

# **Life Beyond the Spawning Grounds: Distribution & Food Web Relations of Herring & Forage Fishes in Puget Sound**

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# Most Forage Fish Data Currently derived from Spawning Surveys

- Trends in spawner biomass, ~age structure, growth & survival estimates by stock & geographic region (e.g., Stick & Lindquist 2009)
- Less information available regarding ontogeny, seasonal diet, distribution, trophic interactions
  - Environmental & ecological factors affecting survival & growth:
    - Predation
    - Competition
    - Food supply
    - Climate forcing? Water quality? Contaminants?

# **Exploit Similar Info-Needs for Juv. Salmon & Forage Fishes**

- Most life stages can be sampled with the same gear at the same times & locations during the growing season
- Methodically record data & archive samples of “non-target” species (freeze)
- Break down salmon v forage fish silos in research, monitoring & restoration
- Benefit from economies of scale

# Objectives

- Summarize some data collected opportunistically (2001-present):
  - Epi-pelagic distribution & Relative abundance
  - Diet, diet overlap, competition, predation
- Highlight opportunities for joint R&M efforts to address juv. salmon survival & forage fish questions:
  - Temporal-spatial distribution
  - Food web interactions
  - Stage-specific growth & survival

# Data Sources

## DFO-Canada Midwater Trawling



July & Sept. cruises ~2001-2013

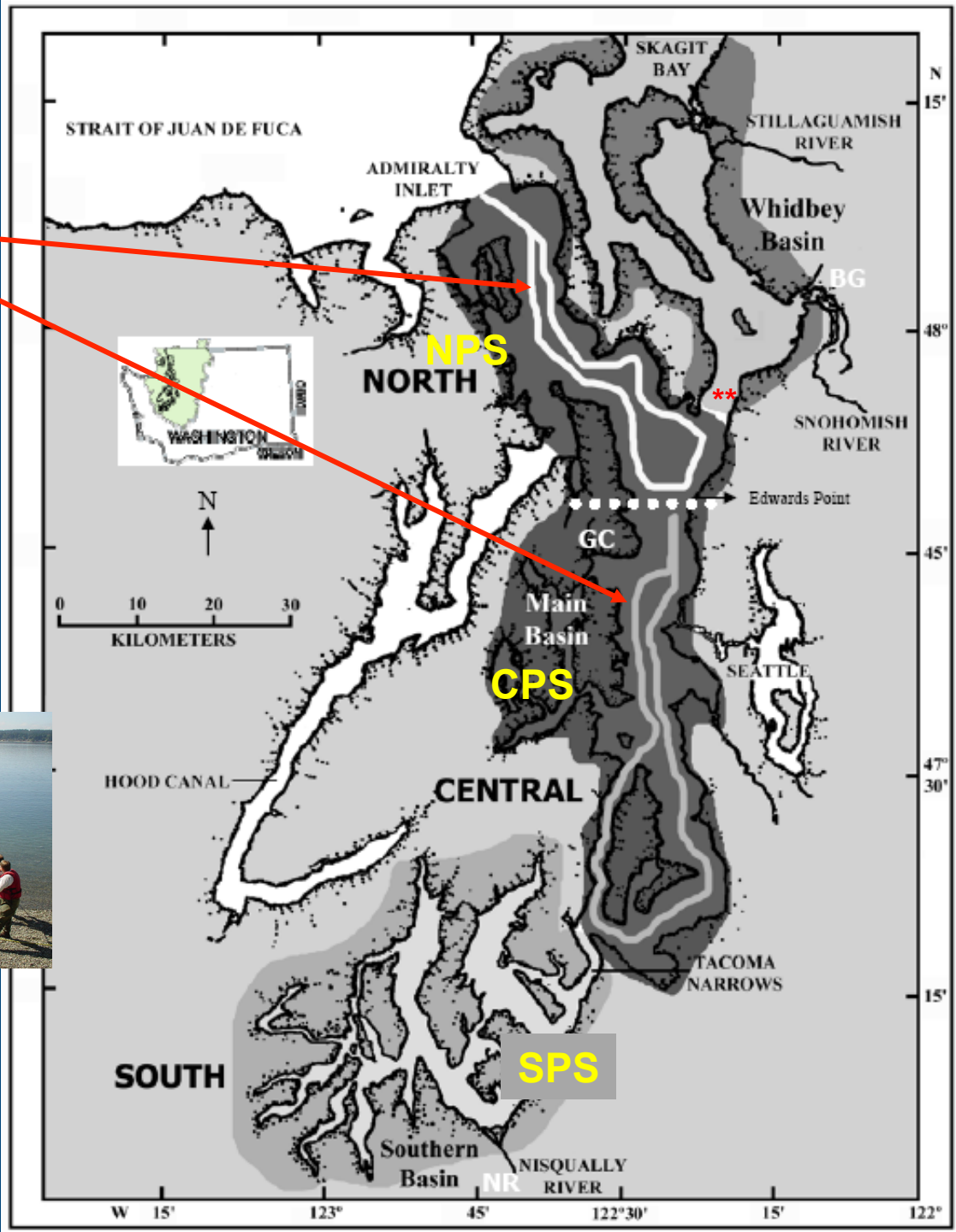
Depth-stratified samples in N & C basins:  
0-15m, 15-30m, 30-45m, 45-60 m

Future Cruises are highly uncertain  
beyond Sept. 2013



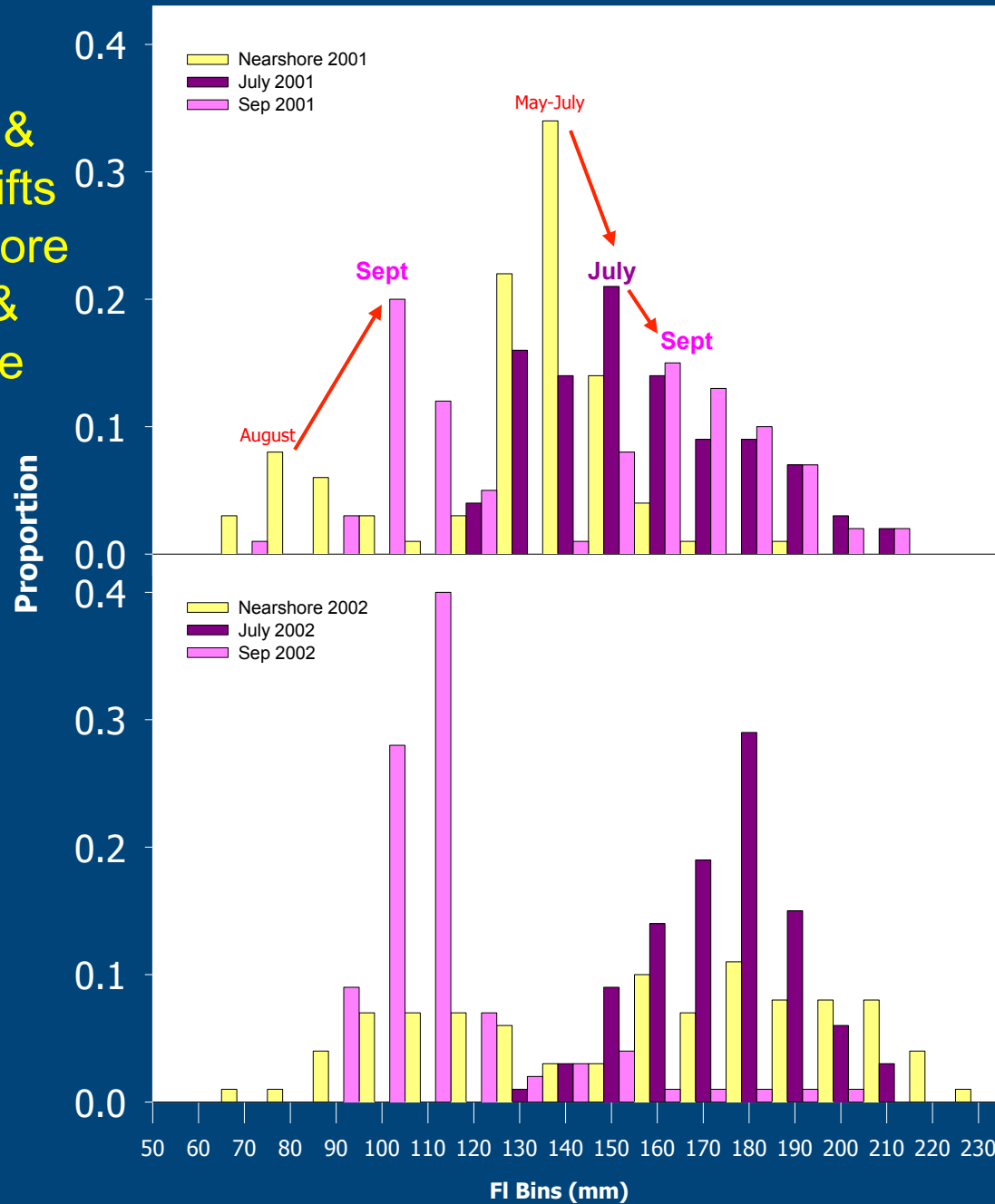
-Beach Seining 2001-2002  
N, C, S basins, Apr-Sept

-Pilot Purse seining \*\*  
June 2003 Mukilteo-Clinton



# Herring: Nearshore-Offshore Size Structure

Ontogenetic &  
Seasonal shifts  
In near-offshore  
Habitat use &  
Size structure



# Offshore Catch Proportions

Herring catches represent a volatile underestimate of spp composition due to patchy encounters with schools during Daylight tows

