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Canadian Science Advisory Secretariat
Pacific Region **Science Response 2019/025**

POPULATION STATUS UPDATE FOR THE NORTHERN RESIDENT KILLER WHALE (*ORCINUS ORCA*) IN 2018

Context

Northern Resident Killer Whales (NRKW) are currently designated as 'Threatened' in Canada under the *Species at Risk Act*, due to their small population size, low reproductive rate, and the existence of several anthropogenic threats that are likely to impede their on-going population recovery or cause future population declines (DFO 2018). Population censusing by photo-identification is a key research activity outlined in the *Species at Risk Act* Action Plan for Resident Killer Whales (DFO 2017) and has been conducted on the NRKW population each year since 1973, making it one of the longest-running, continuous time series of data for a cetacean population.

This report presents updated population information for NRKW in 2018 and supplements existing publications, particularly between releases of NRKW photo-identification catalogues. Please cite this document according to the citation provided at the end of this report. The demographic data presented here are not intended to be analyzed for further studies without permission of Fisheries and Oceans Canada's (DFO) Cetacean Research Program. Please contact the Cetacean Research Program[1] for data use requests relating to this report.

This Science Response Report results from the Science Response Process of February 2019 on the 2018 Report on the Northern Resident Killer Whale annual census.

Background

The Northern Resident Killer Whale population ranges throughout the coastal waters of British Columbia, Canada and the western United States, from southern Washington State to southeastern Alaska (Ford et al. 2000). The population consists of three acoustical clans (called A, G and R clan), each with a distinct set of dialects (Ford 1991). Photographs of natural markings on the dorsal fins and saddle patches of whales are used as unique identifiers (Bigg 1982) that allow individuals to be recognized each time they are encountered, which makes it possible to track changes in their life history statuses (e.g. events such as birth, sexual maturation, reproduction, and death) with a high degree of accuracy. Each year, extensive field effort is undertaken to find and photograph as many individuals from this population as possible and note their reproductive status and health condition.

Historically, NRKW census efforts tended to be geographically restricted to the waters off northeastern Vancouver Island and temporally restricted to the summer months (July-August). In more recent years, however, the geographic range of the census effort has expanded to include all coastal waters of BC and the temporal range of photo-identification data has broadened as well. To keep census data comparable across the entire time series of the study, the 'census window' is defined as July 1st - August 31st (see Olesiuk et al. 2005). The status of

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an animal is assessed and documented during that window. For example, if a calf was born in October 1976, its existence would not have been known to researchers until the 1977 census field work began, and thus it could have been born anytime from September 1976 to July 1977; therefore the calf would simply be designated as a 1977 birth. If the same situation were to occur in a more recent year (e.g. 2017) when the birthdate of an early autumn calf is often precisely known, to remain consistent with the study's historical data, the calf would be assigned a birth year of 2018. In some cases, an animal is only encountered outside of the census window during a given year; in these instances, its status information tends to be assigned to the census window immediately following the encounter. For example, an animal seen in June 2017 but missing from its matriline in October 2017 would be considered "alive" during the 2017 census window, but "missing" for the 2018 census.

Although the majority of NRKW are photographed each year, it is not always possible to locate every matrilineal group during each field season due to the large range of this population, its growing size since the study began, and the tendency for matrilines to split apart over time (meaning an increasing number of matrilineal groups must be found each year). Conditions in the exposed and remote areas in which this population is found can also make it difficult to locate and photograph every matriline. Thus, there is often uncertainty in the number of living animals each year, and an animal's life history status in a given year is sometimes determined by its status in a future census year. For instance, an animal that is seen alive after not being censused for several years will have its status for the intervening years assigned retroactively. Thus, some of the recent annual counts presented in this report may not remain the same in future census updates for this population.

Analysis and Response

The methodologies for estimating population parameters that are presented in this report are a brief description of methods that have been previously published in more detail. For more information, see Bigg et al. (1990), Olesiuk et al. (2005), Stredulinsky (2016) and Towers et al. (2015). Methods for collecting and analyzing census data are not discussed but are provided in Bigg et al. (1986), Ellis et al. (2011) and Towers et al. (2012).

