WDFW Review of 2018 SRKW Priority Chinook Stock List:

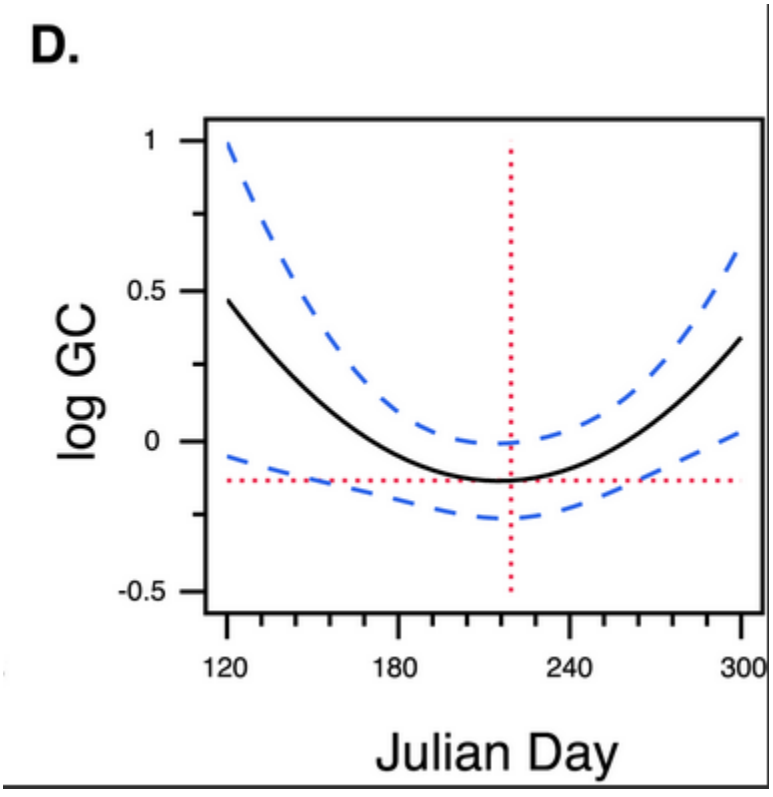
1.) Determining the time period or periods with the greatest nutritional stress to SRKW

The 2018 NMFS Biological Opinion stated:

"Seasonal mortality rates among Southern and Northern Resident whales may be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) identified high neonate mortality that occurred outside of the summer season. At least 12 newborn calves (9 in the southern community and 3 in the northern community) were seen outside the summer field season and disappeared by the next field season. Additionally, stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman et al. 2004)."

Wasser et al., 2017 demonstrated that nutritional stress for SRKW is highest in the winter and early spring using physiological indicators and that nutritional stress was lowest in the summer, near the peak of the Fraser River Chinook run (Figure 1; approximately Julian day 220).

Figure 1: Glucocorticoid concentrations versus Julian day in SRKW (Wasser et al., 2017):



Similar to the nutritional stress data, the independent science panel (2012) recommended:

"The Panel found the evidence for strong reliance on Chinook salmon in the summer convincing. However, given that the density of Chinook salmon in the summer as they migrate to the Fraser River is far higher than the density in the rest of the year when Chinook salmon are spread over a much larger area, it seems unlikely that the summer period would be the most critical period where Chinook salmon abundance affected SRKW vital rates."

Despite the above information, the abundance of Chinook in the summer may be key for SRKW to provide the needed reserves to survive the nutritionally-taxing winter and spring time periods (Wasser et al., 2017). Additionally, "peanut head syndrome" has been noted during both winter and summer months (Teresa Mongillo, pers. Comm.).

