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

Early marine survival of steelhead smolts in Puget Sound

Megan Moore
United States. National Marine Fisheries Service, megan.moore@noaa.gov

Barry Berejikian
United States. National Marine Fisheries Service

Fred Goetz
United States. Army Corps of Engineers

Thomas Quinn
University of Washington

Sayre Hodgson
Nisqually Indian Tribe

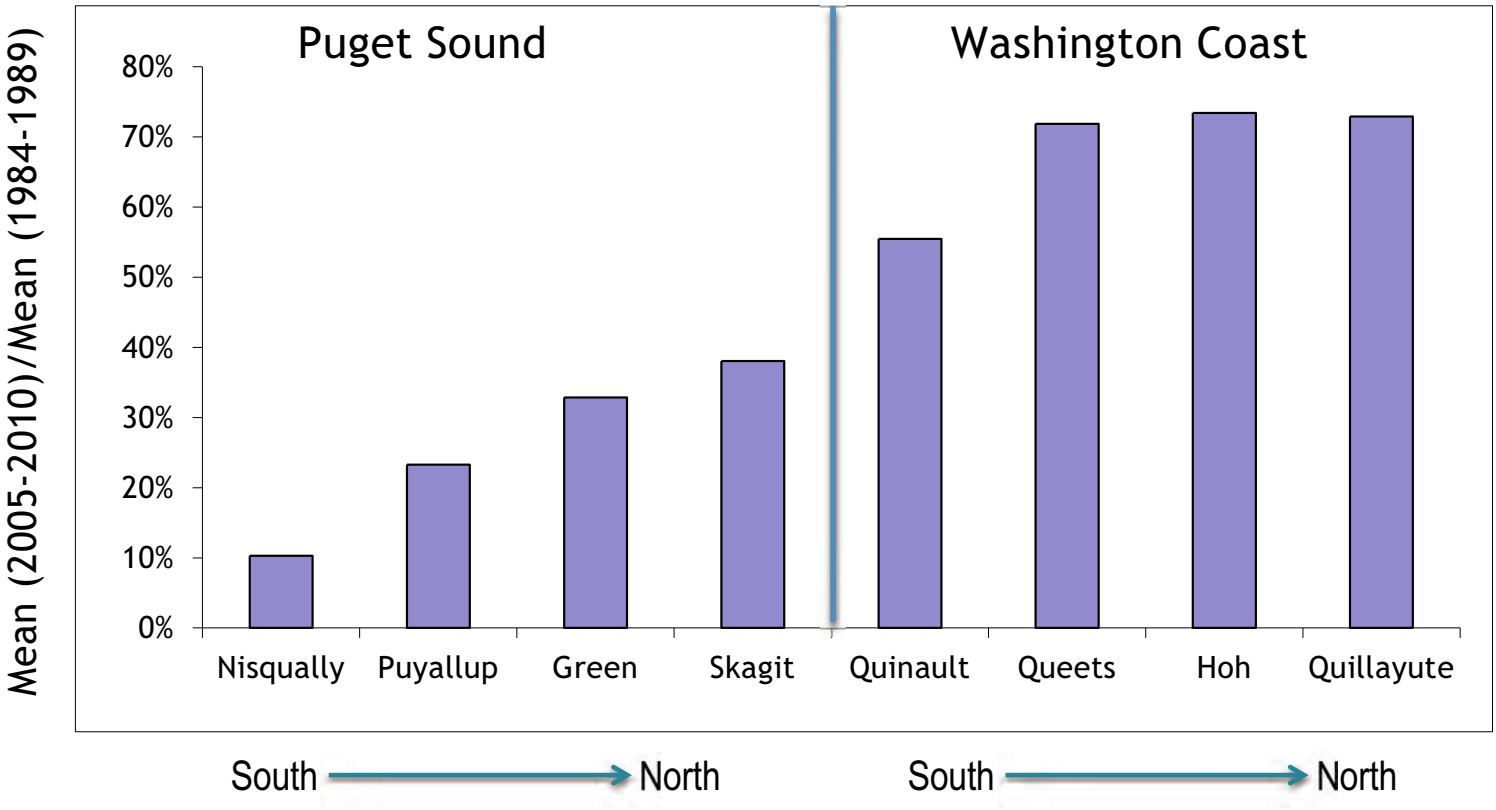
See next page for additional authors

Speaker
Megan Moore, Barry Berejikian, Fred Goetz, Thomas Quinn, Sayre Hodgson, Ed Connor, and Andrew Berger

