Variations in size, growth and survival of hatchery Columbia River Chinook salmon in the Northern California Current

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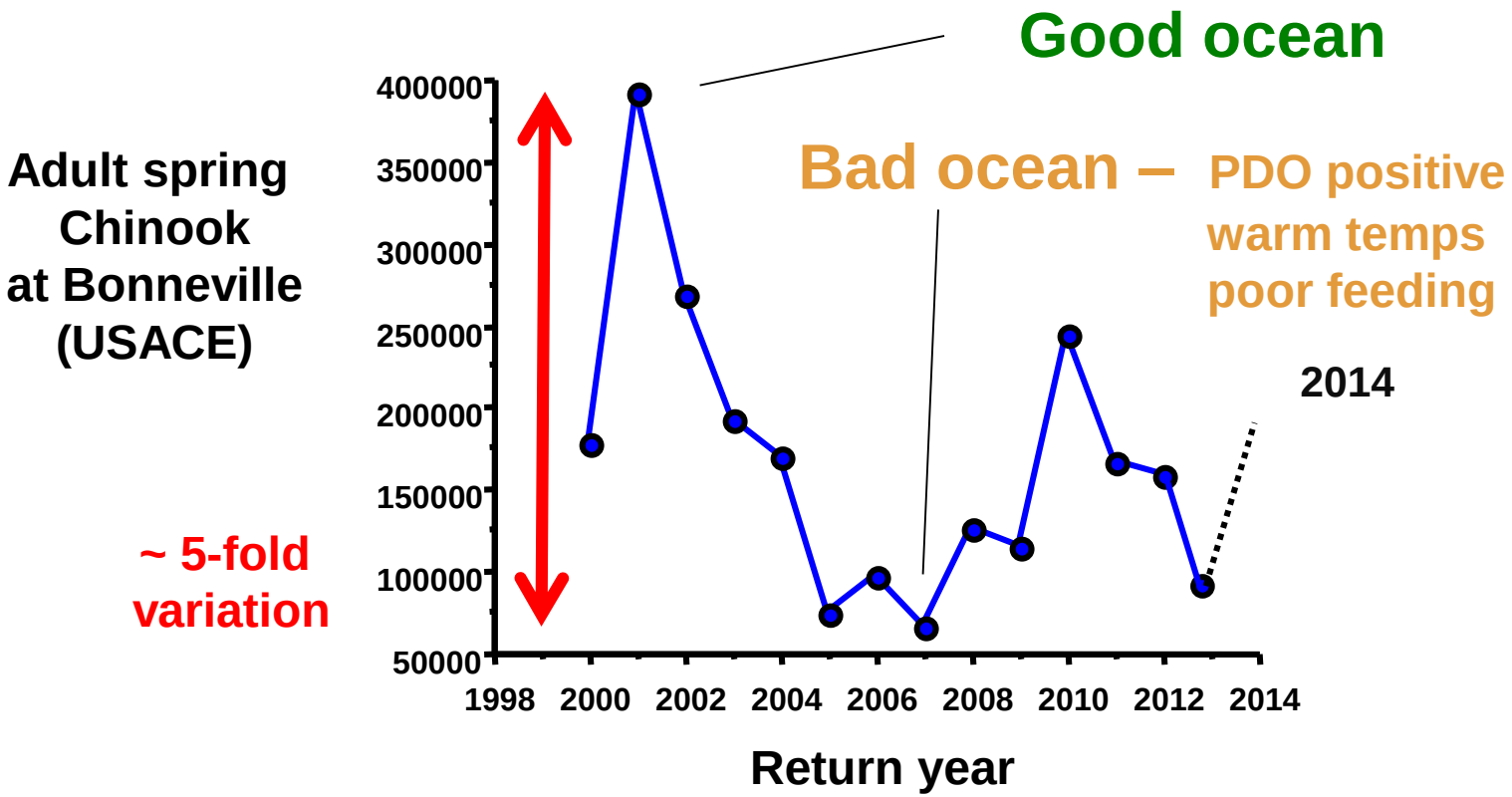
Abundance of Columbia River Spring Chinook salmon adults varies inter-annually

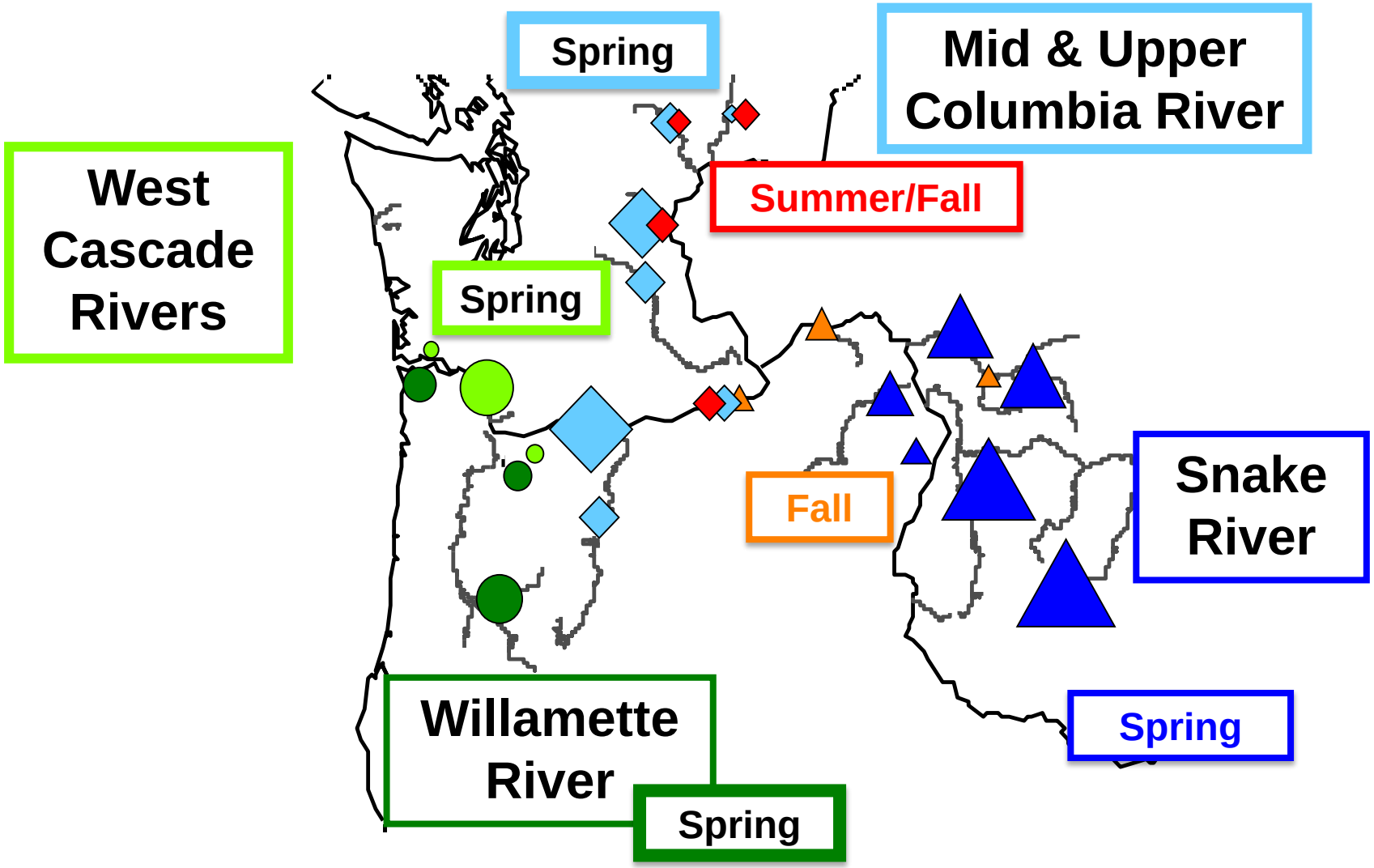
Smolt production relatively constant during this period



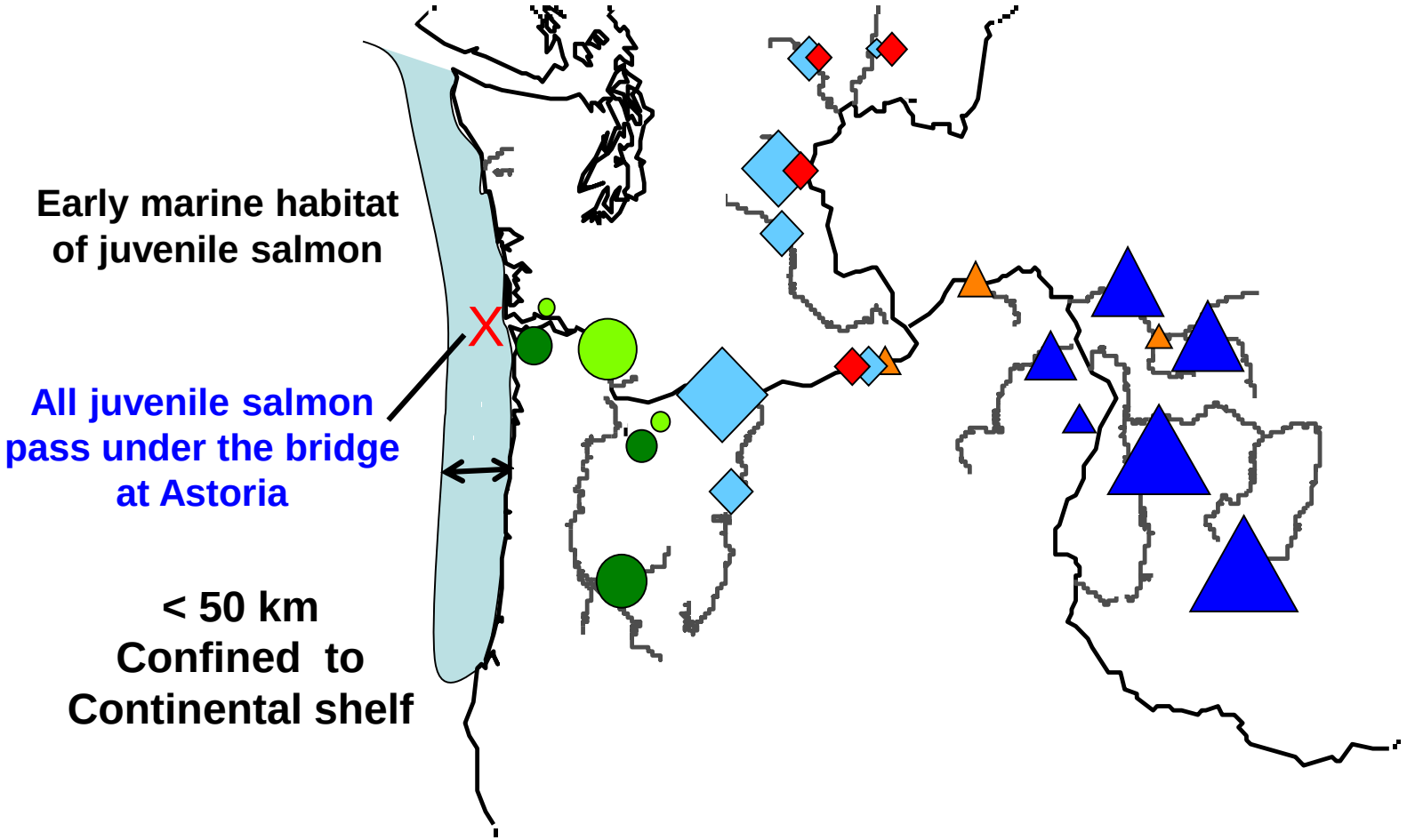
There is an emerging consensus that ocean conditions limit adult salmon abundance

Yearling Chinook salmon Columbia River hatchery production ~ 33 million/year

6 major stocks



Parr from different stocks are widely spaced geographically; Potential for interactions increase as fish smolt and migrate to the ocean



Goal: generate discussion on interactions between ocean resources, smolt abundance and smolt size on a stock-specific basis.