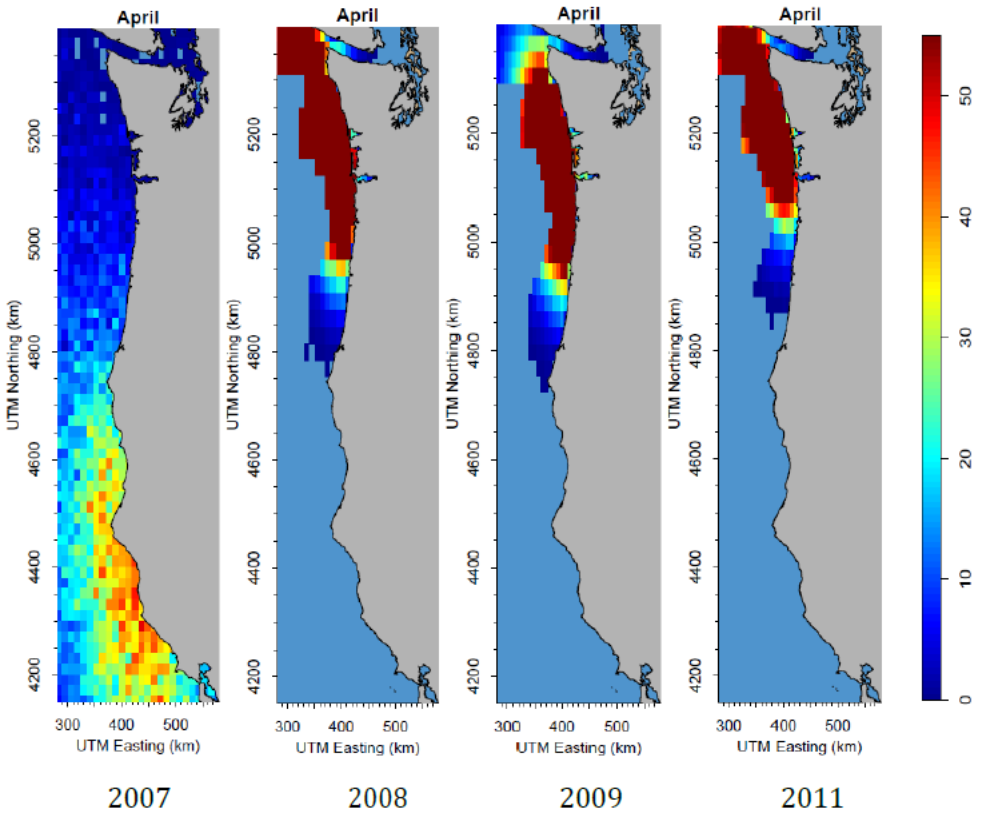
Given the above information, it is our recommendation that the most nutritionally important Chinook stocks for SRKW are those that contribute to the winter and early spring diet, due to higher nutritional stress during that time period. However, because there is some evidence that summer time period abundance can also be important, this period should not be entirely discounted, but rather given less weight than the winter and early spring period.

2.) Determining the location of SRKW during the time period or periods of high nutritional stress

During the winter and early spring period, K and L-Pod are most concentrated around the mouth of the Columbia River and Westport (Hanson et al., 2018). However, in January and February, approximately 50% of the K and L-Pod coastal presence is estimated to be South of Falcon (Summarized data from Teresa – "Spatial Use…xlsx"; email on 6/6/2019).

K and L-Pod winter and early spring distribution seems to vary highly across years. For example, see coastal SRKW detections in 2007 relative to other years (April) from Hanson et al., 2018 below:

Figure 9. Estimated spatial distribution for April 2007-2011, using (1) simulated movement tracks from the state space models of previously tagged Southern Resident killer whales, and (2) acoustic detections and confirmed sighting reports as data. The spatial locations across simulations have been aggregated into 2-km grid cells. Scale colors are proportional to the maximum counts (i.e., a relative scale, not probabilities of occurrence) with dark blue, gray blue, and white areas all equal to zero.



From our interpretation of the information above, we would consider the most important areas in the winter and early spring for K and L-Pod to be:

- Washington Coastal (particularly North of Neah Bay, near Westport, and near the mouth of the Columbia)
- Oregon Coastal (primarily January through March)
- California Coastal (primarily January/February)

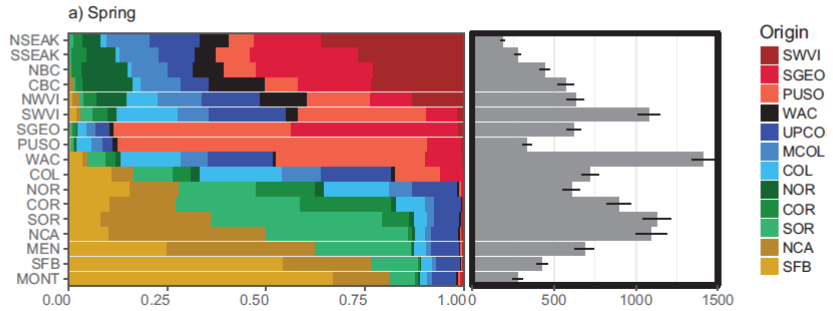
For J-Pod, special consideration should be given to the Salish Sea area in the winter, particularly North of Neah Bay, Northwest of Texada Island, and West of Whidbey Island (Hanson 2017 Power Point presentation; but see additional investigation section below). J-Pod does not appear to frequently use coastal locations (Hanson 2017 Power Point presentation) and could be considered separately to K and L-Pods.

