RC #___ RC 69

Effectiveness of Gillnet Mesh Sizes in the Nushagak District Commercial Sockeye Fishery Based on Selectivity Curves Developed from the Port Moller Test Fishery

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Conclusion

Restricting mesh size in the Nushagak District to a maximum of 4¾" when targeting Sockeye Salmon can be expected to:

- increase the average annual Sockeye catch from the Nushagak District,
- lessen the frequency and magnitudes of over-escapement events to the Wood River,
- decrease the vulnerability of King Salmon to Sockeye gear, and
- decrease the use of the WRSHA.

These benefits would be most significant in years when there is a large contrast in the age of returns to the Wood and Nushagak rivers. By increasing the harvest rate on the Wood River fish in the district, we should expect that in at least some years less fishing time would be needed for a given harvest level. Less fishing effort in the district can only decrease bycatch of non-target species. In addition, vulnerability of King Salmon in the Sockeye fishery will only fall with decreasing mesh size.

Introduction

The retention rate of salmon in gillnets is affected by the body size of the fish relative to the mesh size to which it is exposed. Mesh-specific selectivity curves quantify the retention rates (sometimes called "relative selectivity") of fish varying in body size. Beginning in 2009, the Bristol Bay Science and Research Institute (BBSRI) began conducting research on gillnet selectivity at the Port Moller Test Fishery (PMTF). Based on this research, the traditional gillnet used at Port Moller was changed in 2011 from four 50 fathom shackles of 5⅛" mesh to four shackles alternating between 4½" and 5⅛" mesh. This change was made because 5⅛" mesh selects for 3-ocean fish over 2-ocean fish at a ratio of about 1.4:1. Conversely, the smaller 4½" mesh selects 2-ocean fish over 3-ocean fish at a ratio of about 1.2:1. Aside from offsetting the age composition bias in the PMTF catches, the addition of the smaller mesh allowed for the estimation of contact selectivity curves for various mesh sizes. That is, for any given mesh size the relative selectivity across fish lengths can be estimated, and the fish length for which it is most selective can be determined (relative selectivity is then set to one for this size). Moreover, selectivity can be estimated for any age or stock for which the length frequency distribution is available. For this exercise, the average shaped selectivity curve based on PMTF data 2009-2018 was used to approximate performances of varying mesh sizes on stocks in the Nushagak District commercial fishery.

During years dominated by 2-ocean fish to the Wood River (e.g., 2018), tailoring mesh size to maximize efficiency in catching smaller fish may help to increase Sockeye Salmon catch, lessen over-escapement, reduce the amount of fishing time in the district, and reduce the frequency of being restricted to the Wood River Special Harvest Area (WRSHA). In addition, using a similar mesh size for 2-ocean fish during runs dominated by 3-ocean fish may have little risk of reducing the fleet's efficiency due to the shape of the selectivity curve (we expound on this idea below).

Objective

Assess how catches, exploitation rates, and escapements vary across mesh sizes for each stock in the Nushagak District for years contrasting in run size and age composition.

Methods

The average PMTF selectivity curve was applied to the 2011 and 2018 Nushagak runs. These two recent runs provide a strong contrast in the age- and size-composition. For each year, the most likely mesh that was used by the fleet was determined by adjusting the mesh size and exploitation rate until simulated and observed escapements matched. Subsequently, 4½", 4¾", and 5" mesh sizes were applied to estimate how fishery metrics (age-specific catch and escapement) would have changed across Nushagak District stocks for both years.

