Submission to NMFS Five-Year Status Review of Southern Resident Killer Whales

Submitted by

Dr. Nick Gayeski, Wild Fish Conservancy

Misty MacDuffee, Raincoast, Conservation Foundation

Dr. Deborah Giles, Wild Orca

June 21, 2021

To Whom It May Concern,

We appreciate the opportunity to provide NMFS with information and recommendations for its 2021 Five-year Review of the Status of Southern Resident Killer Whales (SRKW) distinct Population Segment (DPS). Herein, we provide several documents pertaining to recent population viability analyses (PVAs) of the SRKW DPS. All demonstrate that the probability of quasi-extinction to 30 animals or less, or to only one sex remaining exceed 20% (0.20) within fewer than 100 years. This is a dire situation for the DPS and indicates that NMFS' 2008 SRKW Recovery Plan and related management actions by NMFS are failing to secure the requisite high probability of survival required to prevent extinction, much less initiate the recovery of the DPS.

We also recommend that the Biological Review Team (BRT) conducting the review evaluate the PVAs described in Lacy et al. 2017 and Murray et al. 2021 to inform both management actions and identify a PVA modeling approach for NMFS. It is critical that the public and scientific community have confidence that NFMS' approach to estimating SRKW extinction risk is scientifically robust and credible. It is further critical that NMFS recognize that the current status of the DPS, based on the evidence of the PVAs of Lacy et al. and Murray et al., is dire and requires strong precautionary actions that address the primarily limiting factors to survival and recovery over which NMFS and other federal and state agencies have the most direct control.

Specifically, as we discuss in further detail below, marine Chinook harvest requires far greater consideration to mixed stock catch removals, Chinook abundance within SRKW foraging grounds, population structure including size and age composition, and lastly precautionary modelling and management approaches that reflect a current understanding of rapidly changing marine environments that are difficult to predict and dictate far greater consideration to ecosystem function than are currently in place.

Evidence from the last decade shows a poor ability to adequately predict Chinook abundance and allowable harvest limits in mixed stock west coast fisheries in Canada and the US. This results in fishing above catch ceilings set by the PST[1] and a lower abundance of Chinook salmon in SRKW critical habitat and feeding grounds. As NMFS has identified, low Chinook salmon abundance has been associated with low killer whale fecundity and survival (Hanson et al. 2021). Chinook removal above catch ceilings further reduces prey to SRKWs from runs known generally to be important in their diets, such as those that return to Puget Sound, Georgia Strait, Canada's Fraser River (summer and fall runs) and the Columbia River (spring, summer and fall runs), as well as other coastal stocks returning to Washington, Oregon and California.

In addition to imprecise and inaccurate aggregate abundance forecasts, there are considerable uncertainties regarding the appropriate Chinook stock aggregate and levels of pre-season abundance that correlate to positive SRKW fecundity and survival rates. Additionally, a critically important feature of an appropriate Chinook stock aggregate is the age- and size-composition.

Preferred prey

It is well-known that SRKW are highly specialized predators that feed primarily on Chinook salmon. What seems less appreciated is the importance of Chinook age and size that constitutes their preferred prey. Ford and Ellis (2005) found resident killer whales preferentially select for Chinook that are four and five years or older with corresponding body sizes of greater than 740 mm fork length (29 inches) and body masses of at least 8-13 kg (17 lbs or more). Analyses by NMFS's Dr. Eric Ward shows strong selectivity (preference) by SRKW for Chinook five years (> 800 mm FL) and older. NMFS has so far failed to account for age and size criteria as a

[1] AABM fisheries managed under the PST occur in Alaska and British Columbia. Alaska has exceeded its catch ceilings (by 5% or greater) more than 50% the time since 2010 (range is from 6.48% (2010: ~15,000 fish) to 31.42% (2020: ~64,000 fish). By comparison, BC (combined NBC & WCVI) exceeded its catch ceiling once (8.36% in 2016, representing ~13,000 fish).

fundamental aspect of preferred prey. Historically, these Chinook ages and sizes would have comprised the majority of Chinook salmon stocks with which SRKW co-evolved. As age at maturity and size at age of Chinook salmon has declined over the last century, half century, and in recent decades, the proportional abundance of the larger, older Chinook (i.e. preferred prey) has also declined. This decline is in addition to observed declines of aggregated Chinook salmon abundance regionally and internationally.