3.) Determining the Chinook stocks most likely to be in the area during the time period or periods of high nutritional stress

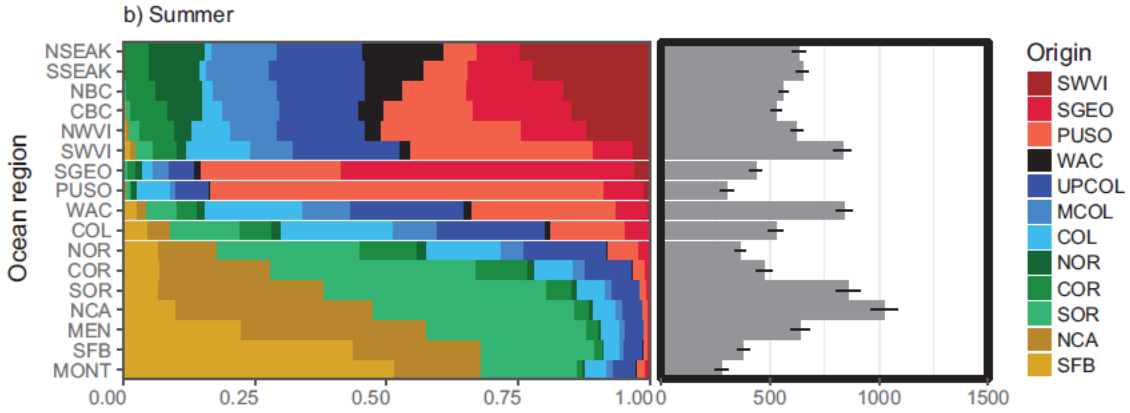
For this section, we used analyses conducted in Shelton et al., 2018. Note that this analysis does not include Spring stocks.

For the fall stocks that are in the Shelton et al., 2018 model, the Washington coastal abundance in the Winter-Spring time period is largely comprised of Columbia River and Puget Sound stocks (see figure below, taken from Shelton et al., 2018). The Columbia coastal abundance in the Winter-Spring time period is primarily comprised of Columbia River and South of Falcon stocks. South of Falcon area abundances are comprised predominantly of South of Falcon stocks and Puget Sound area abundances are comprised predominantly of Puget Sound stocks. The Georgia Strait area, which is of importance to J-Pod in the winter, is primarily composed of Puget Sound and Georgia Strait stocks.

Fig. 5. Distribution and abundance of fall Chinook salmon age 3 and older in the ocean. We show proportional contribution of age 3+ fish to each ocean region (left panels) and total abundance (right panels) at the beginning of spring (*a*), summer (*b*), and fall (*c*) seasons. Results arise from simulations assuming median fishing mortality for each area and season (see Fig. S1.9[1]) and a single juvenile mortality rate shared across all regions.

