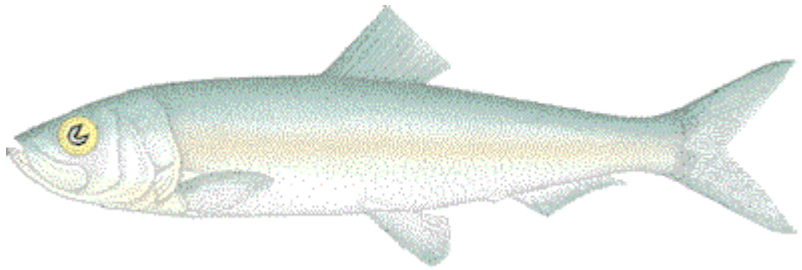
An index of relative biomass, abundance, and condition of juvenile Pacific Herring (*Clupea pallasi*) in the Strait of Georgia, British Columbia



Jennifer L. Boldt[1], Matthew Thompson[1], Charles Fort[1], Chris Rooper[2], Jake Schweigert[3], Terrance J. Quinn II[4], Doug Hay[3], and Thomas W. Therriault[1]

[1]Fisheries and Oceans Canada, Nanaimo, Canada. E-mail: Jennifer.Boldt@dfo-mpo.gc.ca

[2]National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, U.S.A.

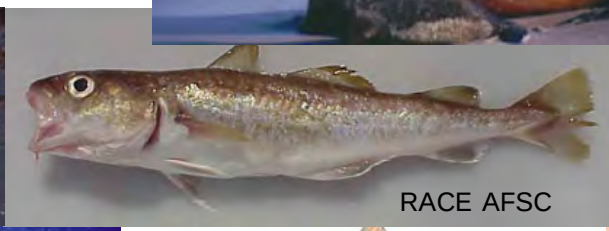
[3]Emeritus Fisheries and Oceans Canada, Nanaimo, Canada.

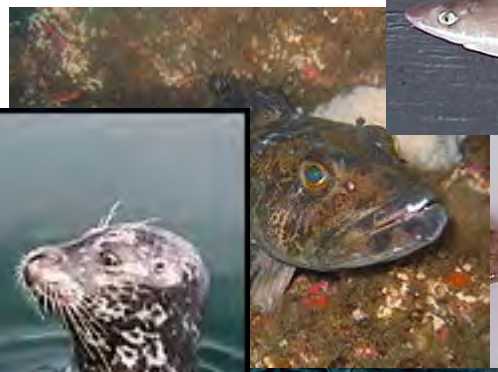
[4]Juneau Center, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, U.S.A.

PICES 2015, Qingdao, China

Pacific Herring in B.C.

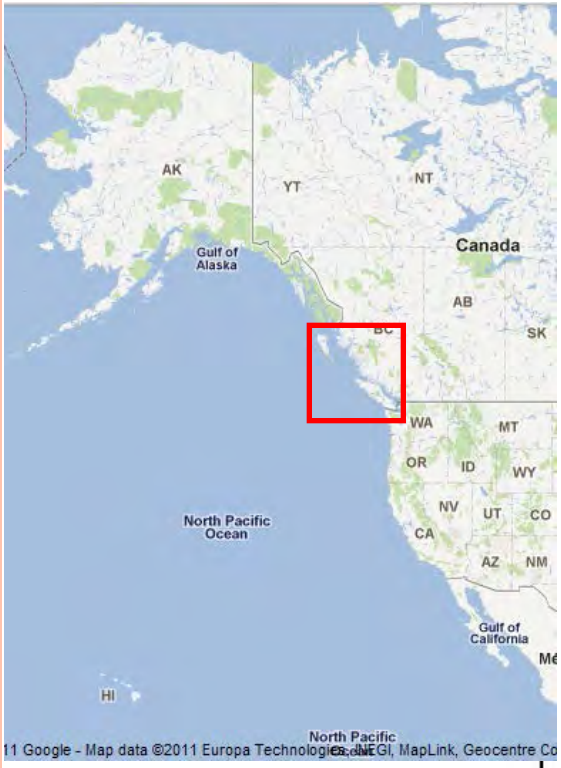
- Forage for marine mammals, seabirds, and predatory fish –including Chinook and Coho Salmon
- Important cultural species
- Important commercial species