Age overfishing

In addition to lowering the overall abundance of primary prey within critical habitat, mixed stock marine Chinook fisheries also harvest immature Chinook, as these fisheries are conducted on Chinook salmon rearing grounds. The harvest of immature Chinook skews the age composition of Chinook populations towards younger and hence smaller individuals. A reduction in the size and number of older females has adverse implications for Chinook productivity (as fecundity is related to the length of female Chinook salmon), as well as for Chinook recovery and resilience, (since large female Chinook have advantages on spawning grounds that improve egg deposition and survival). So in addition to fishery removals that directly lower Chinook abundance, marine Chinook fisheries can skew the age structure toward younger and smaller fish, and a lower abundance of larger older preferred prey for SRKWs.

NMFS needs to determine the fisheries management measures required to ensure the DPS has a high probability of securing regular annual access to the minimal numbers of large (>740 mm FL) Chinook conservatively estimated to be necessary to secure the survival of the current SRKW population and to provide modest annual increase in population numbers. The Status Review should determine the extent to which current Chinook salmon harvest management measures have failed to secure these levels of abundance of Chinook with the requisite age and size composition.

Preserving reproductive potential

Premature deaths of adult and juvenile SRKWs (i.e. mortality rates up to 2-3 times greater than expected; DFO 2017) have been occurring within all three pods for almost two decades. These events underscore the precarious nature of this population whose individuals are generally failing to successfully feed, mature and reproduce, or meet normal life expectancies. In this small and declining population, reproductive potential is eroded with every death regardless of sex or age (due to the cultural importance of post-reproductive females and the concern for inbreeding from too few suitable mature males).

A critical attribute of the current SRKW DPS demographic is the low birth rate. Even recent minor improvements to birth rates in 2019 – 2021 are still below the number of annual births expected for a healthy resident killer whale population, as is generally the case for Southern Alaska Resident Killer Whales (SARKW) (Murray et al. 2021, Table 1). Additionally, the challenge for more than a decade has been keeping young calves (and fetuses in pregnant females) alive to become breeding adults. The cause is largely attributed to the poor nutritional condition of the mothers (Wasser et al. 2017).

Compared to a healthy resident killer whale population, even the recent minor uptick in SRKW births is low. Murray et al. 2021 (attached) use demographic data from the Southern Alaska Resident Killer Whale (SARKW) population as a reference for a healthy resident killer whale population against which to compare the demographic performance of the SRKW population. Their Table 1 lists the following parameters for the mean annual birthrate of mature females in the SARKW population:

- Females ages 10 to 30: mean = 0.233, standard deviation = 0.118,
- Females ages 31 to 50: mean = 0.154, standard deviation = 0.118.

As of 2020, there are 18 females between the ages of 10 and 30 in the SRKW population, and 16 females between the ages of 31 to 50. The mean annual birth rates are Bernoulli rates (probabilities of an individual mature female having a birth in year x, and, hence, the number of annual births of a group of similar individuals each of which has the same Bernoulli probability of birth) will be distributed as a binomial with parameters n (number of females) and p (probability of in individual female giving birth in year x).

The Beta Distribution is the parametric distribution for a binomial rate parameter. Accordingly, to account for the variability in the mean birth rates of the SARKW population given in Table 1 of Murray et al. 2021, we simulated (in Matlab) 50000 binomial trials of annual births with parameters

- n1(females ages 10 to 30) = 18, and p = p-female1; and
- n2 (females ages 31 to 50) = 16, p-female2,

where p-female1 is drawn randomly for each trial from a Beta distribution with alpha parameter = 2.76 and beta parameter = 9.08, which yields a mean p of 0.233 with standard deviation of 0.188. P-female2 is drawn randomly from a Beta distribution with alpha = 1.287 and beta = 7.071, which yields a mean p of 0.154 with standard deviation of 0.118. The resulting distribution of annual births from 18 females ages 10 to 30 and from 16 females ages 31 to 50 will each be distributed as a Beta-Binomial Distribution. This provides a robust estimate of the probability distribution of expected annual births to females1 and females 2 and to their sum, the total number of annual births expected from all 34 mature females. Summary results for all 34 mature females are listed in the table below;

Table 1. Probabilities of numbers of annual births for a healthy resident killer whale population with a total of 34 mature females between the ages of 10 and 50. ‘P(Interval)’ is the probability of the annual number of births falling within the number of births in the ‘Interval’ column.