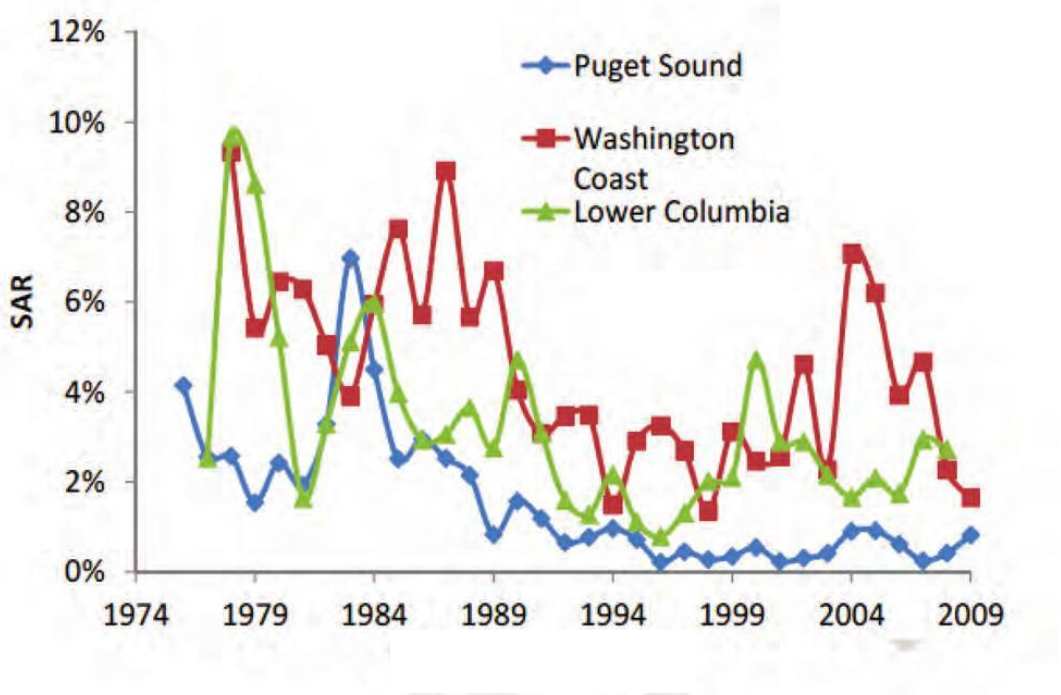
Survival of steelhead in Puget Sound and Hood Canal

Megan Moore, NOAA Fisheries
Barry Berejikian, NOAA Fisheries
Manchester Research Station
and
Salish Sea Marine Survival Project
Steelhead Workgroup