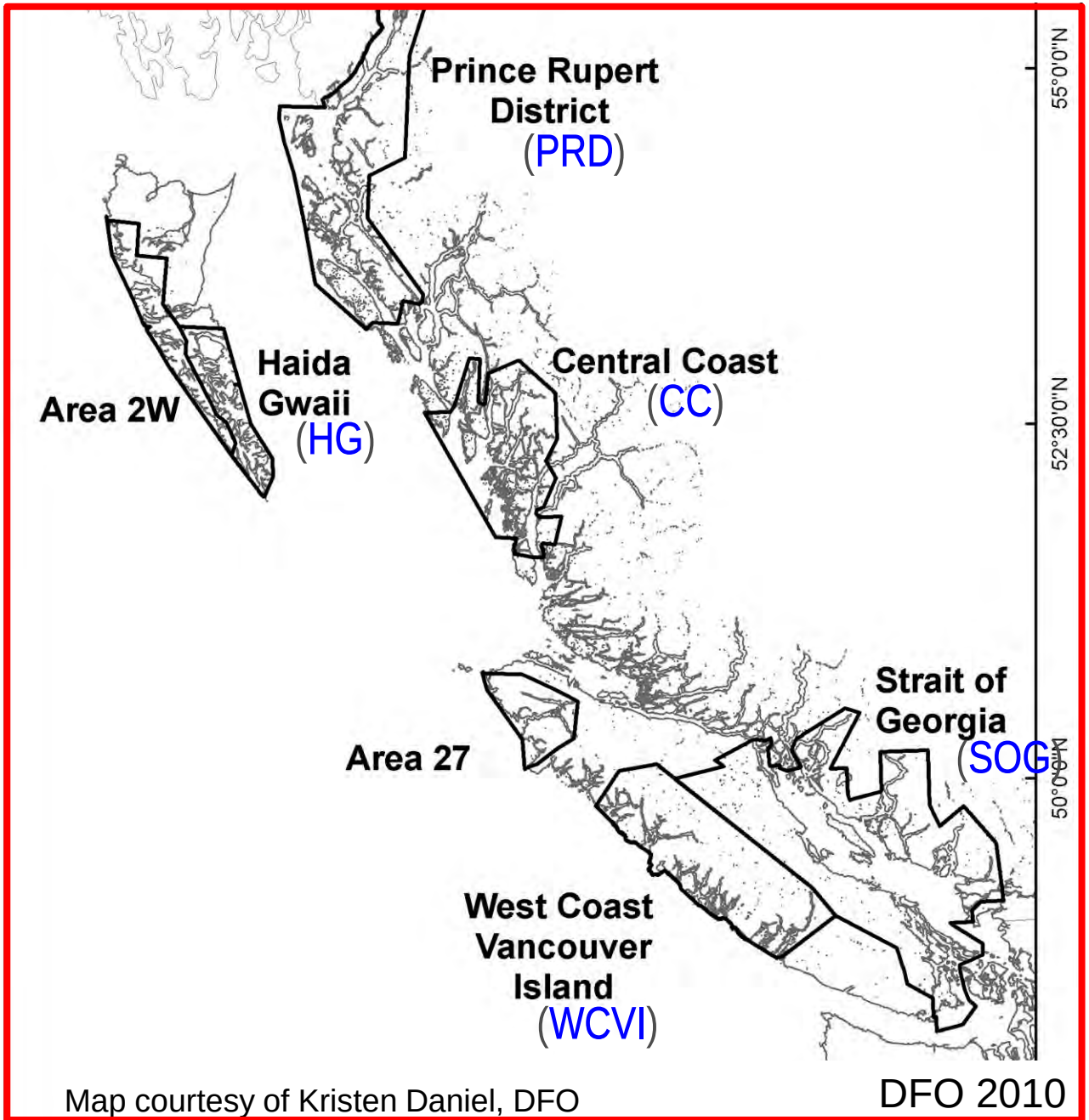




British Columbia Pacific Herring

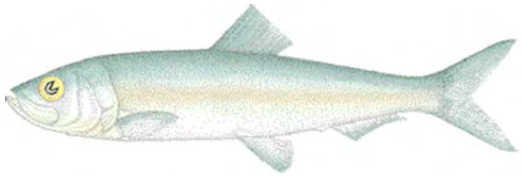
5 major & 2 minor fishing stocks





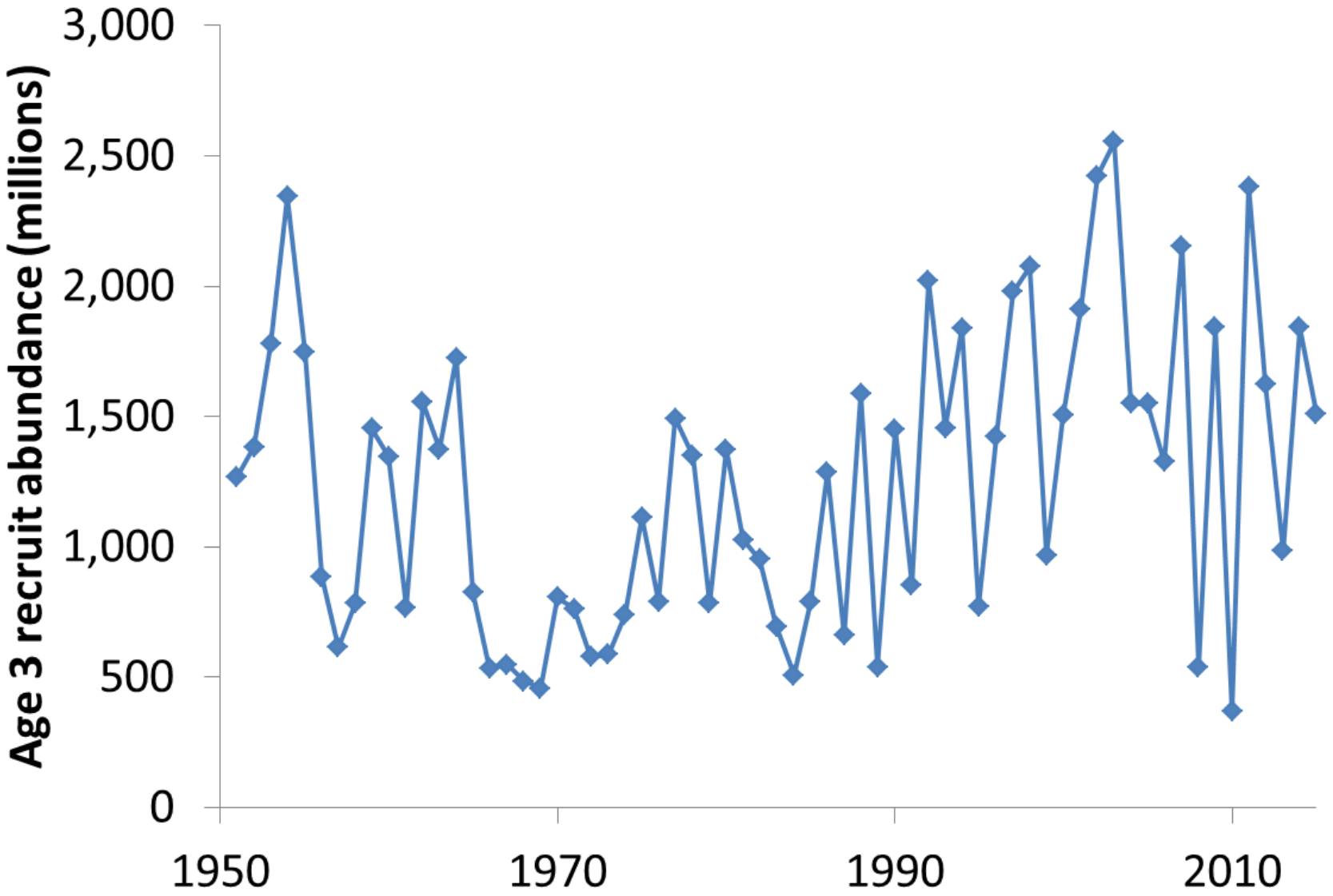
Map courtesy of Kristen Daniel, DFO

DFO 2010




Adults
Spawning
Mar-Apr
Eggs
Hatching
2 weeks
Larvae
Apr
Metamorphosis
May-Jun
Age-0
Jul-Oct
Offshore migration
Oct-Nov
Age-1 & 2
Inshore migration
Oct-Feb
Recruitment

Pacific Herring Recruits, 1950-2014 (DFO) Stock Assessment Output



Background

- Is there an indicator of recruitment to the adult spawning population?
- Do trends in age-0 herring affect trends predator populations (e.g., Coho and Chinook Salmon)?