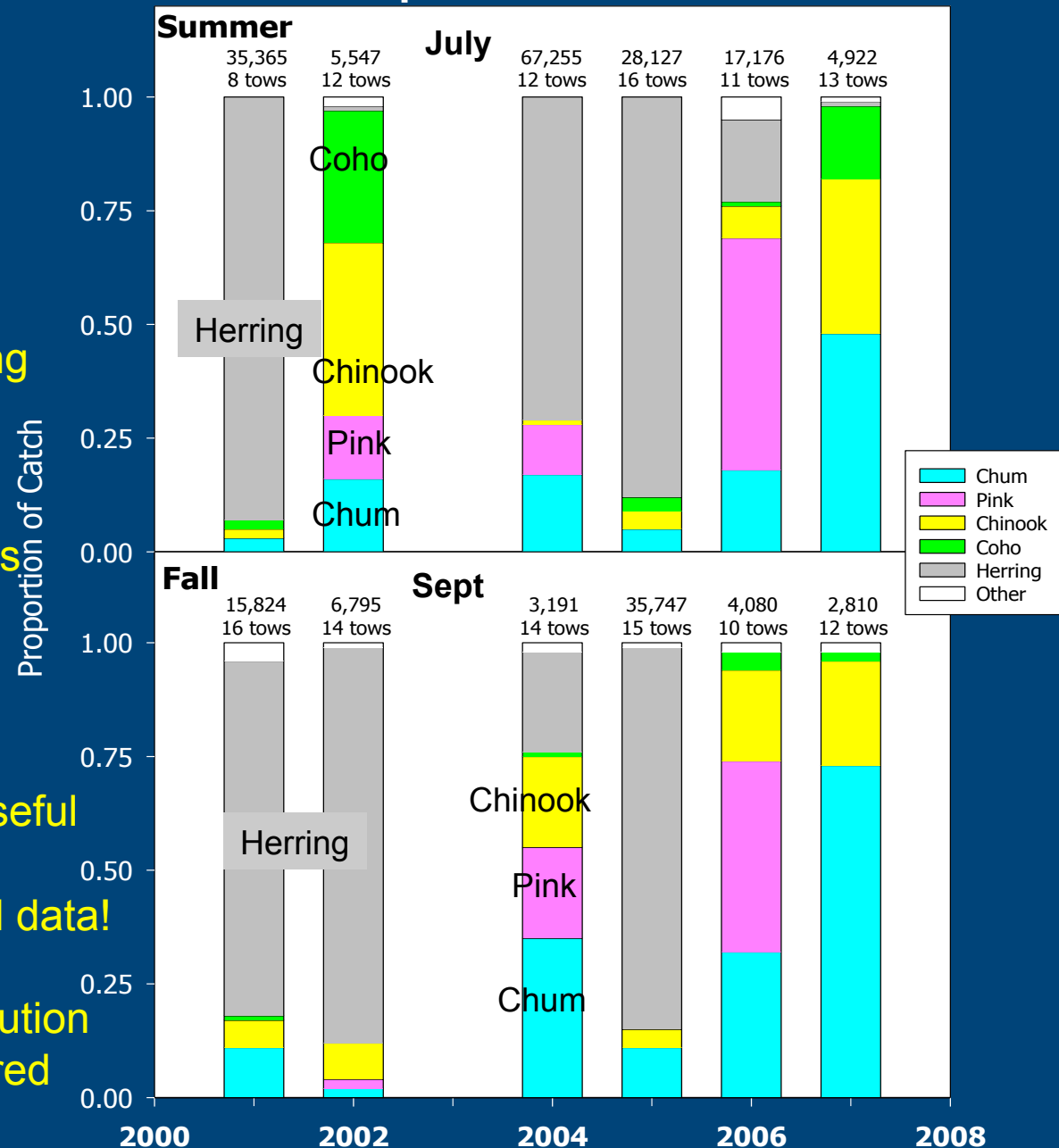
Forage fish abundance trends from these data are dubious

BUT

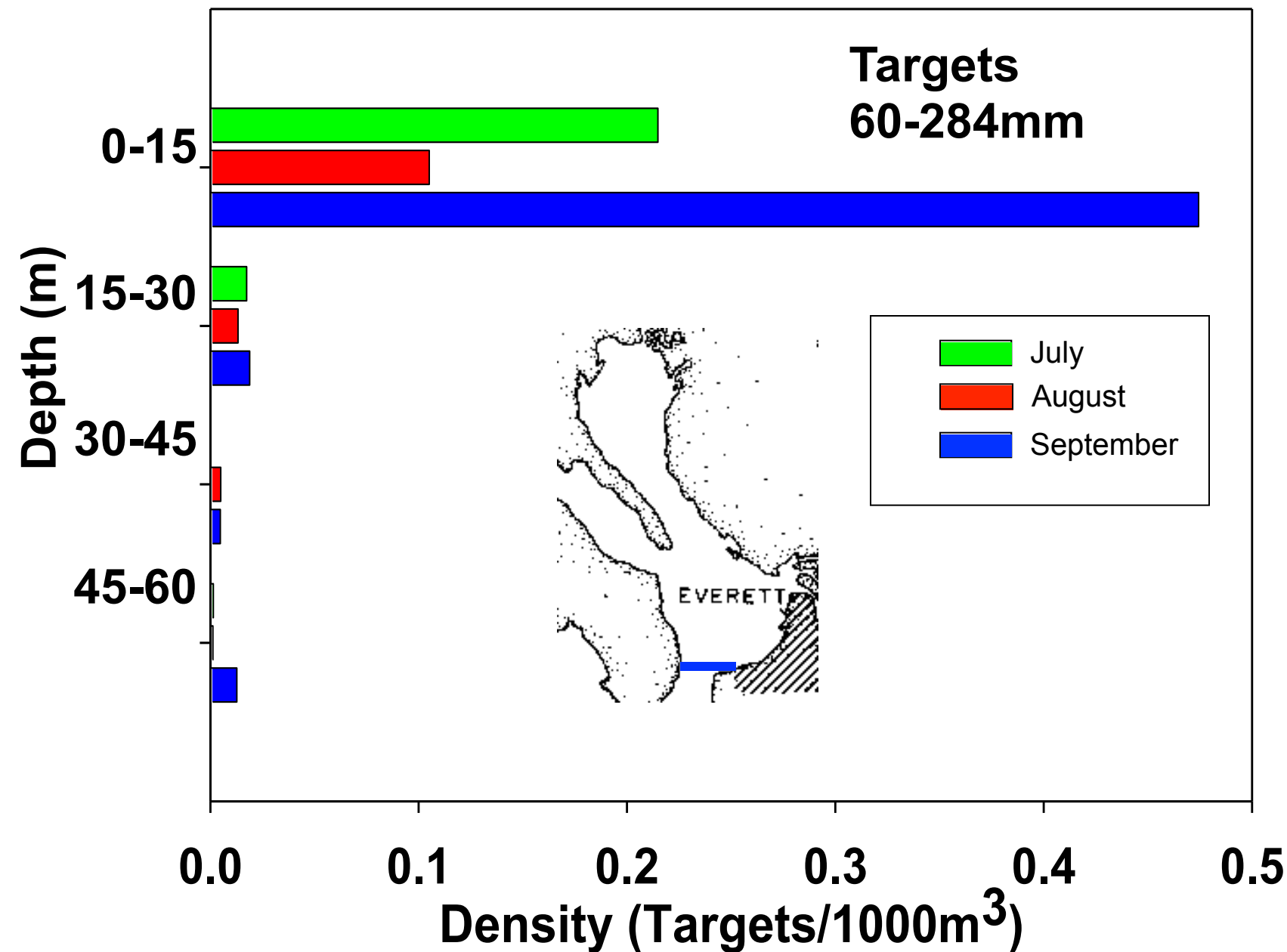
Depth distribution patterns useful

Excellent source of biological data!

Relative abundance & distribution  
Data for juv. salmon considered  
More reliable than for herring