Outline:

marine growth and survival

varying size-biased survival of hatchery smolts

size and marine growth

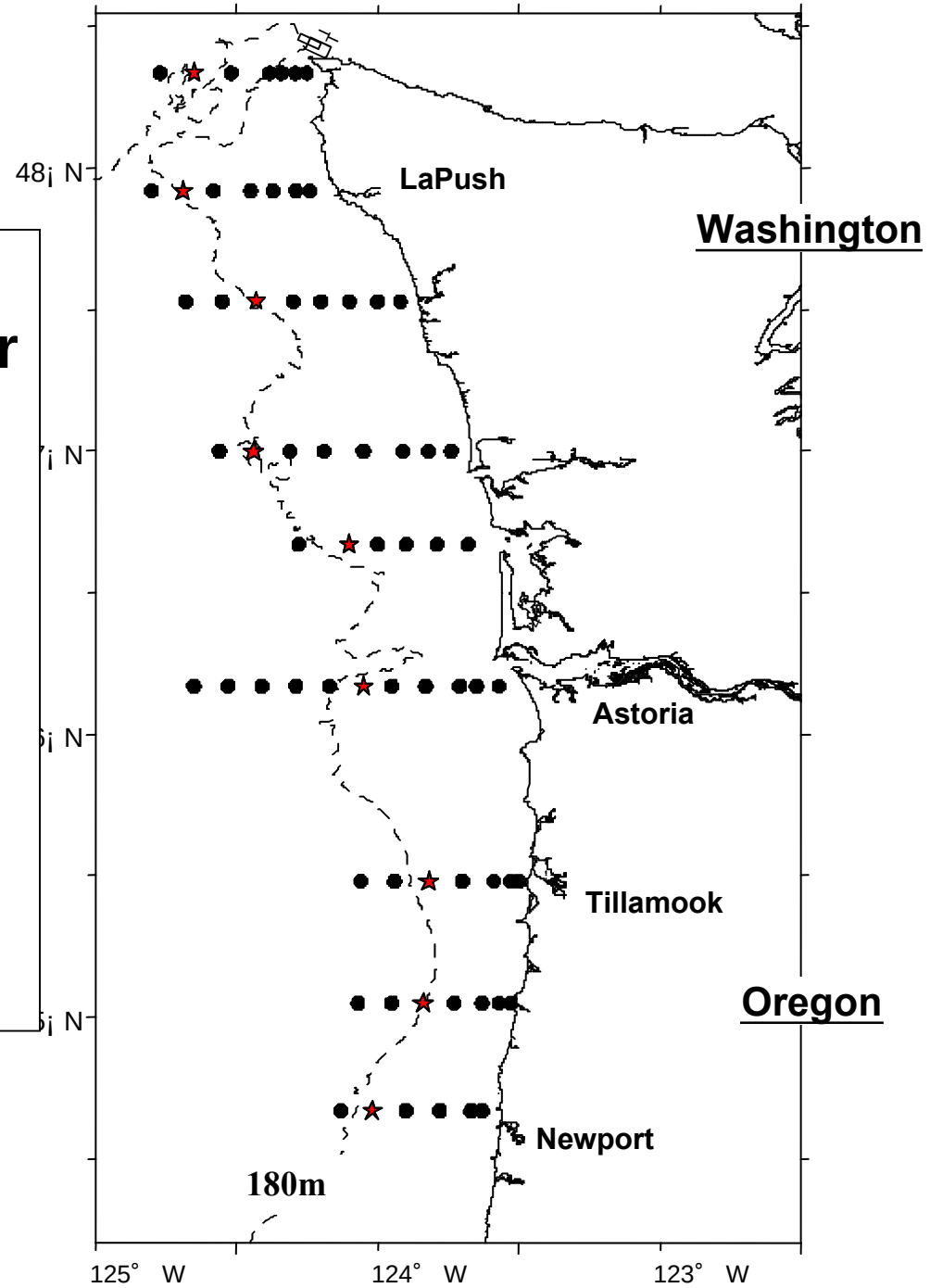
Data: NOAA Juvenile Salmon Ocean Survey, 1998 - present

NOAA Salmon Survey
May, June and September starting in 1998

2013, 2014 June only

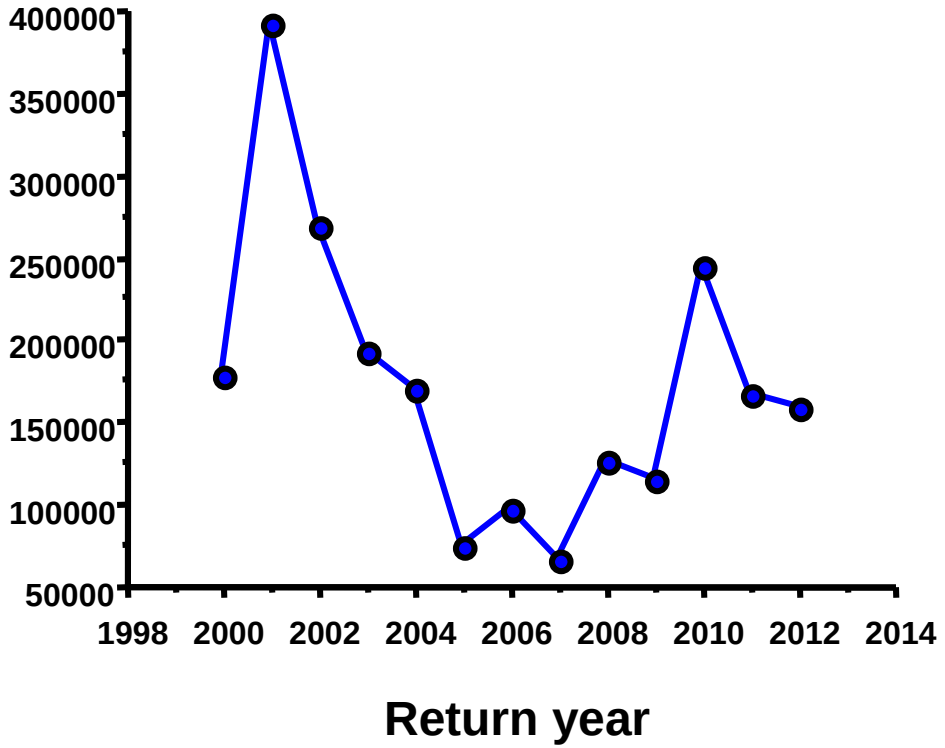
This talk:
May and June data

[Yearling Columbia River Chinook salmon]

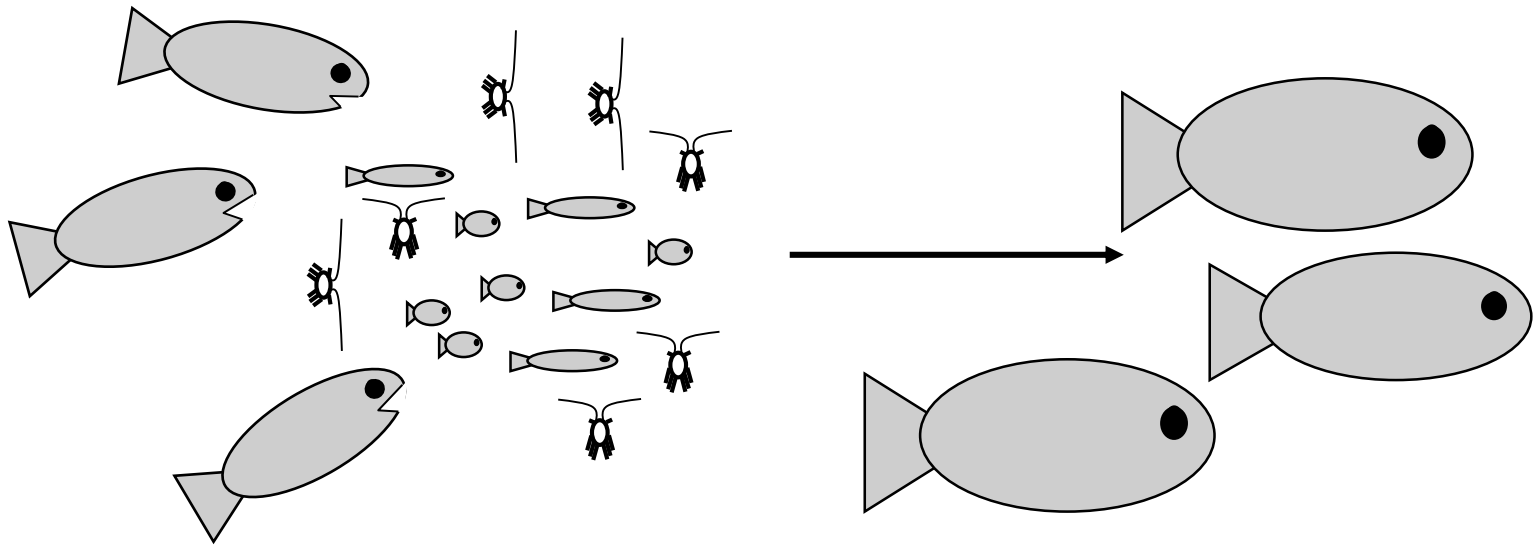


Why does marine survival vary?

