopefuls offer clear difference to voters

The philosophies of the candidates for governor diverge on issues from taxes to abortion

By JEFF MAPES
THE OREGONIAN

VOTE 2002

KULONGOSKI
Don't borrow to balance budget

MANNIX

For the first time in 12 years, Oregon has a competitive race for governor — and this time it isn't hard to find big differences in the candidates.

In 1990, when Democrat Barbara Roberts won an upset victory over Republican Dave Frohnmayer, many voters complained they had trouble distinguishing between the two on issues. Both were veteran state officeholders who campaigned in favor of a sales tax and against the Measure 5 property tax limit and supported abortion rights.

No such problem this year.

Democrat Ted Kulongoski and Republican Kevin Mannix noisily disagree on taxes, spending, the economy, education, the environment, abortion, crime, government regulation and who has the best

Adaptations of Salmonids to Dynamic Environments

- **Straying of adults**
- **High fecundity**
- **Multiple life histories**
- **Mobility of juveniles**

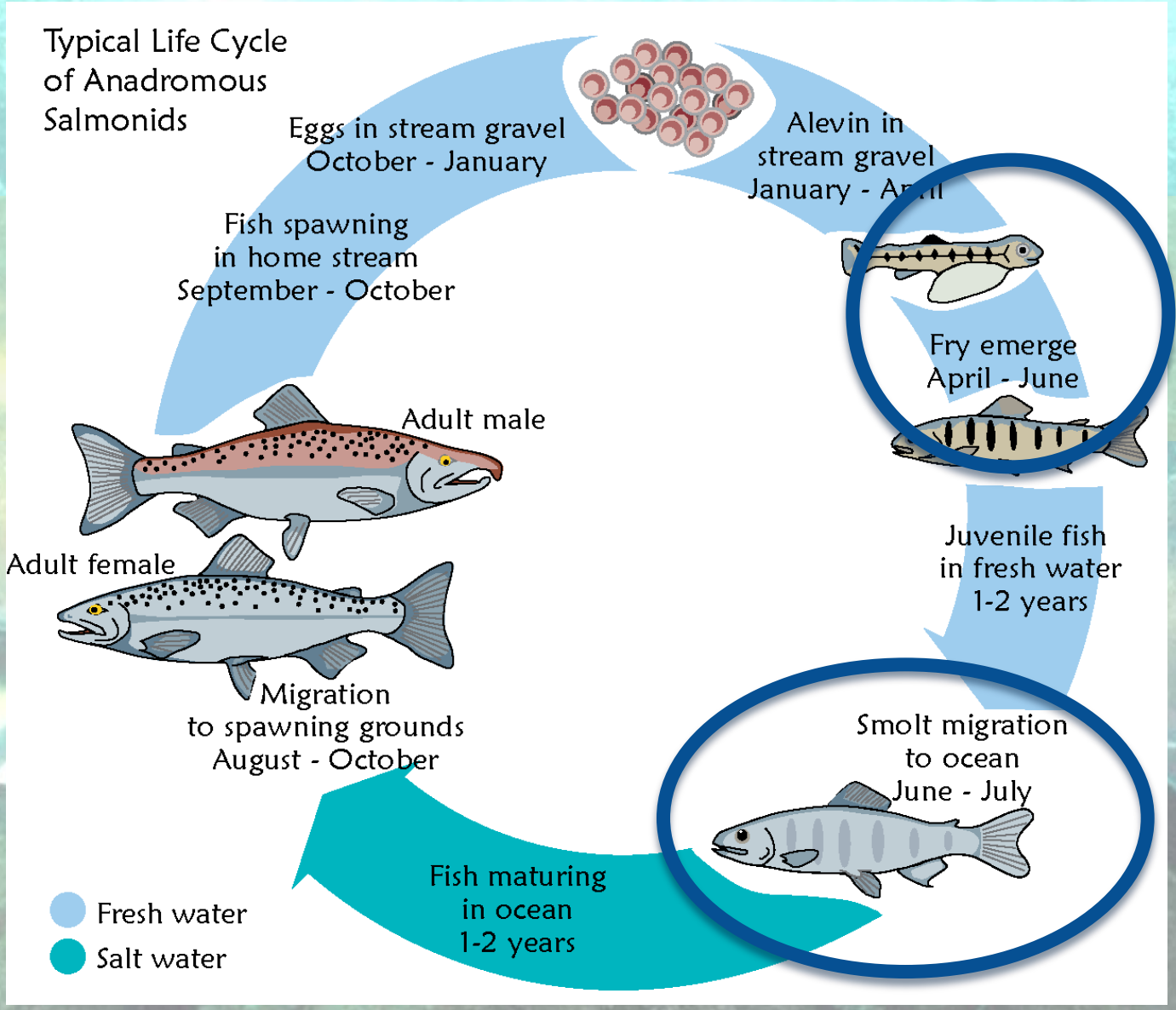
Sometimes High Intensity Trauma Happens

L.M. Reid

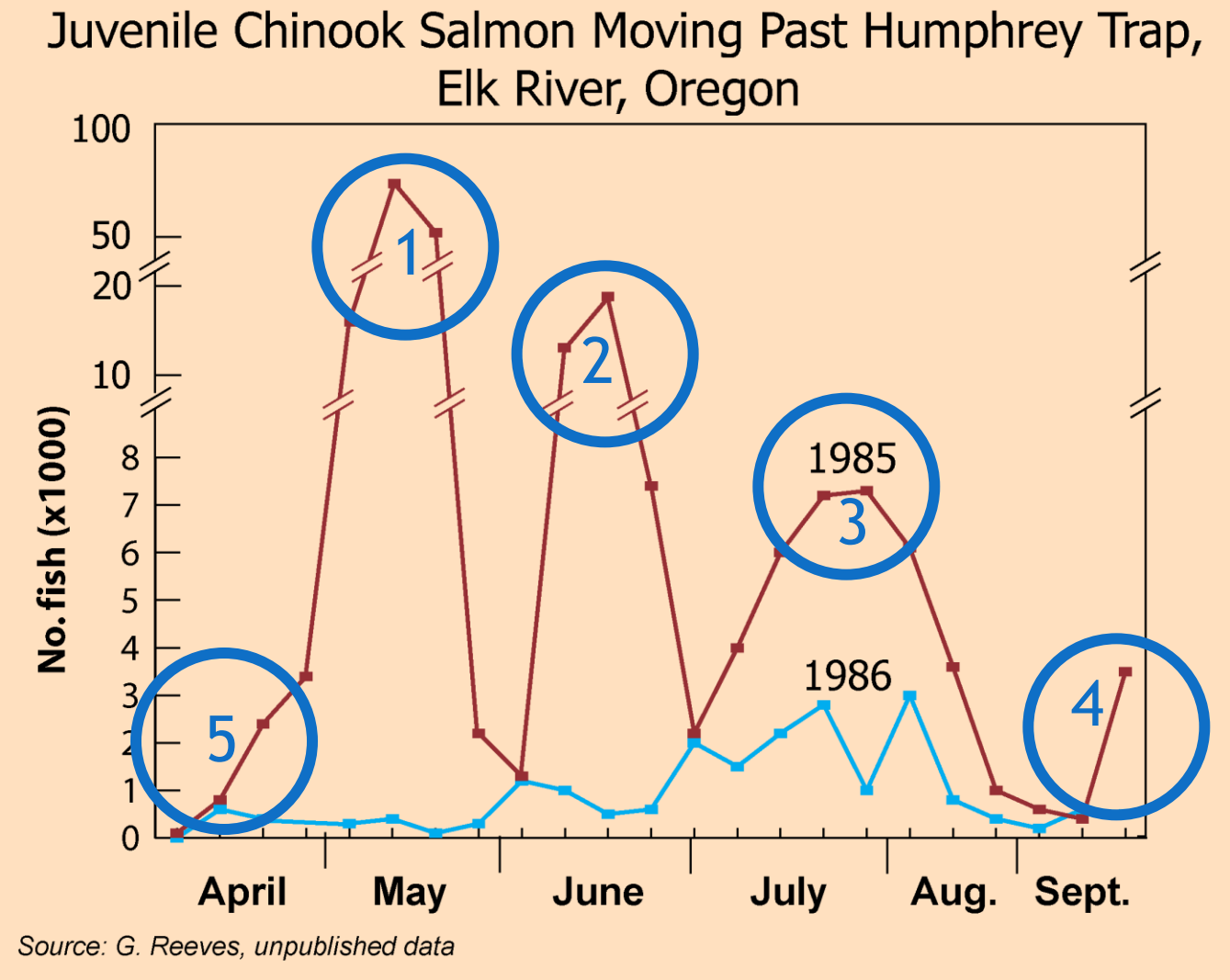
Percent of Life-History Type in Returning Populations of Sockeye on the Copper River Delta (1987 -1997)

