May 1st, 1:30 PM - 3:00 PM

Marine Survival of Puget Sound Chinook salmon-New studies on size-selective mortality and critical growth periods

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Marine Survival of Salmon:
Size-selective Mortality and Critical Periods

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SALISH SEA MARINE SURVIVAL PROJECT
www.marinesurvivalproject.com

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Celebrating 25 Years!

USGS
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SAFS
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UNIVERSITY OF WASHINGTON

Washington Sea Grant
Pacific Salmon Commission
Salmon Recovery Fund Board
Nisqually, Tulalip, Skagit Coop. & Lummi Tribes
NOAA, WDFW, Kwiaht, DFO-Canada, Pac. Salmon Foundation

Study Objectives

- Use Size-selective mortality to identify critical periods of growth that influence survival to adulthood
  - Which life stages & associated habitats?
  - FW, estuarine delta, marine nearshore, offshore?
- Diagnose what factors limit growth or survival during critical periods
  - Food supply or quality
  - Temperature
  - Competition
  - Predation
  - Approach & example of pilot results

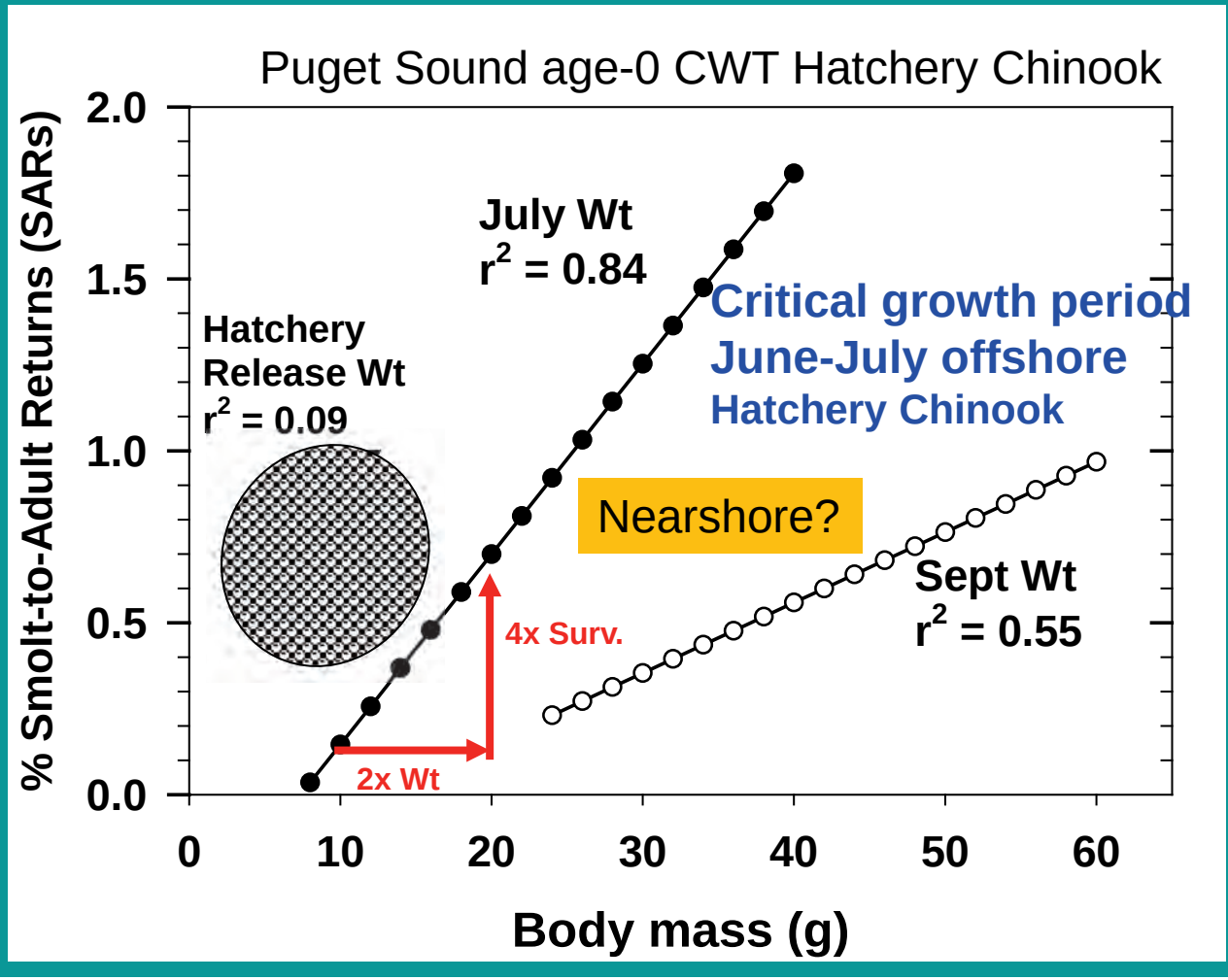
Survival Linked to Size & Growth at Specific Life Stages

Size at release & Marine entry NOT Correlated to Surv.

Marine survival Strongly linked to Wt after 1 month Epi-pelagic feeding In Puget Sound through July

2-3 fold Wt gain during 1º pelagic feeding

Weaker pattern In Sept.



Do critical periods vary among stocks?
(Nisqually, Snohomish, Skagit, Nooksack)
Critical periods in FW, estuarine, nearshore or offshore life stages?

Duffy & Beauchamp 2011 CJFAS 68:232-240

Hatchery: pre-release size structure & scales
release date & abundance

Outmigrant Trap
Timing, Abundance
Size, Scales, (~Diet & Otoliths from morts)
Weekly Feb/Mar to ~July

Estuarine Channels (trap or B Seine)
& Nearshore Beach Seine
Timing, Abundance
Size, Scales, Otoliths, Diet
2x per month

Offshore Midwater Trawl
Depth-stratified 15-m depths
Timing, Abundance
Size, Scales, Diet
Including predatory fish
July & Sept

Offshore Purse seining
Timing, Abundance
Size, Scales, Otoliths, Diet
~2x per month
Including predatory fish
mid-Apr to mid-Oct

Returning Adults: Scales & Otoliths
& Residents

Track Specific Populations thru Early marine life stages

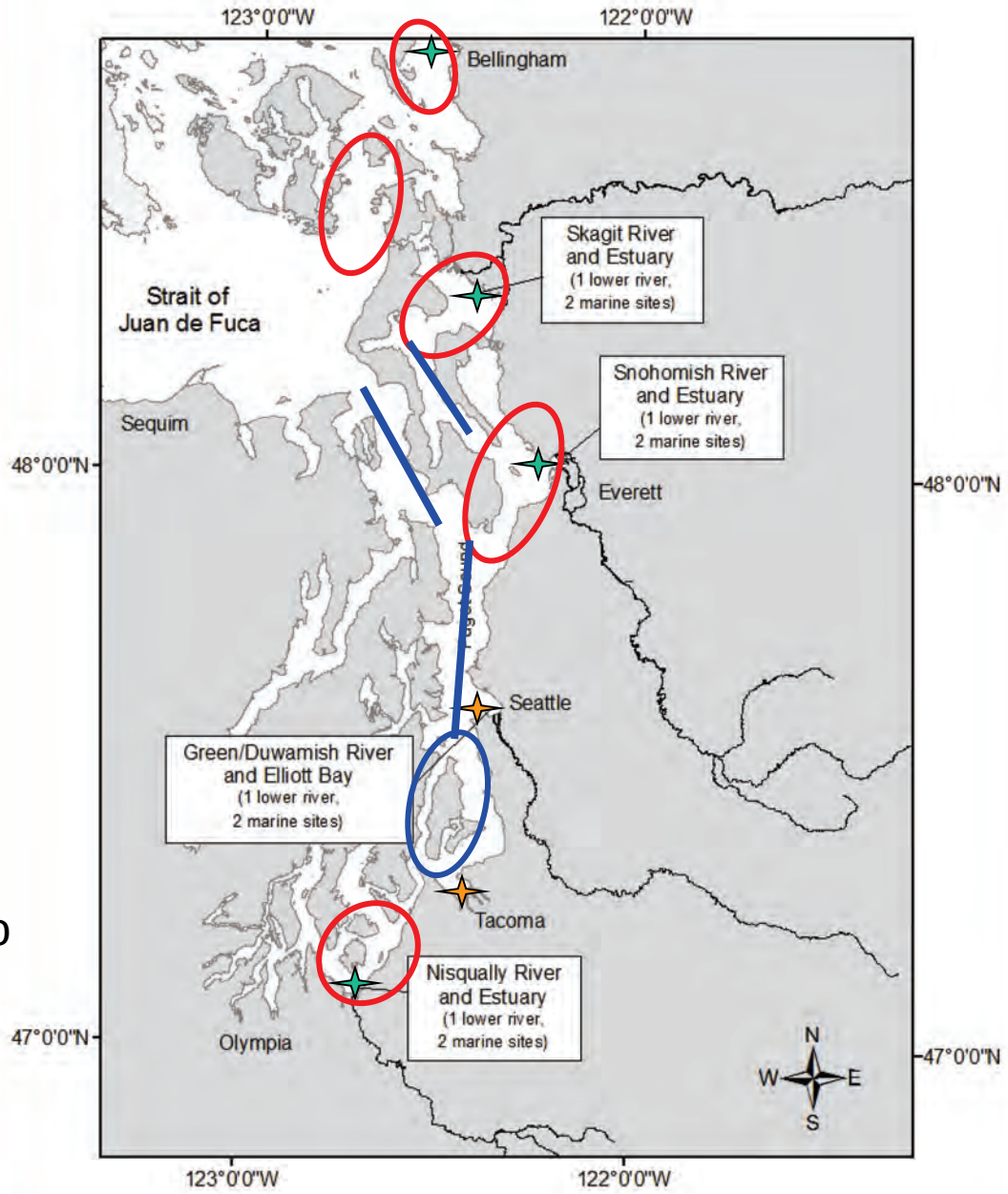
Methodical near/offshore sampling
For selected watersheds