Results and Discussion

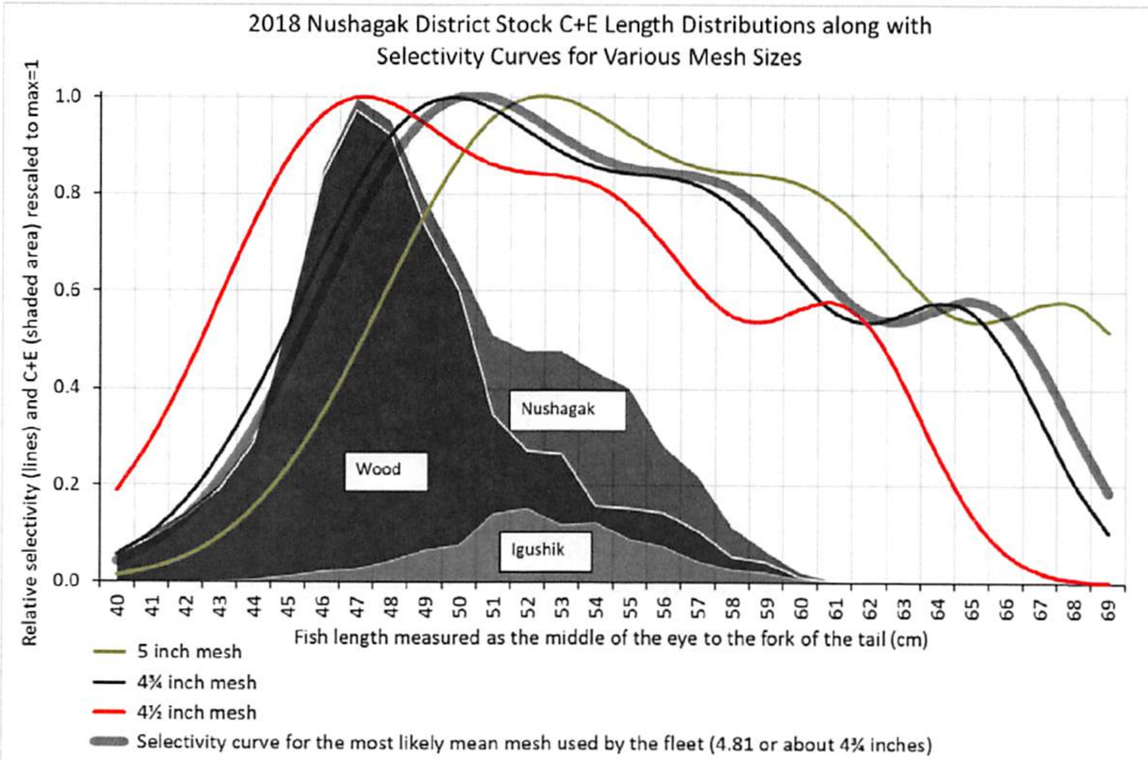
The 2011 run totaled 6.8 million and was comprised of 71% 3-ocean fish; in 2018 the run was 33.8 million with 32% being ocean age 3. In both years, Igushik and Nushagak stocks were dominated by 3-ocean fish, whereas this component was largely absent for the Wood River stock in 2018 (see Figure 1 for length distributions by stock and year overlaid with various selectivity curves). Interestingly, differences in catches across meshes were greatest for the Wood River stock in 2018.

Overall catch was estimated to have been greater for 5" versus 4½" mesh in 2011 and while this pattern reversed in 2018, the differences were not the same (Figure 2). In 2011, switching from 4½" to 5" mesh would increase catch by about 394 thousand or 9%; switching from 5" to 4½" mesh would increase catch by about 6.5 million or 32%. Mesh sizes to maximize catch were estimated to be 4¾-5" and 4½" in 2011 and 2018, respectively. Not surprisingly, the average mesh size used by the fleet was estimated to be close to 4¾" in both years. As this estimate is an average, one should not interpret this result to mean that every fisher was using this mesh size. In reality, mesh sizes likely ranged from 4½" to 5¼" (anecdotal reports indicate this to be the approximate range, but no official records were available).

Exploitation rates were more consistent across meshes within stock-year combinations more evenly split between ocean ages (Figure 3). The greatest differences occurred for the 2011 Nushagak stock (96% 3-ocean) and 2018 Wood River stock (4% 3-ocean) but were more pronounced for the latter. Exploitation changed more between 4¾" and 5" mesh than between 4¾" and 4½" mesh. This result occurred because of the shape of the selectivity curve and the differences in where small versus large fish are caught. The three modes on the selectivity curve going from right to left correspond to fish being (1) tangled around their head, (2) gilled just behind the gill plates, or (3) wedged between the gill plates and the dorsal fin (Figure 4). The curve descends faster on the left side causing small fish to be missed by larger meshes at a greater proportion than large fish are missed by smaller meshes. Consequently, a smaller mesh (say, 4½") will miss proportionately fewer fish in a 3-ocean dominated year than will a larger mesh (5" or 5⅛") in a 2-ocean dominated year.