Age	Mean	Range
2		
0.1	0.09	0.03 - 0.3
3		
0.2	6.2	1.9 - 12.4
1.1	2.6	0.9 - 7.9
4		
0.3	7.1	2.7 - 18.5
1.2	39.8	27.9 - 56.7
2.1	0.03	0.0 - 0.14
5		
0.4	0.02	0.0 - 0.08
1.3	45.3	33.2 - 55.0
2.2	0.39	0.0 -3.2
6		
1.4	0.07	0.0 - 0.03
2.3	0.4	0.0 - 1.9

From: Powers et al. 2007


Typical Life Cycle
of Anadromous
Salmonids
Eggs in stream gravel
October - January
Alevin in
stream gravel
January - April
Fry emerge
April - June
Juvenile fish
in fresh water
1-2 years
Smolt migration
to ocean
June - July
Fish maturing
in ocean
1-2 years
Migration
to spawning grounds
August - October
Adult female
Adult male
Fish spawning
in home stream
September - October
Fresh water
Salt water

Life-history Variation



Moving Forward

- Hydrograph and temperature regimes

Moving Forward

- Hydrograph and temperature regimes
- Timing of selected life-history events

Moving Forward

- Hydrograph and temperature regimes
- Timing of selected life-history events
- Focus on life-history diversity & not just abundance

Moving Forward

- Hydrograph and temperature regimes
- Timing of selected life-history events
- Focus on life-history diversity & not just abundance
- Challenge assumptions & beliefs as develop adaptation & mitigation