Size structure
Timing & duration
Total/relative abundance
Diet & Body Condition
Environmental Conditions

Freshwater:
Hatchery Release
Smolt traps

Estuarine & nearshore Marine:
Estuarine Tide channel traps 2x/mo
Beach seining 2x/mo Mar-Sep/Oct

Offshore:
Zooplankton 2x/mo Apr-Oct
Purse seining 1-2x/mo May-Sep
DFO Midwater Trawl: Sep



Grants approved, no funding, DFO

Timing of Life Stage Pulses: Downriver Migrants

Timing of Life Stage Pulses:
Estuarine Delta & Nearshore

Timing of Life Stage Pulses:
Offshore (within Puget Sound)

Estuarine
Delta & Nearshore

Offshore w/in
Puget Sound

River
Migrants

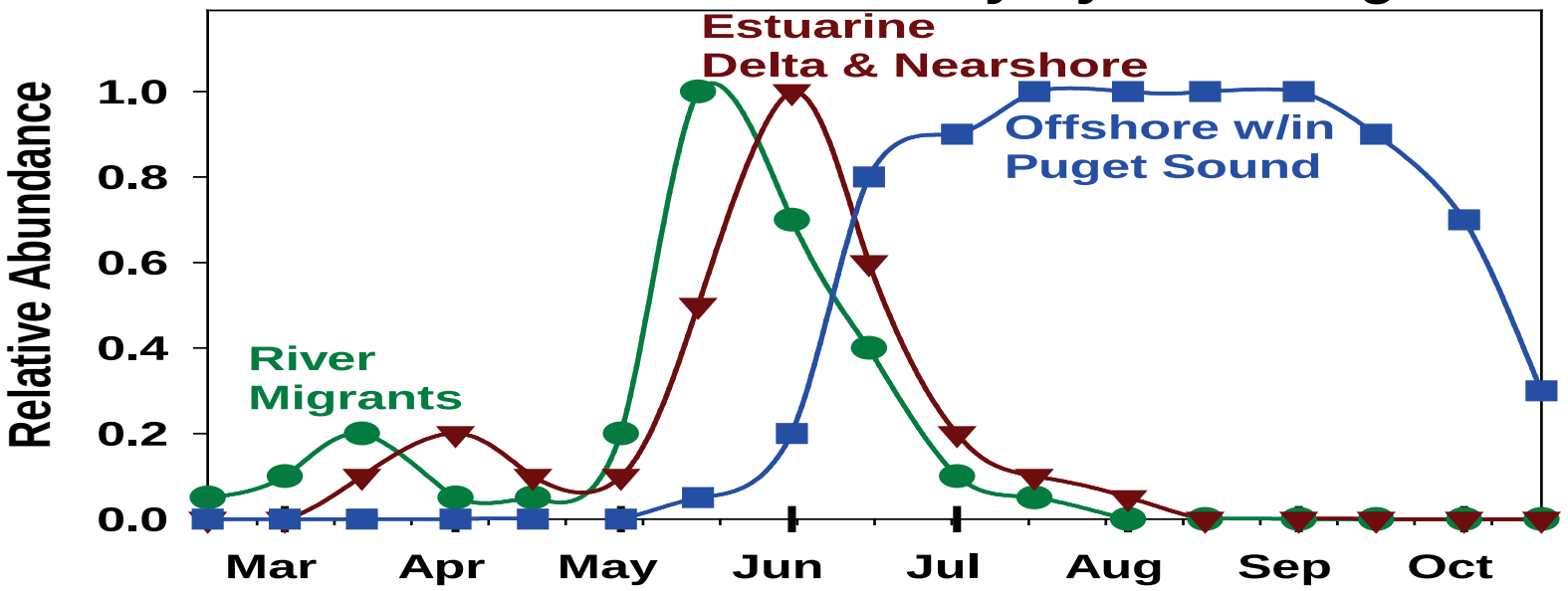
Relative Abundance

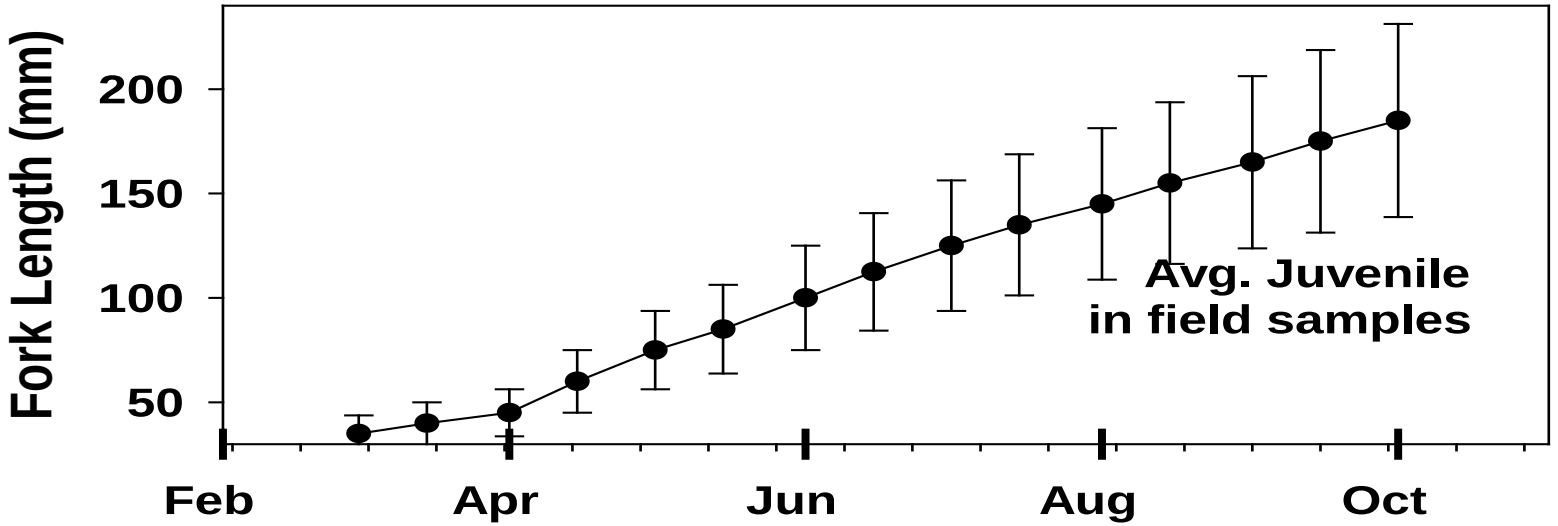
1.0
0.8
0.6
0.4
0.2
0.0

Mar Apr May Jun Jul Aug Sep Oct

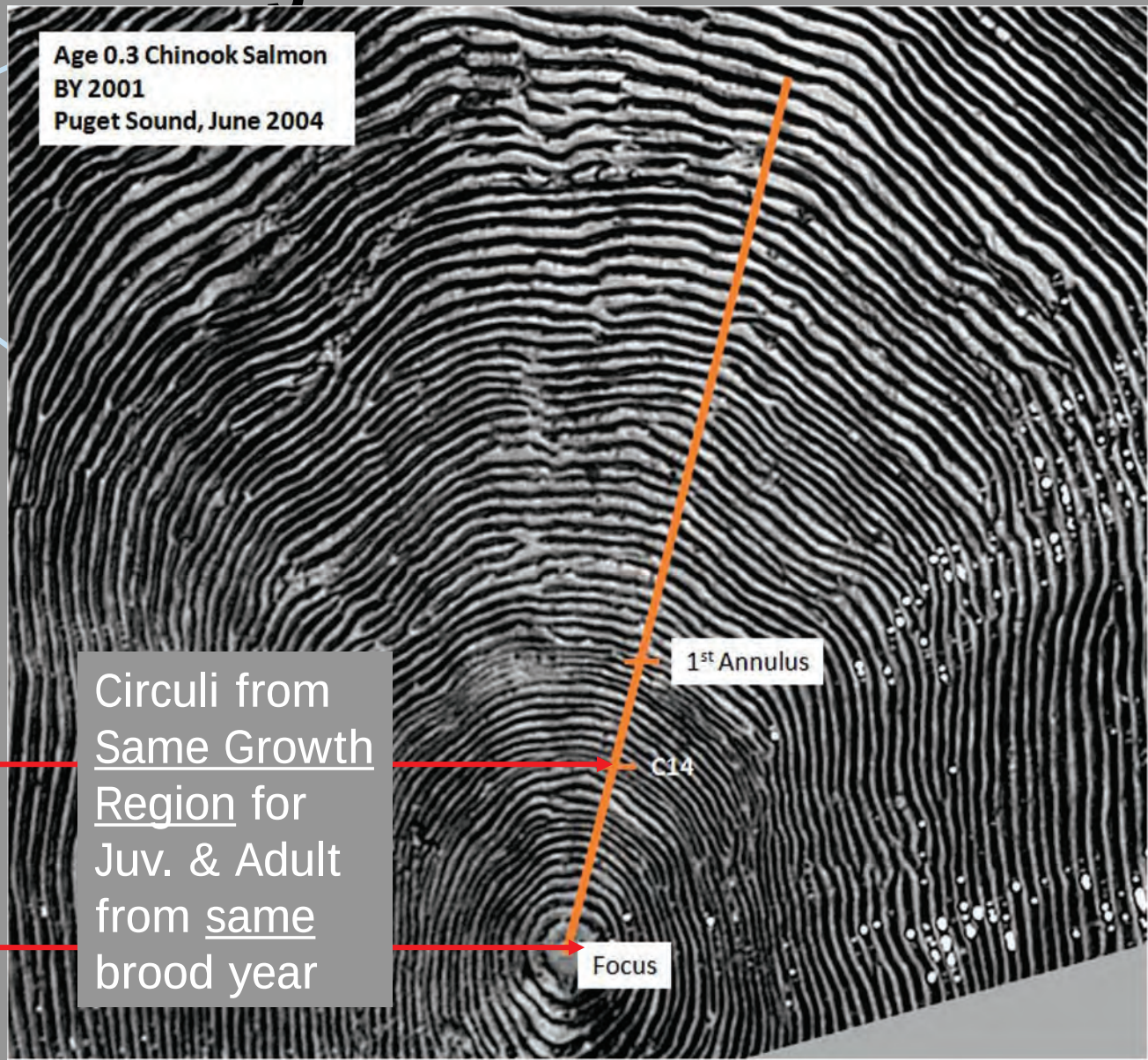
Date

Size-Selective Mortality by Life Stage

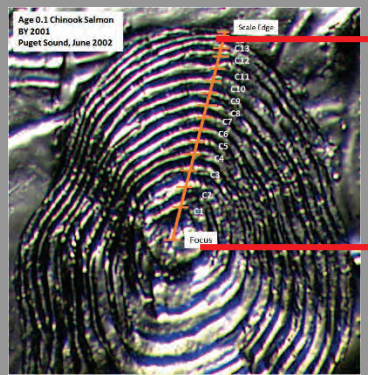




SSM: Scales used to back-calculate growth history of known-origin Juveniles & Adults