Threatened steelhead

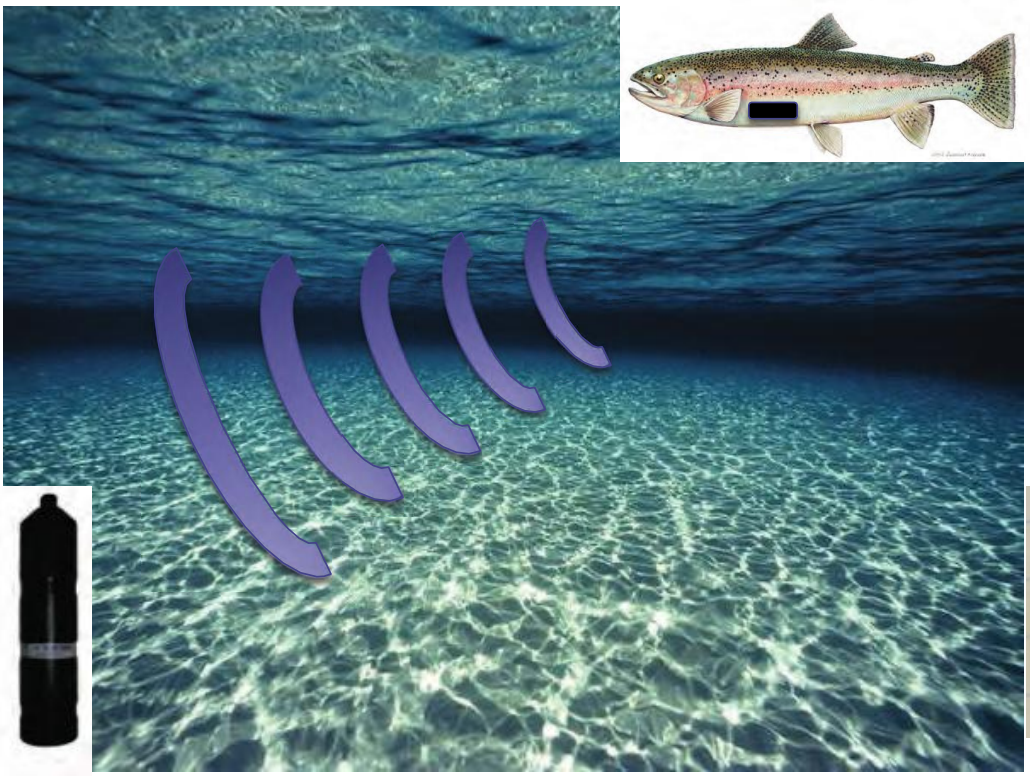


Marine survival trends



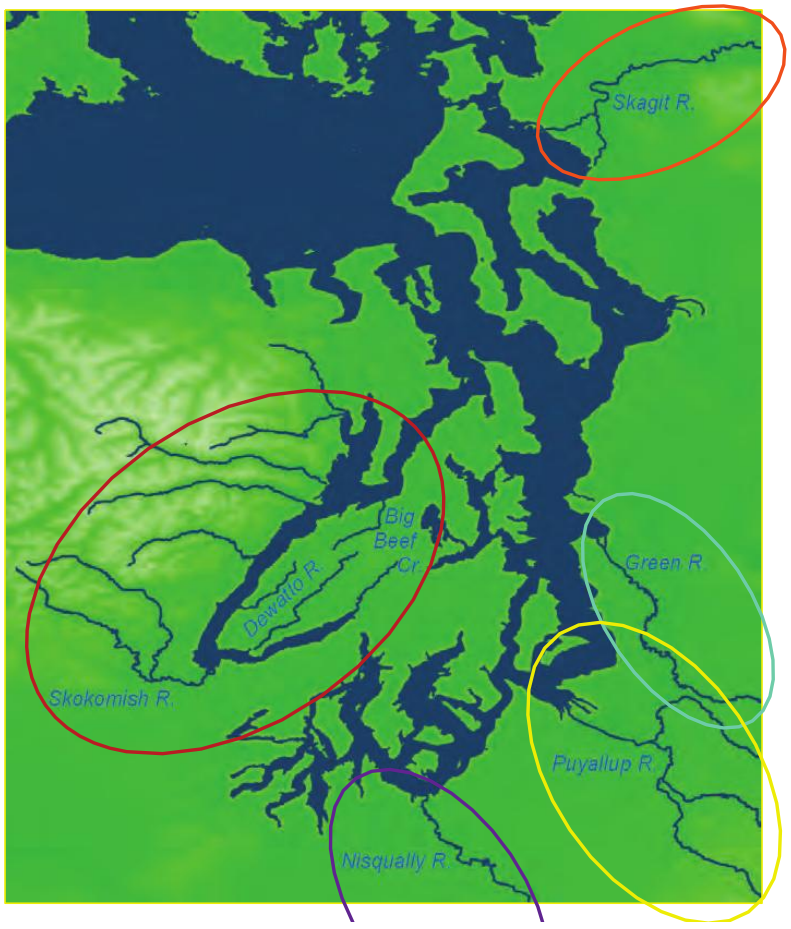
- Marine survival rates have declined dramatically over the last 25-30 years
- Puget Sound populations have not rebounded in recent years as have coastal and Columbia populations
- Marine migration through Puget Sound seems to be a major limiting factor

Acoustic telemetry



7mm and 9 mm transmitters @ 69kHz, 136 db

Puget Sound Telemetry Project



Hood Canal Rivers: 2006-2010
362 tagged smolts
NOAA Fisheries

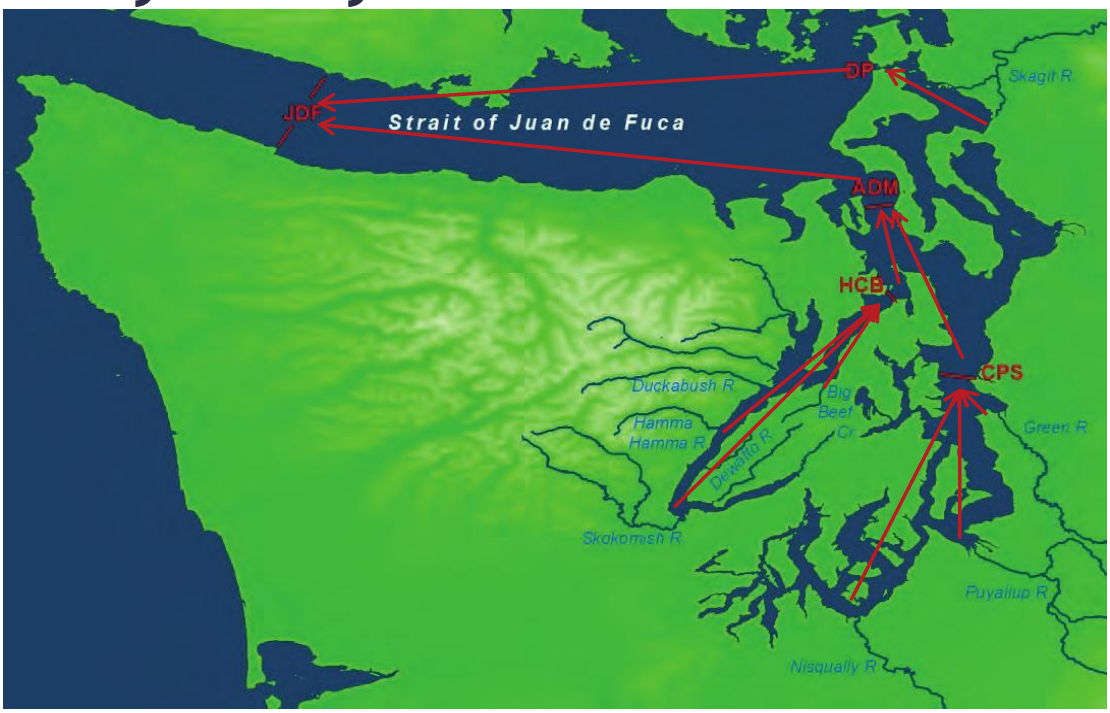
Green River: 2006-2009
337 tagged smolts
Fred Goetz, Tom Quinn/UW

Puyallup River: 2006, 2008-2009
206 tagged smolts
Puyallup Tribe

Nisqually River: 2006-2009
187 smolts tagged
Nisqually Tribe

Skagit River: 2006-2009
250 smolts tagged
Seattle City Light

Telemetry array



Migration Segments		
Hood Canal	**Puget Sound**	**Skagit**
River Mouth - HCB	River Mouth - CPS	River Mouth - DP
HCB – ADM	CPS – ADM	
ADM – JDF	ADM – JDF	DP - JDF