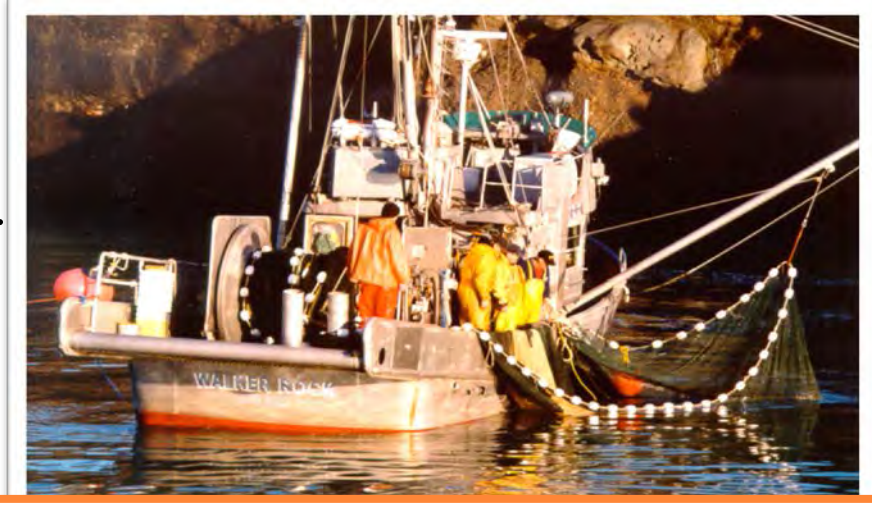
- Need a time-series indicator of age-0 herring biomass to begin answering these questions.

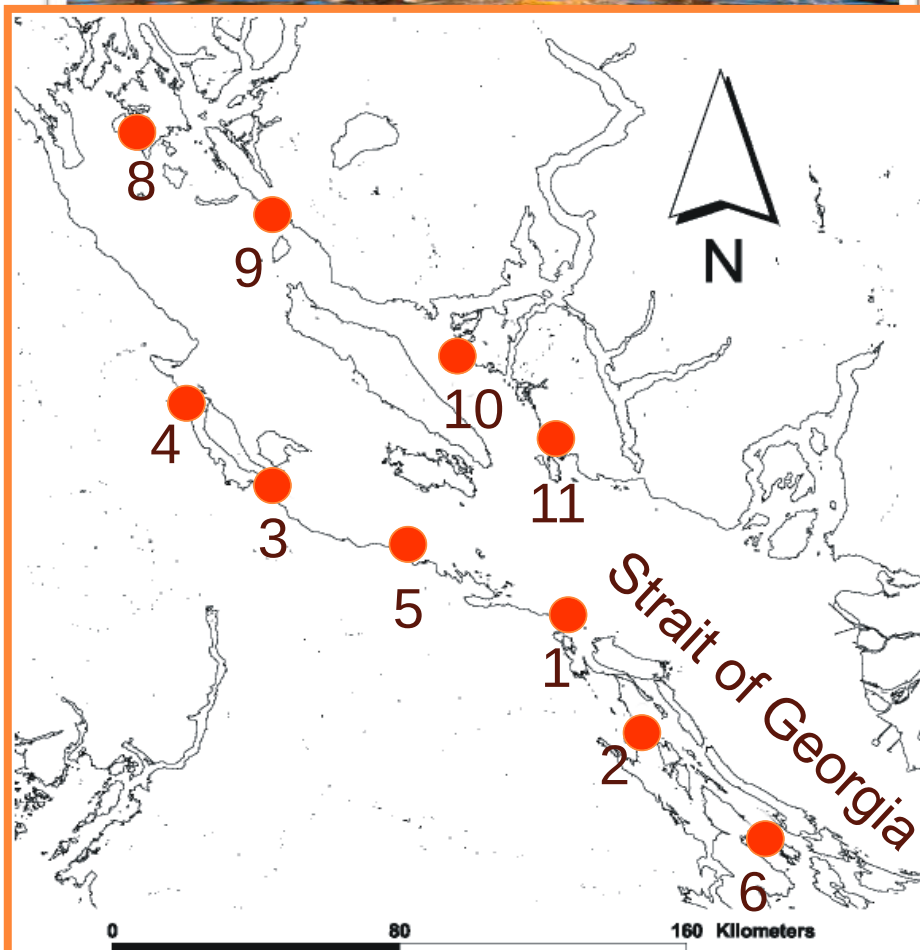
Objectives

- Update age-0 herring time series *(previously examined with varying data and methods by Hay et al. 2003 and Schweigert et al. 2009)*
- Identify suitable data and statistical methods for estimating an index (and associated variance) of the relative biomass or abundance of age-0 herring.
- Determine if survey estimates of age-0 herring biomass (abundance) are indicative of recruitment, by relating them to age-3 herring abundance from the stock assessment model.
- Examine annual variation in herring lengths, weights, and fish condition (length-weight residuals).

Sampling

- Annual 1992-2014 (except 1995)*
- September-October*
- 10 "Core" Transects
  - 5 open water, 5 channel
  - 3 or 5 stations each
- Night sampling (fish at surface)
- Small purse seine (183 x 27 m)
- F/V Keta 1992-1994
- R/V Walker Rock 1996-2015