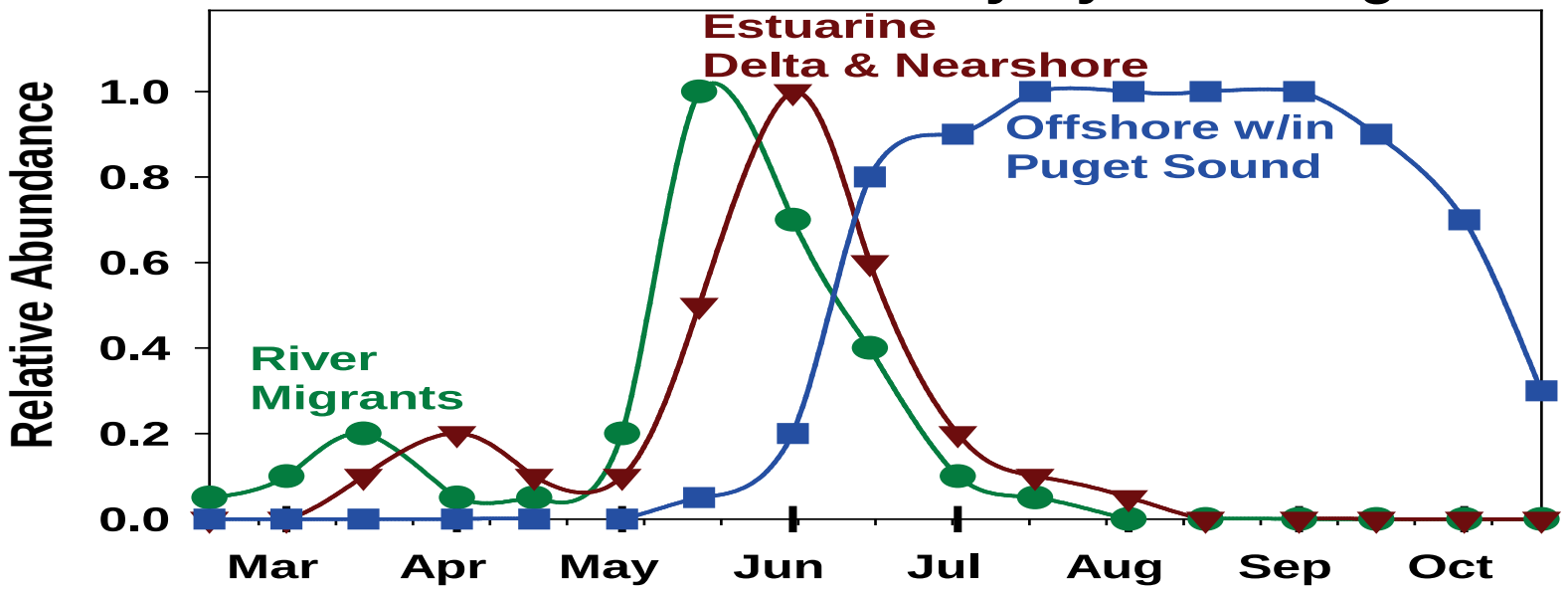


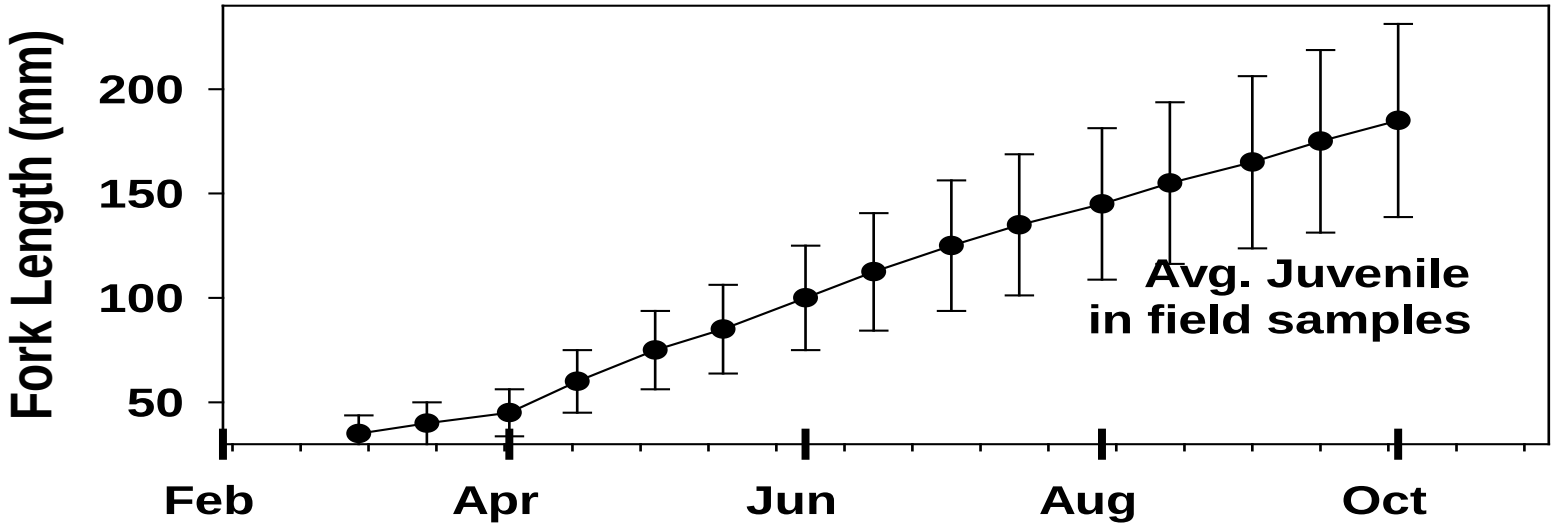
Age-0 Chinook
BY 2001, June 2002 in PS



Circuli from Same Growth Region for Juv. & Adult from same brood year

Size-Selective Mortality by Life Stage



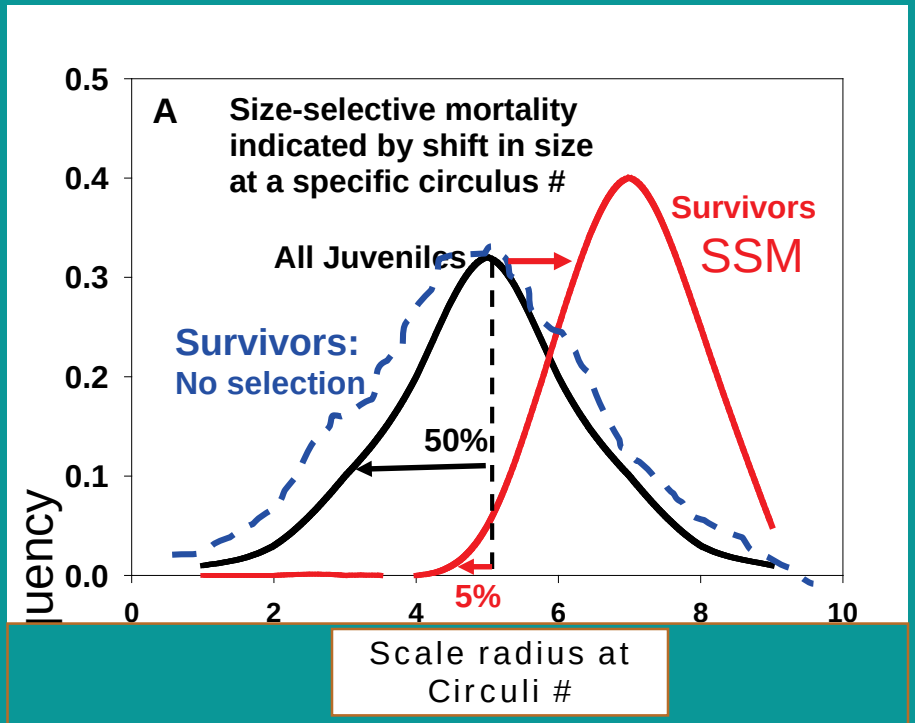


Size Selective Mortality (SSM)

For each life stage:
SSM Inferred by comparing Size distributions (scale radius at specific circuli) for juveniles to:
-Juveniles at later life stages
-Adult survivors from that same group

Larger individuals survived at a Disproportionately higher rate.