Finally, using 4½" mesh in 2018 would have reduced over-escapement to the Wood River by about 3.5 million compared to what was observed (Figure 5).

As mentioned above, the fleet utilizes a range of mesh sizes and requiring a single mesh size would not be feasible without imposing undue economic hardship. Some fishers will inherently switch to smaller mesh sizes given that they have the gear available and a proportionately larger 2-ocean component is anticipated. Others may stay with larger gear because smaller gear is unavailable or because they believe targeting 3-ocean fish will high-grade their catch and increase overall profit. At any rate, the average mesh size tends to be around 4¾". The results from this exercise indicate that capping mesh size at 4¾" will stop large 2-ocean Wood River runs more efficiently and pose little risk of missing 3-ocean runs. Some fishers will want to fish even smaller gear, but the idea is simply to truncate the upper end of the mesh size distribution to better prosecute the fishery.



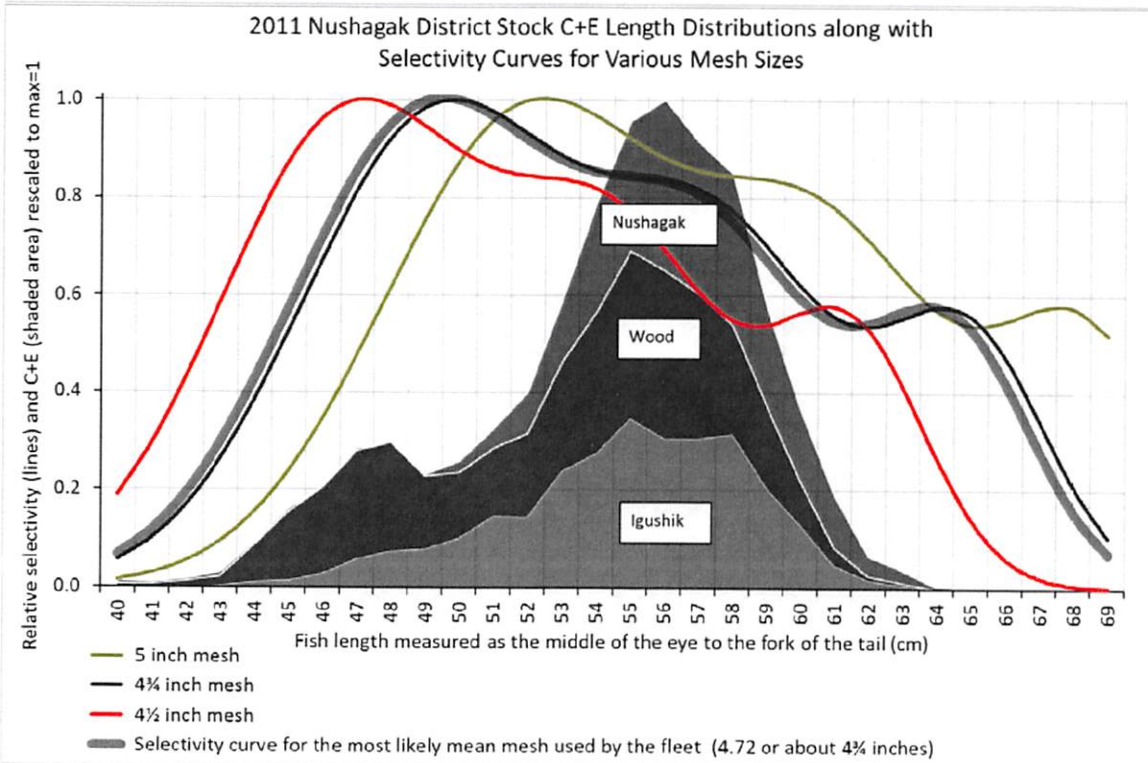
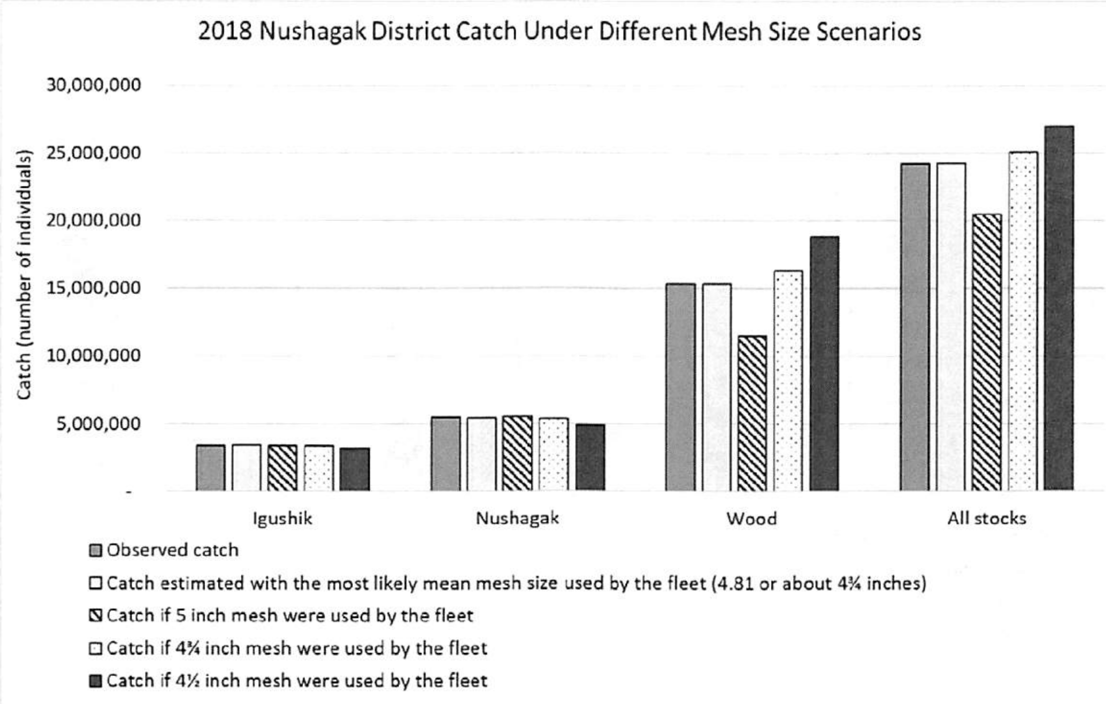