# Split-beam Hydroacoustics 2002



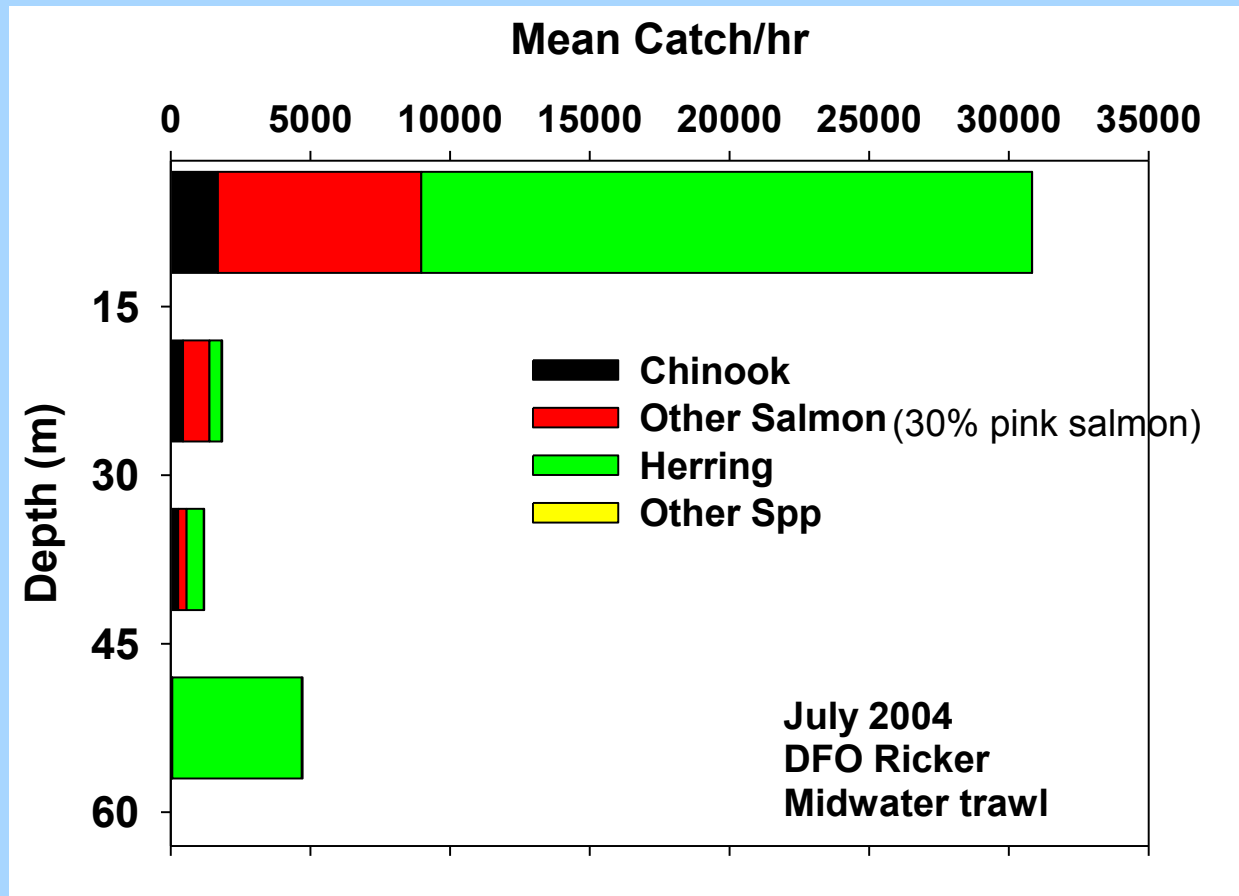


# Abundance & Spatial-Temporal Overlap of Potential Pelagic Competitors

## Daylight Planktivore Community

**Herring** dominated the Biomass of epi-pelagic Planktivores during Critical July growth period

All planktivorous fishes Concentrated in 0-15m During July.





# Purse Seining: Live Capture of Pelagic Salmon





# Epi-Pelagic Fish Community Sampled with Purse seines

Juvenile salmon & forage fish  
Prevalent in epi-pelagic zone

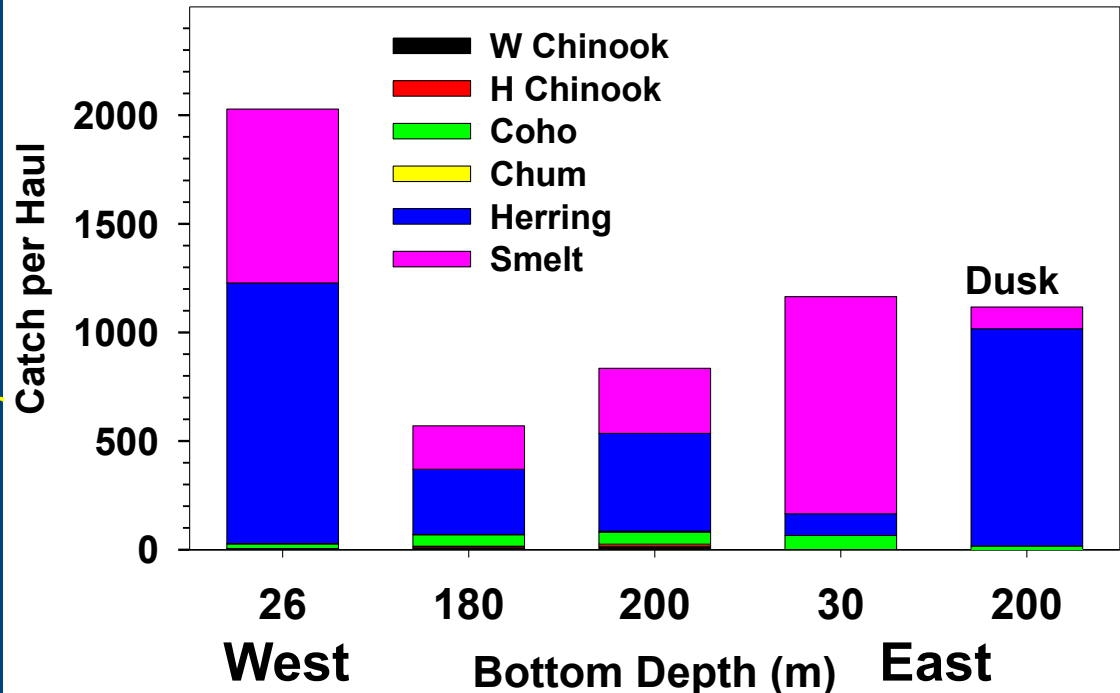
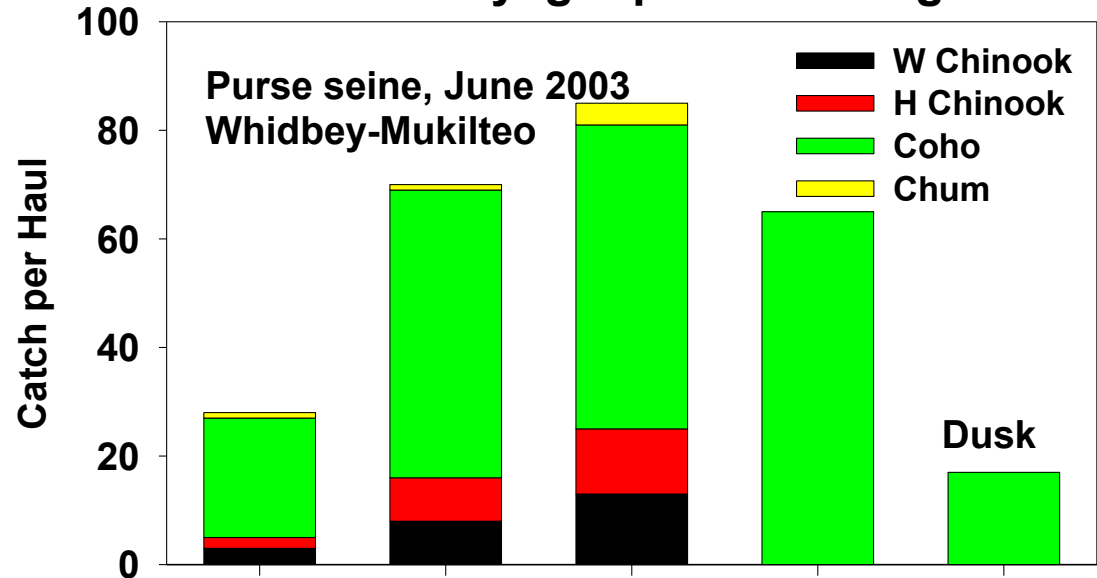
Forage fish abundance MUCH  
HIGHER than juv salmon

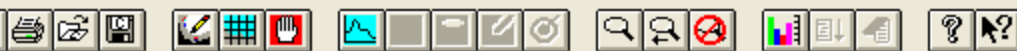
Surf Smelt & Herring dominate  
The epi-pelagic catch

Surf smelt densities seem higher  
Closer to shore slope than in  
mid-channel

Smelt rare in Ricker MW Trawls

June 2003- Daylight purse seining

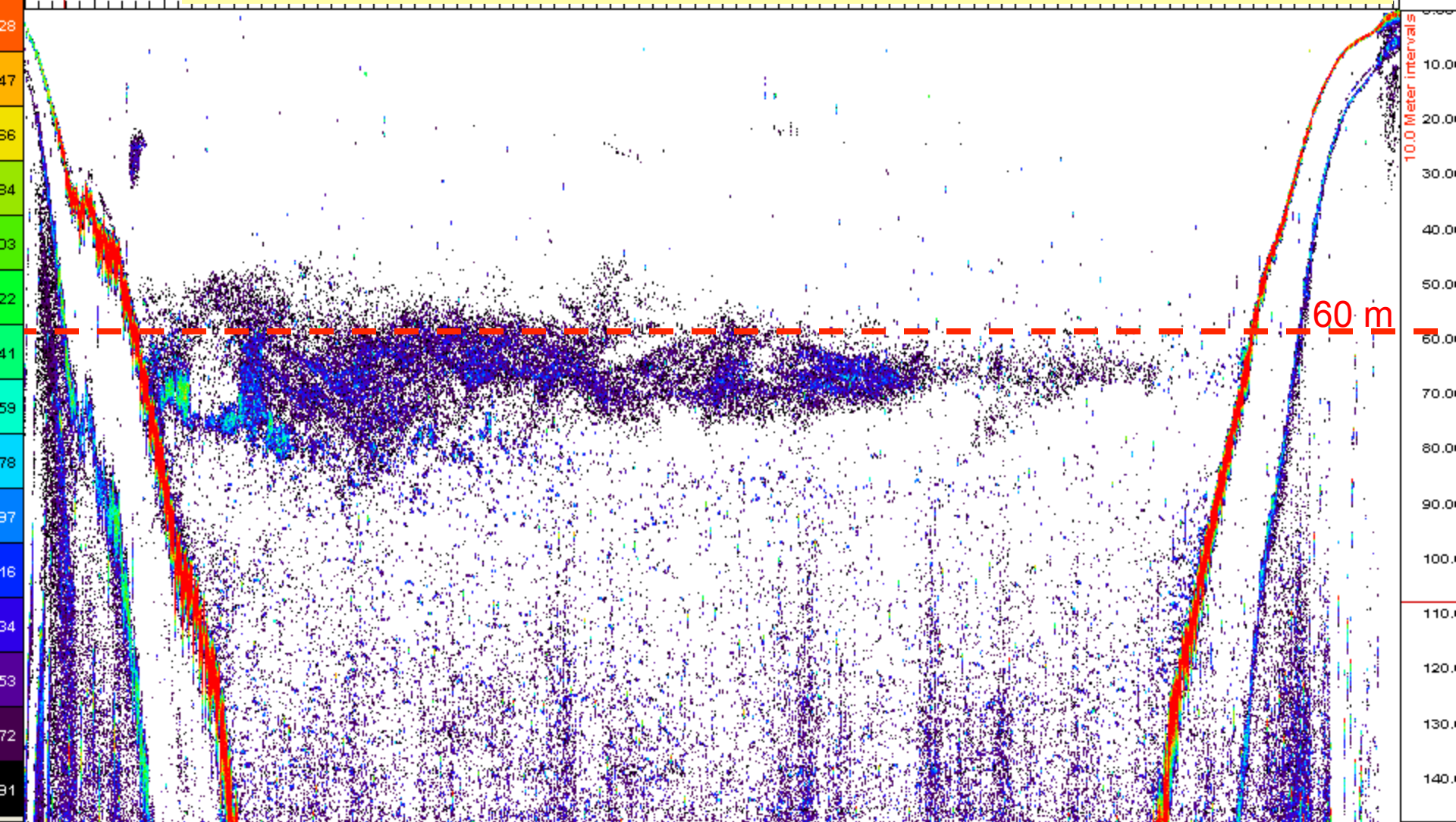




N619PS9.DT4 - Channel 1 Echogram

100.0 Ping Intervals  
0 100 20

DAYLIGHT: Mukilteo (7:38pm) to Possession (7:57pm)