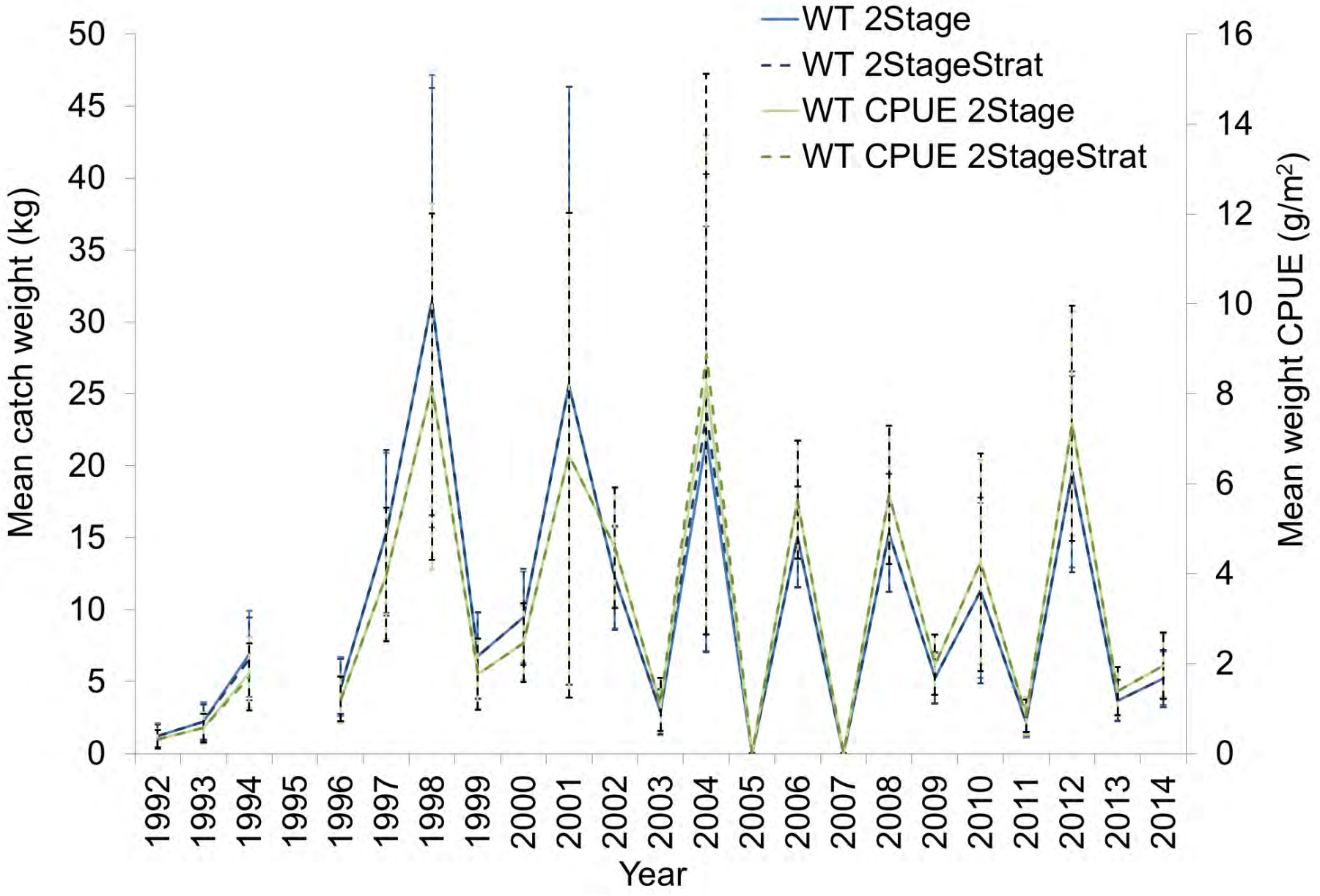


* Data from earlier years and other months were collected, but not as consistently.

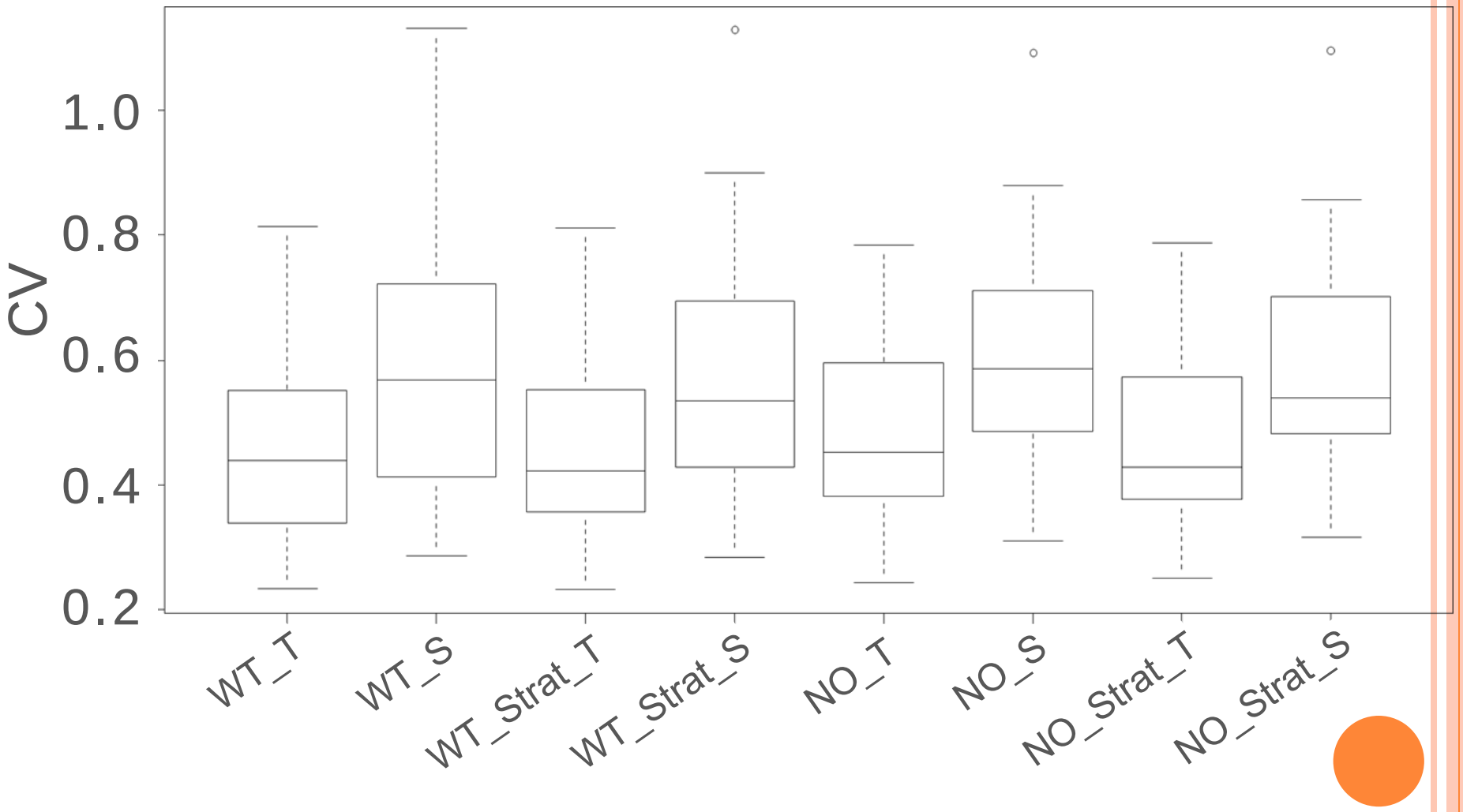
Unbiased Estimates of Relative Biomass and Abundance Age-0 Herring

- Two methods:
  - two-stage (transect, station)
  - two-stage, stratified (open water and channel transects)
- Four types of catch data:
  - weight
  - weight CPUE
  - abundance
  - abundance CPUE
- Three scenarios:
  - 1992-2014 –same net
  - 1996-2014 –same net (most likely)
  - 2002 –change of net
- Two methods for estimating variance:
  - Thompson 1992 = less conservative
  - Szarzi et al. 1995 = more conservative
- Herring lengths, weights, and fish condition (length-weight residuals) were summarized