Life-history Cycle of a '1-year Aquatic Insect' on the Copper River Delta

Adults **Eggs** **Early Instars** **Larvae/ Pupae**

June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May

Birds: Nesting/ fledging

Leaf drop

Life-history Cycle of a '1-year Aquatic Insect' on the Copper River Delta

Adults **Eggs** **Early Instars** **Larvae/ Pupae**

June July Aug. Sept. Oct. Nov Dec. Jan. Feb. Mar. Apr . May

Birds: Nesting/ fledging

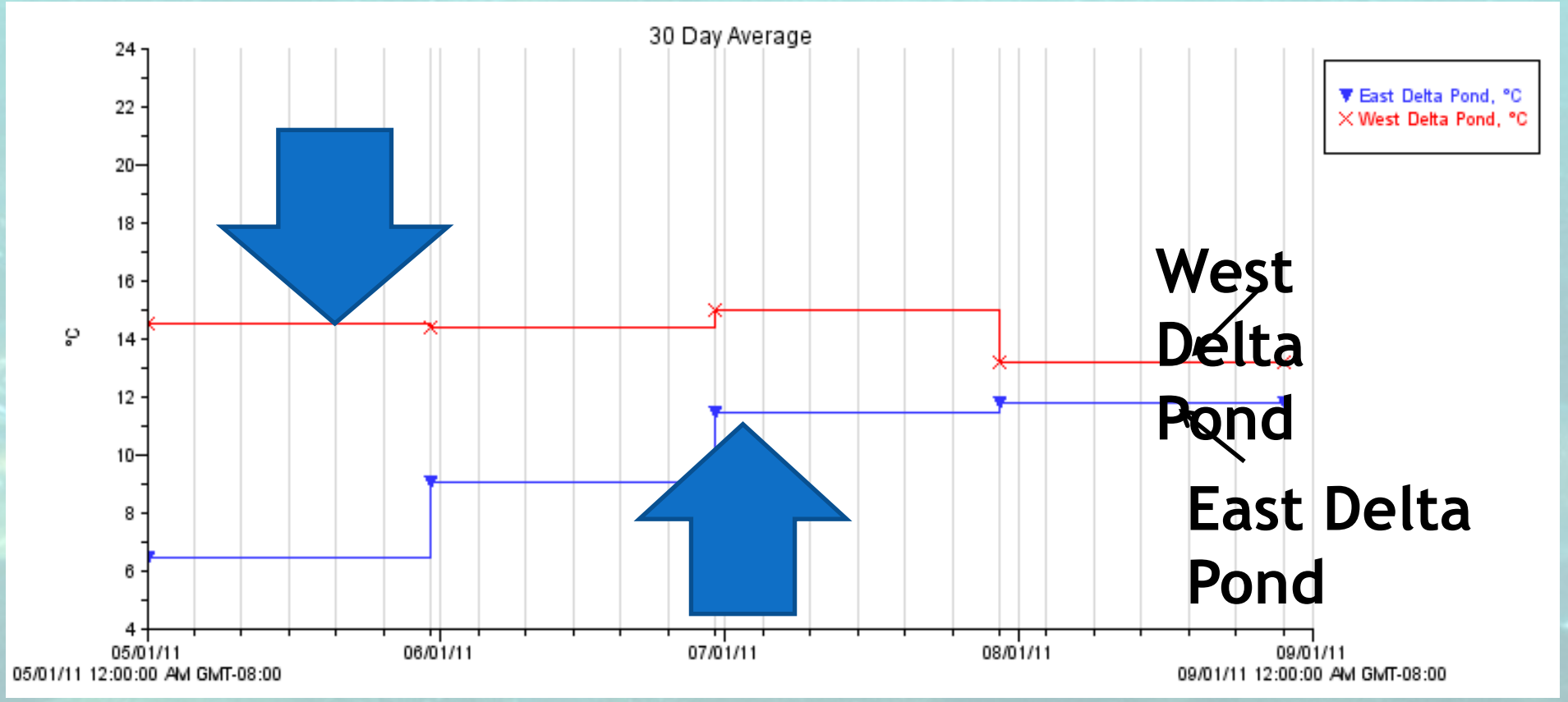
Leaf drop

Insect, with 1° C change in water temp.

Eggs **Early Instars** **Larvae/ Pupae** **Adult s**

June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar? Apr. May?