Adult spring Chinook at Bonneville

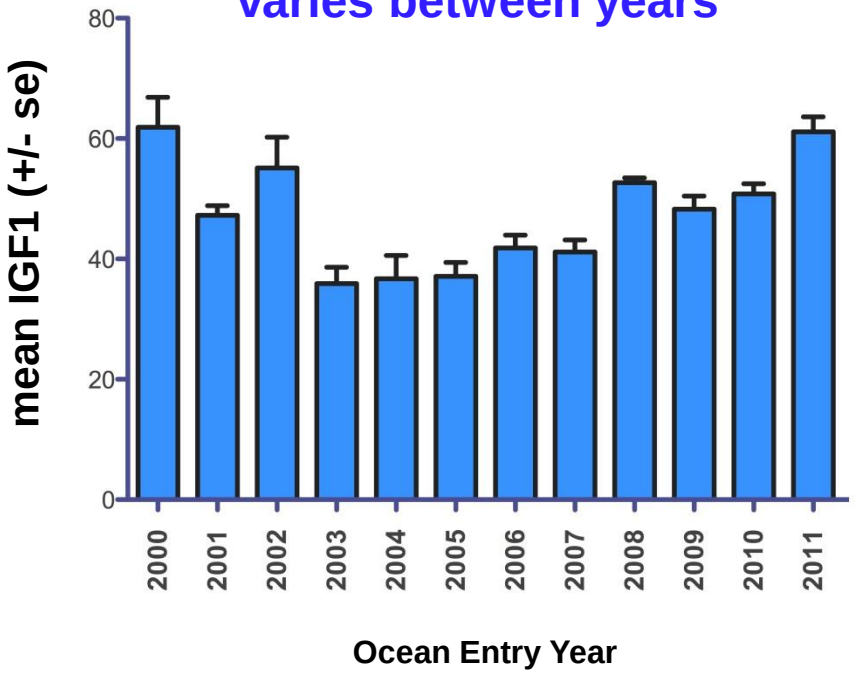


What do juvenile salmon do in the ocean?
Eat & Grow

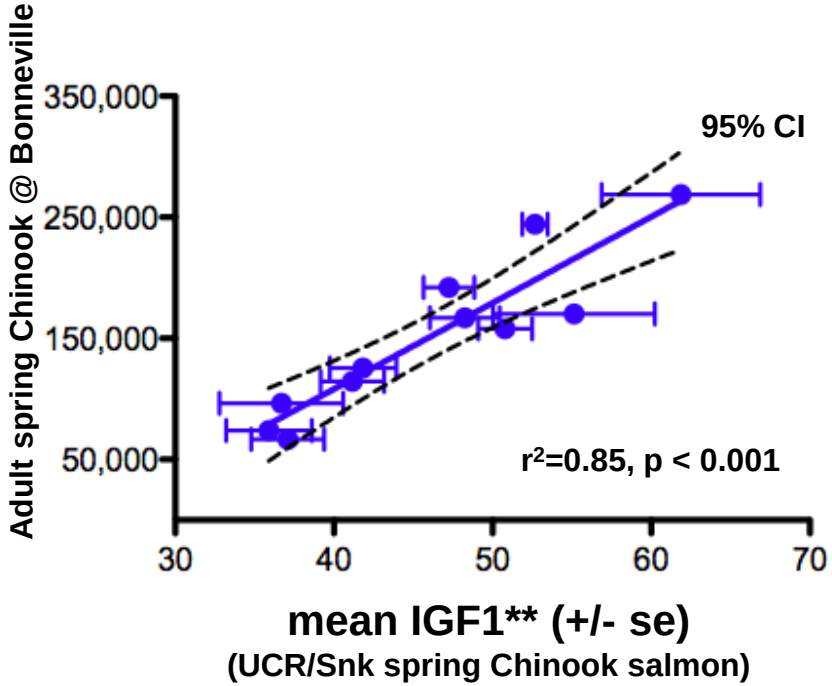


Marine growth* varies between years, growth is related to survival (Columbia River spring Chinook Salmon)

Growth* of UCR/SnkR Spring Chinook varies between years



Growth is related to adult return



*Growth in June ~ 2 - 6 weeks post-ocean entry
** IGF1 is a hormone that reflects growth rate

Growth varies

=> Food is limited in some years

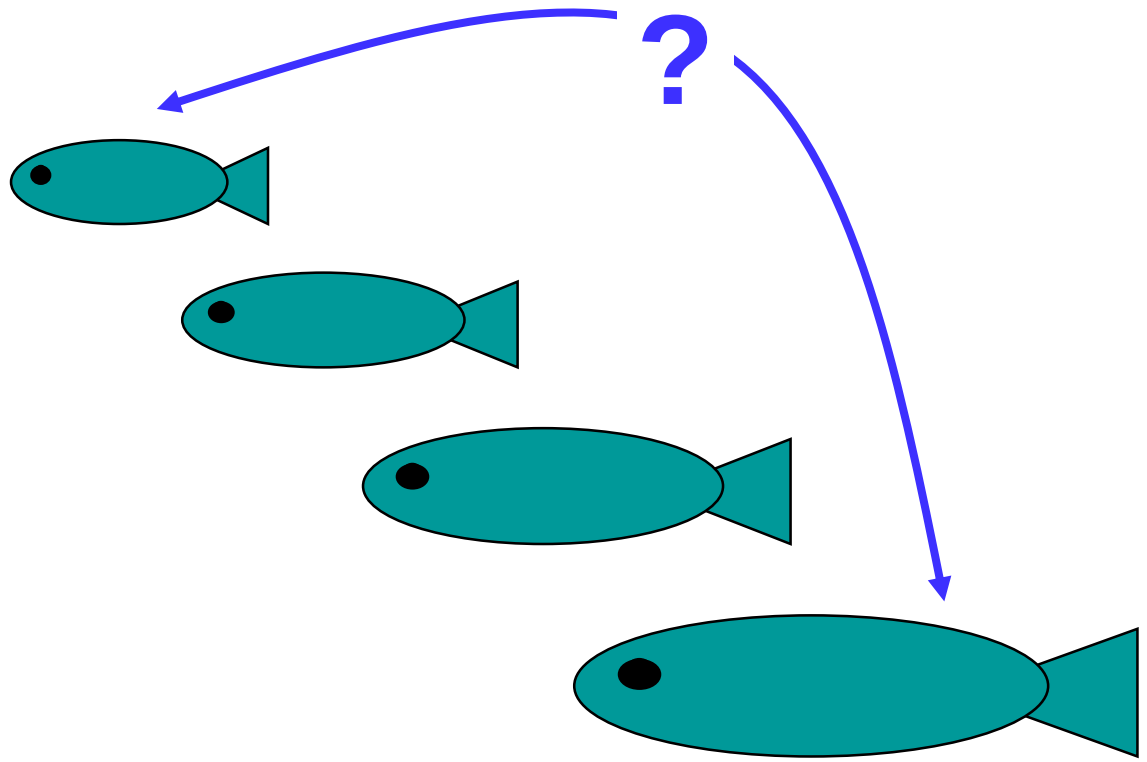
If food is limited

=> there is competition for food

Change focus from the ocean to hatcheries

Most (all?) hatcheries have size @ release targets

How does smolt size at release relate to marine survival?



1. Does size of smolts relate to survival?
2. Does this vary between years (ocean conditions)?

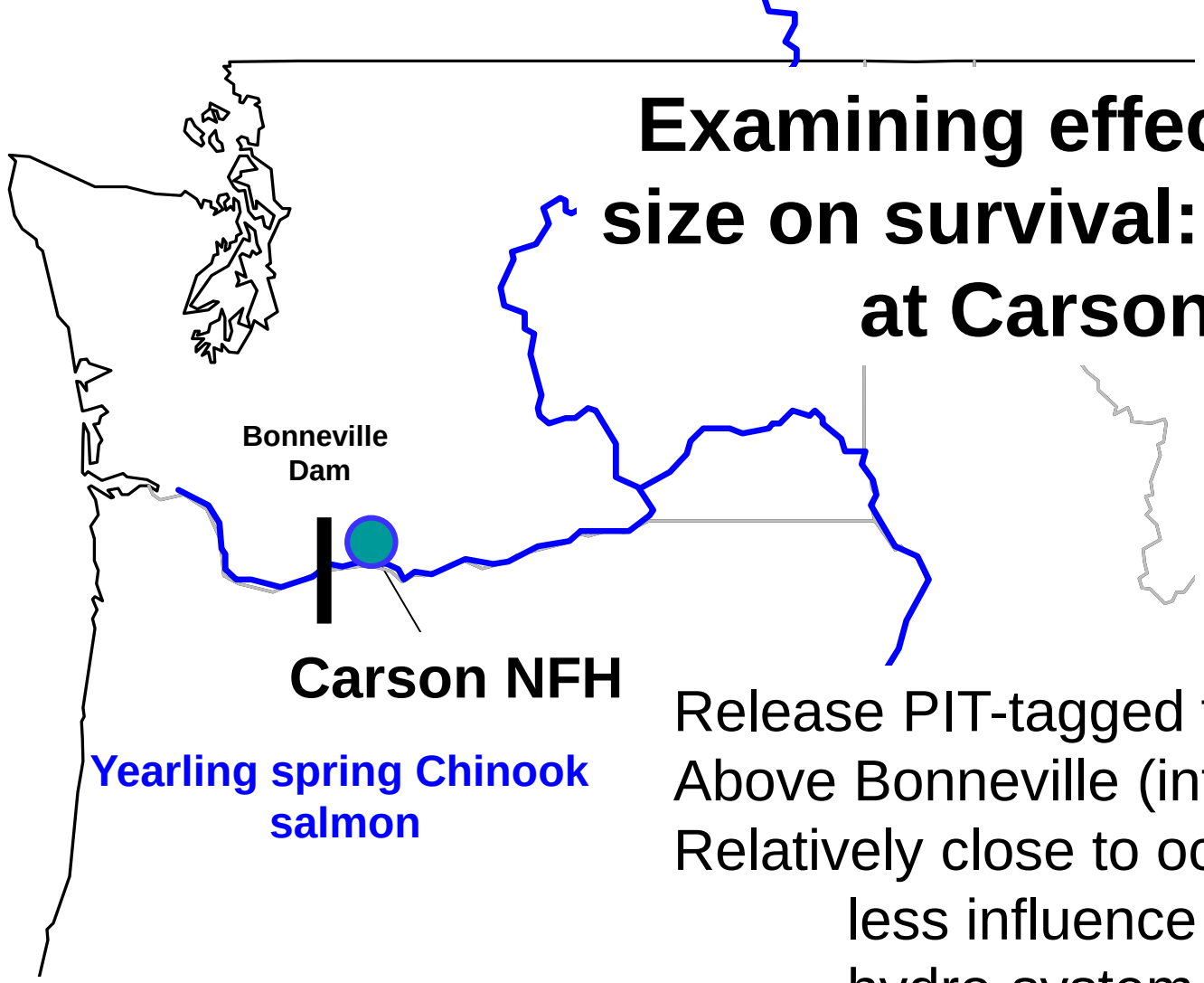
Historic - compare release groups of different mean size (CWT)