Figure 1. Length frequency distributions for stocks within the Nushagak District years 2011 and 2018 superimposed with selectivity curves for varying mesh sizes.



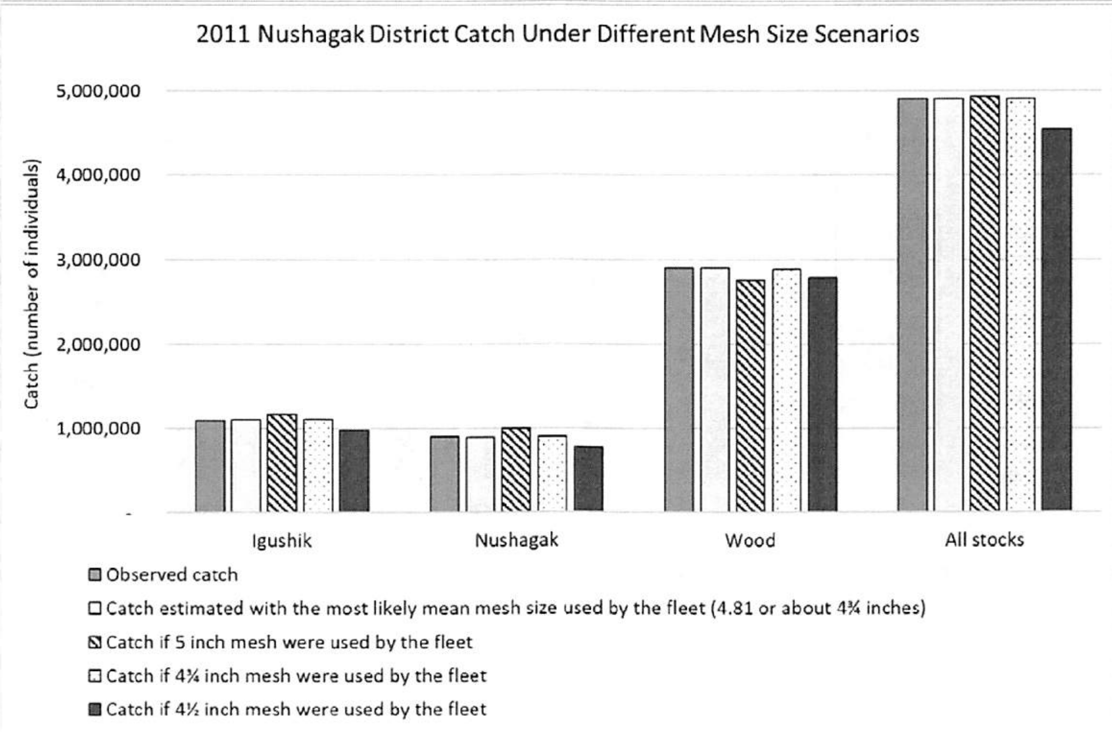
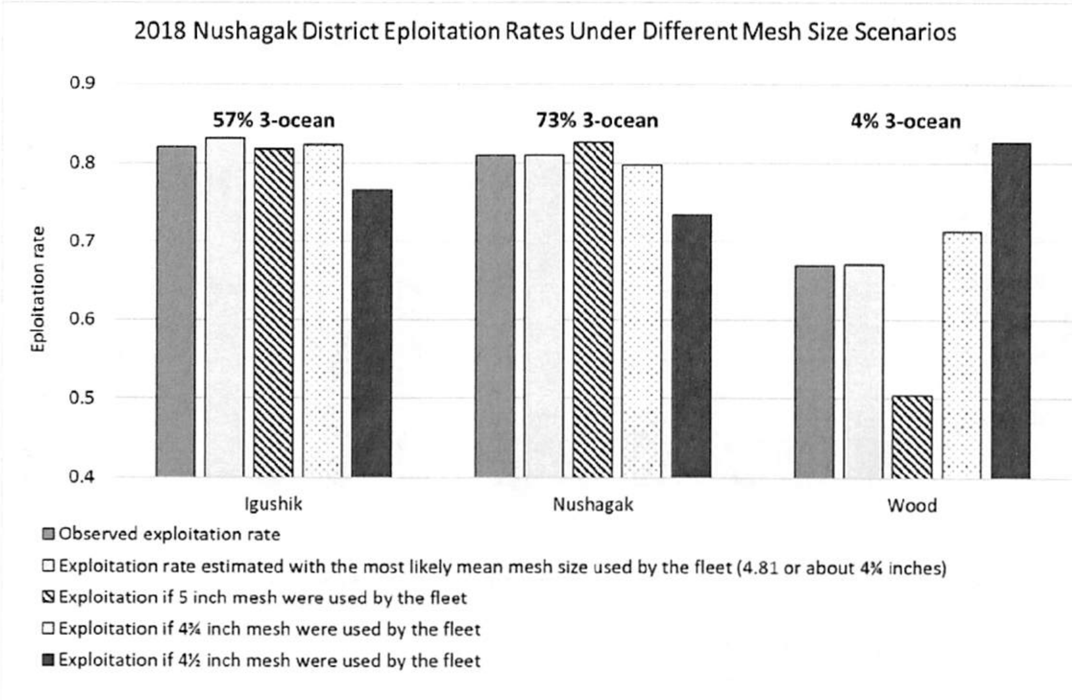


Figure 2. Catch observed and simulated with various mesh sizes for stocks within the Nushagak District years 2011 and 2018. Note: vertical axis scales are not consistent between years.