Thermograph



Oncorhynchus mykiss

Photo: J. McMillan

Steelhead

Anadromous life history

Photo: J. McMillan

Rainbow Trout

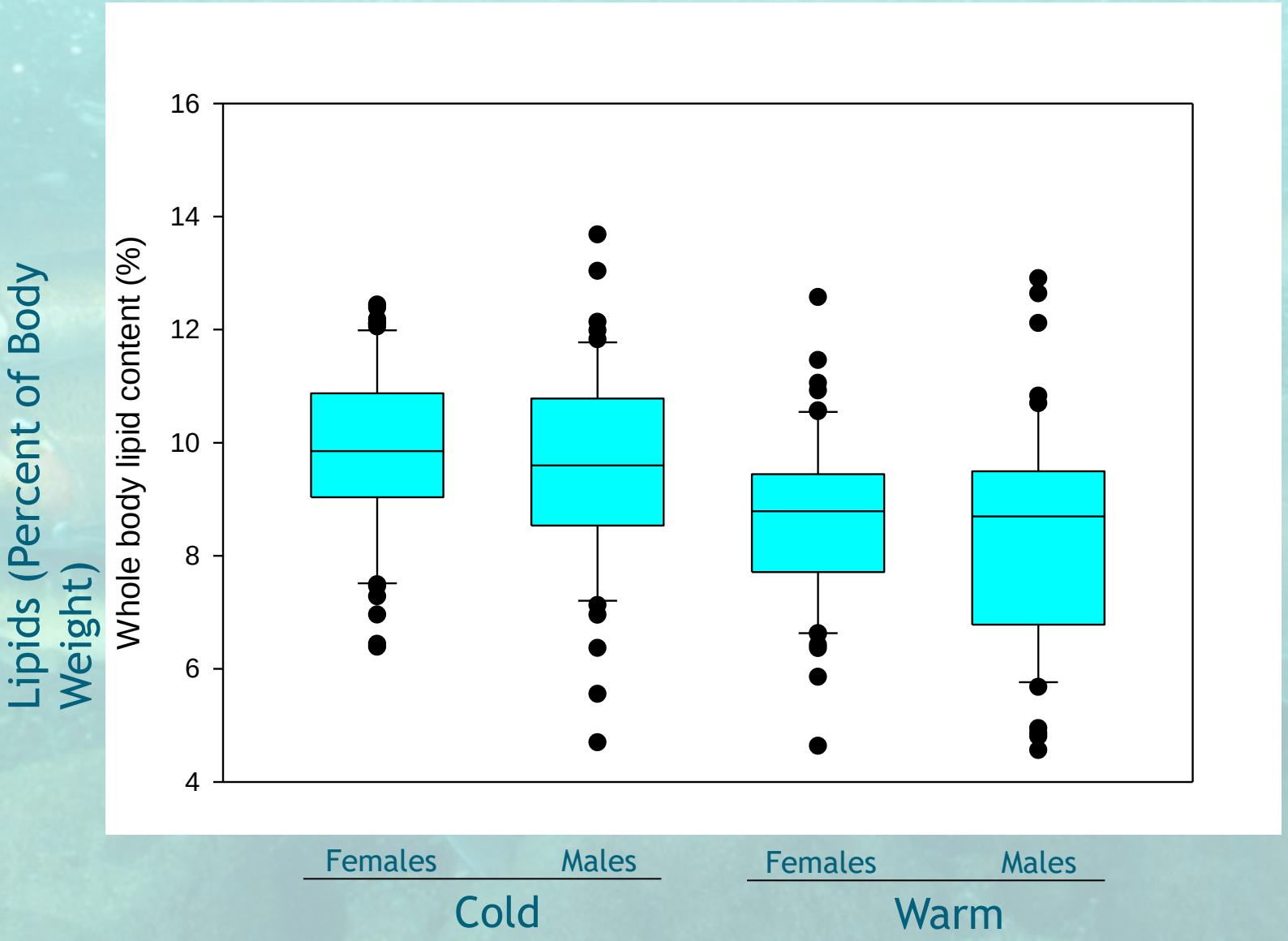
Resident life history