1. **Yes, big > small**
2. **Not explicitly addressed, experiments expensive**
   => limited to a couple of years

Present – new opportunity = PIT-tags, compare individuals

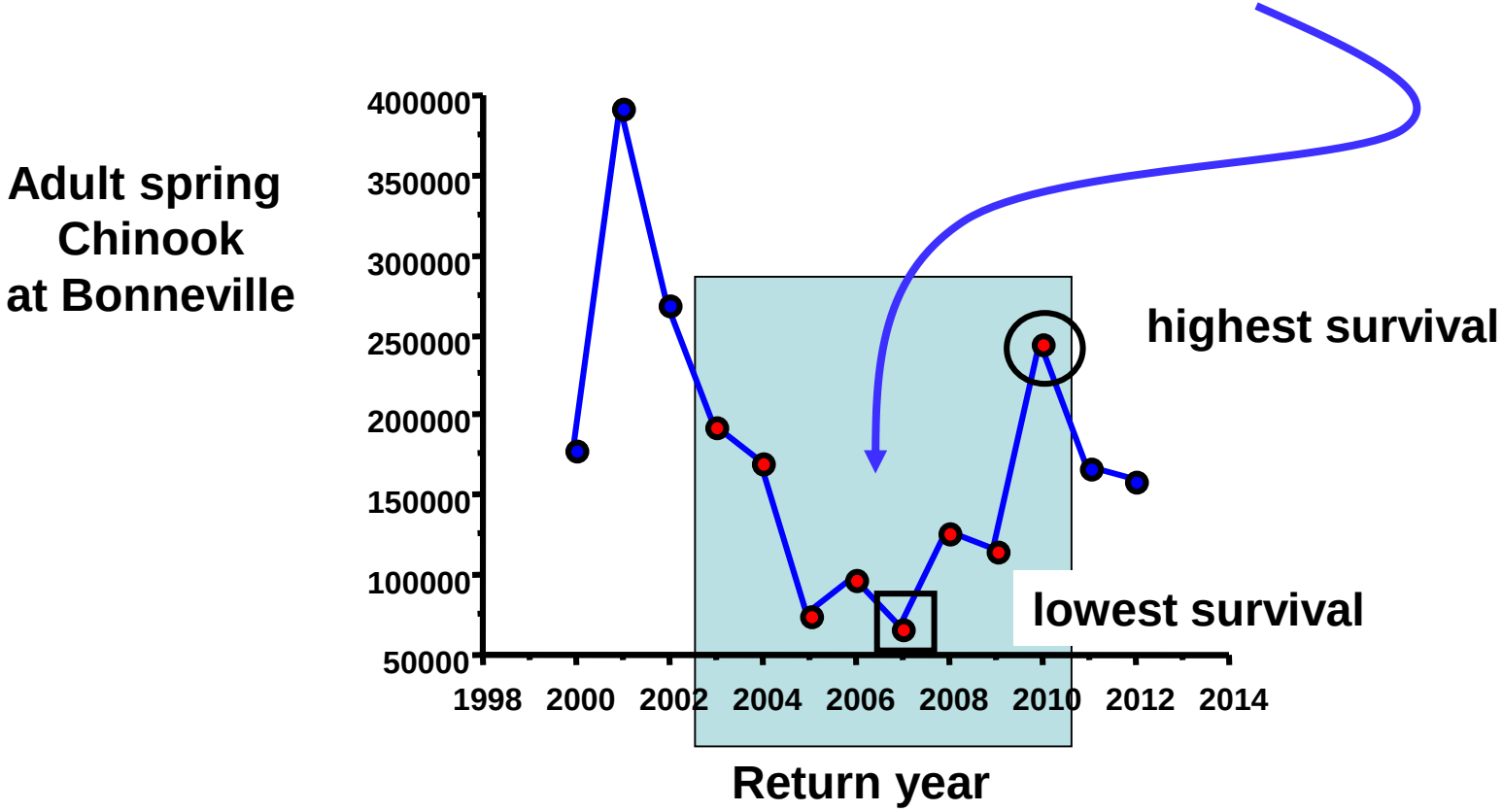
1. **Lots of data, surprisingly little analysis**
2. **Wait for ~ 2 minutes**

Examining effects of smolt size on survival: data fishing at Carson NFH

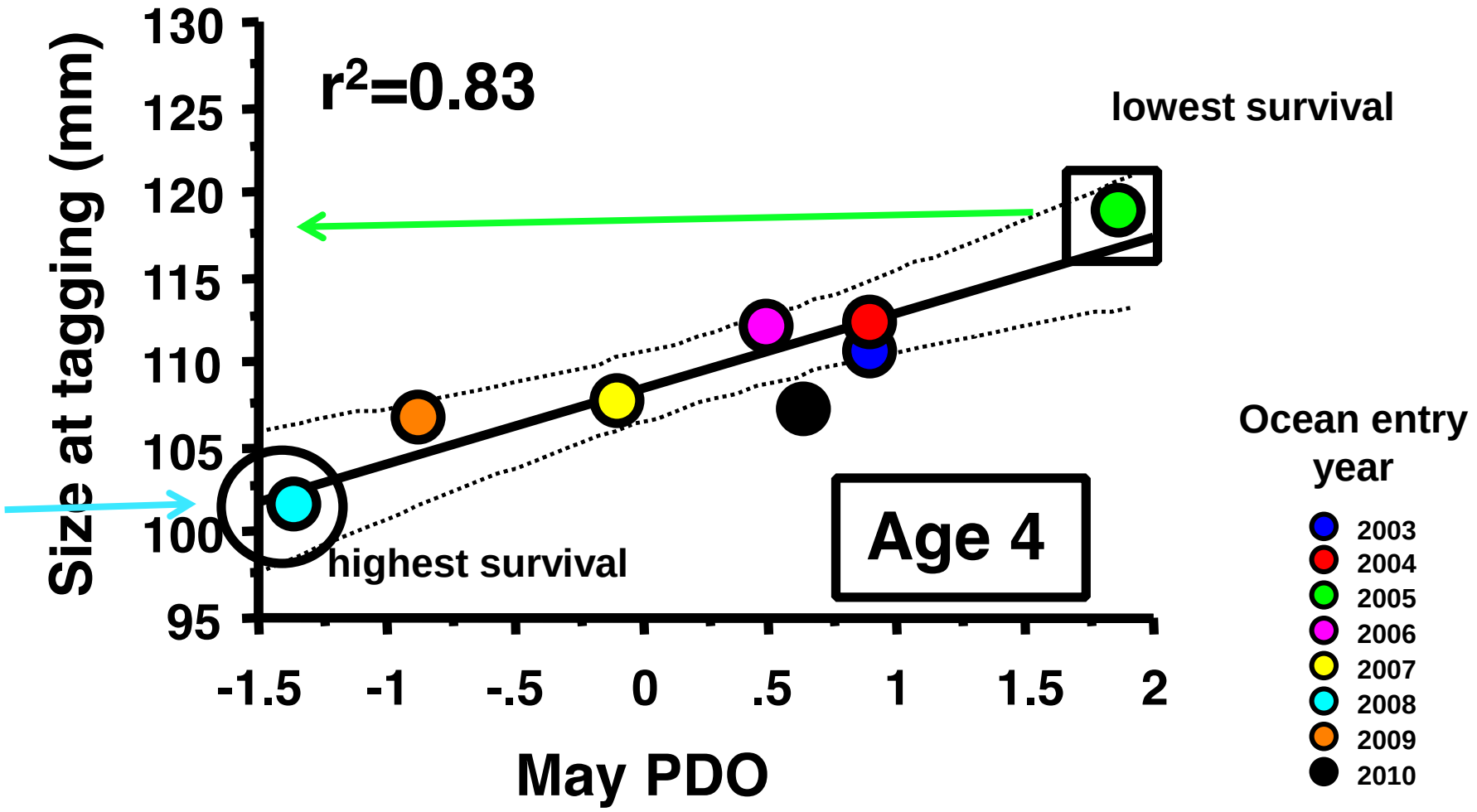


Release PIT-tagged fish
Above Bonneville (interrogate adults)
Relatively close to ocean:
less influence riverine and
hydro-system mortality
No Barging
Consistent annual timing of PIT-tagging
(2003 – 2010)

Overall adult returns vary during 8 years of Carson data: ocean conditions vary

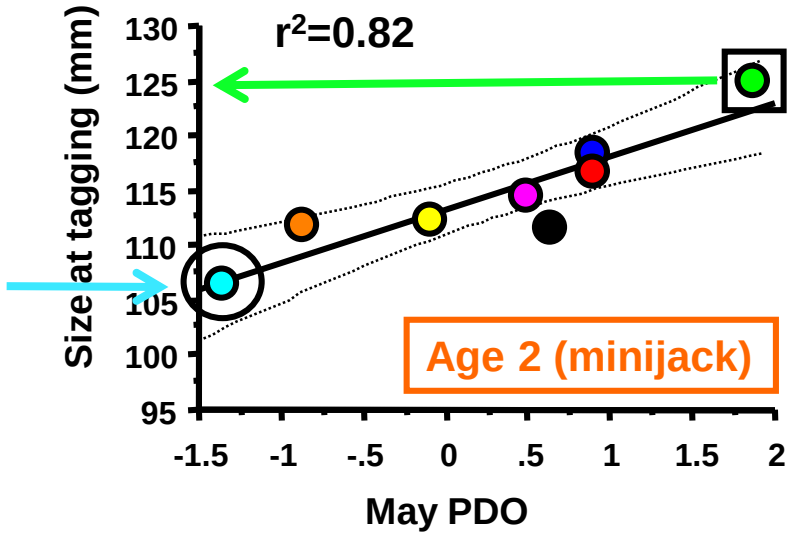


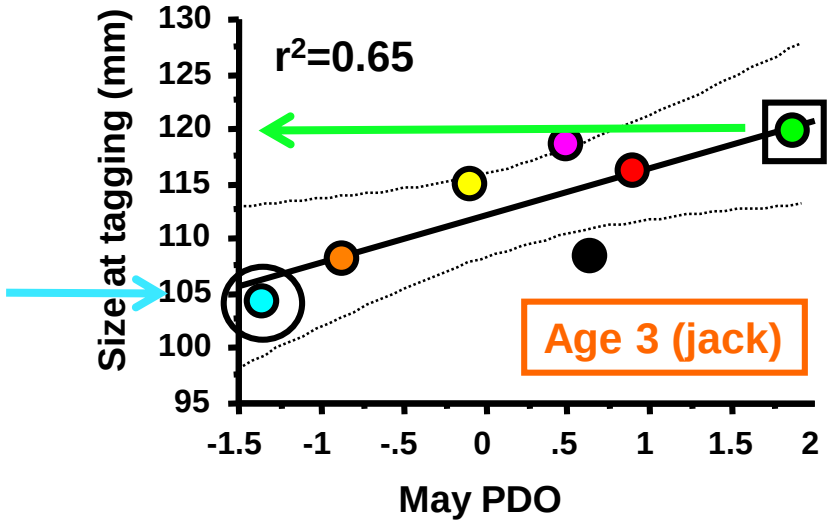
Smolt size of surviving Carson adults varies by year in relation to ocean conditions