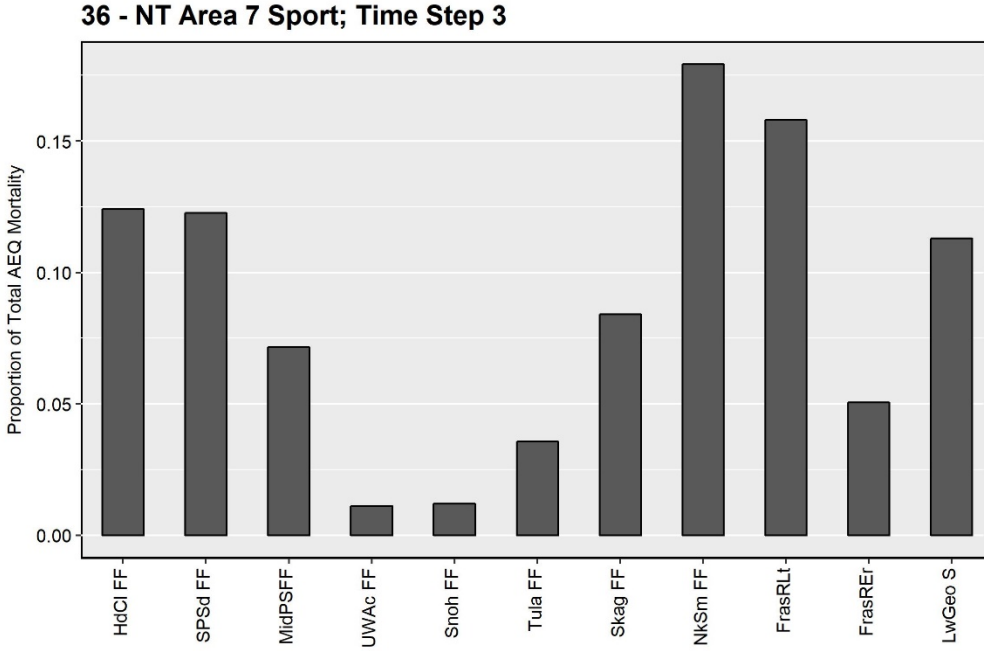


For the stocks of importance during the summer, Shelton et al., 2018 suggests that Puget Sound is the most important stock in the Puget Sound area:

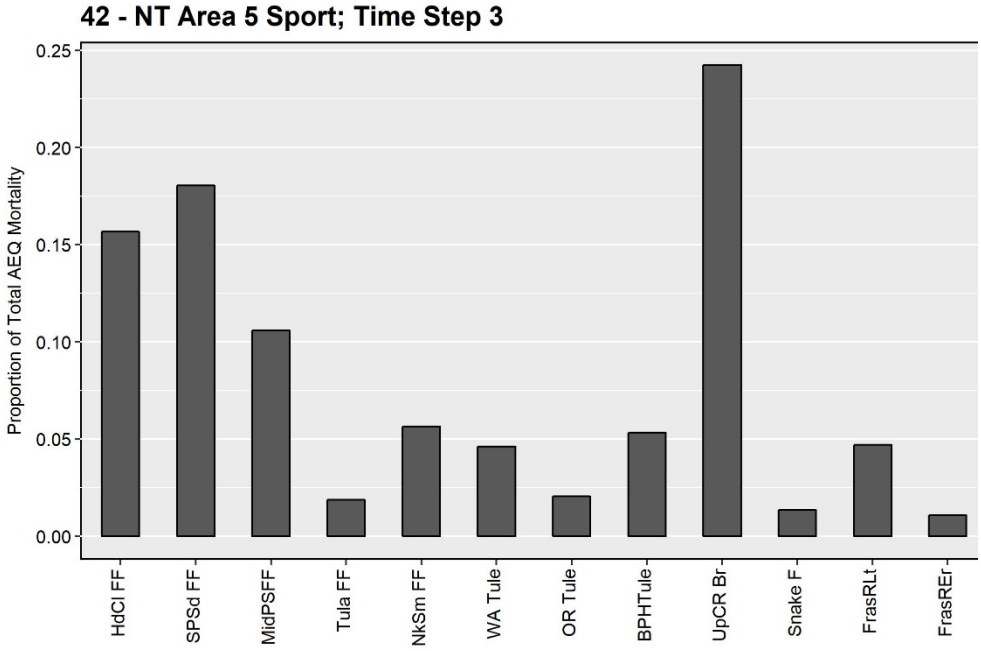


However, the area designated as "PUSO" in Shelton et al., 2018 encompasses quite a large area, and SRKW are most frequently observed within the San Juan Island and Strait of Juan de Fuca areas. FRAM fishery stock compositions indicate that within the San Juan Island area, Lower Georgia Strait and Fraser stocks (SGEO in Shelton et al., 2018) can make up a significant portion

of the localized abundance in addition to Puget Sound:



Similarly, near the entrance to the Strait of Juan de Fuca, the localized contribution from Columbia River fall stocks (Upriver Brights; Bonneville Pool Tules; Oregon Tules, Snake Falls; and Washington Tules) may be high:



Where additional investigation may be warranted:

- One source of uncertainty in Shelton et al., 2018 is that Chinook distribution information does not include spring stocks. With an unknown spring stock contribution to the spatial abundance, it makes it difficult to determine the importance of the fall stocks. If, for example, WA coastal/Columbia abundances in the winter/spring are comprised only 5% of spring stocks, then the list above is likely to be fairly accurate and may not necessitate including spring stocks. However, if the WA coastal/Columbia abundance in the winter/spring is largely comprised of spring stocks, then solely considering the fall stocks is unlikely to give an accurate representation of area stock-composition.
- There is additional body size information that could be taken into account when assessing WA coastal/Columbia abundance. In the winter/spring, spring stocks returning would be large, mature fish that, on average, will provide greater nutritional content than immature fall fish in the area.
- The stock composition of the WA coast in the winter/spring is comprised largely of Puget Sound fall fish. This result is surprising given distribution and biological knowledge of other fall stocks. Chinook stocks generally head north from their location of origin rather than south. For example, Georgia Strait, Fraser, and Vancouver Island fall stocks have a relatively small contribution to Puget Sound winter/spring fisheries (e.g., in all Puget Sound marine areas from 5 through 13, Canadian fish are estimated to comprise less than 10% of the catch on average in FRAM base period years). Therefore, more information as to how stock compositions are constructed in the Shelton model would be beneficial. The only winter/spring fishing occurring on the Washington Coast is within treaty troll, primarily in marine catch area 4B. Marine area 4B occurs within Juan de Fuca, and marine area 4 very likely has a much larger contribution of Puget Sound fall stocks than the other coastal fisheries. Given that the area outside of the Westport (marine area 2) is a hotspot for SRKW activity in the winter, if the Shelton model is using recoveries in 4/4B as a surrogate for the entire WA coastal area during the winter, there are likely to be inaccuracies in assessing the stock composition of the WA coastal area.
- The information in section 2 above is related to the distribution of all SRKW pods. It seems likely that different pods face different threats, with all six of the most recent SRKW deaths occurring in J-Pod (see Agenda Item B.3 slides for May SRKW Ad Hoc Workgroup meeting). J-Pod appears to demonstrate the highest correlation between body condition and pod size (Agenda Item B.3 slides) and has a different winter distribution to K-Pod and L-Pod (Hanson 2017 Powerpoint slides). Therefore, perhaps, when examining Chinook abundance, special consideration should be given to a J-Pod-specific analysis.
- Information related to J-Pod distribution in the Winter appears to be quite limited compared to K and L-Pod distribution. The review of J-Pod distribution here is primarily based on two satellite tags (one deployed in February of 2012 for 3 days; one deployed in December of 2014 for 49 days). While J-Pod does not appear to consistently use coastal areas in the Winter (Hanson et al., 2018; 2017 Hanson Powerpoint presentation), additional information related to J-Pod spatial use within Puget Sound may be beneficial.

Assessment of the Priority Stock List Versus Above Technical Information:

If considering the information above, the stocks that we would rank as "high priority" are as follows:

- **Columbia River Springs** – Unknown overlap with SRKW distributions, but presumed high for K and L-Pods. Noted in the literature as likely to be a highly important component to SRKW diet (Wasser et al., 2017).
- **Puget Sound Falls** – High overlap with Summer SRKW distributions, high overlap with Winter SRKW distributions (Shelton et al., 2018).
- **Columbia River Falls** – Medium overlap with Summer SRKW distributions, high overlap with Winter K and L-Pod distributions (Shelton et al., 2018).
- **Strait of Georgia** – Medium overlap with Summer SRKW distributions, low overlap with Winter K and L-Pod distributions with K and L-Pods, but a high overlap with Winter J-Pod distributions (Shelton et al., 2018). Note that past studies have suggested that Fraser Chinook are likely a highly important component to SRKW diet (Hanson et al., 2010; Wasser et al., 2017).

We would consider the following stocks as "medium priority":

- **Washington Coastal Springs** – Unknown overlap with SRKW distributions, however, likely to be at least medium, given where SRKW are present in the winter.
- **South of Falcon Springs** – Unknown overlap with SRKW distributions, however, likely to be at least medium, given where SRKW are present in the winter.
- **South of Falcon Falls** – Low overlap with Summer SRKW distributions, medium overlap with Winter K and L-Pod distributions (Shelton et al., 2018). However, in some years, there is a high overlap with Winter SRKW distributions (Shelton et al., 2018; Hanson et al., 2018).

In general the "high" and "medium" priority categories assigned above match those in the priority stock list. However, Spring stocks generally ranked lower on NOAA's priority list than the categories developed here. The medium-low prioritization of Columbia River/Coastal Spring stocks is cause for concern given:

- Knowledge about when SRKW are likely to experience the greatest nutritional stress (winter/spring; see #1 above).
- Knowledge of SRKW distributions during the time of greatest nutritional stress (K and L-Pods: primarily along the Washington coast, with frequent concentrations around the mouth of the Columbia; see #2 above).
- A lack of knowledge about the contribution of Spring stocks to the winter/spring WA coastal abundances (see first "Where additional investigation may be warranted" point above).
- Knowledge of the biology of Spring stocks (mature fish must return to the river of origin in the winter/spring).

Therefore, it is our recommendation to retain the prioritization list as-is for fall stocks, but to consider all Columbia Spring stocks as high priority stocks.

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