Mark-Recapture Model: Cormack-Jolly-Seber

Population	N_{2006}	N_{2007}	N_{2008}	N_{2009}
Hood canal	106	170	109	78
Green	100	89	98	50
Nisqually	55	49	14	69
Puyallup	50	0	90	66
Skagit	23	47	100	80
TOTAL	**334**	**355**	**411**	**293**

N=1393

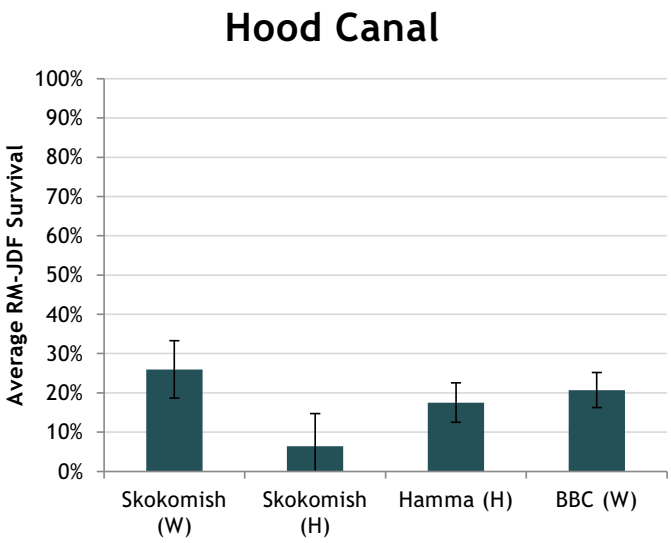
Variables included in the survival analysis

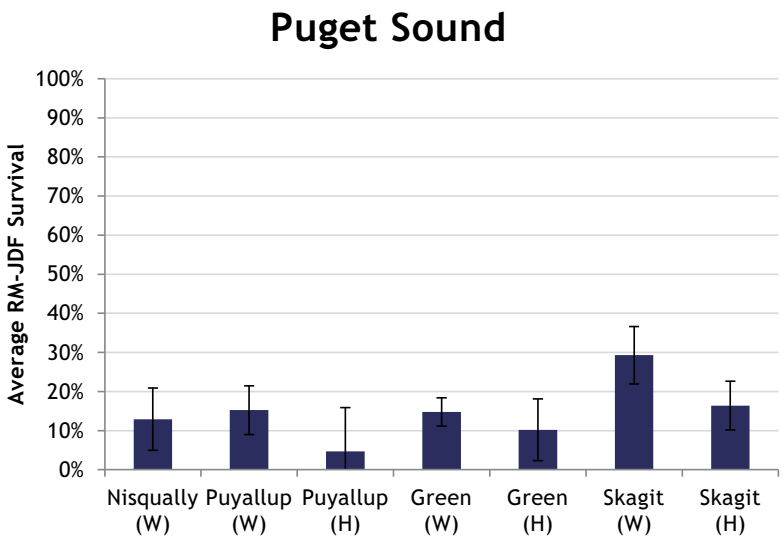
Factors: Population
Region (HC, SS, Skagit)
Rear type
Migration Segment
Year
Tag Type

Covariates: Distance
Body Length

Model with lowest AICc = ~Segment:population+year+reartype

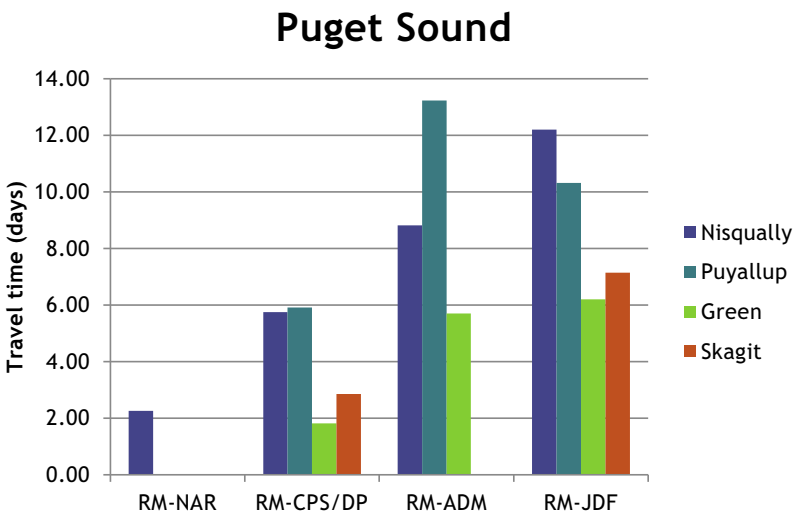
Marine survival is low in Hood Canal and Puget Sound