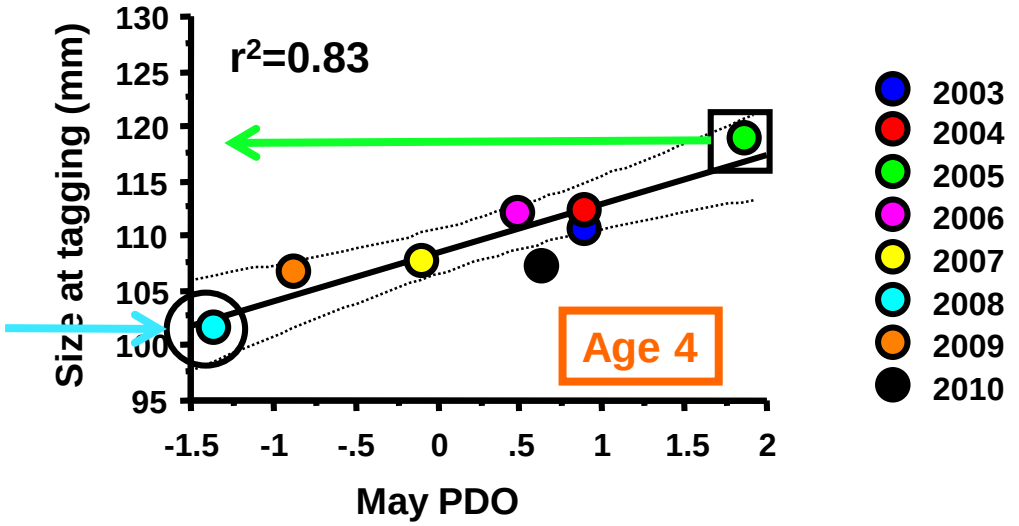


Not mean size of all smolts, mean smolt size for surviving adults

Pattern is similar across 3 age classes: smolt size of surviving Carson adults is greater in bad ocean years





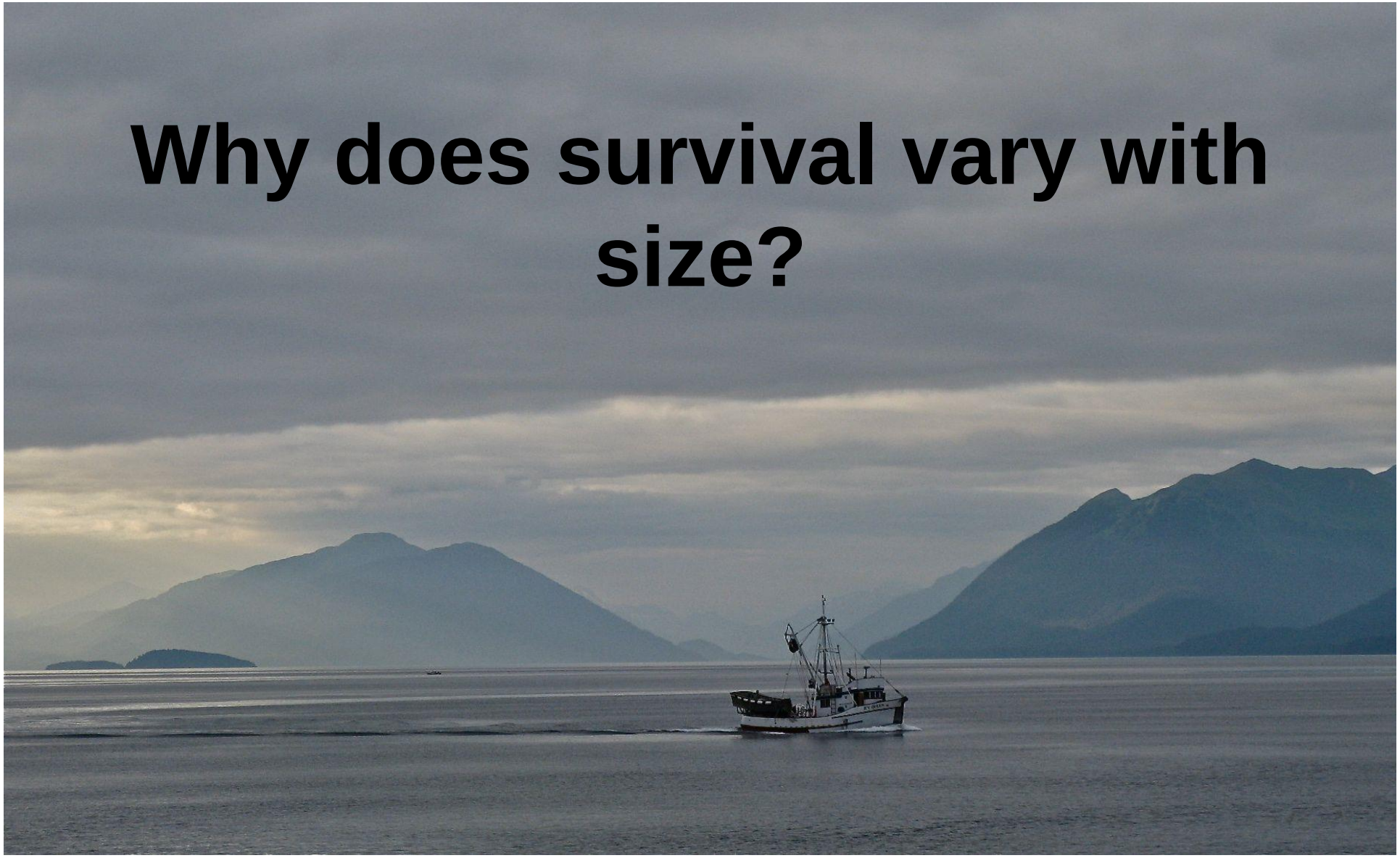


(-PDO = "good" for salmon)

Size selective mortality occurs in 1st ocean year (same pattern multiple ages)

More intense selection in “bad” ocean years (larger smolt size of surviving adults with + PDO)

Why does survival vary with size?

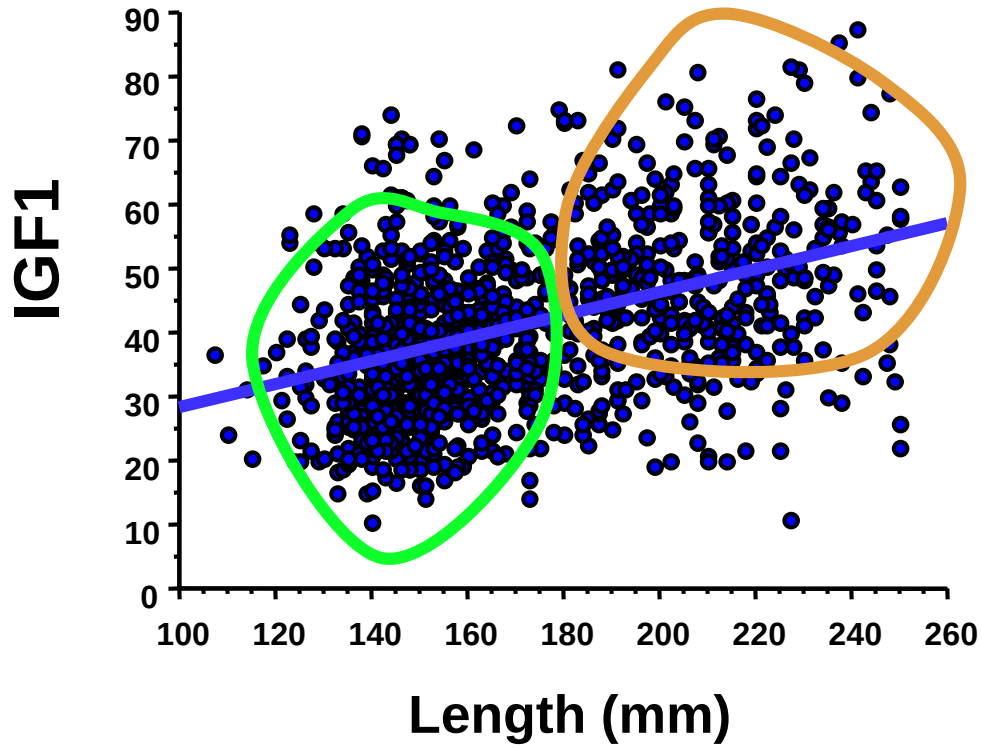


What about salmon in the ocean?