ing: 57, Depth: 109.68 meters

06/19/03 02:52:40

47° 56.9200' N

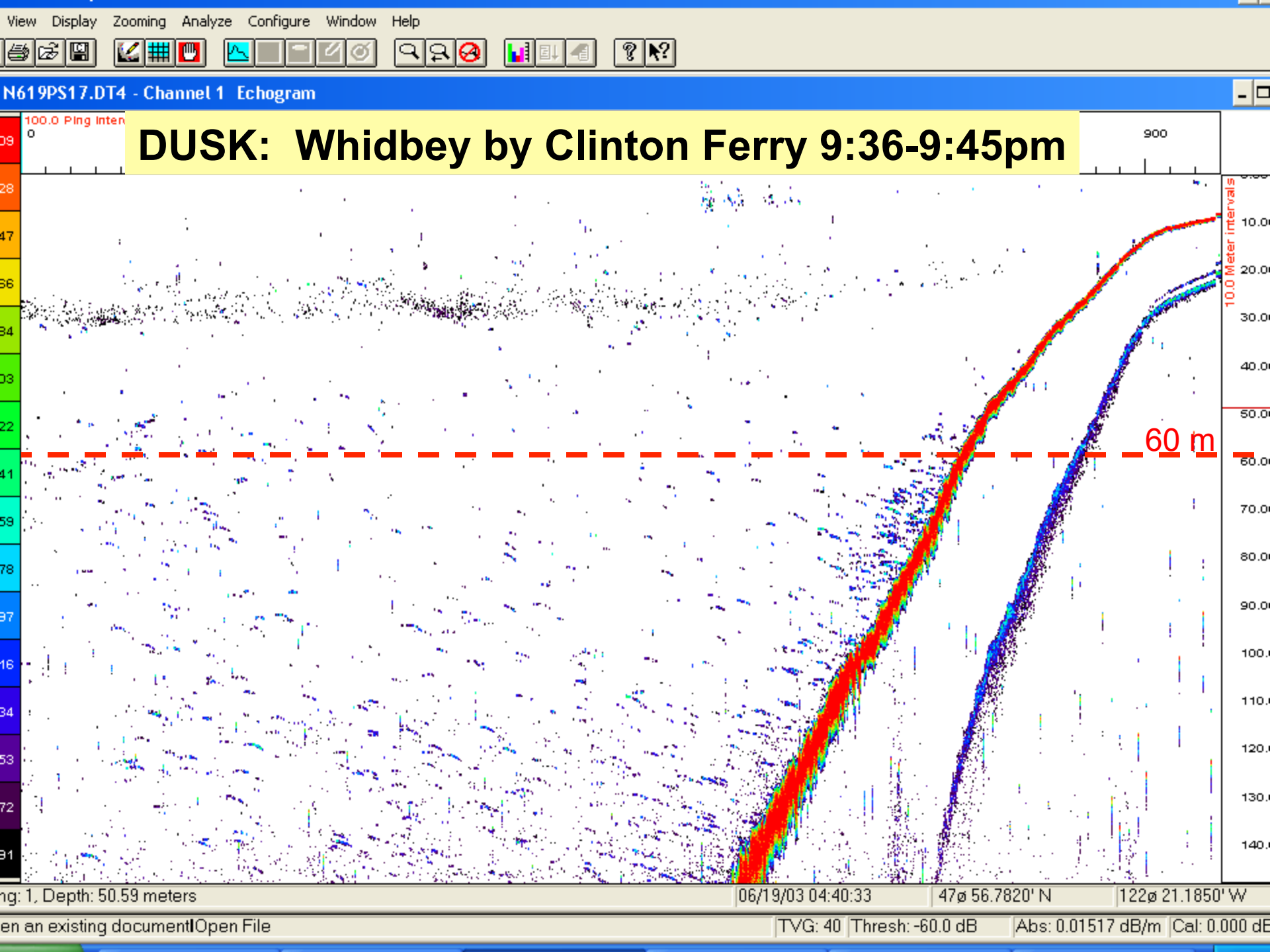
122° 21.1430' W

Open an existing document | Open File

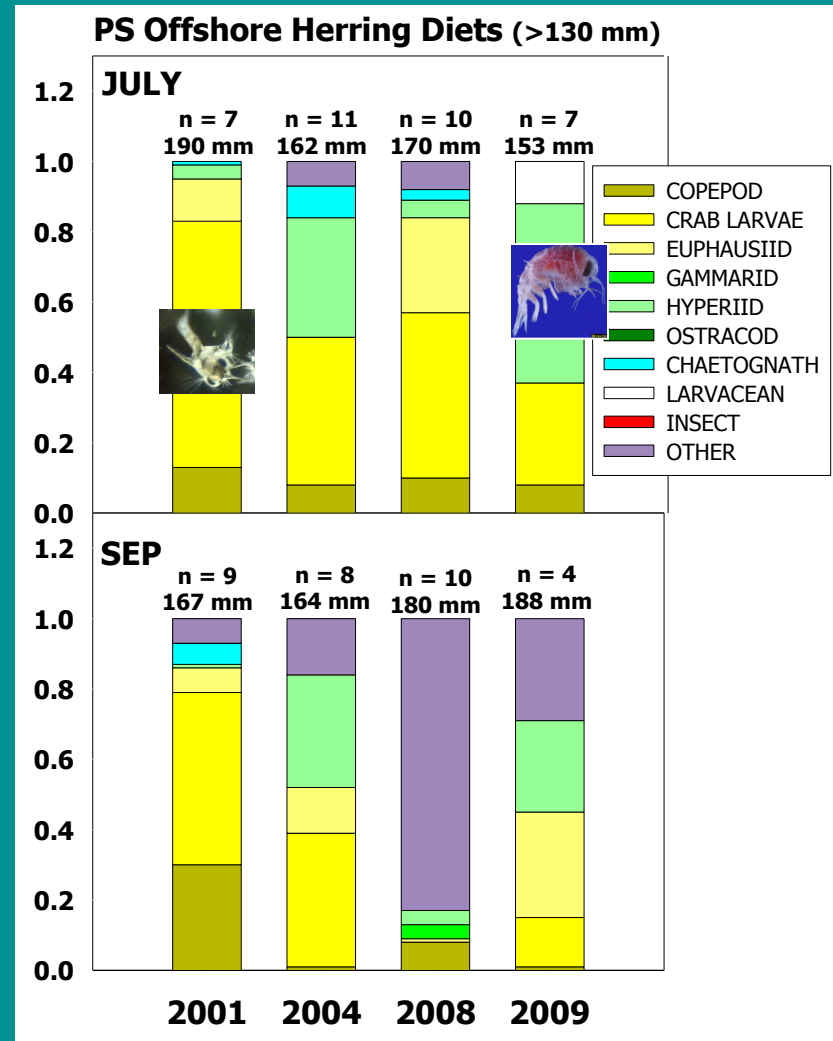
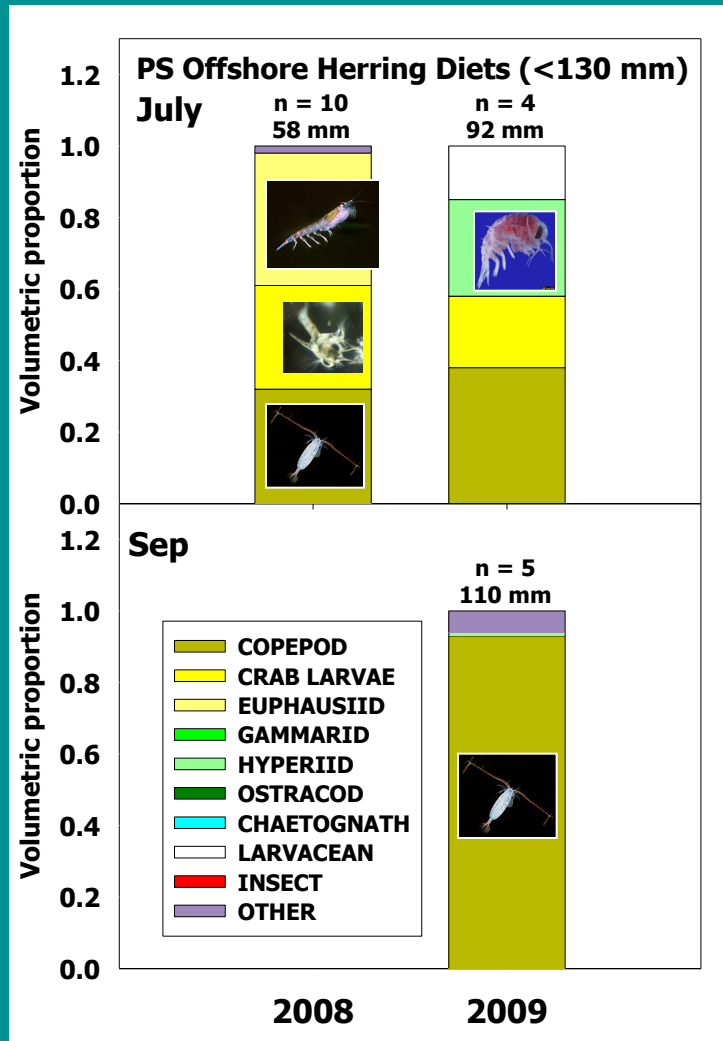
TVG: 40 Thresh: -60.0 dB

