

## 2021 South Sound Science Symposium Project Summary

**Title: Environmental fluctuation and shifting predation pressure contribute to variation in Puget Sound steelhead survival**

**Authors:** Moore M, Berejikian B, Greene C, Munsch S

**Organization:** Northwest Fisheries Science Center, NOAA Fisheries

**Project contact email:** [megan.moore@noaa.gov](mailto:megan.moore@noaa.gov)

**Additional links to presentations, publications, posters:** [https://www.int-res.com/articles/meps\\_oa/m662p139.pdf](https://www.int-res.com/articles/meps_oa/m662p139.pdf)

**Project Summary:** Puget Sound steelhead (*Oncorhynchus mykiss*) are listed as threatened under the Endangered Species Act, and low survival in the marine environment is one factor limiting recovery. Steelhead must migrate through distinct freshwater, estuarine, and coastal habitats on their route from natal streams to the ocean and back to complete their life cycle. Nisqually River steelhead smolts were monitored throughout their outmigration from freshwater to the Pacific Ocean using acoustic telemetry. Steelhead survived poorly through Puget Sound from 2006-2009 and in 2014 (5-14% survival from river mouth (RM) to the Strait of Juan de Fuca (JDF)), then experienced consistently higher survival from 2015-2019 (16-38% from RM-JDF).

Monitored steelhead travel rapidly through Puget Sound, completing this portion of the migration in an average of 8.6 to 12.1 days. Travel rates in the years of lowest survival (2014) mirrored those in highest survival years (2016 and 2017), indicating that differences in neither time exposed to Puget Sound conditions nor migration behavior explained interannual variation. Rapid travel time and low survival rates suggest that predation was the predominant source of mortality.

Puget Sound temperature increases associated with the Northeast Pacific heat wave from late 2014 to 2016 were followed by decreased mortality of steelhead smolts migrating through Puget Sound from 2015 through 2017. Linear modelling shows that steelhead smolt mortality rates decreased with increases in average Puget Sound annual temperature in the year prior to steelhead migration ( $r^2 = 0.75$ ,  $p = 0.001$ ).

One of the many ecological changes that accompanied the increased marine temperatures was a rise in abundance of northern anchovy (*Engraulis mordax*) in Puget Sound. Anchovy occurrence in Skagit Bay surface trawls, used as a proxy for Sound-wide abundance, was positively related to average Puget Sound temperature ( $r^2 = 0.67$ ,  $p = 0.004$ ) during 2006-19. The years of lowest steelhead mortality coincided with abundant larval and post-larval anchovy during the year prior to steelhead migration ( $r^2 = 0.57$ ,  $p = 0.01$ , figure). We hypothesize that high abundance of larval anchovies in the year prior to smolt migration resulted in increased abundance of age-1+ anchovy in the year of smolt migration. Age-1+ anchovies, comparable in size to a steelhead smolt, then provided an alternative prey source for predators of migrating steelhead smolts, therefore reducing predation on steelhead smolts during outmigration.

## 2021 South Sound Science Symposium Project Summary

Interactions between telemetered harbor seals (*Phoca vitulina*) and steelhead smolts provided evidence of harbor seal prey switching during years of high anchovy abundance. Vemco mobile transceivers, capable of detecting tagged steelhead, were affixed to harbor seals at major Central and Northern Puget Sound haulouts. In 2014, a year of low steelhead survival, data from 11 seal-mounted transceivers detected predation of 10% and 17% of available tagged smolts at haulouts in Admiralty Inlet and Central Puget Sound. In 2016, when survival was at its peak, detected predation events dropped to 0-2%. This putative prey switching reduced predation pressure on steelhead enough to substantially lower annual mortality rates. These results highlight the importance of environmentally-driven fluctuations in controlling predator-prey dynamics that affect marine species of conservation concern.

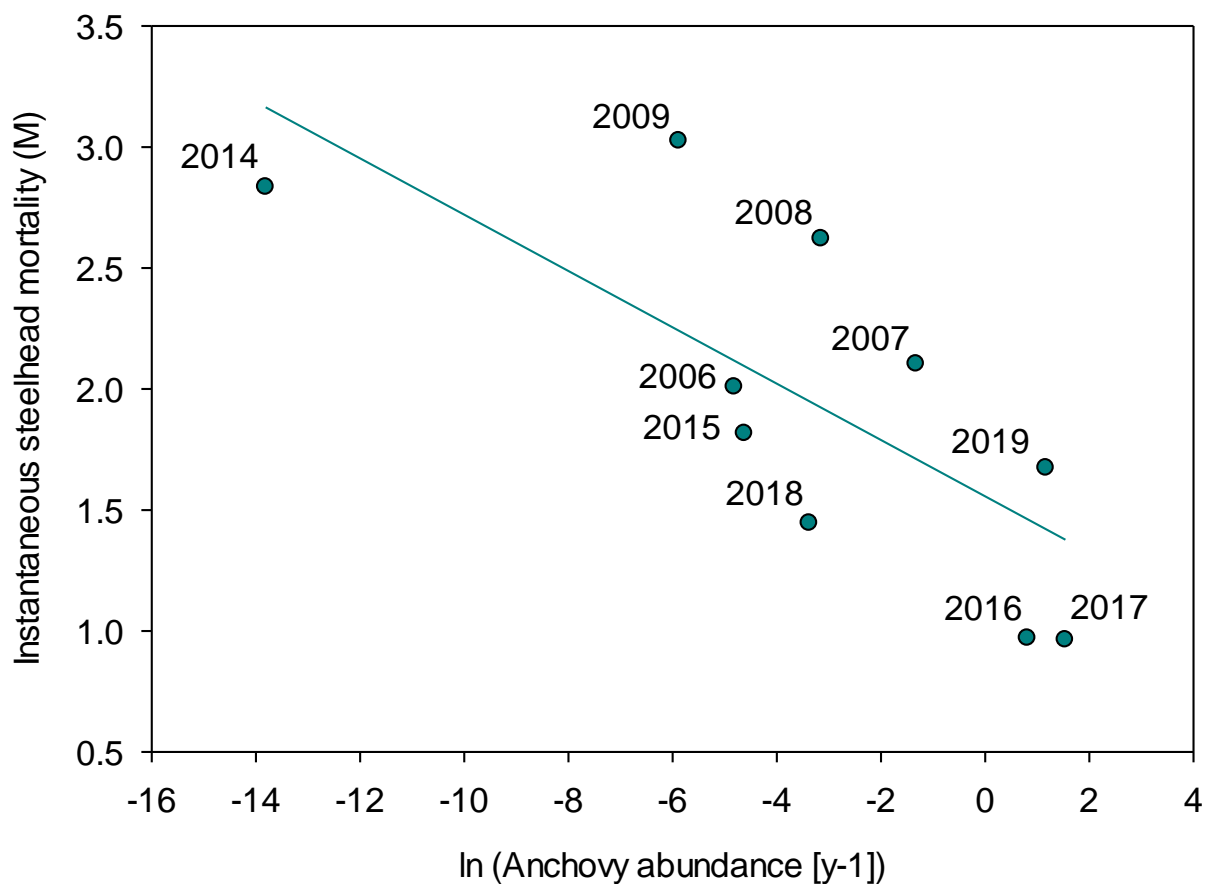


Figure. Between the years 2006 and 2019, Nisqually steelhead smolt mortality rate was strongly negatively related to anchovy occurrence during the year prior to migration, suggesting that age-1 anchovies provide alternate prey for steelhead predators, therefore reducing steelhead smolt mortality in Puget Sound.