#Births	P(#Births)	Cumulative P	Interval	P(Interval)
0	0.06	0.06	2 to 4	0.20
1	0.11	0.17	2 to 5	0.23
2	0.06	0.22	3 to 5	0.15
3	0.08	0.30	3 to 6	0.29
4	0.12	0.43	3 to 7	0.29
5	0.02	0.45	3 to 8	0.41
6	0.14	0.59	4 to 6	0.16
7	0.01	0.60	4 to 7	0.17
8	0.11	0.71	4 to 8	0.28
9	0.02	0.73	5 to 9	0.28

10	0.08	0.81	5 to 10	0.36

Significantly, the probability that the mean number of annual births is greater than 3, is greater than 70% (1 – 0.30 = 0.70 (70%)), the probability that the mean number is greater than 4 or 5, is greater than 55% (1-0.43 = 0.57 (57%)); 1 – 0.45 = 0.55 (55%), respectively). The probability that the mean number of births is greater than 6 or 7, is greater than 40% (1 - 0.59 = 0.41 (41%)); 1 – 0.60 = 0.40 (40%), respectively). The maximum number of births in the SRKW population over the past decade has never exceeded 3, and most frequently has been between 0 and 2. This is clearly abnormally low for a resident killer whale population. Addressing this needs to be reflected in the new Five Year Review.

Further, as we show below, the recent (2019 to 2021) uptick in births may be the result in large part of recent reductions in Chinook harvest in British Columbia due to a combination of management actions by DFO (2018- 2020) and reduced fishing pressure from Covid-19 measures in effect through 2020. The BRT needs to carefully evaluate this matter, as it likely significantly affects the understanding of the potential for further reductions in coastwide Chinook harvests to achieve significant near-term benefits to the DPS.

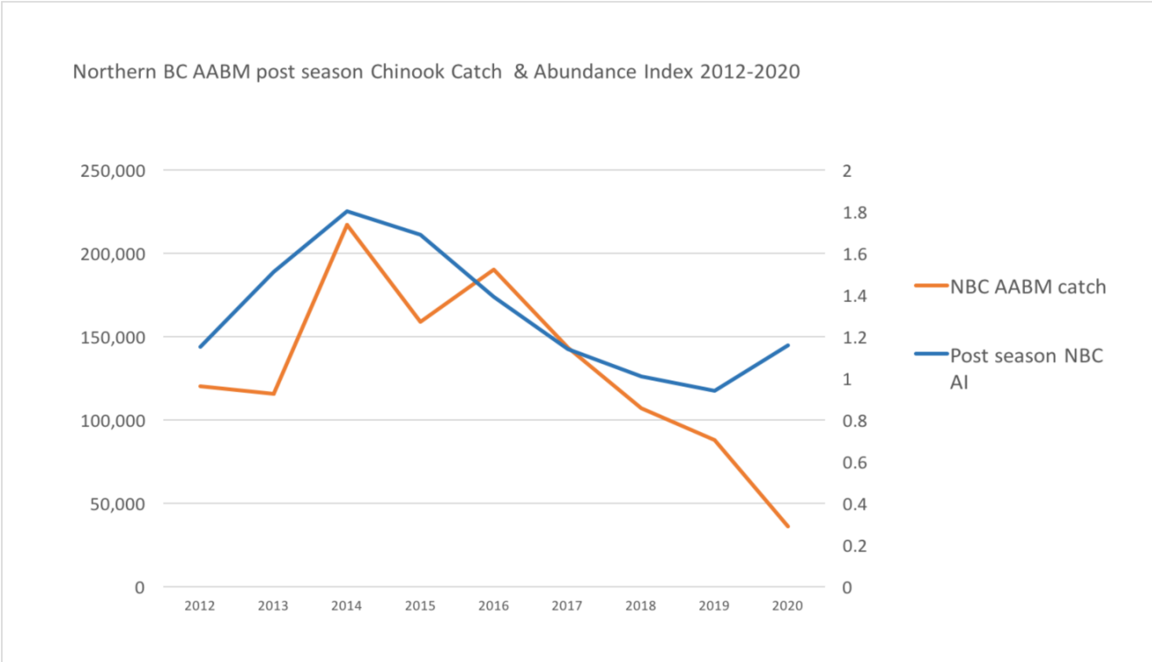

Figure 1. Post season Abundance Index (AI, blue) as determined by the PSC's Chinook Technical Committee for Northern BC and the observed Chinook catch (orange) in Northern BC from 2012- 2020. Northern BC is one of three west coast fisheries managed under the PST's Aggregate Abundance Based Management (AABM). Catches are affected by the forecasted pre-season abundance and its corresponding catch ceilings (not shown), and then evaluated against observed abundance post season. The index is a relative indicator of Chinook abundance. The highest index for NBC since 2012 was 1.8 in 2014. Greater deviation in catches from the AI since 2018 are due to reduced fishing pressure from domestic (BC) Chinook management measures and response measures (such as travel restrictions) in 2020 for Covid-19.