In this hypothetical example:
-The Smaller 50% of juveniles contribute only 5% of the surviving adults



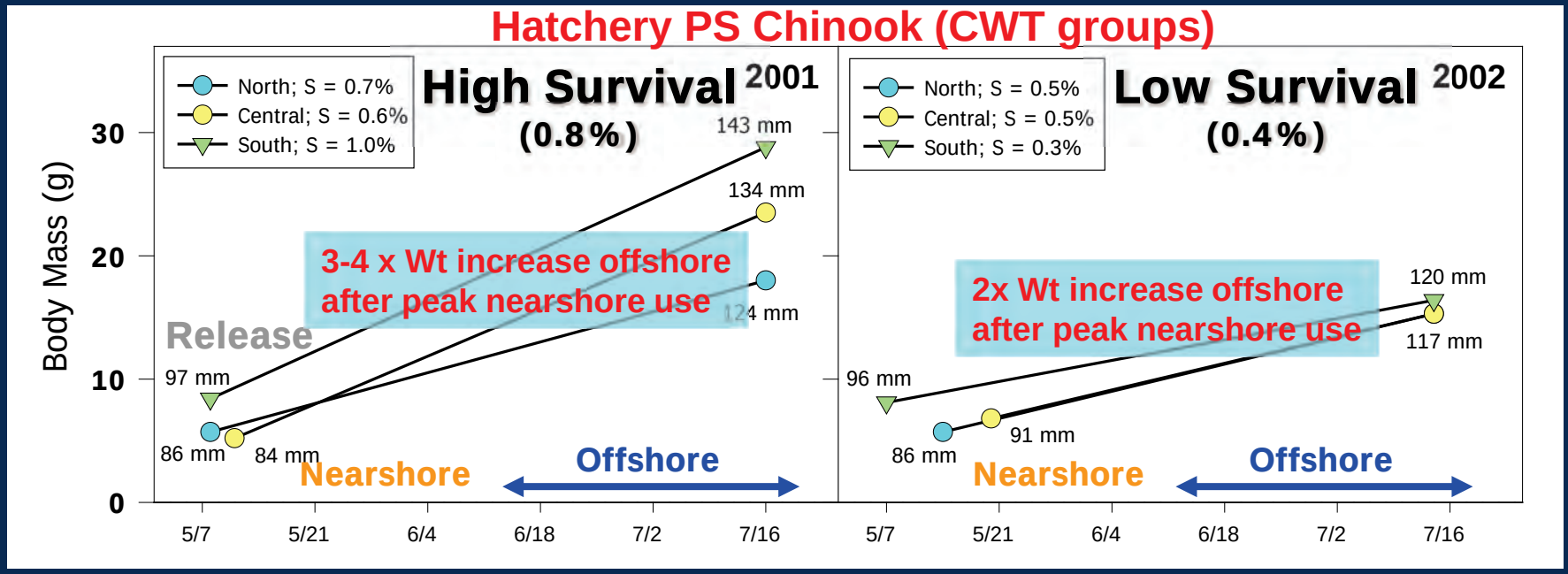
If significant SSM observed between periods,

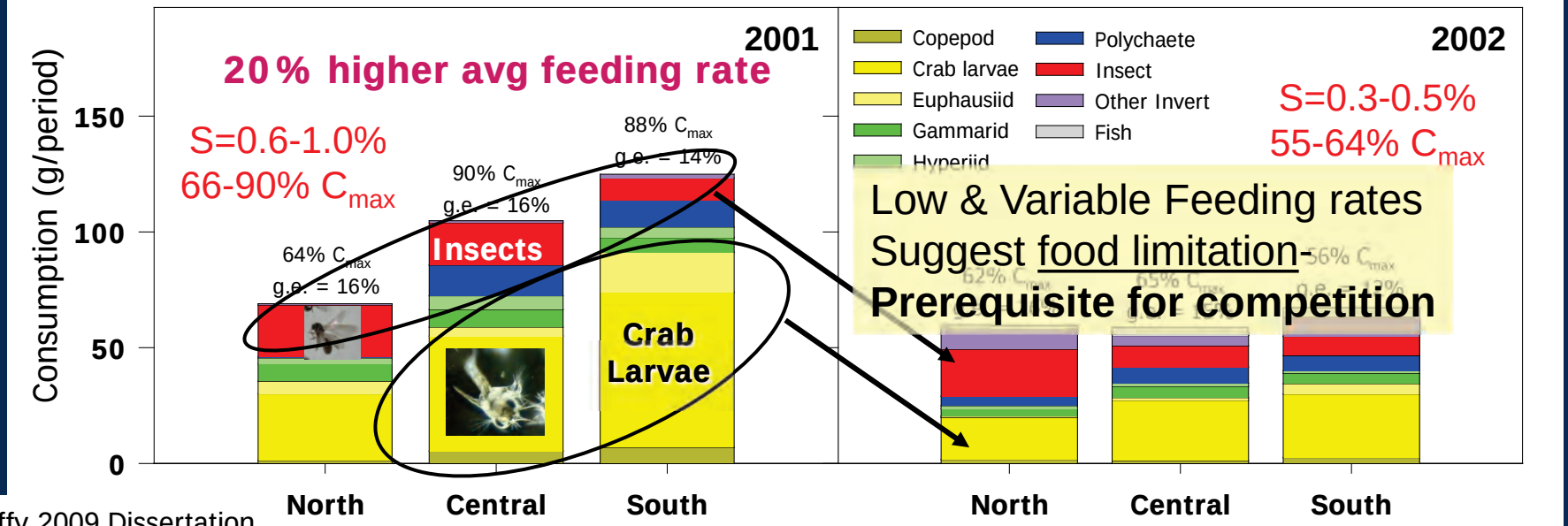
Then diagnose factors affecting growth within these periods based on bioenergetics modeling

Examine scale-based size distributions at circuli #s corresponding to:

-Hatchery release
-Smolt outmigration
-Delta & Nearshore Marine rearing
-Offshore rearing
-Returning Adults