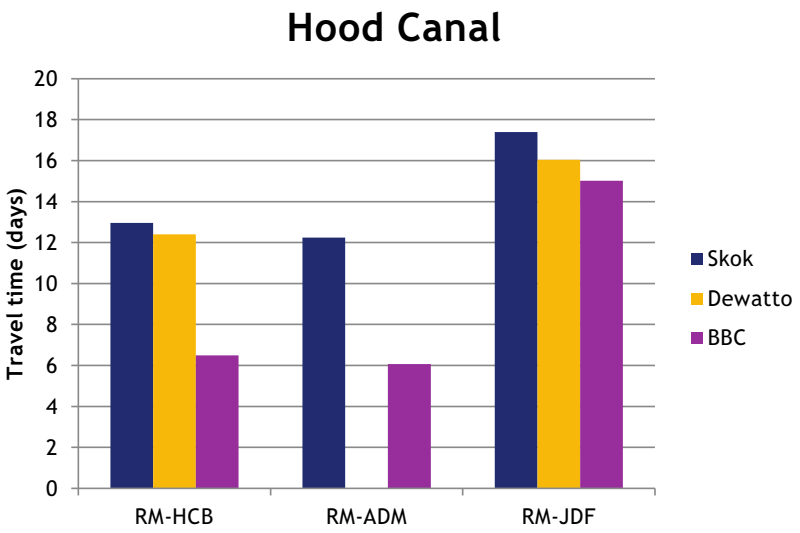




Combined early marine survival estimate = 17% (hatchery = 12% , wild = 20%)

Travel Times





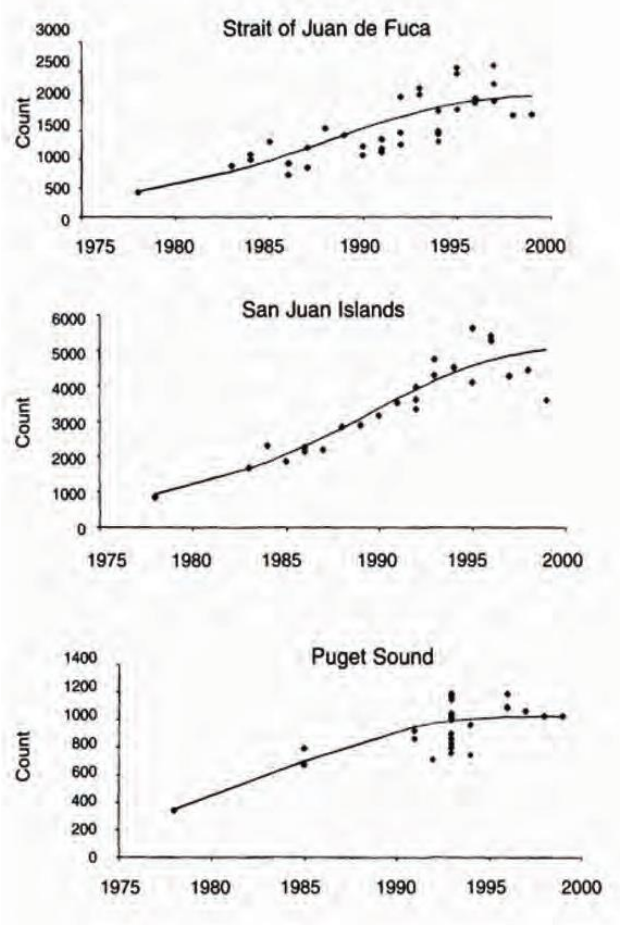
Potential factors affecting marine survival (why do so many steelhead die so quickly)

- Freshwater influences
  - Reduced diversity ('Portfolio effect': e.g., *Schindler et al. 2012. Nature*)
  - Hatcheries (genetic or ecological)
  - Water quality (toxic contaminants)
  - Disease-causing pathogens (nanophyetus)

- Changes in the Puget Sound ecosystem that have influenced predator-prey dynamics
  - Avian predators: cormorants, Caspian terns, common mergansers, and loons
  - Mammalian predators: harbor seals, harbor porpoise

Predator-prey interactions (harbor seals)