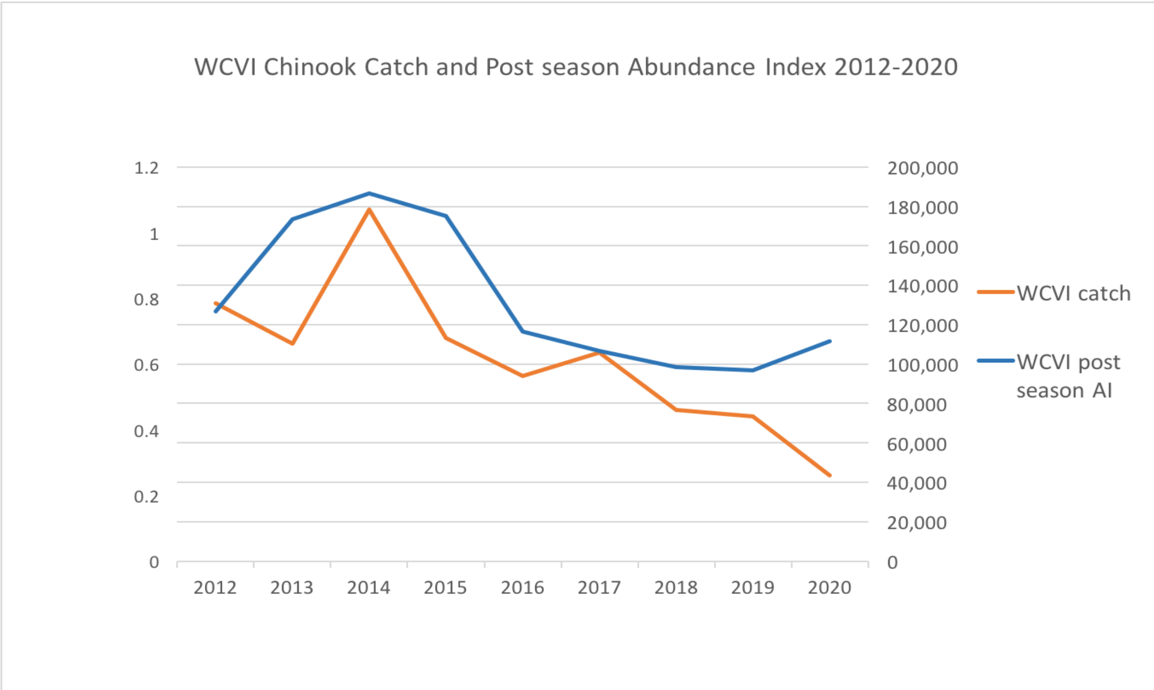

Figure 2. Post season Abundance Index (AI, blue) as determined by the PSC's Chinook Technical Committee for the West Coast of Vancouver Island and the observed Chinook catch (orange) in WCVI from 2012- 2020. WCVI is one of three west coast fisheries managed under the PST's Aggregate Abundance Based Management (AABM). Catches are affected by the forecasted pre-season abundance and its corresponding catch ceilings (not shown), and then evaluated against observed abundance post season. The index is a relative indicator of Chinook abundance. The highest index for WCVI since 2012 was 1.12 in 2014. Greater deviation in catches from the AI since 2018 are due to reduced fishing pressure from domestic Chinook management measures in BC and response measures (such as travel restrictions) in 2020 for Covid-19.

Table 1. Post Season Abundance Index (AI) for the three AABM fishery areas (SEAK, NBC and WCVI) and the Total Allowable Catch (TAC ceiling) allowed in accordance with respective AIs. The last 2 columns show the change in harvest relative to the 2009 PST catch agreement.

	SEAK Post season AI	SEAK TAC	NBC Post season AI	NBC TAC	WCVI post Season AI	WCVI TAC	Total BC TAC	BC TAC change relative to 2017	SEAK TAC change relative to 2017
2017	1.31	215,800	1.14	148,200	0.64	95,800	244,000		
2018	0.92	118,700	0.89	115,700	0.59	127,766	243,466		
2019	1.04	140,323[2] (137,200)	0.94	122,200 (122,200)	0.58	76,000 (86,840)	198,200 (209,040)	-5.18%	+2.27%

[2] Catch ceiling not consistent with 2019 PST SEAK AI

2020	1.11	140,323 (154,120)	1.16	141,700 (141,700)	0.67	78,500 (100,300)	220,200 (242,000)	-9.0%	-8.95%

Table 2. Allowable TAC vs observed catches in the AABM fisheries (SEAK, NBC and WCVI), percent reductions relative to 2017 catch ceilings under the 2009 PST agreement, and number of Chinook that weren't caught based on CTC catch and abundance models.