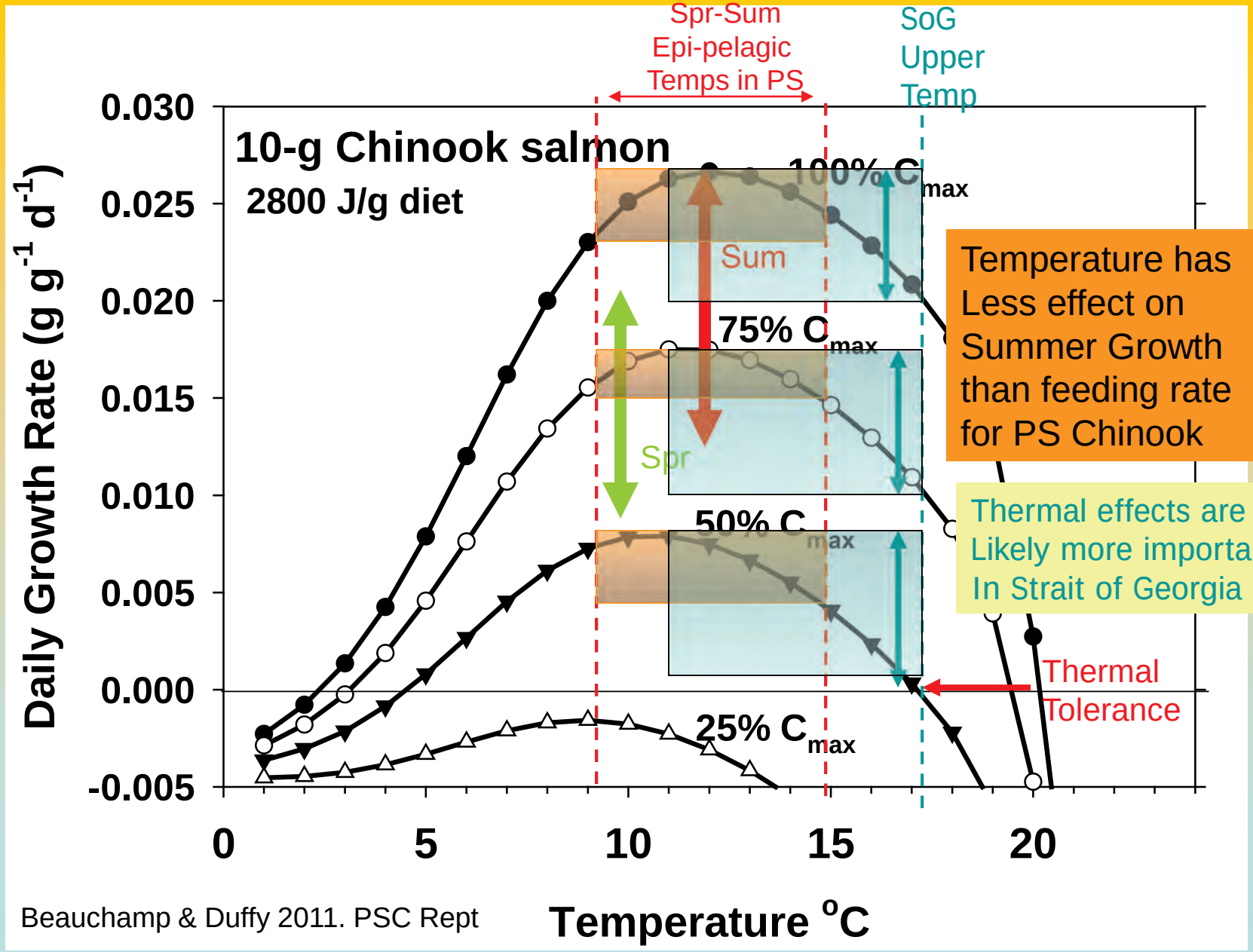
Higher Feeding Rate = Higher Growth & Survival





Duffy 2009 Dissertation

Temperature Effects on Metabolism, Feeding & Growth



Beauchamp & Duffy 2011. PSC Rept

Summary Approach

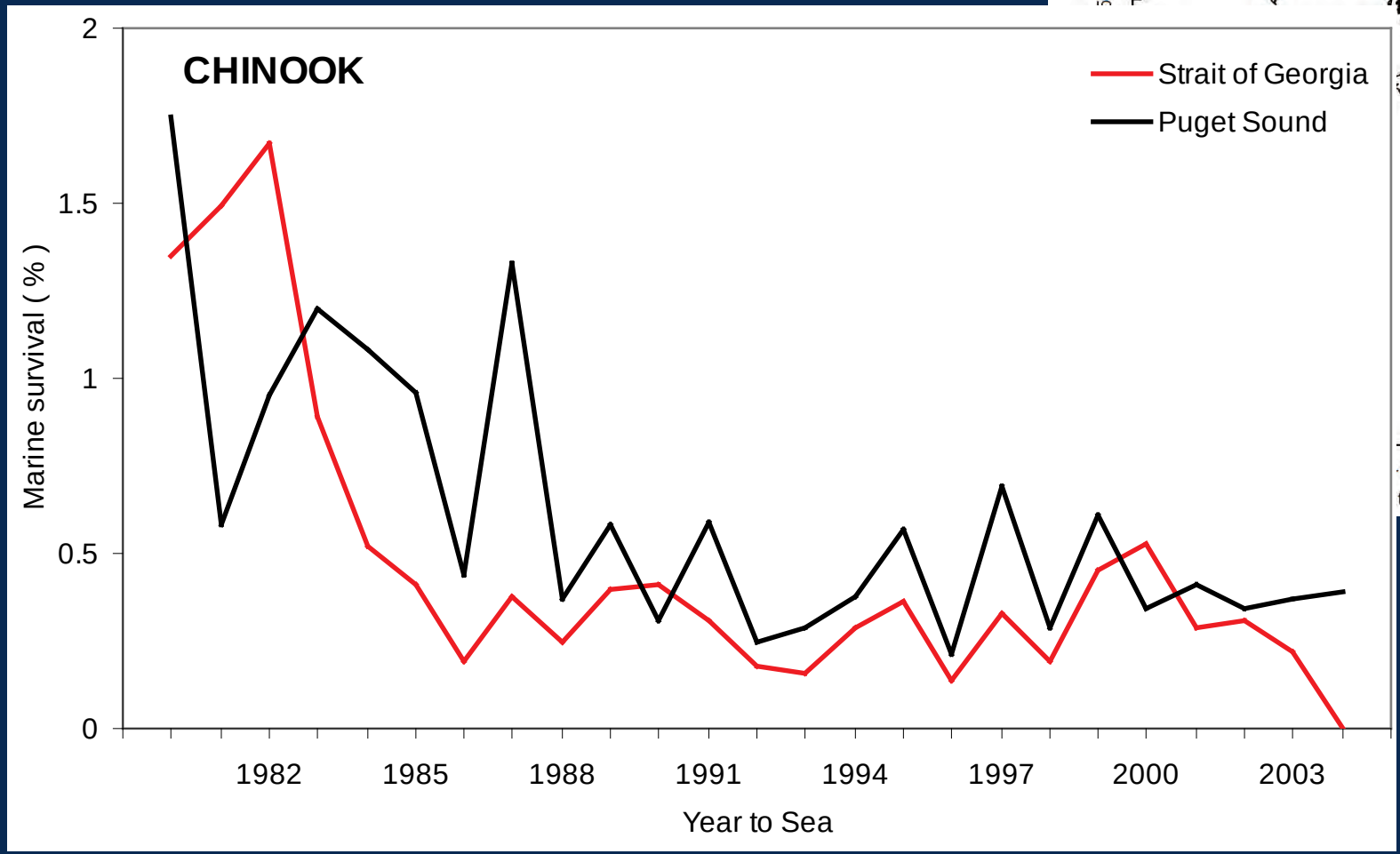
- Identify Critical Periods: “Let the fish tell us what’s happening!”
  - Critical periods can vary among Spp & Stocks
    - Methodical Sampling: Hatchery & smolt traps in FW, estuarine & nearshore marine, local epi-pelagic, open ocean, Adult returns
  - Use SSM to identify critical periods and associated habitats (lengths, scales &/or otoliths)
  - Diagnose factors affecting growth & survival within critical periods
  - Can Inform restoration efforts & priorities