Abs: 0.01517 dB/m

Cal: 0.000 dB

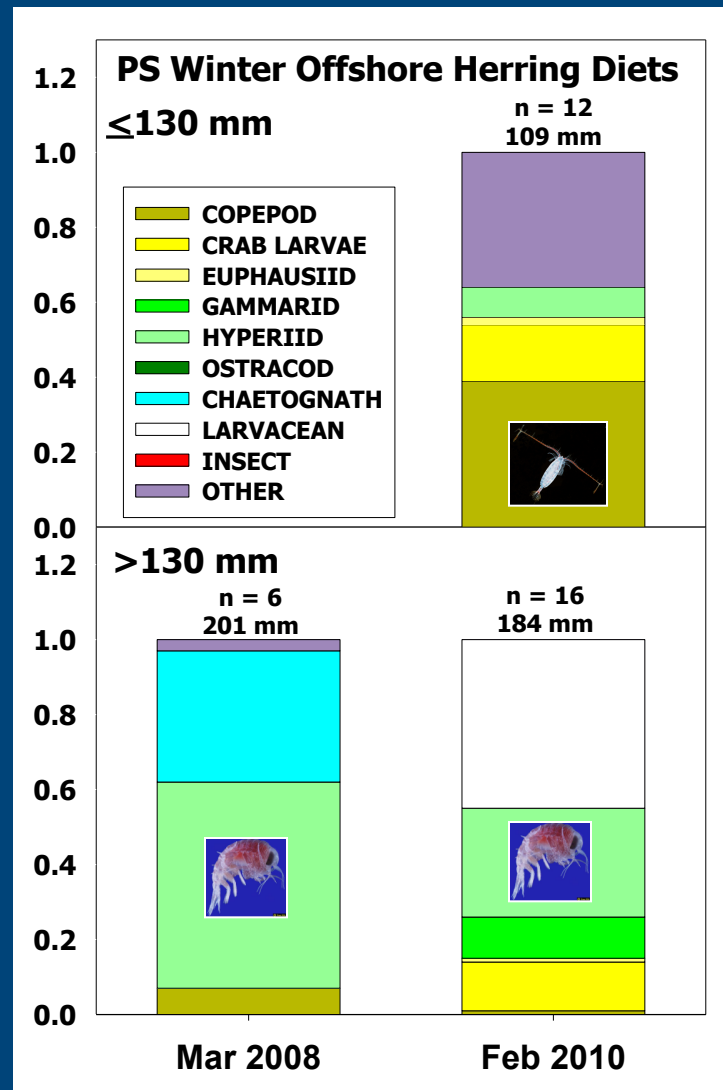


# Summer Herring Diet by Size class, Year, and Month



Small herring feed more heavily on Copepods than older herring  
Larger herring eat more crab larvae & amphipods

# Winter Herring Diet by Size class, Year, and Month



Small herring feed more heavily on Copepods than older herring  
Larger herring eat more amphipods