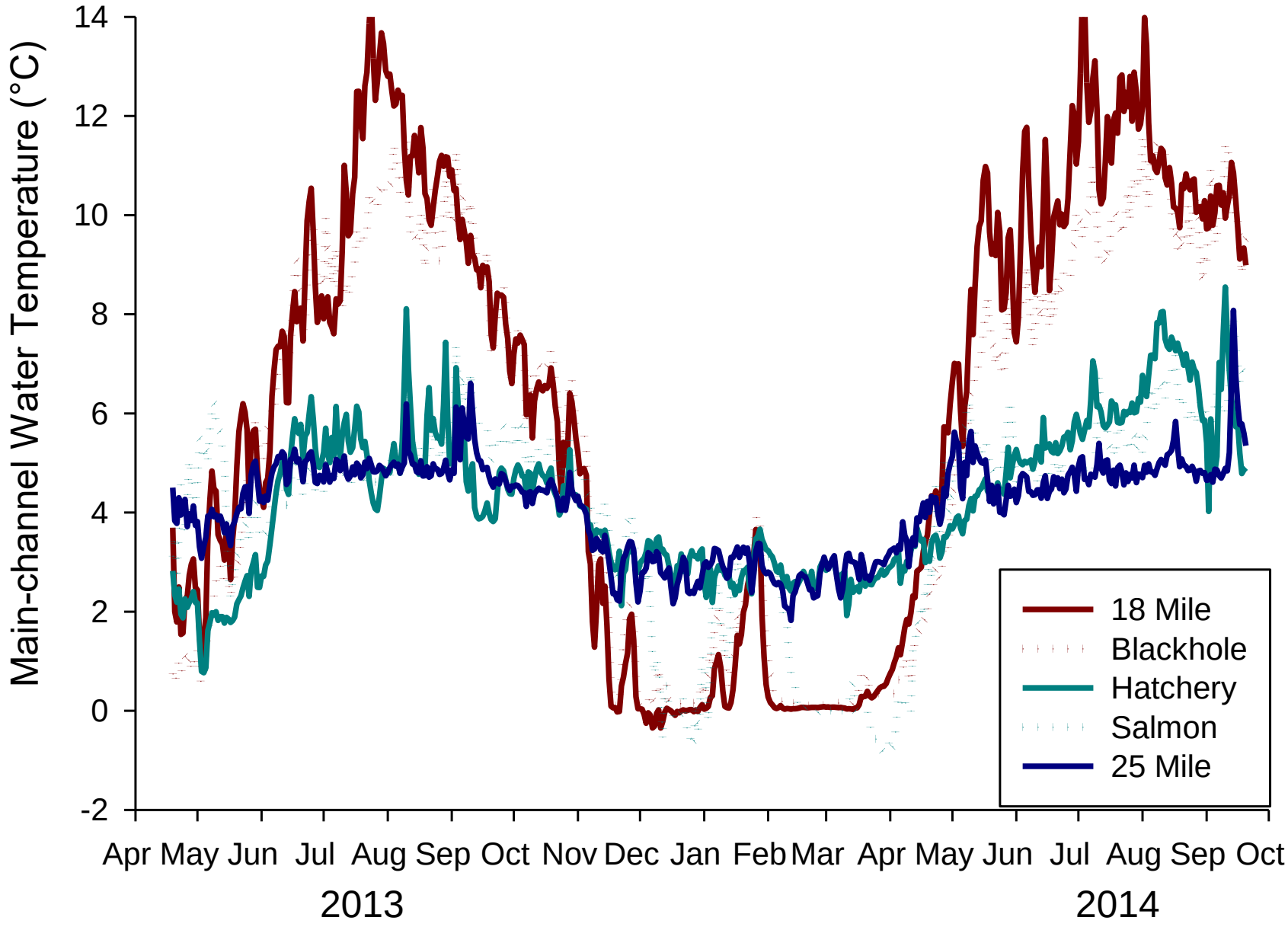
Determination of Life History

Smolting fish

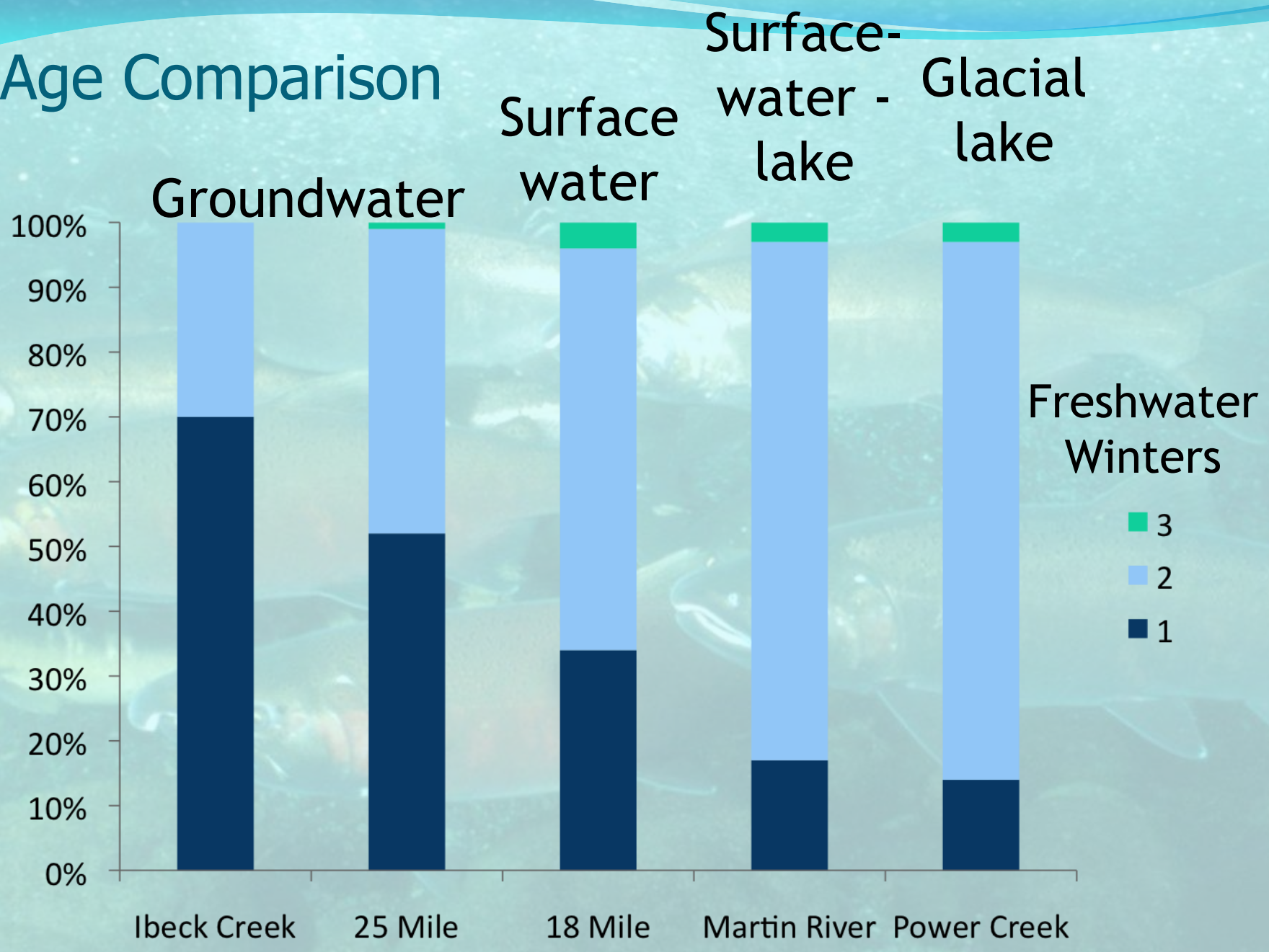
Maturing fish

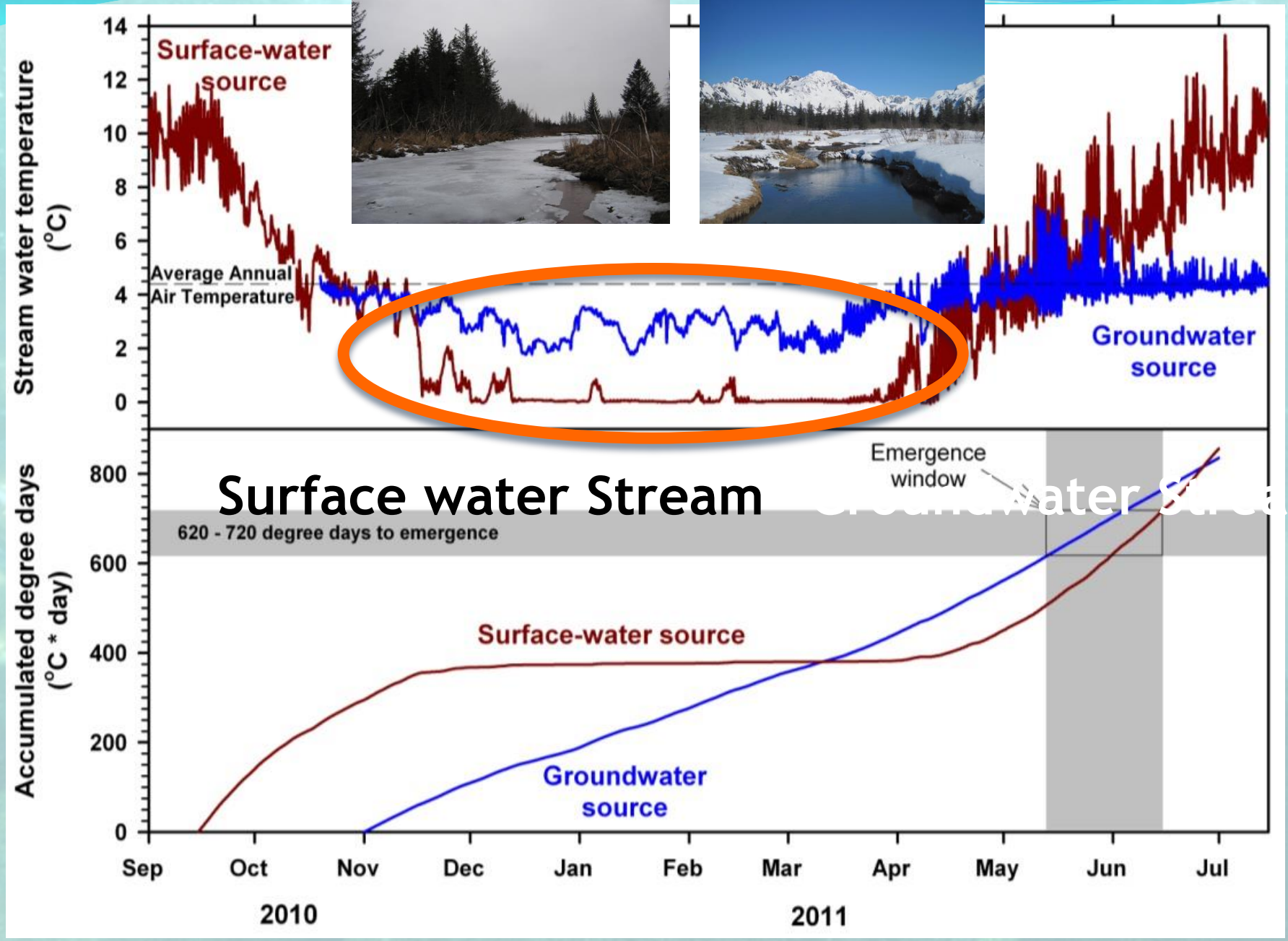
Energy storage & Water temperatures




Main-channel Water Temperature (°C)
14
12
10
8
6
4
2
0
-2
Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
2013
2014
18 Mile
Blackhole
Hatchery
Salmon
25 Mile