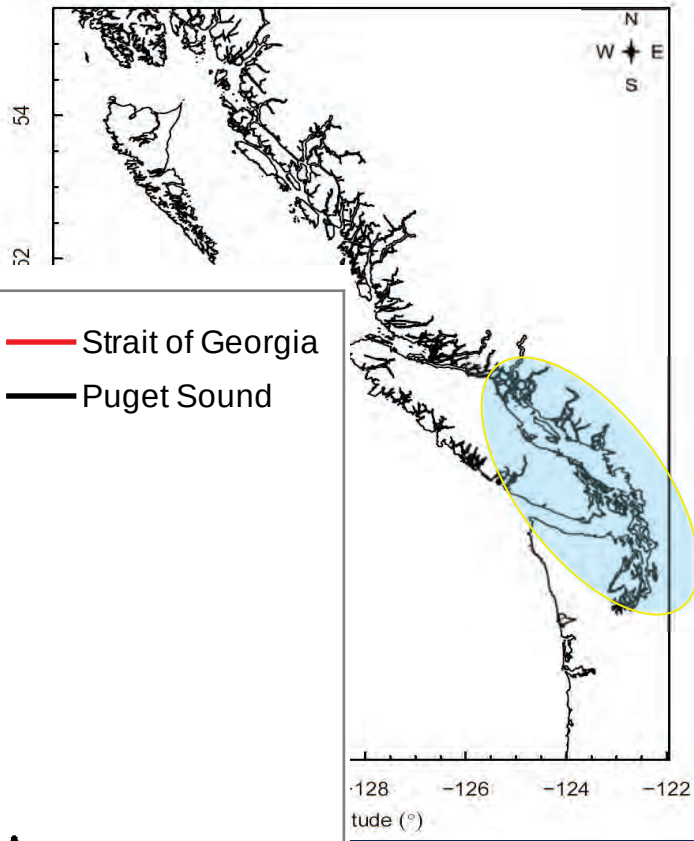
Size-Selective Mortality

- Size-selective Mortality (SSM) is Prevalent
  - Stage-specific size positively correlated to survival
- Can be used to identify critical periods of mortality or growth which influences mort
  - SSM differs among Spp, stocks, life stages
- Shifts in size-at-age distribution among life stages reflects timing & magnitude of SSM
  - Need to account for stock origin & migration
- SSM doesn't rely on serial abundance est.
- SSM can link **top-down** & **bottom-up** factors affecting Survival & Growth

Marine Survival trends for Hatchery Chinook

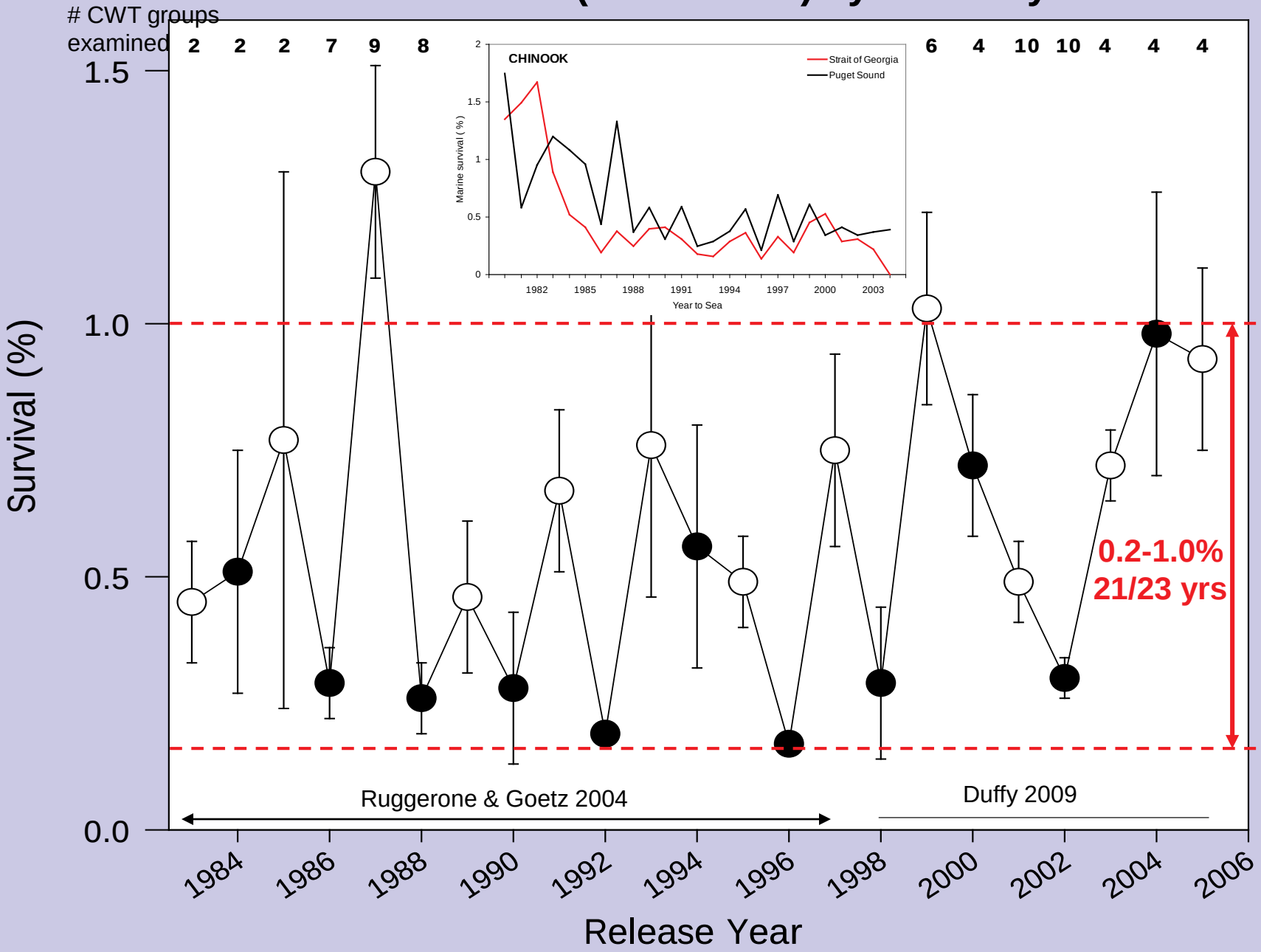
Marine survival of hatchery Chinook in the Salish Sea region declined 1980s & remained low-but not adjacent regions



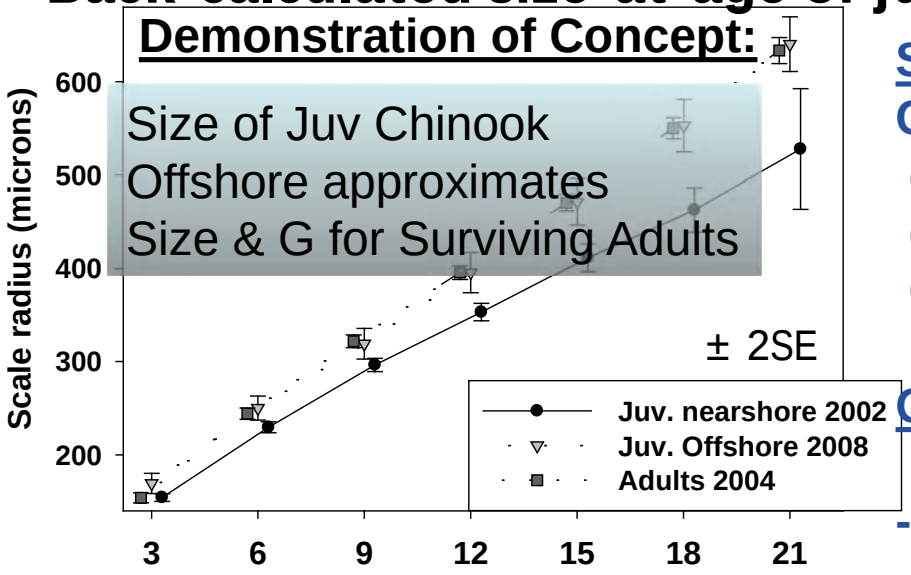


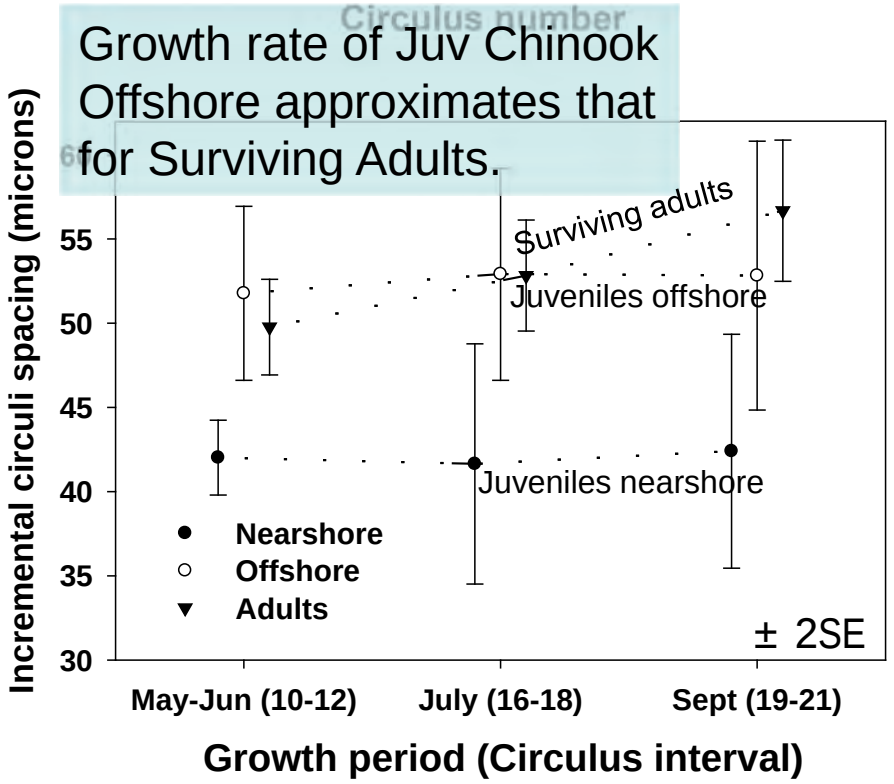
Beamish. 2011.