# Strong Diet Overlap during Critical Growth Period Between juvenile Salmon spp. and Herring

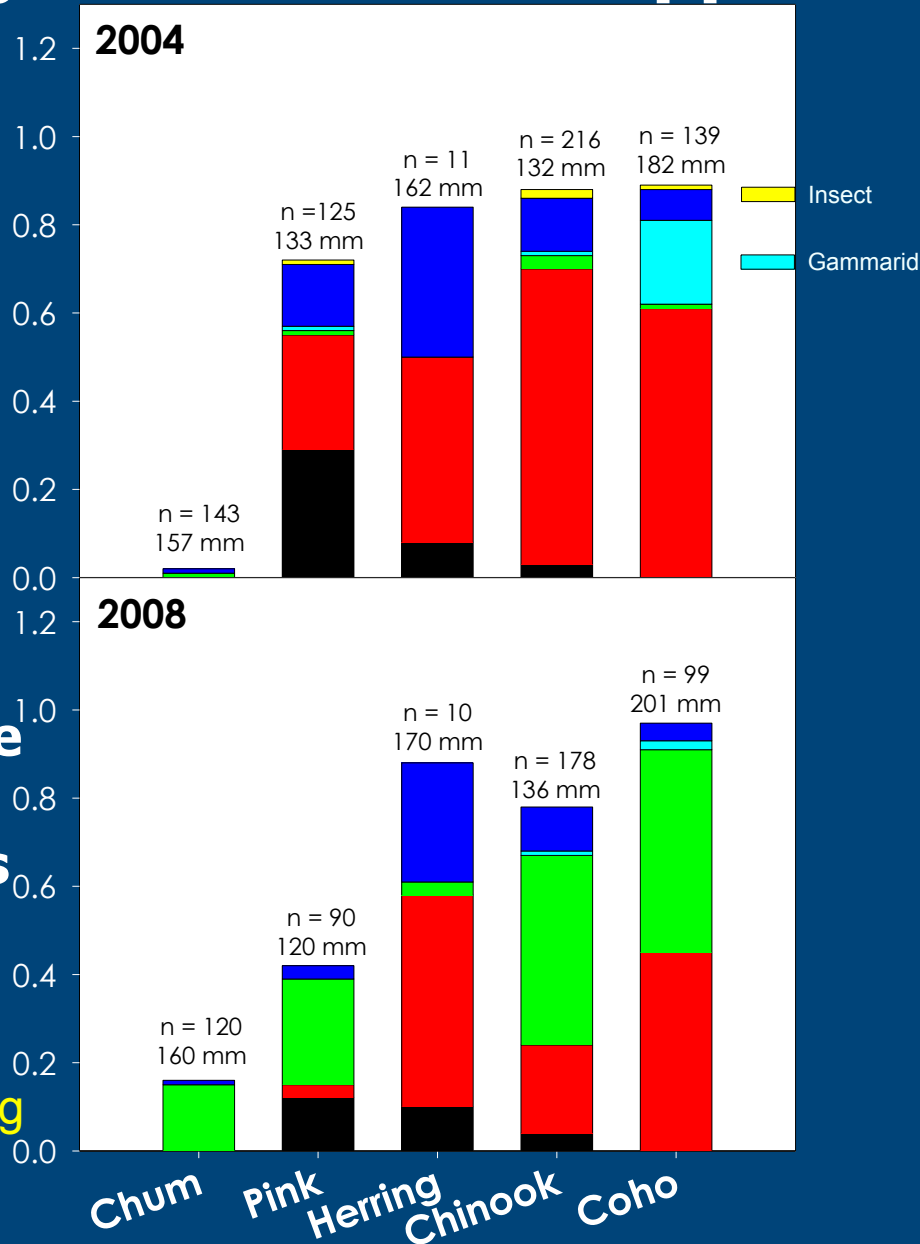
**JULY**

## Key Prey Overlap:

- Crab Larvae
- Hyperiids
- Euphausiids

**Key Prey & degree  
of Diet overlap  
Vary among years**

**Chum Salmon show  
Least overlap with  
Other salmon & herring**



Hyperiid



Crab Larvae



Copepod

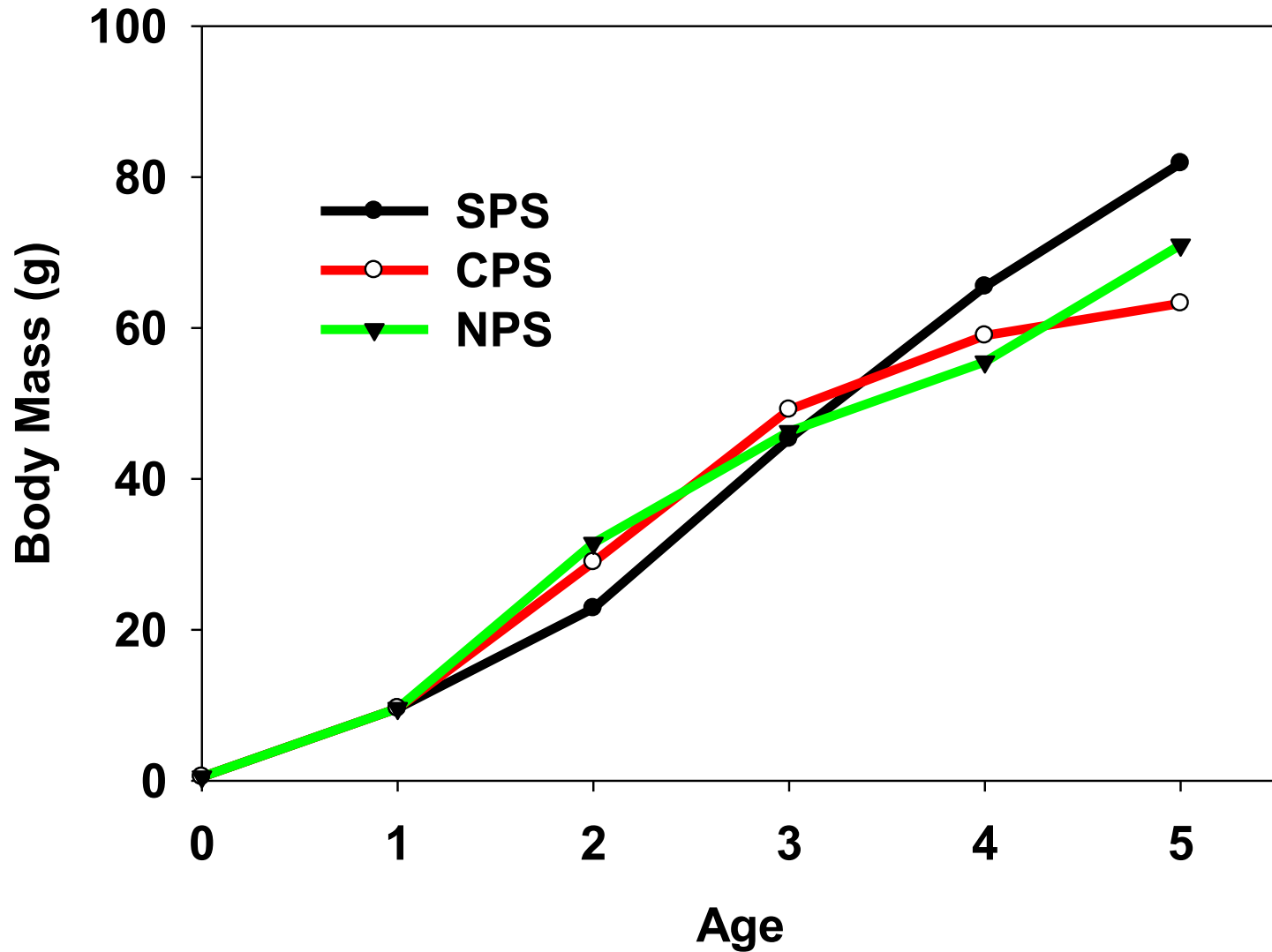


Euphausiid





## Herring Size-at-Age (from Stick & Lindquist 2009)



# Potential Inter-specific Competition for Food

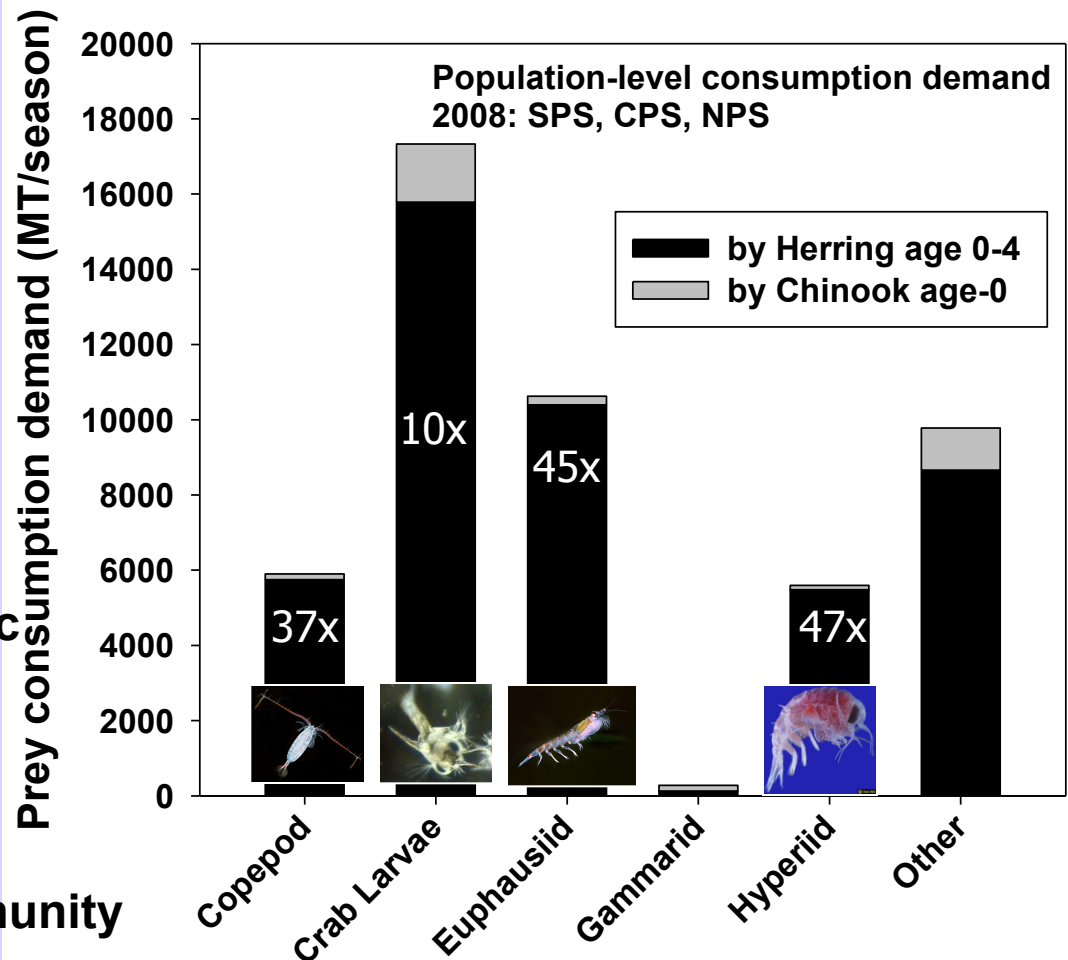
**Herring remove  
10-47x more Biomass  
of key shared prey than  
H+W Chinook during  
Critical May-July period**

## CONCLUSION:

On average, Competition  
driven 1° 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



## Existing Knowledge

- Epi-Pelagic planktivore community biomass dominated by herring
- Significant diet overlap between Herring and Juvenile Chinook
- Herring consume 10-40x the biomass of prey shared by Chinook
- Potential for considerable competition effects on growth
- Other salmon and forage fishes also overlap and compete, but impose lower consumption demand than herring

# Conclusions & Recommendations

- Consider Carrying Capacity for entire planktivorous fish community rather than for single species
  - Considerable diet overlap among Herring & juvenile salmon. Less know about other forage fishes
  - Forage fish biomass & dynamics can potentially overwhelm trophic effects of juv. salmon
  - Must consider interactions at proper temporal-spatial scales
    - Competition could vary significantly among regions, months, & years
  - Need zooplankton data!!

# Predators



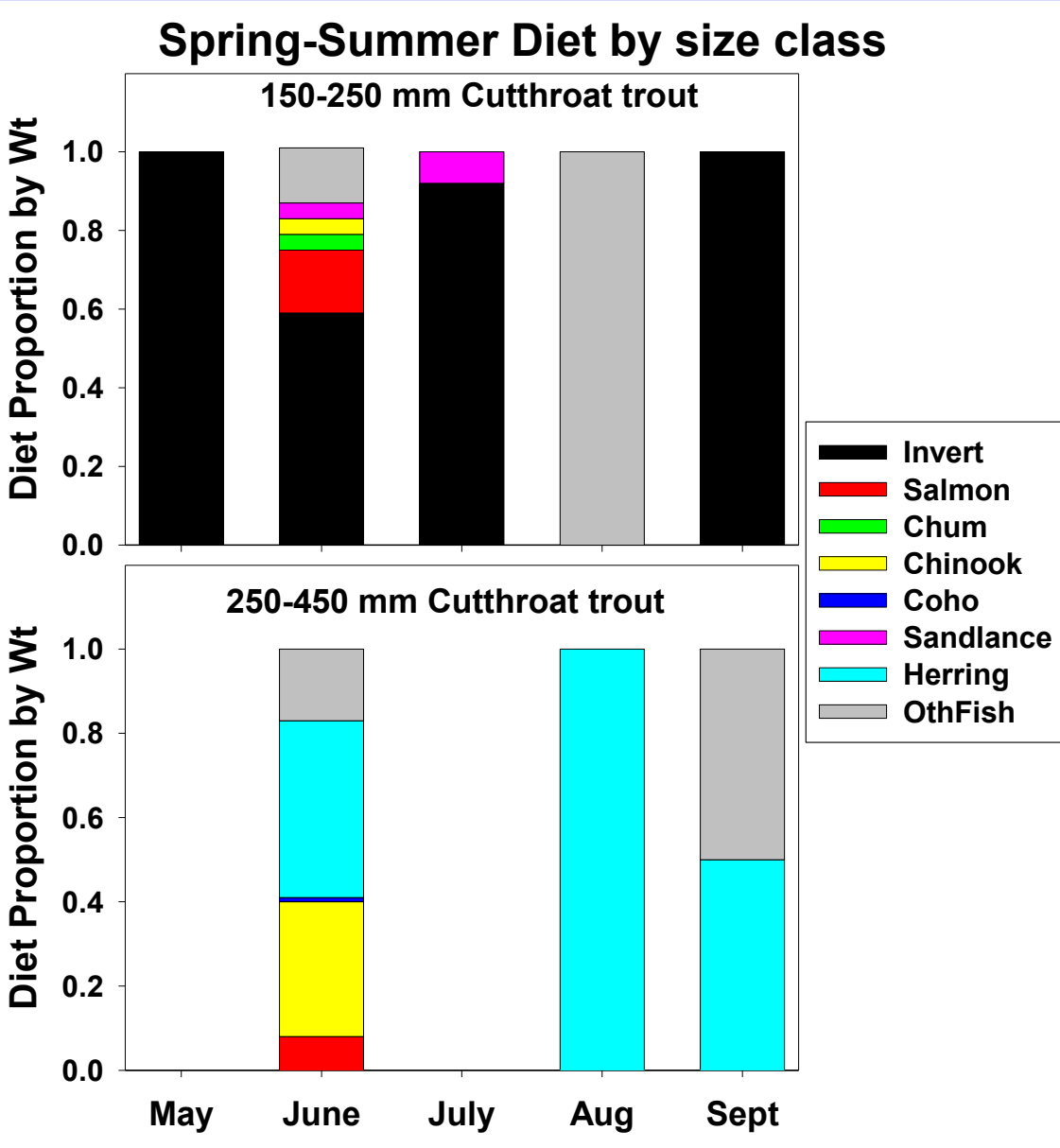
# Sea-run Cutthroat Trout

Relatively low abundance

Primarily a nearshore predator

Smaller Less Piscivorous trout  
Eat juv. salmon & sandlance

Larger (FL > 250 mm) trout are  
Highly piscivorous and primarily  
eat Herring & juv Salmon