NOAA Juvenile Salmon Ocean Survey

1998 - present

Yearling Columbia R Chinook salmon: marine growth varies with size

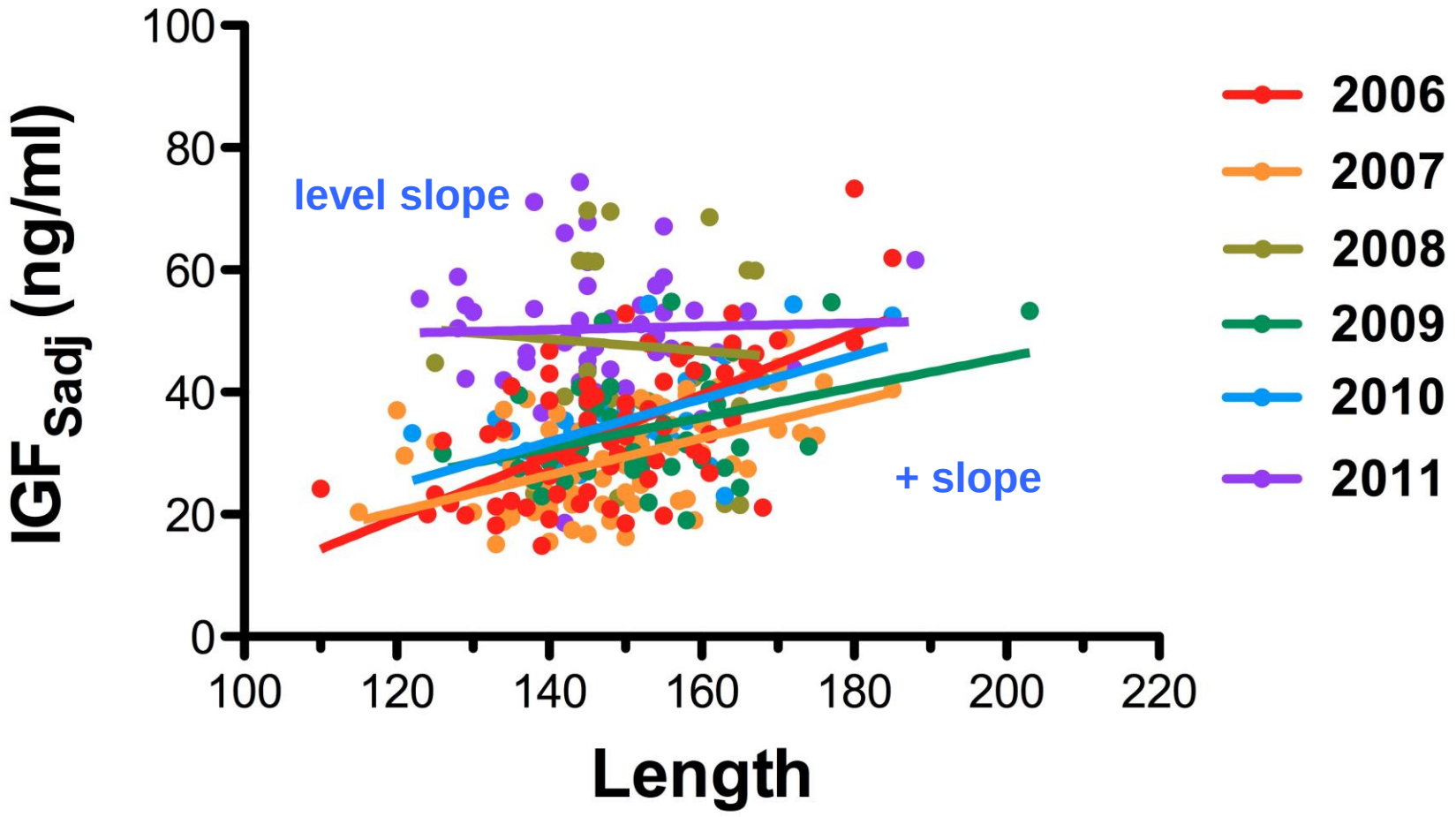


$p<0.001$, $r^2=0.20$

2006 - 2011, May, all stocks

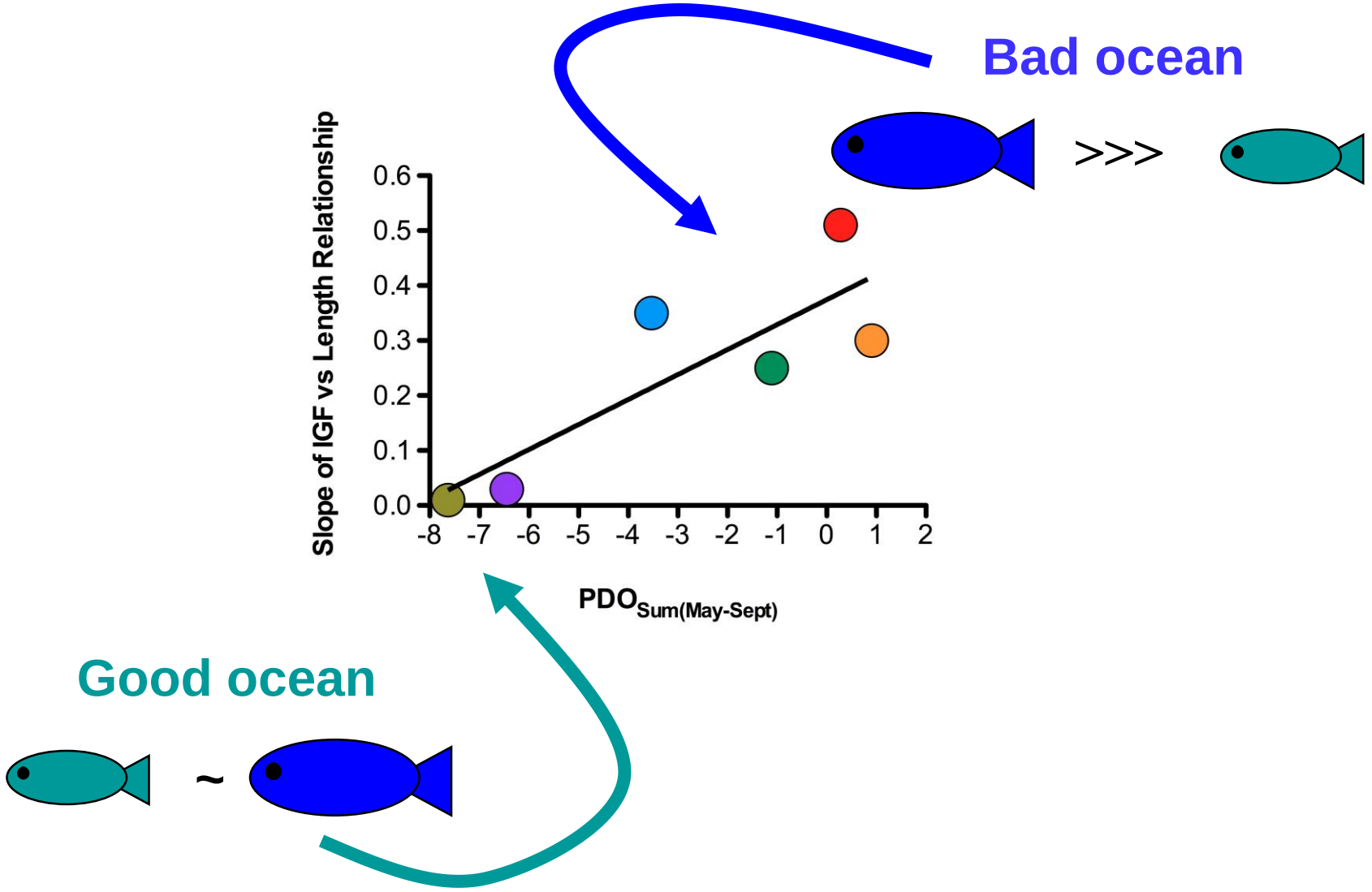
IGF1 - size relationships vary between years in May

(slope of regression line)