Survey Catch Weights & CPUE (se) Age-0 Herring

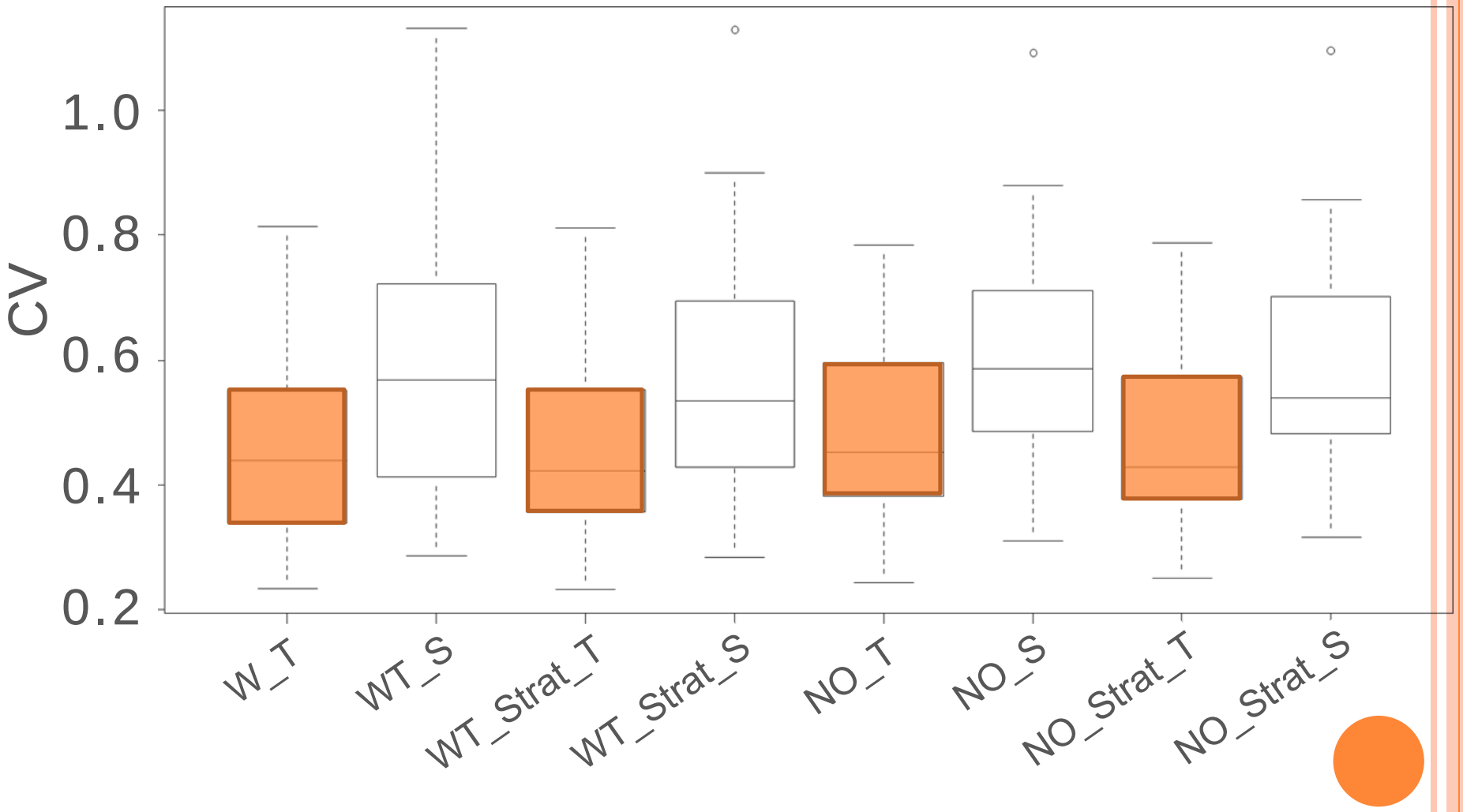


CVs For Different Estimators



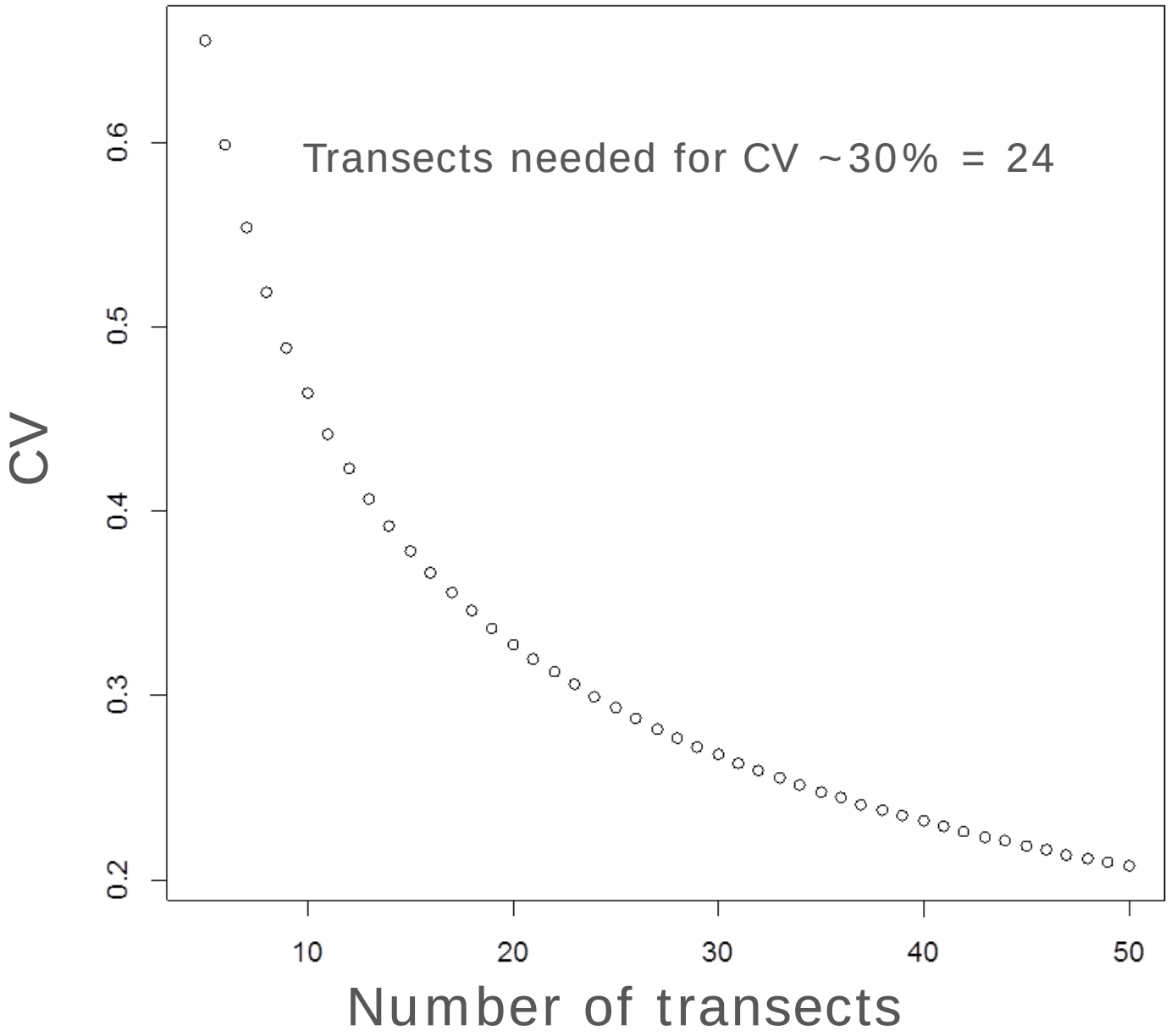
T=Thompson (1992) variance; S=Szarzi et al. (1995)