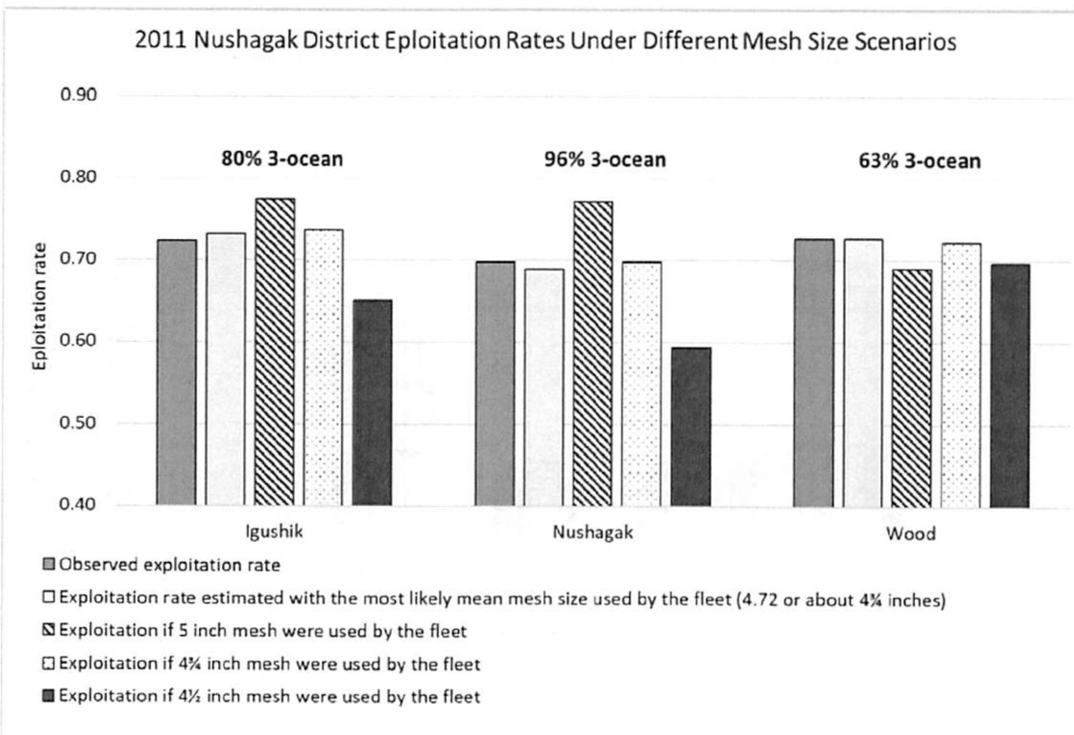


Figure 3. Exploitation rates observed and simulated with various mesh sizes for stocks within the Nushagak District years 2011 and 2018. The ocean age component is given above each stock.