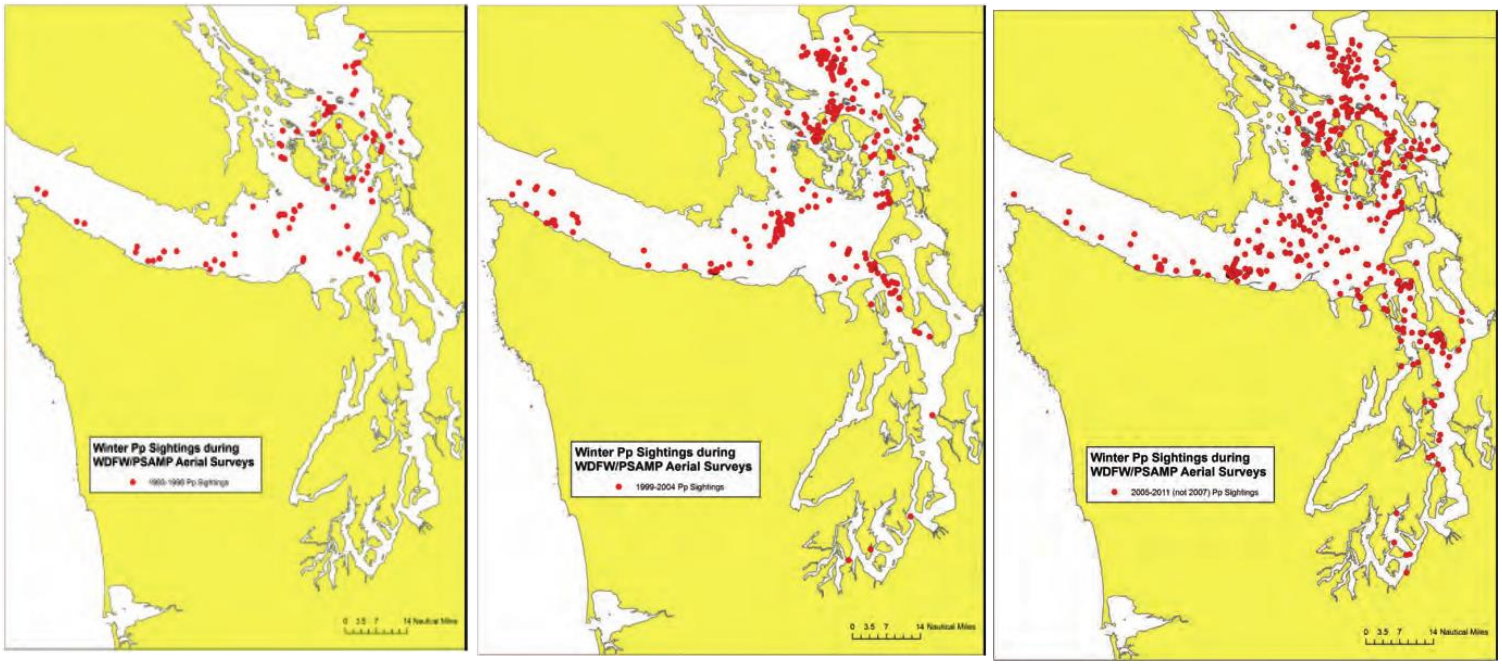
Harbor seal counts



Jeffries et al. 2003 J. Wildlife Manage.

Predator-prey interactions (harbor porpoise)

1993-1998 | 1999-2004 | 2005-2011



(J. Evenson, WDFW, 2013, unpublished data)