CVs For Different Estimators



T=Thompson (1992) variance; S=Szarzi et al. (1995)

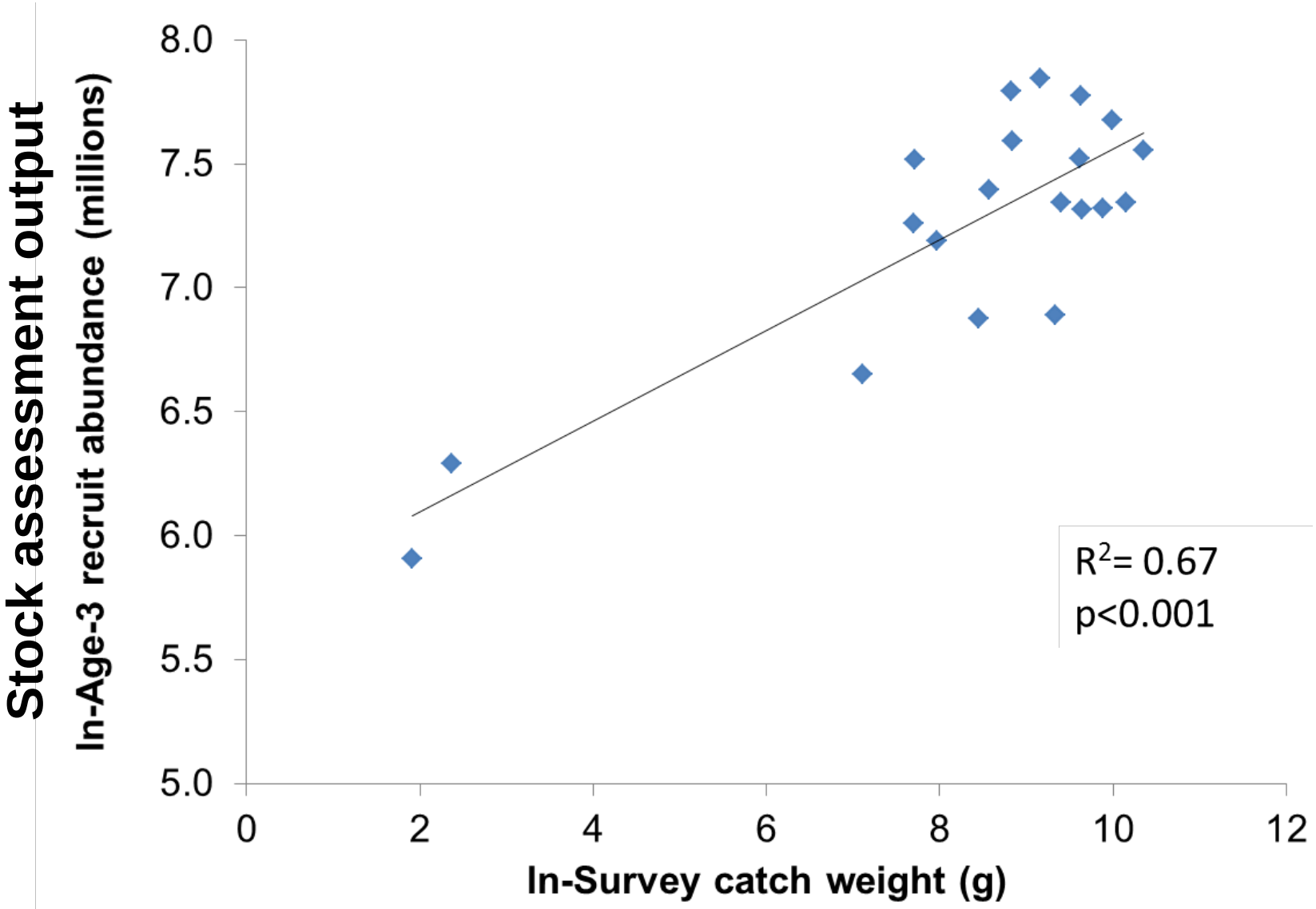
CV as a Function of Sample Size



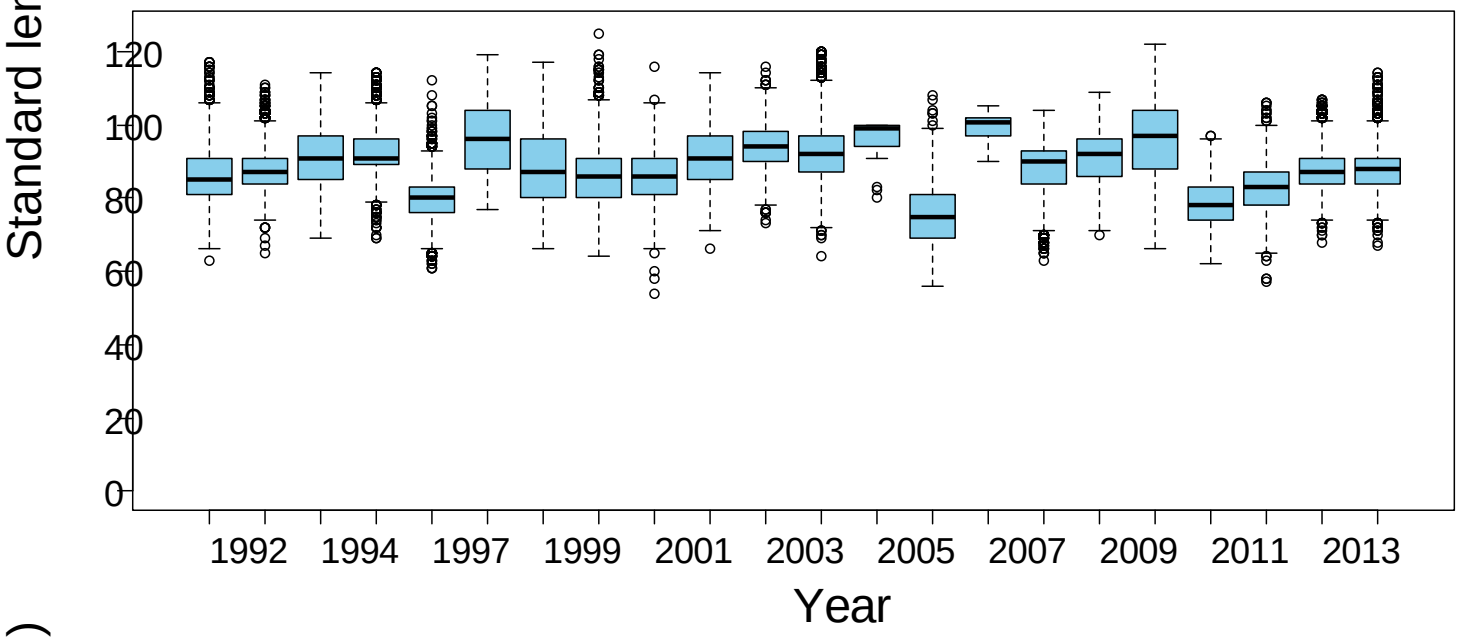
Question:

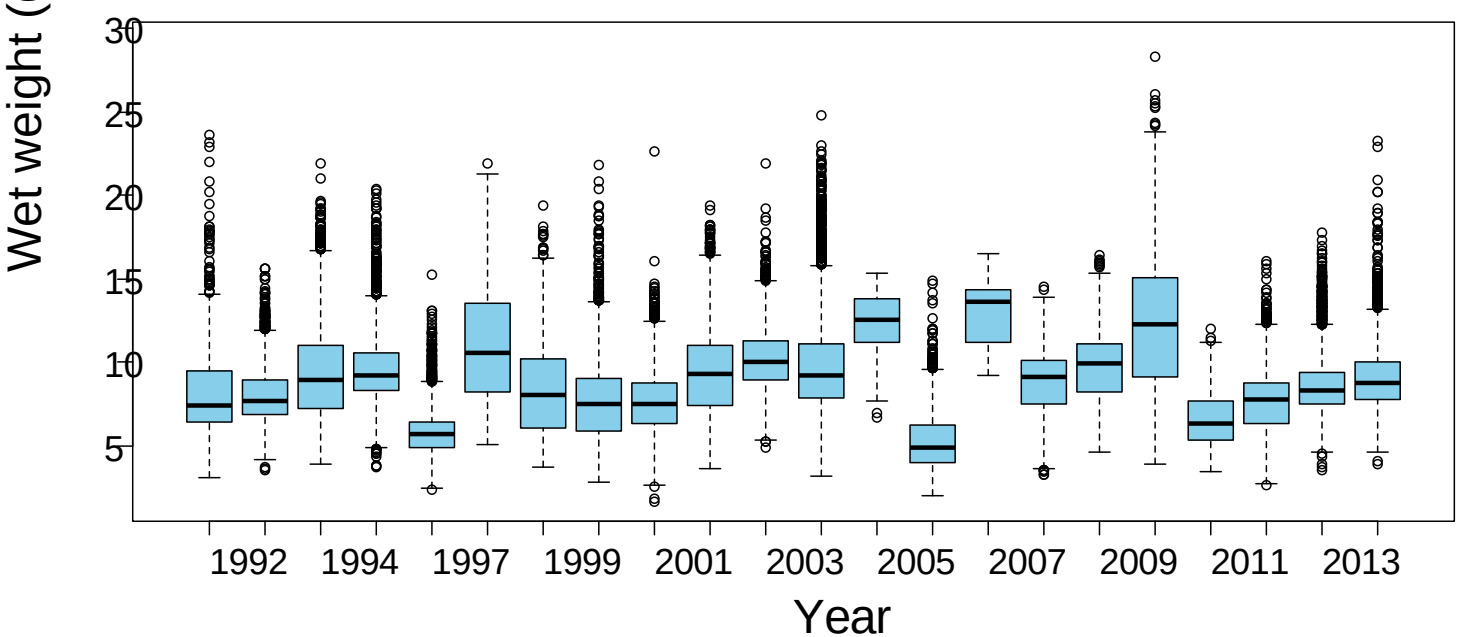
- Is there an indicator of recruitment to the adult spawning population?

Age-3 Recruits from Stock Assessment vs. Age-0 Survey Catches (with 3 year lag)