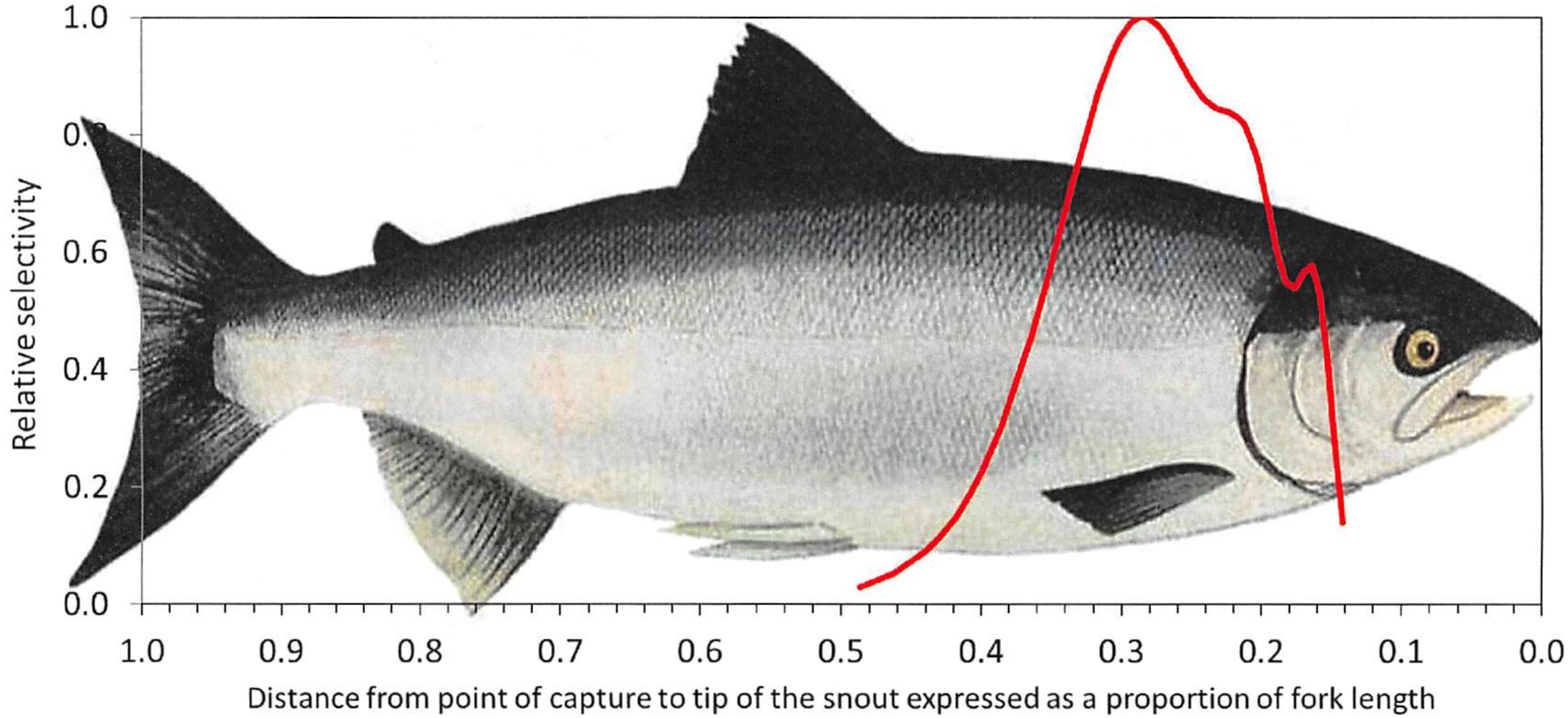
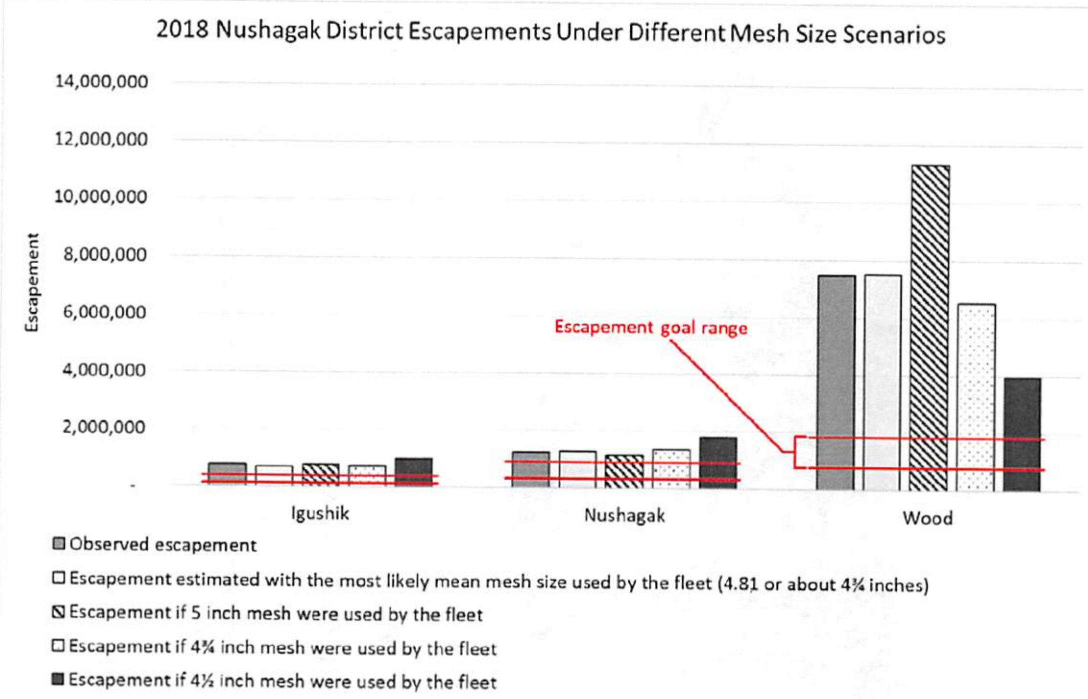