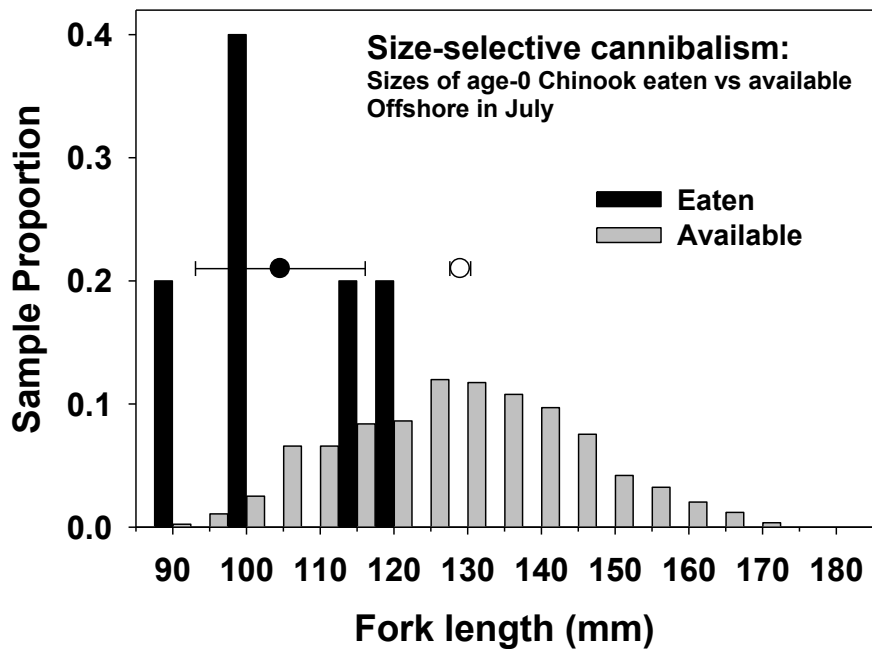
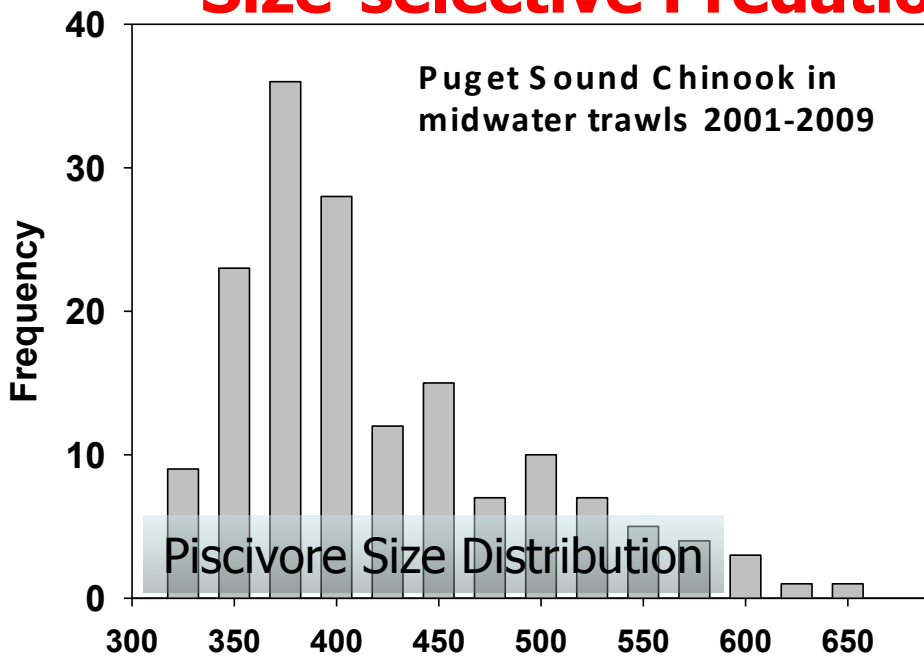




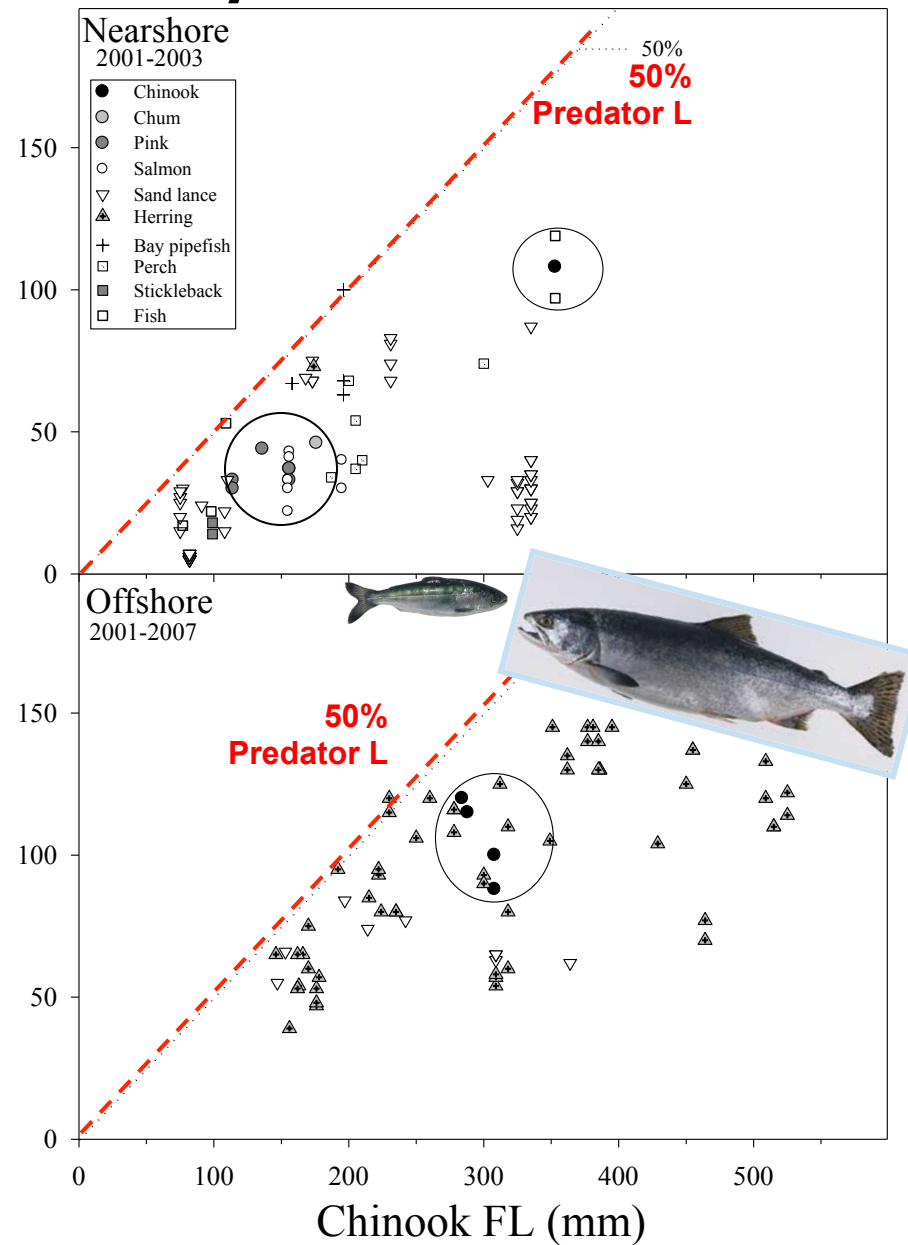
# **Predatory Juvenile & Resident Chinook Salmon**

- **Relatively abundant predator**
- **Feed in Nearshore & Offshore Habitats**
  - **Nearshore predation by juveniles primarily in June-July**
  - **Offshore predation year-round by Resident & older juvenile Chinook**