BACKGROUND: Puget Sound Hatchery Chinook Salmon Marine Survival Rates (smolt-adult) by release year



Back-calculated size-at-age of juvenile & adult Puget Sound Chinook





SSM & Critical period approach:

Compare size-specific contributions of different life stages to adult returns & diagnose limits to growth & S in Critical periods

Questions for 2014-2015:

-Timing of life stages pulsing through specific habitats

-Size-specific contribution to later stages

-Identify critical life stages & assoc.habitat

-Growth performance w/in life stage/habitat

-Diagnose factors limiting growth:
- **-Food supply (production, competition)**
- **-Food quality (energy content)**
- **-Thermal effects on metabolism**

-SSM Predation impacts by resident salmon

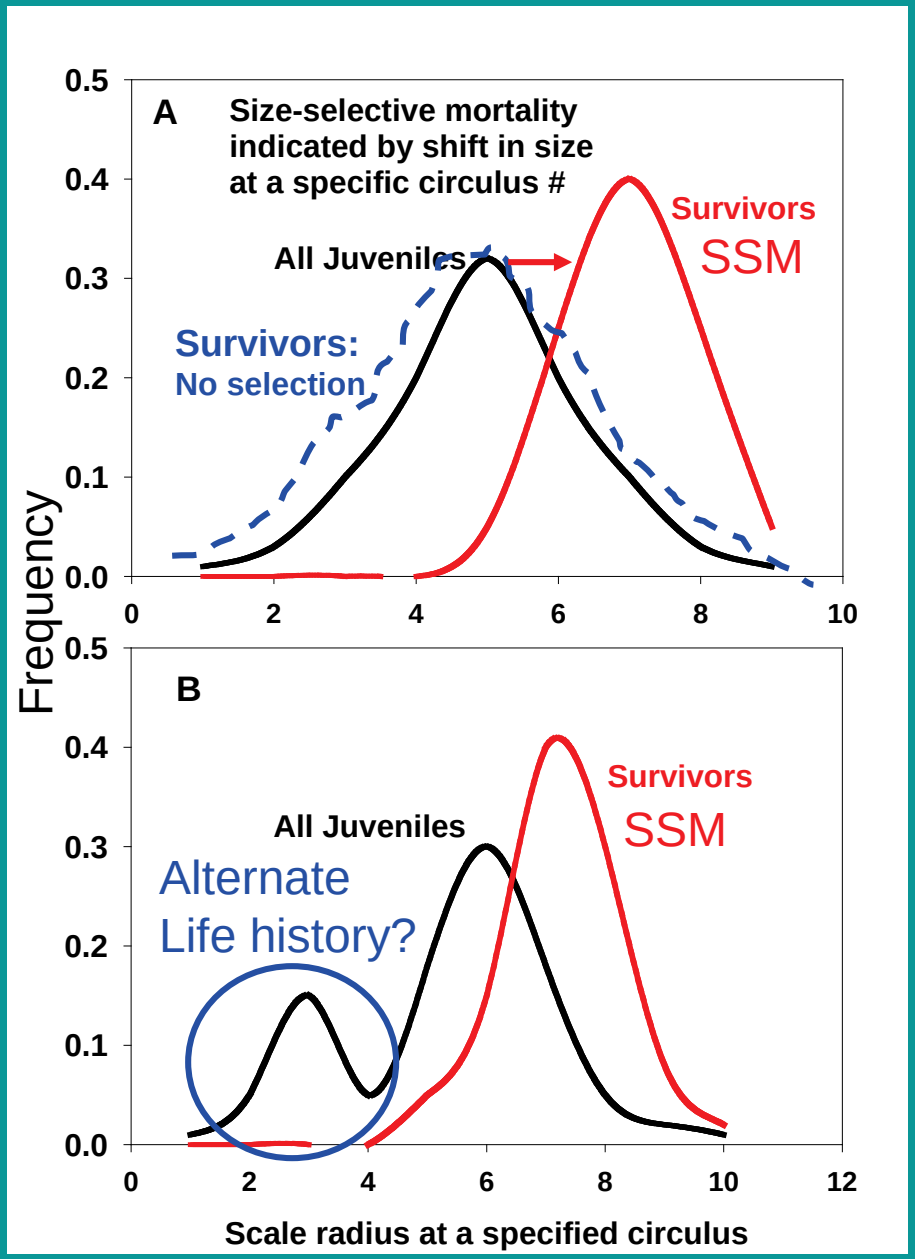
Size Selective Mortality (SSM)

For each life stage:
SSM Inferred by comparing Size distributions (scale radius at specific circuli) for juveniles to:
-Juveniles at later life stages
-Adult survivors from that same group

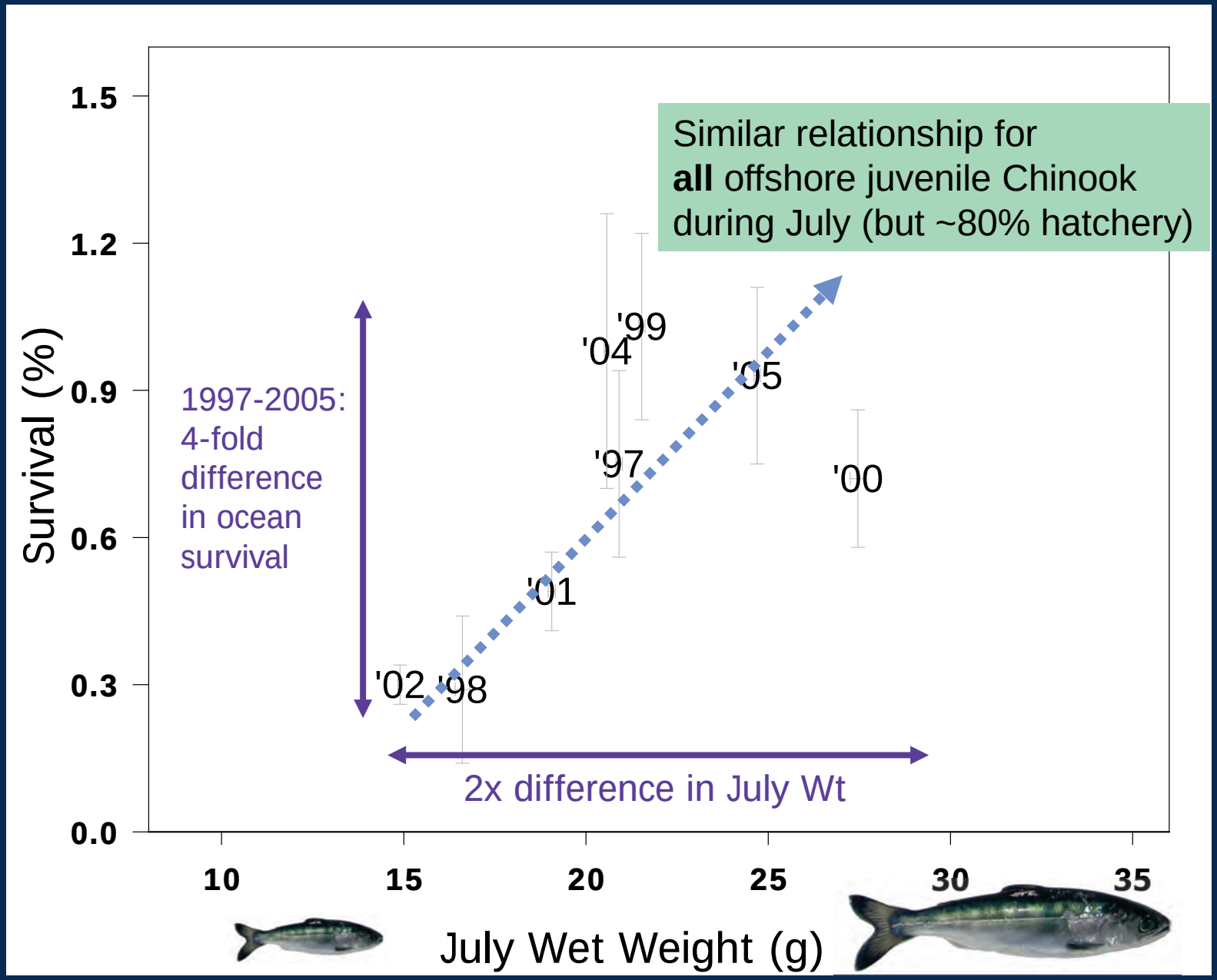
Larger individuals survived at a Disproportionately higher rate in Both hypothetical examples A & B

B, 2nd mode of smaller juveniles did not survive to Adulthood.