	SEAK TAC (TAC 2009 PST)	SEAK Obs. Catch	NBC TAC (TAC 2009 PST)	NBC Obs. Catch	WCVI TAC (TAC 2009 PST)	WCVI Obs. catch	BC obs. catch (TAC 2009 PST)	BC % catch change relative to 2009 TAC	Alaska % change relative to 2009 TAC	Total % change relative to 2009 TAC	# of Chinook remaining in water
2017	215,800	178,348	148,200	143,330	95,800	105,588	249,218 (211,500)	+17.83%	-17.35%	-0.48%	
2018	118,700	127,766	115,700	108,976	127,766	85,300	194,276 (243,466)	-20.2%	+7.63%	- 12.57%	39,994
2019	140,323[3] (137,200)	140, 307	122,200 (122,200)	88,026	76,000 (86,840)	73,482	161,508 (209040)	-22.7%	+2.27	-20.34%	44,425
2020	140,323 (154,120)	204,624	141,700 (141,700)	36,103	78,500 (100300)	45,581	81,684 (242,000)	-66%	+32.77%	-33.23%	109,802

List of documents submitted:

R.C. Lacy, R. Williams, E. Ashe, K.C. Balcomb III, L.J.N. Brent, C.W. Clark, D.P. Croft, D.A.

Giles, M. MacDuffee & P.C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. *Scientific Reports.* 7: *14119* | DOI:10.1038/s41598-017-14471-0.

Murray, C.C., L.C. Hannah, T. Doniol-Valcroze, B.M. Wright, E.H. Stredulinsky, J. C. Nelson, A. Locke & R.C. Lacy. 2021. A cumulative effects model for population trajectories of resident killer whales in the Northeast Pacific. *Biological Conservation* 257. https://doi.org/10.1016/j.biocon.2021.109124.

Declaration of Dr. Robert Lacy for Plaintiff Wild Fish Conservancy in United States District Court Western District of Washington at Seattle, Case No. 2:20-cv-00417-MLP. April 15, 2020.

Second Declaration of Dr. Robert Lacy for Plaintiff Wild Fish Conservancy in United States District Court Western District of Washington at Seattle, Case No. 2:20-cv-00417-MLP. May 3, 2021.

[3] Catch ceiling not consistent with 2019 PST SEAK AI

References

DFO. 2017. Southern Resident killer whales: A science based review of recovery actions for three at-risk killer whale populations. Fisheries and Oceans Canada

Ford, J.K.B. & G.M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. *Mar. Ecol. Prog. Ser.* 316, 185–199. (doi:10.3354/ meps316185)

Hanson, M. B., C.K. Emmons, M.J. Ford, M. Everett, K. Parsons, L.K. Park, J. Hempelmann, , D.M. Van Doornik, G.S. Schorr, J.K. Jacobsen, M.F. Sears et al. 2021. Endangered predators and endangered prey: Seasonal diet of Southern Resident killer whales. *PloS one* 16, no. 3: e0247031.

Murray, C.C., L.C. Hannah, T. Doniol-Valcroze, B.M. Wright, E.H. Stredulinsky, J.C. Nelson, A. Locke & R.C. Lacy. 2021. A cumulative effects model for population trajectories of resident killer whales in the Northeast Pacific. *Biological Conservation* 257. https://doi.org/10.1016/j.biocon.2021.109124.

R.C. Lacy, R. Williams, E. Ashe, K.C. Balcomb III, L.J.N. Brent, C.W. Clark, D.P. Croft, D.A.

Giles, M. MacDuffee & P.C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. *Scientific Reports*. 7: *14119* | DOI:10.1038/s41598-017-14471-0.

Ward, E. F. 2011. Estimation of age-based selectivity of Chinook salmon by killer whales. Presentation at the NOAA workshop for the Independent Science Panel Report on The effects of salmon fisheries on Southern Resident Killer Whales.

Wasser, S. K., J. I. Lundin, K. Ayres, E. Seely, D. Giles, K. Balcomb, J. Hempelmann, K. Parsons and R. Booth .2017. Population growth is limited by nutritional impacts on pregnancy success in endangered Southern Resident killer whales (*Orcinus orca)*. PLoS One **12**(6).