Herring Biomass

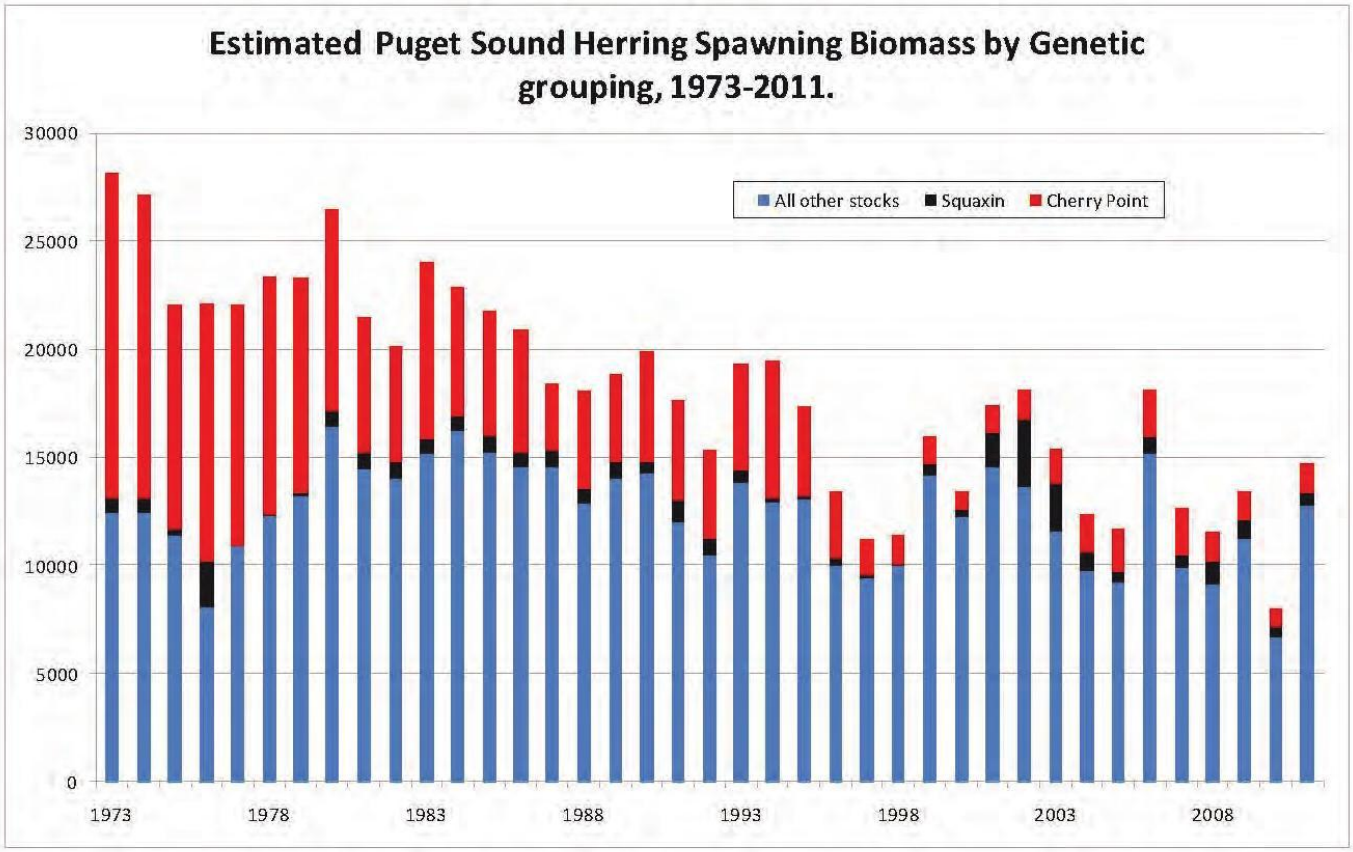
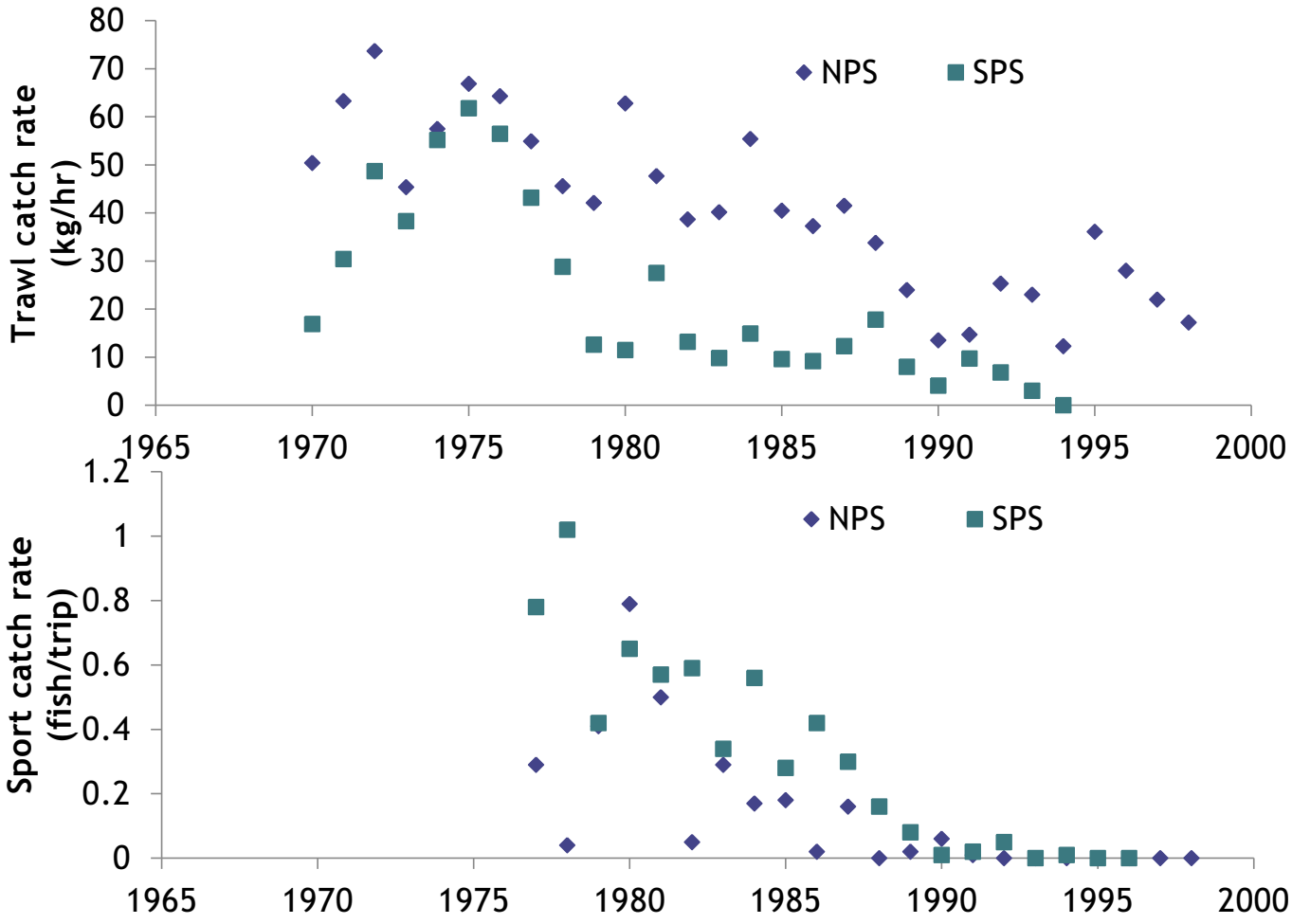


Figure 5. Estimated herring spawning biomass, 1973-2011.

Pacific Cod Abundance



Data source: Palsson et al. via NMFS 2000 Status Review

Summary

- Early marine survival rates of Hood Canal and Puget Sound steelhead populations are low considering short observed travel times
- Travel times within the Puget Sound environment are very short, giving little time for long term sources of mortality to take effect
- Puget Sound has undergone a major ecosystem shift timed with the decline in steelhead abundance and SAR.
- Future studies: tag more steelhead smolts and harbor seals