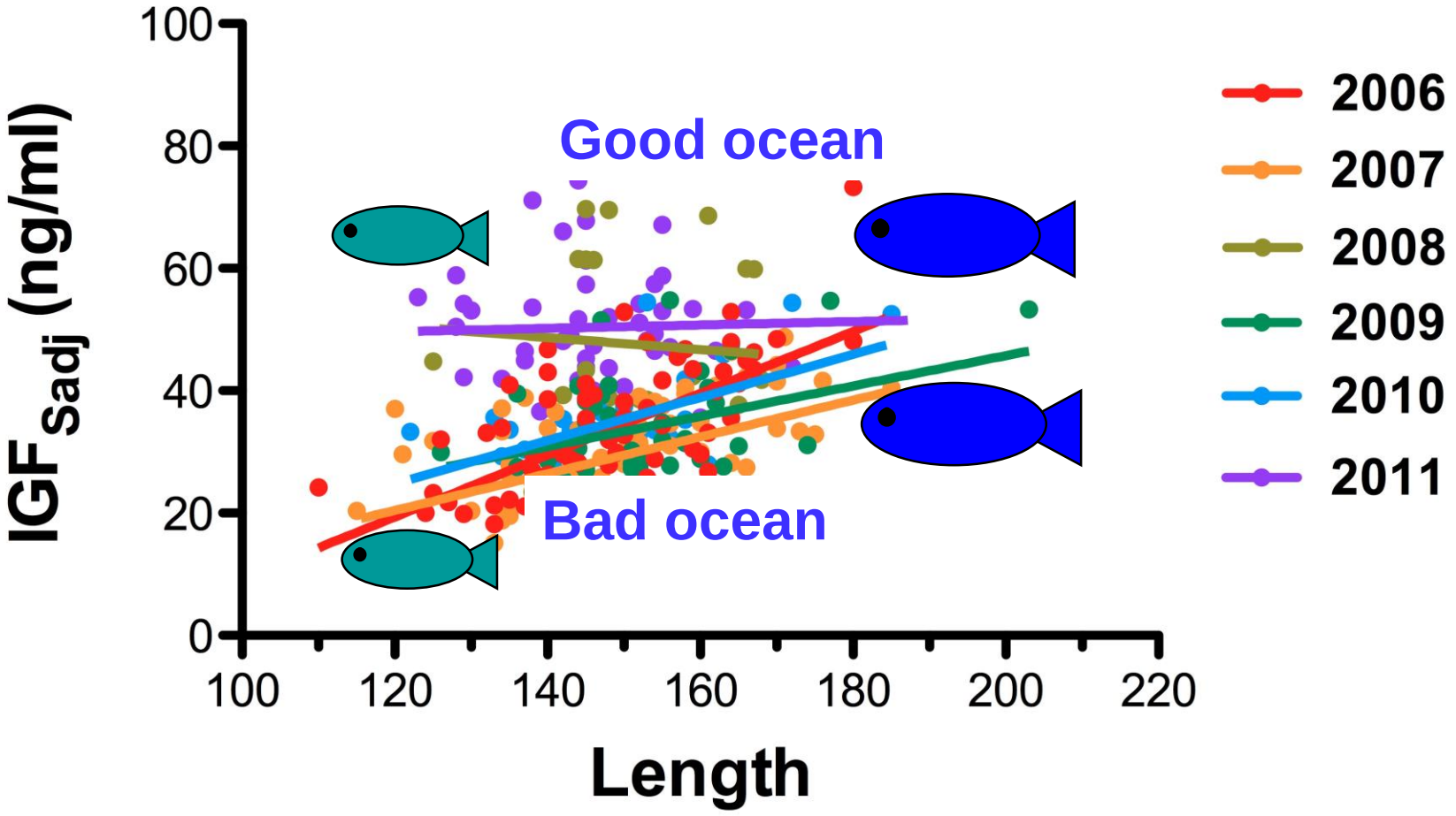


Snake River spring Chinook salmon

IGF vs Length slope varies with ocean conditions



IGF1 - size relationships vary between years due to varying ocean conditions

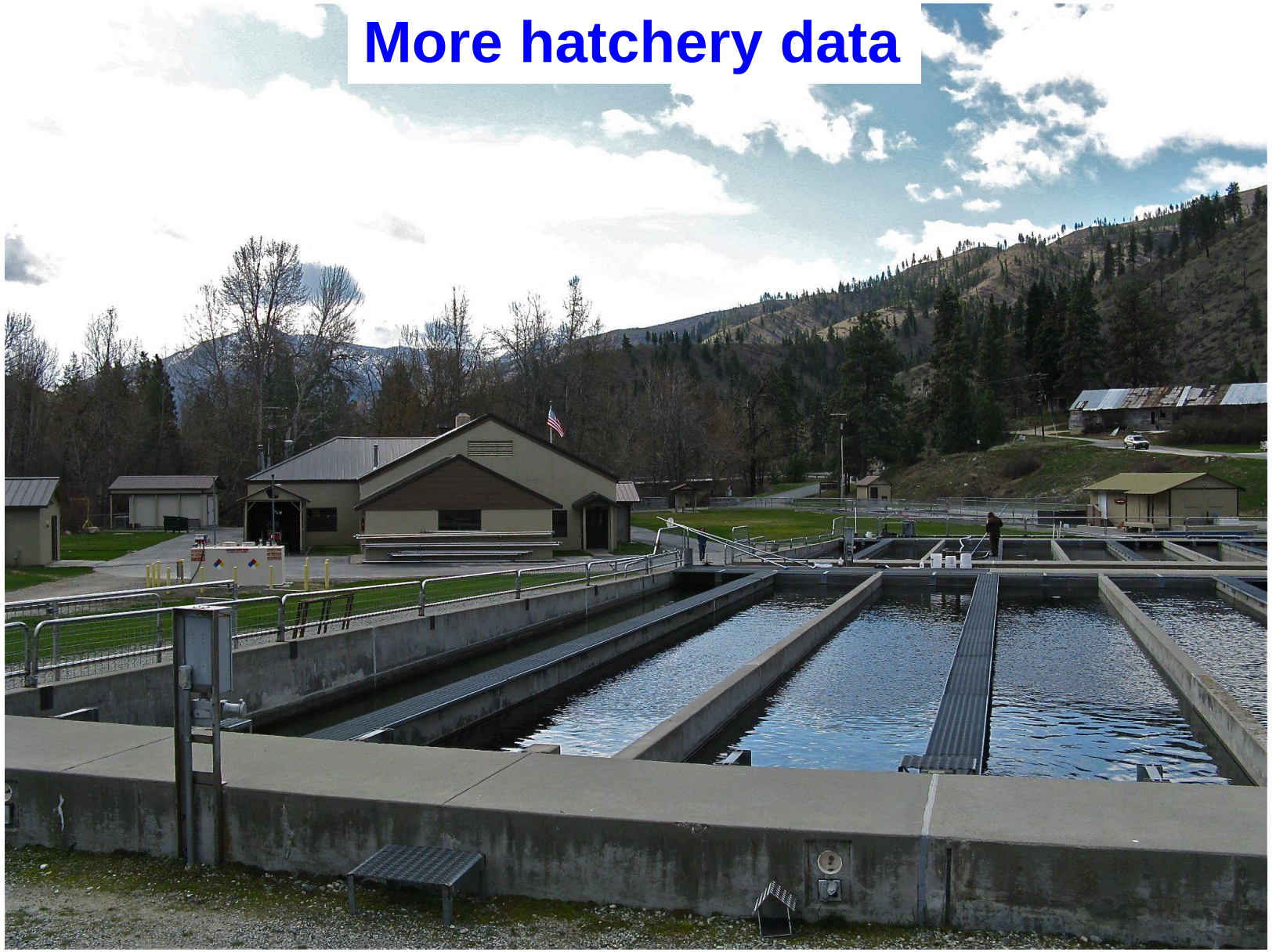


Snake River spring Chinook salmon

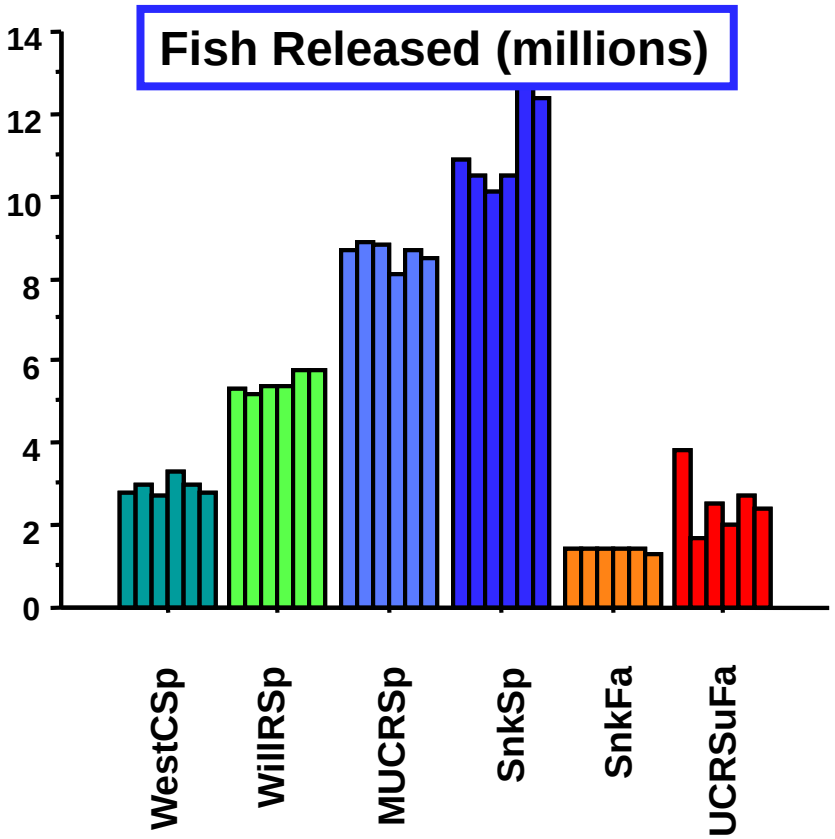
Size- biased growth occurs

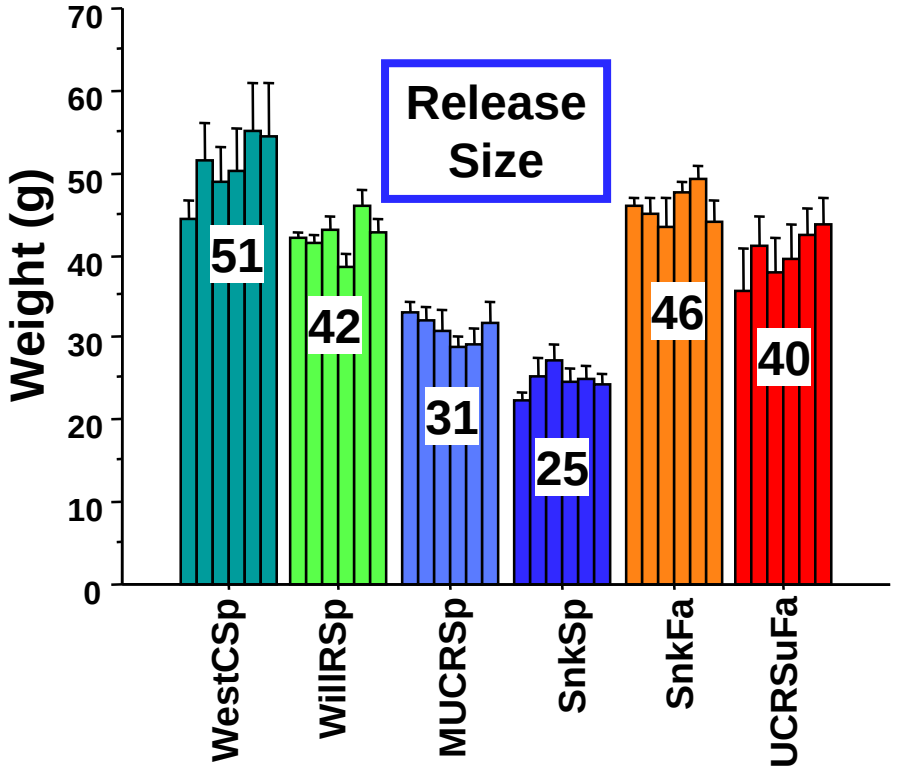
Big fish have higher growth than smaller fish in “bad” ocean years