Age Comparison




Surface-water source
Average Annual Air Temperature
Groundwater source
Stream water temperature (°C)
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8
6
4
2
0
Surface water Stream
Emergence window
620 - 720 degree days to emergence
Surface-water source
Groundwater source
Accumulated degree days (°C * day)
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Nov
Dec
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Feb
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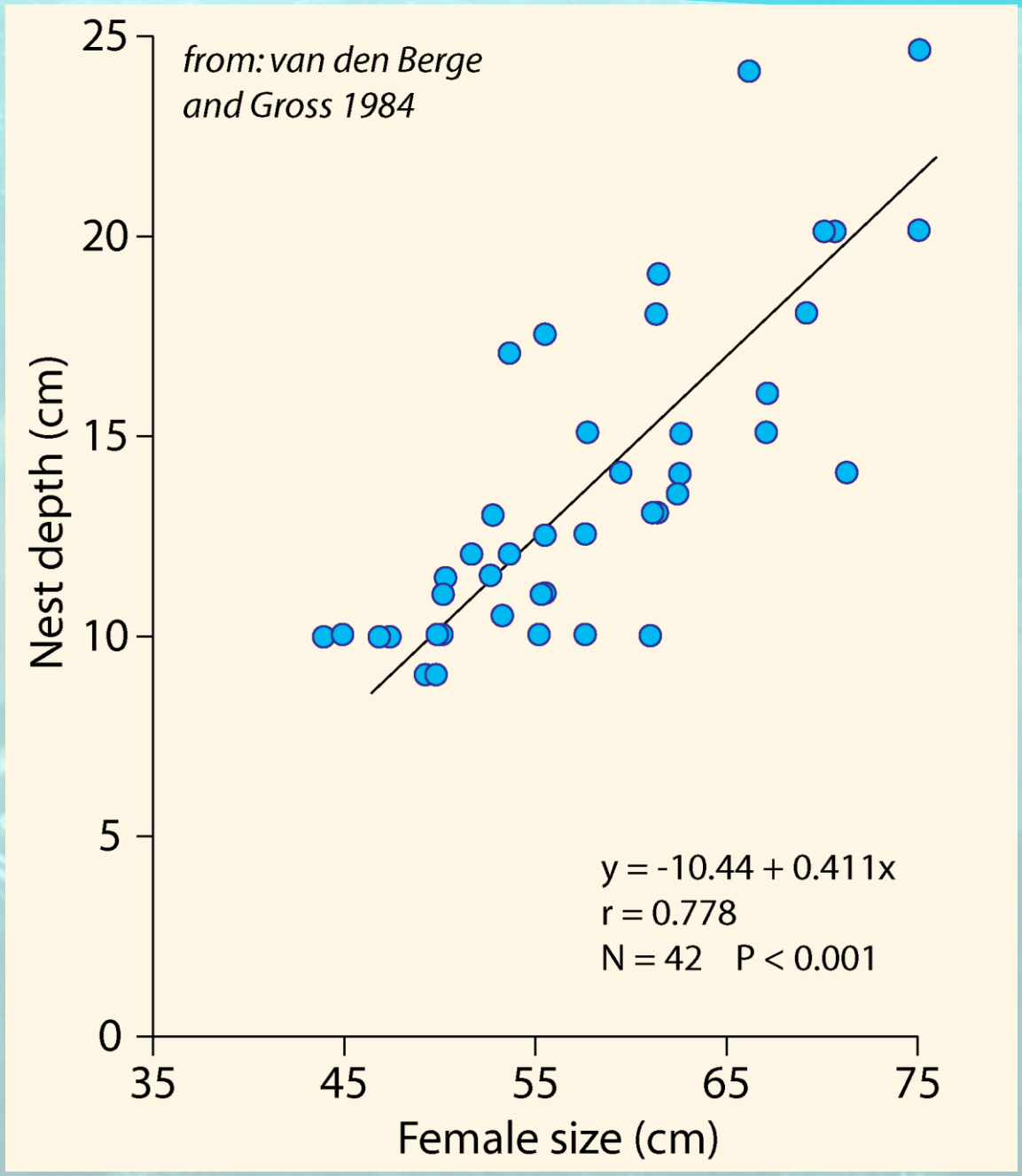
from: van den Berge
and Gross 1984
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0
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75
Female size (cm)
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r = 0.778
N = 42 P < 0.001