SALISH SEA
MARINE SURVIVAL PROJECT
www.marinesurvivalproject.com

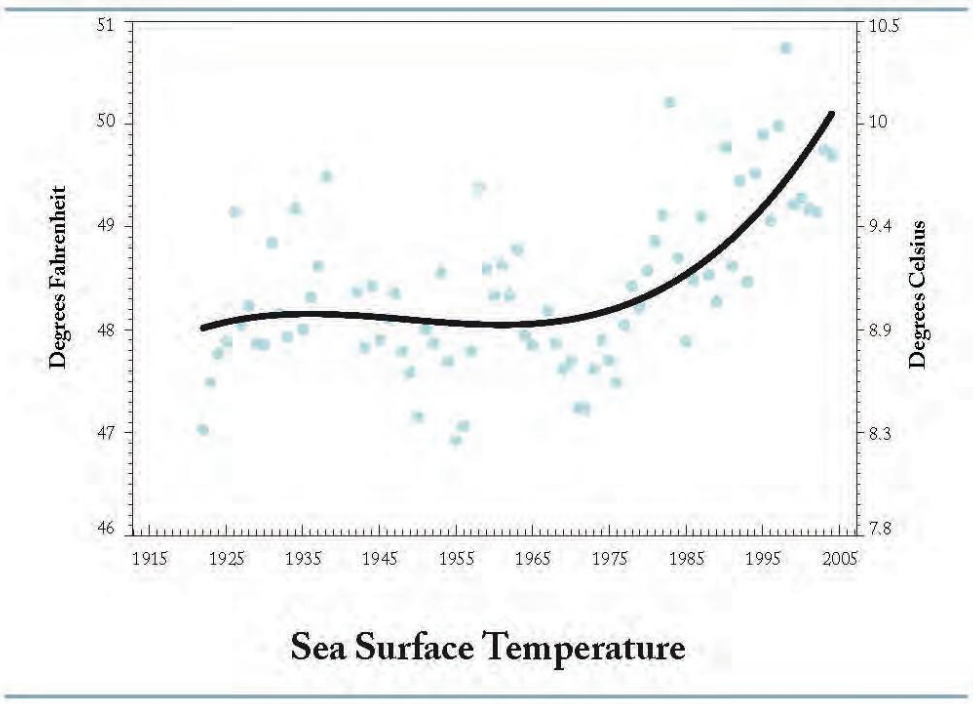
Acknowledgements

Funding provided through NOAA, USACE (Seattle District), UW, Steelhead Trout Club of Washington, Pacific Ocean Shelf Tracking Network (POST)

Survival Modeling Support
Mike Melnychuk (UW)
Jeff Laake (NOAA SWFSC)

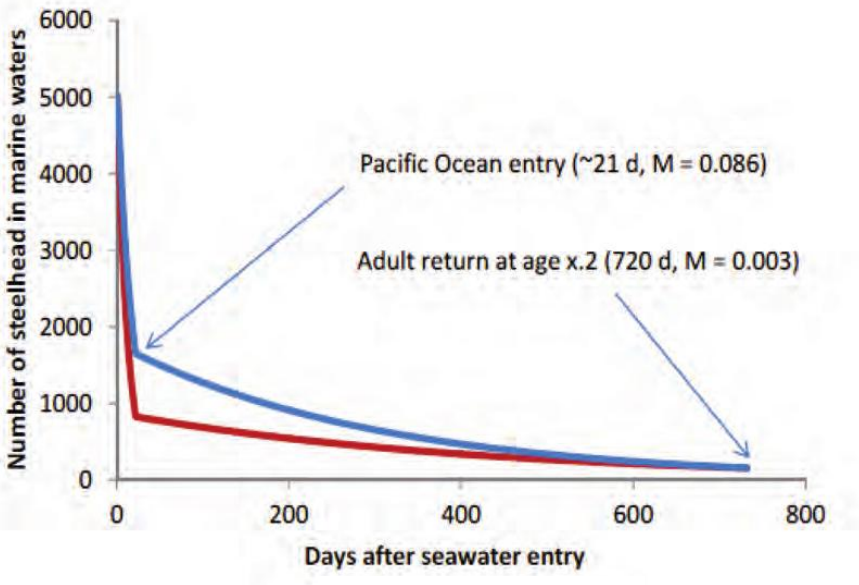
Field/Logistic Support
Skip Tezak ▪ Long Live the Kings ▪ Hood Canal Salmon Enhancement Group ▪ Mat Gillam ▪ R2 Resource Consultants ▪ Bob Leland ▪ Kelly Kiyohara ▪ Pat Michael Brody Antipa ▪ Pete Topping ▪ Deborah Feldman ▪ Kelly Andrews ▪ John Blaine ▪ Jim Deveraux ▪ Correigh Greene ▪ Shawn Larson ▪ Jeff Christiansen John Rupp ▪ Chuck Ebel ▪ Jose Reyes-Tomassini ▪ Jennifer Scheurell ▪ Chris Ewing Dawn Pucci ▪ Kurt Dobszinsky ▪ Paul Winchell ▪ David Welch ▪ Debbie Goetz ▪ Jose Gimenez ▪ Aswea Porter ▪ Emiliano Perez ▪ Craig Smith ▪ Tim Wilson ▪ Florian Leischner ▪ Christopher Ellings ▪ Scott Steltzner

Temperature in Puget Sound (Strait of Juan de Fuca)



Snover, A. K., P. W. Mote, L. Whitely Binder, A.F. Hamlet, and N. J. Mantua. 2005. Uncertain Future: Climate Change and its Effects on Puget Sound. A report for the Puget Sound Action Team by the Climate Impacts Group.

Early Marine Mortality in Puget Sound makes up a substantial amount of overall marine mortality



Slope of the line = instantaneous mortality rate

Red line = estimates from previous telemetry work in Hood Canal

Blue Line = 2x Hood Canal estimates, providing for underestimation of early mortality rate

Assumed 3% Smolt to Adult return rate (SAR)

Where within Puget Sound is survival occurring?