More hatchery data



Release size of yearling Chinook salmon varies 2-fold by stock



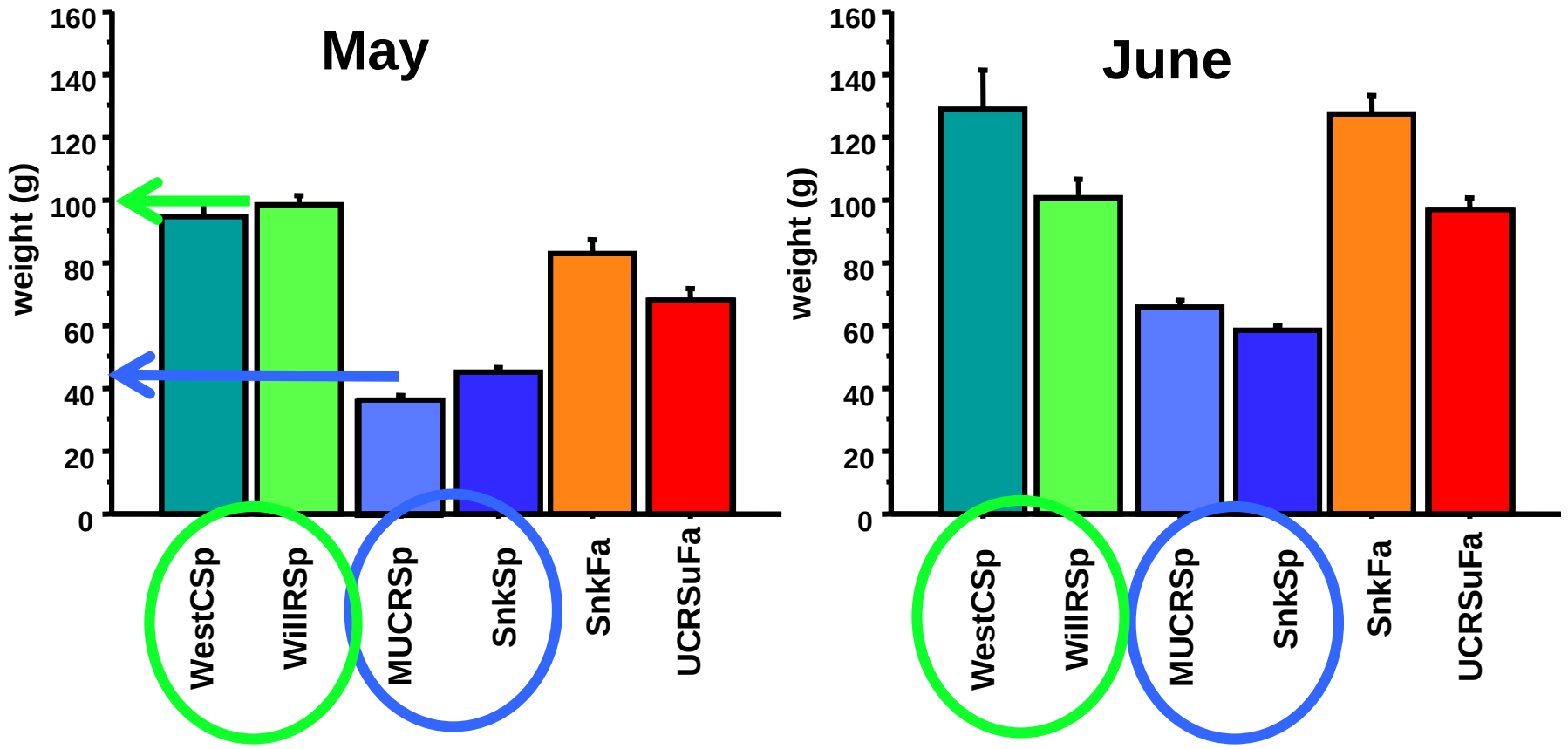


Fish Passage Center

What about salmon in the ocean?

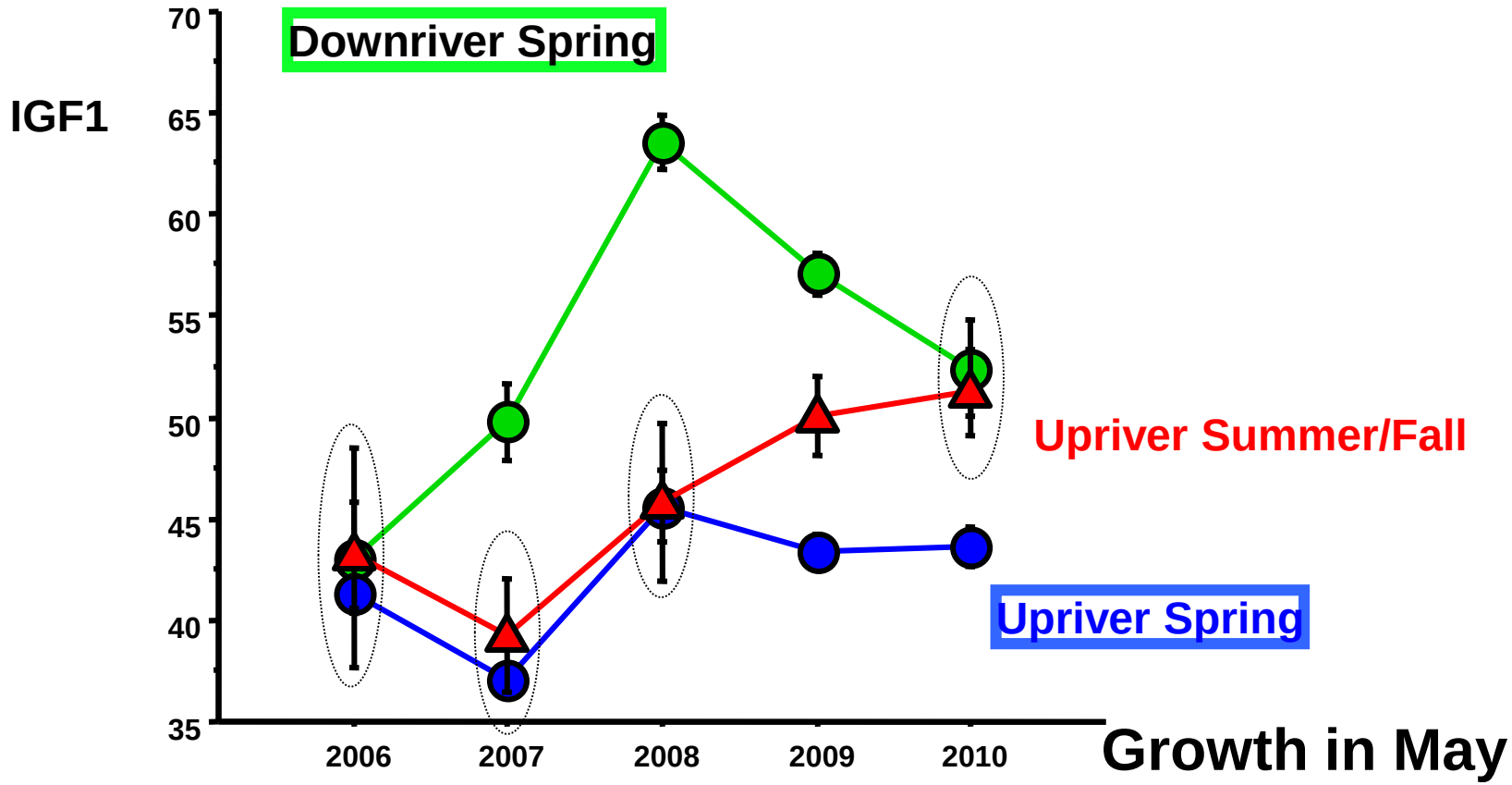
NOAA Juvenile Salmon Ocean Survey

Weight of fish caught in the ocean varies > 2-fold by stock



2006-2011

Smallest fish have the lowest growth by stock



Different stocks have differing smolt sizes

Different stocks have differing early marine growth rates

Do different stocks have differing size-based marine mortality rates?

Do stock specific size-based mortality rates vary with ocean conditions?

Data and analysis needed to confirm preliminary analysis

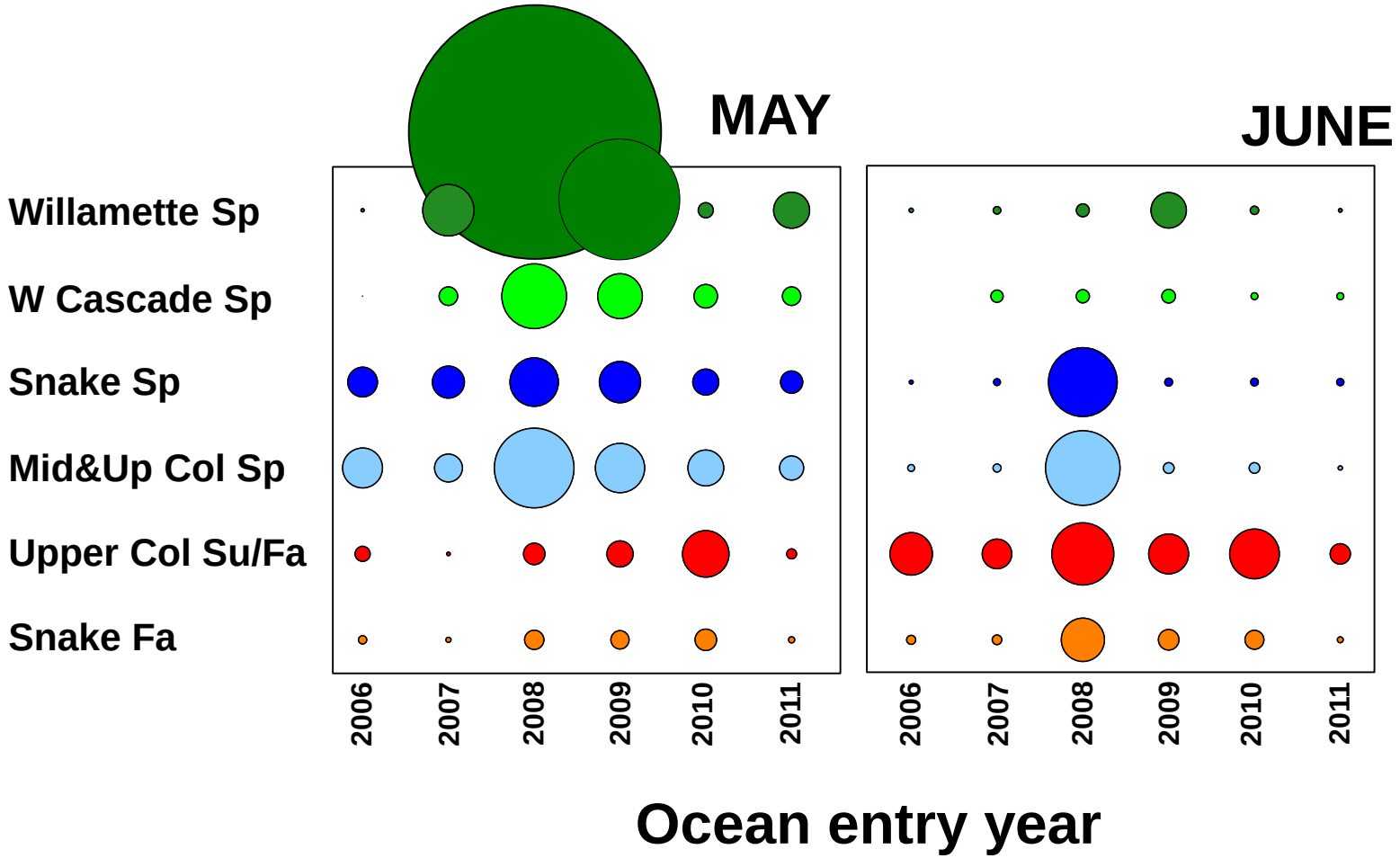
Stock-specific survival data
(hatchery and wild)

More smolt size - survival analysis (and data)
by stock

Acknowledgement of interactions:
years (ocean conditions)
stock
size

Time dependent bonus slide?

Biomass (abundance x weight) varies by stock, month and year



Summary:

- marine growth is limited in some years
- marine survival is related to marine growth

- size selective marine mortality occurs
- more intensive marine size selection in low marine growth years

- differences in growth between big and small fish are greater in years with low marine growth

- size varies among stocks

Interesting questions about current management practices:

1. How many smolts should be released?

Should this vary by year?

How many smolts from what stocks?

2. What should smolt release size be?

Should there be a size limit?

3. When should smolts be released?

Create “windows” of low competition?

Acknowledgements

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