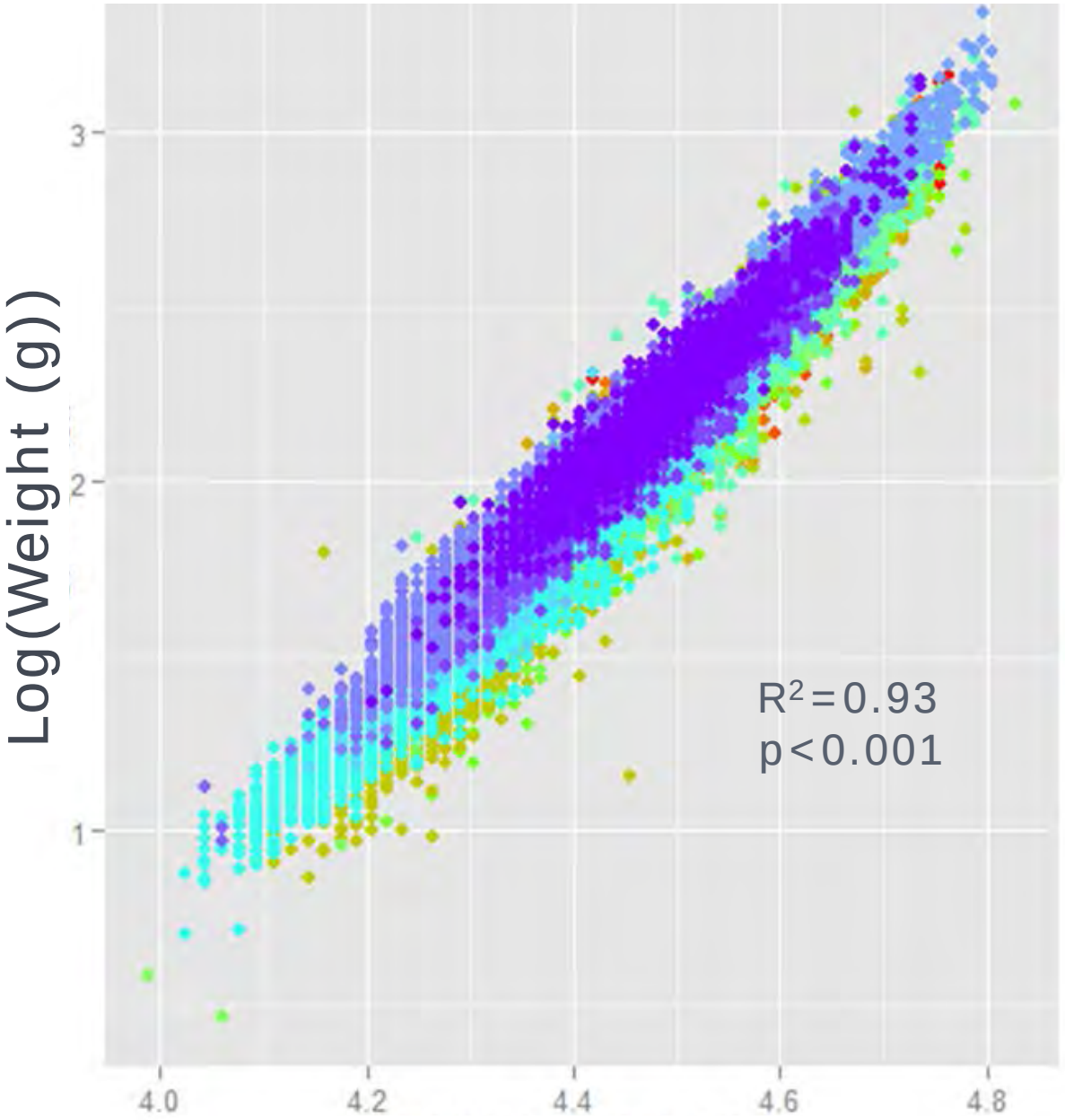
Mean Lengths and weights, 1992-2014





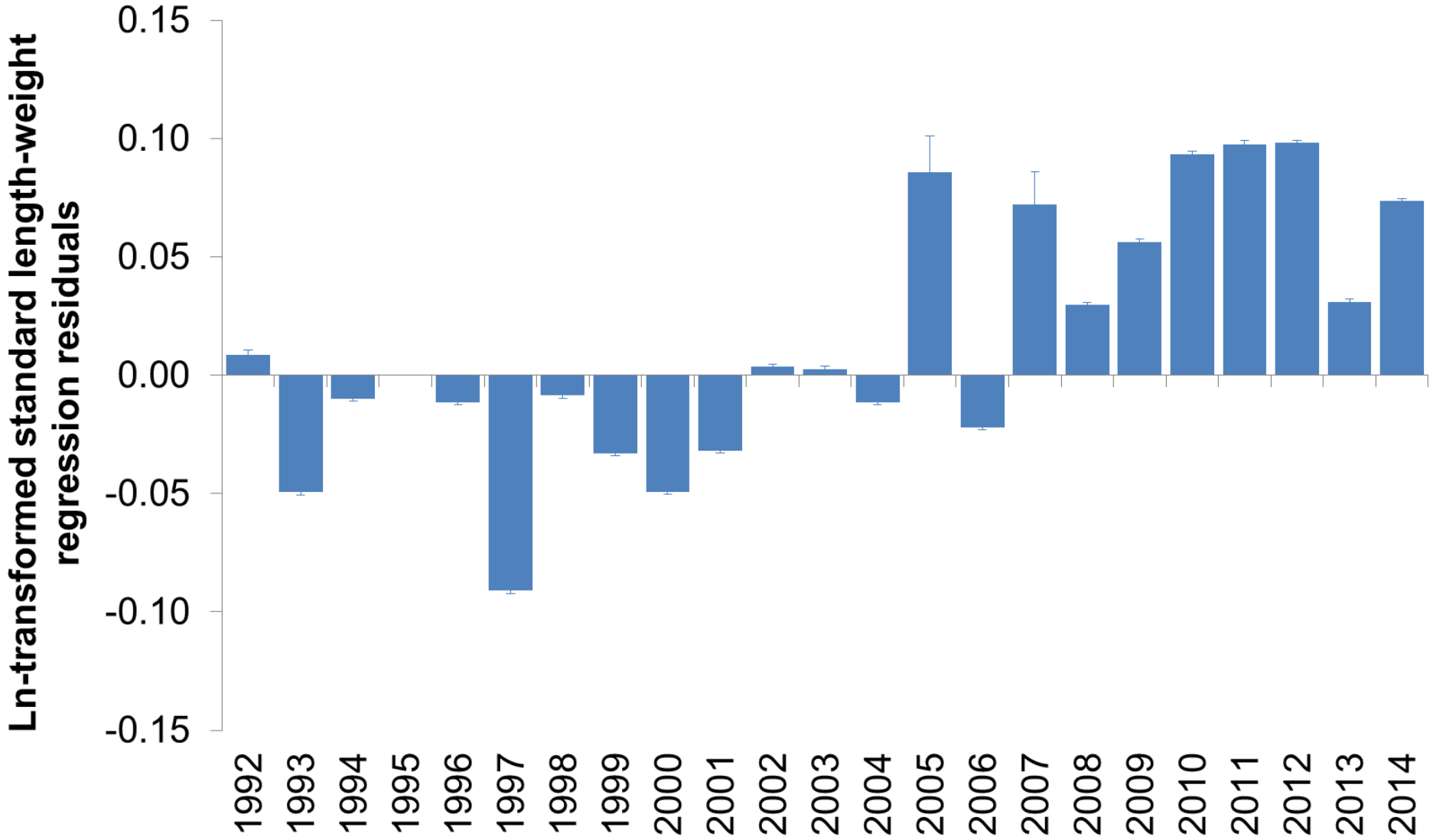
Year	n
1992	1,463
1993	2,919
1994	3,583
1996	3,808
1997	4,221
1998	3,728
1999	2,768
2000	5,921
2001	5,375
2002	5,184
2003	2,819
2004	5,171
2005	30
2006	6,695
2007	22
2008	3,885
2009	2,473
2010	1,899
2011	2,306
2012	4,279
2013	2,553
2014	2,749

Age-0 Herring Lengths & Weights



ANCOVA:
$p < 0.001$ for length, year, length*year

Age-0 Herring Condition



Conclusions

- SOG age-0 herring biomass (abundance) varied interannually
- Minimal differences between weight and abundance trends
- Variance high in years with high catches
- Stratification did not always reduce estimates of variance
- Less conservative estimates of CV~46%
- To get CV~30%, sampling of 24 transects needed
- Age-0 herring biomass may be potential leading indicator of recruitment to the adult population.
- Mean age-0 herring lengths and weights varied annually with no overall trend during the time series
- Length-weight residuals shifted to positive or neutral in 2002 indicating improved fish condition

Recommendations

- Continue sampling core stations and transects, following consistent and standardized practices.
- Take measures of depth at sample locations.
- To reduce CVs, sample more transects, however, limits include higher costs and staffing.
- Calculate multiple indices (catch weight, CPUE, and abundance) using the two-stage method, and the less conservative Thompson (1992) variance estimator.

Next Steps

- Explore links between relative abundance and:
  - biological drivers (e.g., zooplankton prey, predators)
  - environmental drivers (e.g., more site-specific SST)
- Examine age-0 herring as drivers of predator dynamics
- Update community composition and diversity analyses (previously analyzed)

Acknowledgements

- Pacific Salmon Foundation
- Herring Conservation and Research Society
- Doug Henderson
- Kristen Daniel
- Bob Armstrong
- Dennis Chalmers
- Carol Cooper
- Linnea Flostrand
- Carl Haegele
- Vanessa Hodes
- Christa Hrabok
- Doug Miller
- Dan Ware
- Co-op students and volunteers