# Size-selective Predation

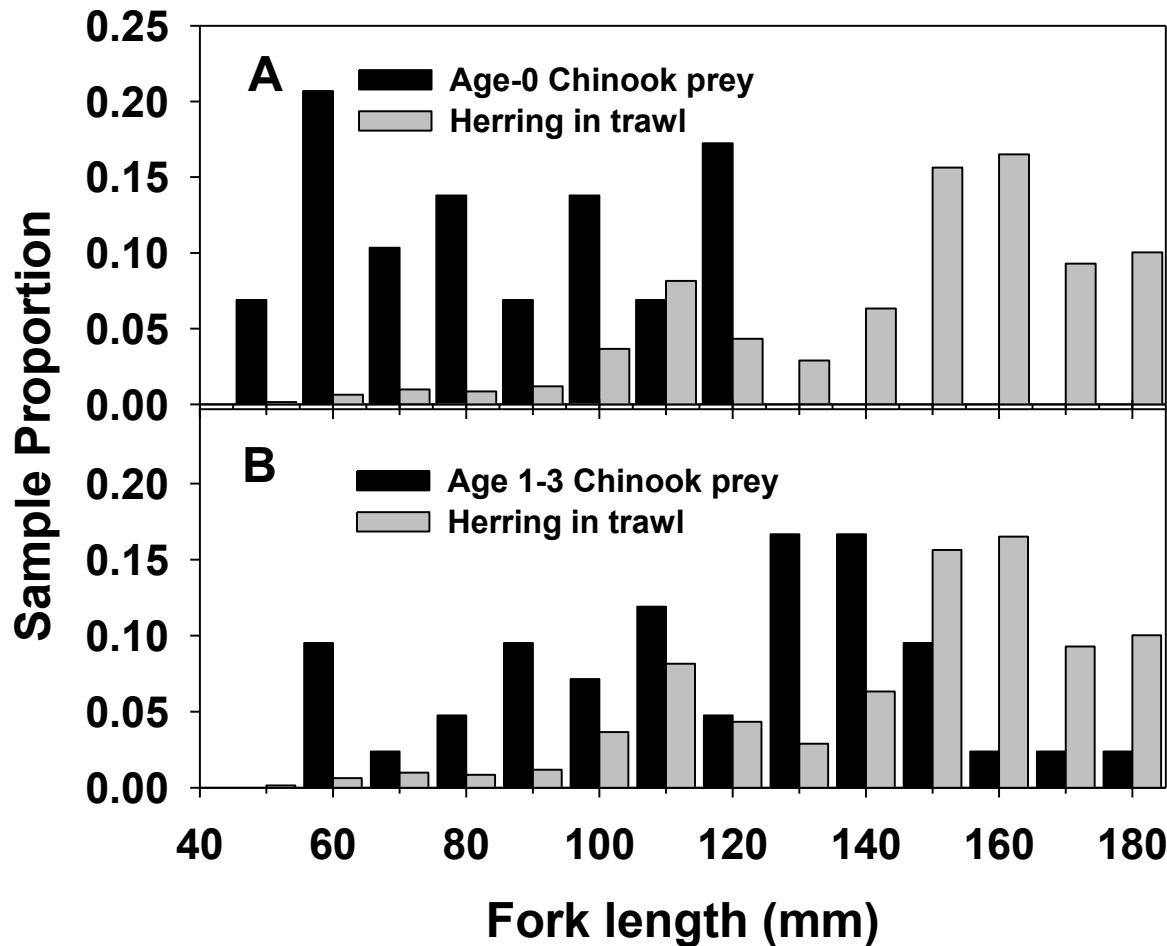


# Prey Size : Predator Size





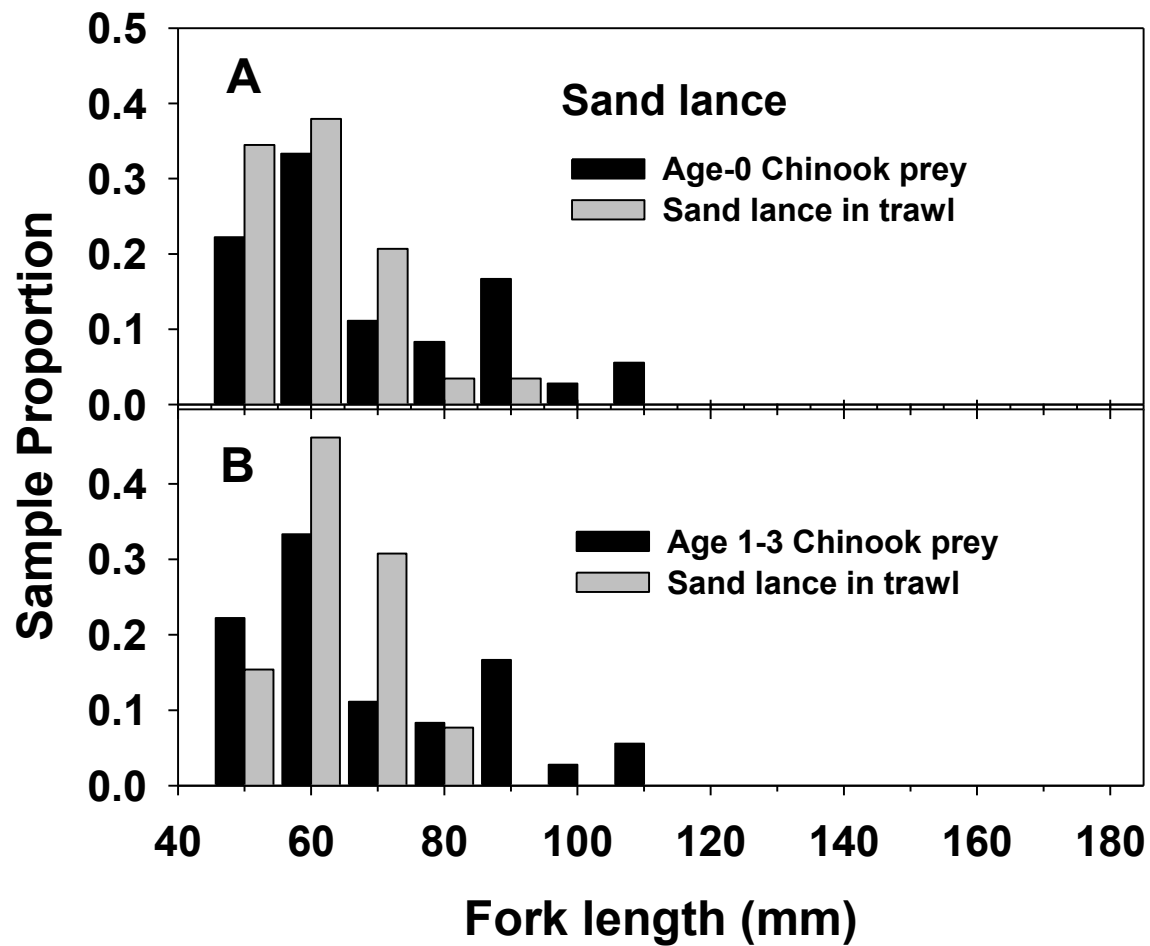
# Size-selective predation on Herring by Juvenile & Resident Chinook Salmon



Herring found in age-0  
Chinook stomachs  
are significantly smaller  
than those sampled  
Concurrently with MW Trawl

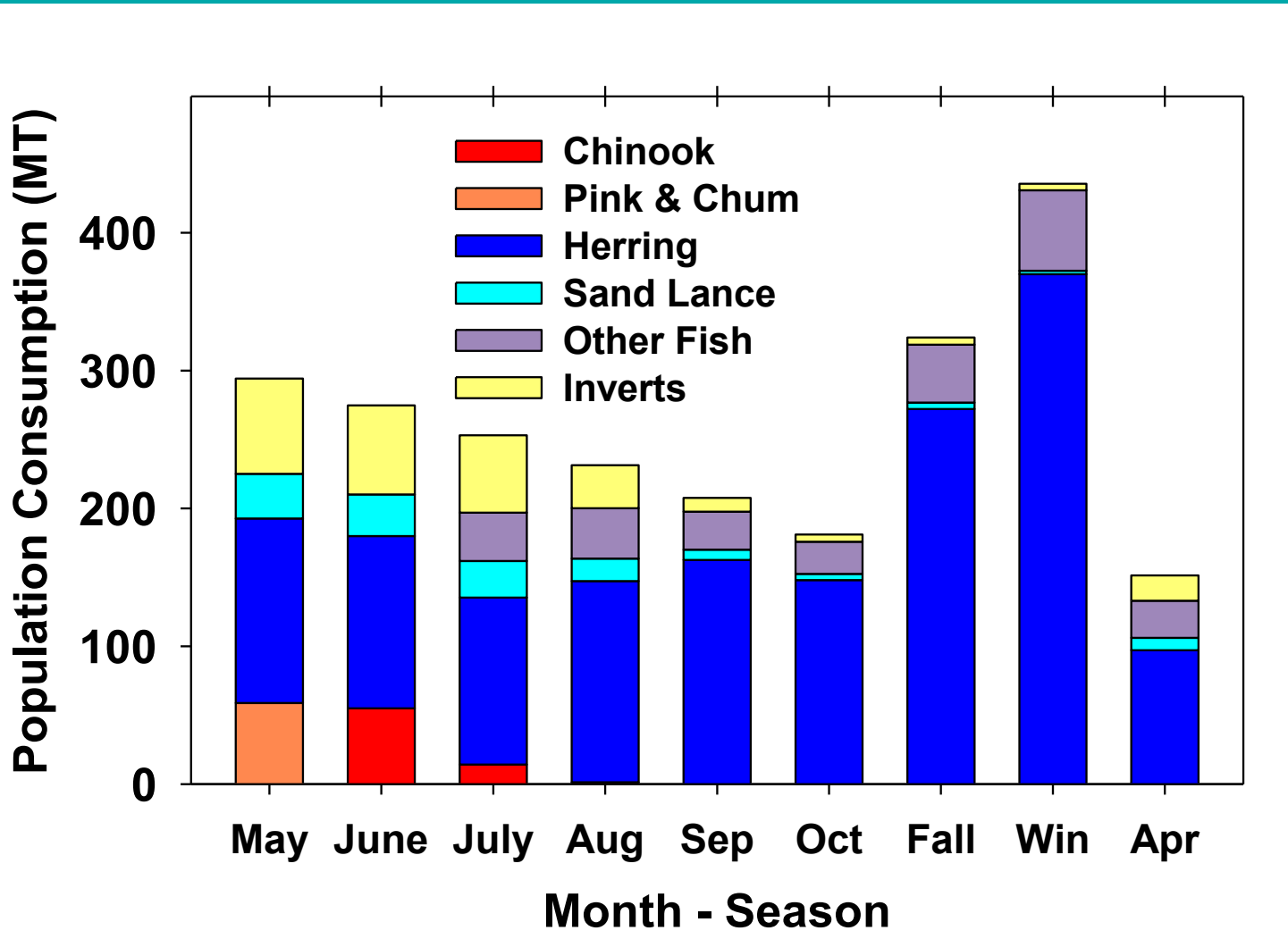
Same for larger resident  
Chinook

## Size-selective predation by Chinook on Sand Lance is less evident



# Simulated Predation Demand by Resident Chinook in Puget Sound

FL > 300 mm



- Herring are the predominant prey of Chinook >300 mm throughout the year
- Over 1,500 metric tons of herring consumed by resident Chinook annually in PS

## Other predators

- Harbor Porpoise & Harbor Seal populations have increased significantly over recent decades
- Piscivorous birds?
- Demersal fishes?

# Exploit Similar Needs for Ecology of Juv. Salmon & Forage Fishes

- Much to be learned about how food web processes & environmental factors limit forage fish:
  - Seasonal food supply & demand
  - Competition
  - Predation mortality, Disease
- Most life stages can be sampled with the same gear
  - Ichthyoplankton sampling an important exception
- Methodically record data & archive samples of “non-target” species (freeze)
- Break down salmon v forage fish silos in research, monitoring & restoration
- Benefit from economies of scale