This mode could represent growth trajectories from an alternative life history strategy that's unsuccessful under prevailing conditions



Rapid Early Marine Growth Improves Survival



Potential Pelagic Competitors During Critical Period:

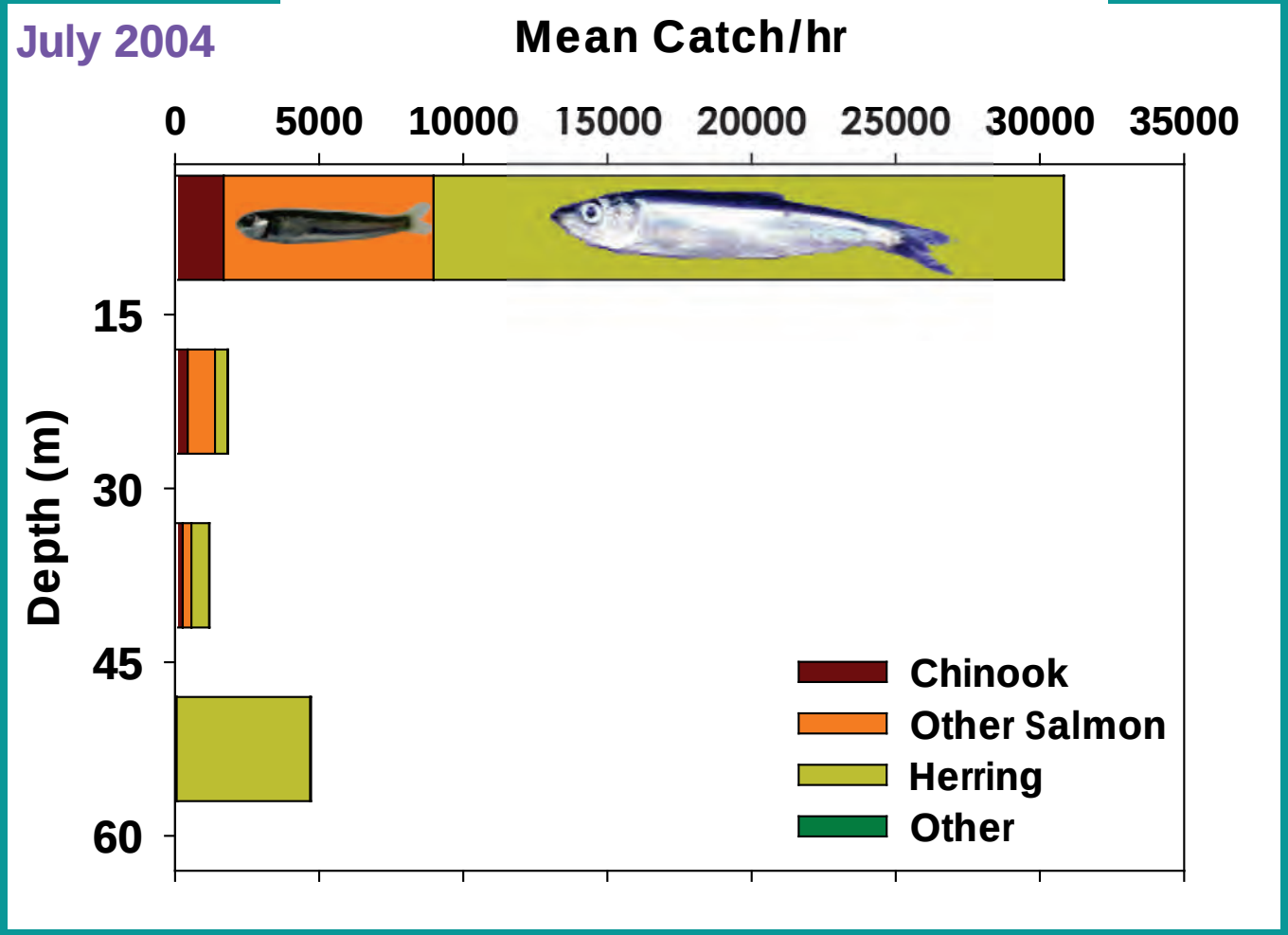
Biomass & Spatial Temporal Overlap

Pacific Herring dominate the biomass of epi-pelagic planktivores

Shallow: 0-15 m

Herring: smaller aggregations at greater depth (scattering layer)

Daylight Planktivore Community



DFO Canada
Midwater trawl

Modeling Process

Consumer Growth

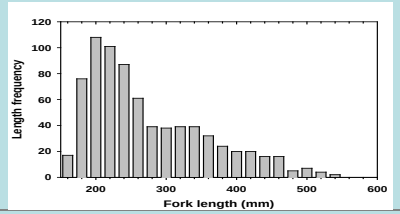
Temporal Diet Composition

Predator Energy Density

Thermal Experience

Prey Energy Density

Bioenergetics Model



Consumer Size Structure & Abundance

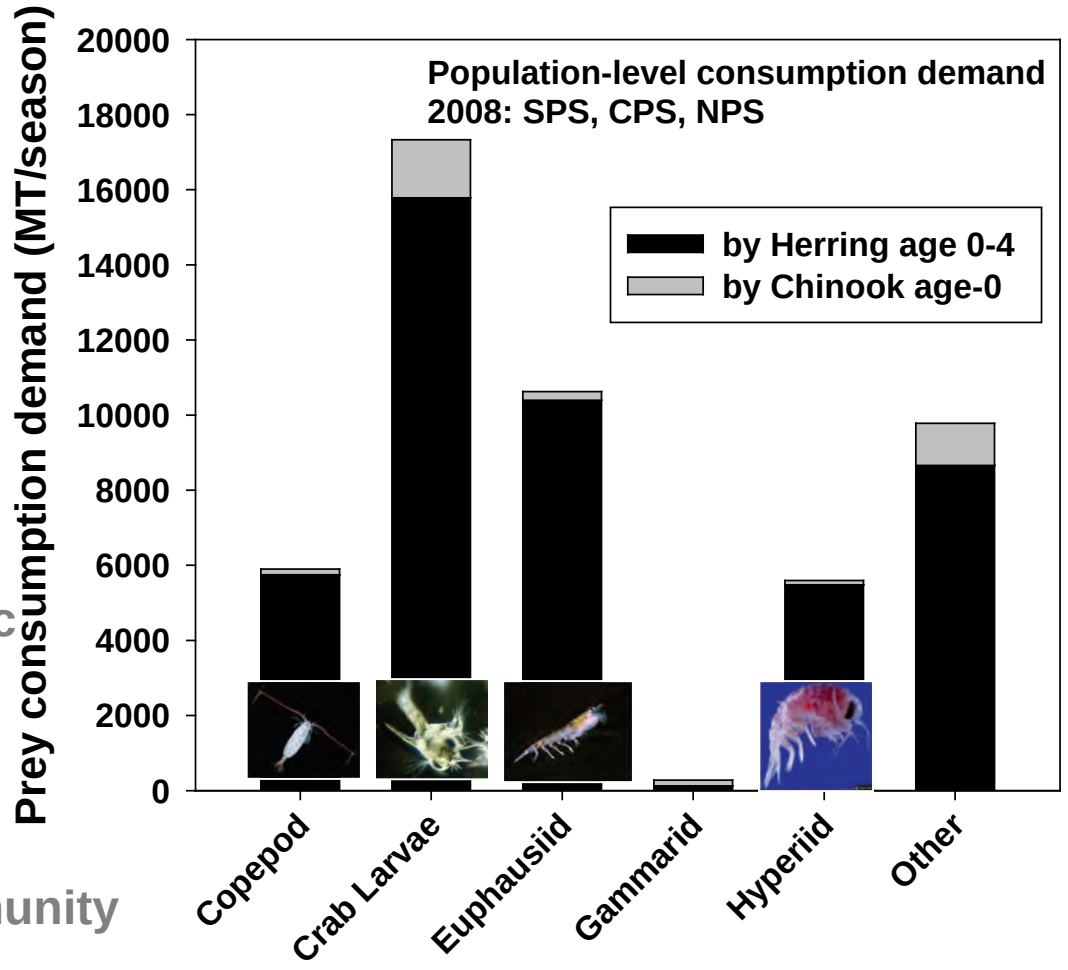
Consumption Estimate

Population Consumption by Herring & Chinook

Compare Consumption Demand by Herring & Chinook for Key Prey During Critical Growth Period (May-July)

Potential Inter-specific Competition for Food

Herring remove 10-47x more Biomass of key shared prey than H+W Chinook during Critical May-July period



CONCLUSION:
On average, <u>Competition</u> driven 1º by Herring in pelagic Habitats of Puget Sound.

But-Competition should be Considered across the entire Epi-pelagic planktivore community

Intensity of competition will likely Vary among regions & months, based on relative abundance & diet of each species