Figure 4. Estimated mean selectivity curve for years 2009-2018 superimposed onto the image of an average shaped ocean phase Sockeye. Starting from right to left three modes aligned with the following body structures: (1) the tangled mode occurred around the preoperculum; (2) the gilled mode occurred just after the gill cover; (3) the wedged mode occurred midway between the gill cover and the dorsal insertion.



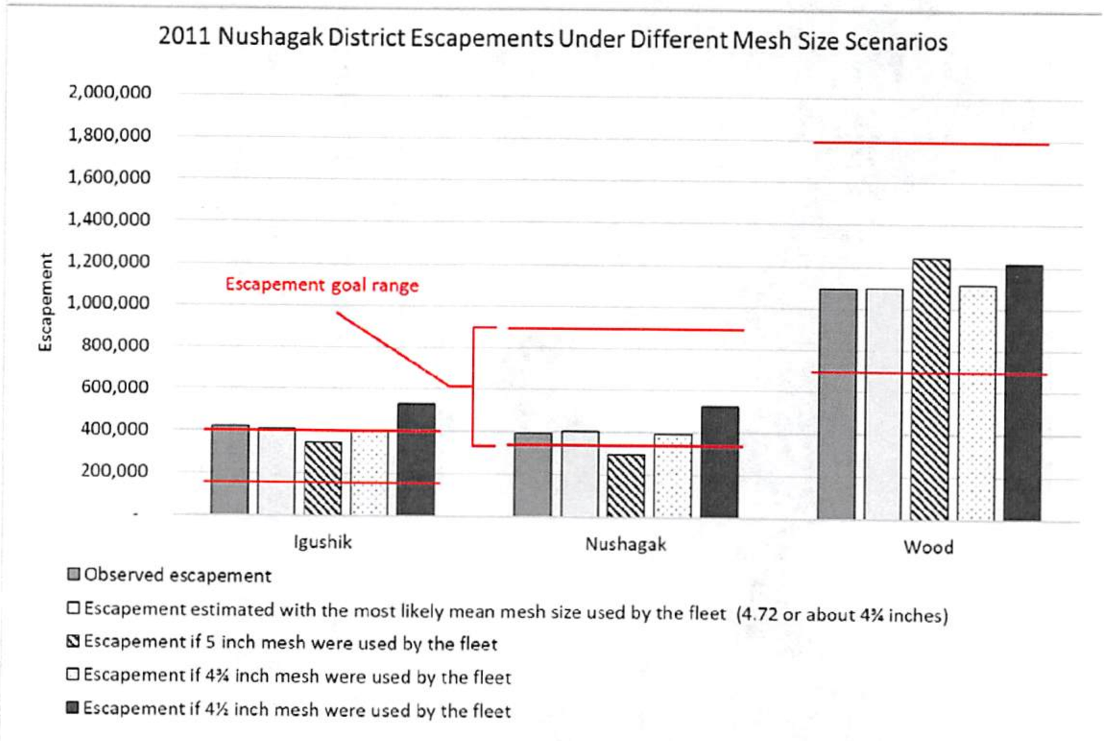


Figure 5. Escapement observed and simulated with various mesh sizes for stocks within the Nushagak District years 2011 and 2018.