Determining ages

For animals born since this study began, young-of-the-year were assigned a year of birth (YOB) equivalent to the census year in which they were first discovered. For newly discovered animals whose body size when first seen suggested that they were born in a previous census year (i.e. they were not young-of-the-year when first seen), YOB was defined as the year of discovery minus the estimated age when first seen (based on expert knowledge of size-at-age). If there was uncertainty in the animal's age when first seen, an animal's 'best' estimated YOB was calculated using the median of the possible age range, rounded up to the nearest whole year. In many cases, this uncertainty is limited to plus or minus a half year, and thus rounding up results in the 'best' YOB often being equivalent to the maximum YOB.

For animals born prior to the study whose ages when first seen could not be confidently estimated, YOB required estimation based on life history parameters of known-age animals. The initial age estimates for these animals were calculated by Olesiuk et al. (1990). Over time, more animals have been tracked since birth, which has allowed NRKW life history parameters (and thus ages of animals born prior to the beginning of the study) to be periodically refined. Re-assessments of life history parameters and ages were conducted by Olesiuk et al. (2005) and are currently being undertaken again.

Determining sexes

Animals in this study were sexed through various means:

- Opportunistic observations: Animals may be sexed through visual observation of their underside. The black and white pigmentation of the posterior-ventral area, as well as the genital slits, are different for males and females.
- Physical manifestation of sexual maturity (see Bigg et al. 1990 for details): for females, this is indicated by the birth of their first calf, and for males, by the onset of accelerated dorsal fin growth or 'sprouting'.
- Genetic analysis of tissue samples: DNA analysis allows sexing of animals whose tissue was collected via biopsy sampling or via post-mortem tissue sampling of their carcass.
- If an animal of unknown sex reaches 15 y of age without sprouting[2] or producing a calf, it is assumed to be female. If it is later confirmed to be male through any of the means noted above, its sex and sex-specific census statuses are corrected retroactively.

Declaring animals dead

NRKW matrilines most commonly travel as a cohesive group; therefore when a group is encountered, any missing individuals can be presumed dead. As some matrilines are encountered infrequently, or in cases where logistical, behavioural, and environmental constraints prevent a thorough censusing of all animals present, we are cautious in declaring an animal dead until we have had a sufficient number of high-quality encounters with its group to be certain that the animal is indeed dead (until this point, absent animals are considered "missing"). Note that a sufficient number of high-quality encounters to establish an animal's death may take multiple census years to reach, as some NRKW groups are infrequently encountered. Year of death (YOD) for such animals was assigned a minimum-maximum range, where the minimum YOD was the first census year in which the animal was noted to be missing (and therefore possibly dead) and the maximum YOD was the census year wherein the animal was confidently designated as dead. An animal's 'best' estimated YOD was considered to be the median of this range, rounded down to the nearest whole year. Since animals are frequently confirmed dead in the census year directly following the year in which they were first noted as missing, the best YOD is therefore often equivalent to the minimum YOD.

Estimating population size

Minimum population sizes were obtained by assuming that all animals that could have been born in the census year had not yet been born, and that all animals that could have been dead (e.g. either missing or declared dead) had died. Conversely, maximum population sizes were calculated by assuming that all animals that could have been born in the census year had been born, and that all animals that could have died were still alive. Note that if entire matrilines were not censused (or were poorly censused) in a particular year, the whales belonging to them were considered to be alive for that year's population estimate (i.e., until future census data indicate otherwise).

'Best' population size estimates were calculated using the animals' best YOB and YOD estimates (see *Determining ages* and *Declaring animals dead* for details). Because best YOB estimates are often equivalent to maximum YOB and best YOD estimates are often equivalent to minimum YOD (as previously described), the best annual population size estimates tend to

[2] Based on 95% probability of sprouting (Eva Stredulinsky, DFO, Nanaimo, BC, unpublished analysis). All males in this population have sprouted by 18 y of age.

be equivalent to the minimum population size estimates in many cases. Annual changes in total population size reported here are based on changes in the best population size estimates between consecutive census years, and therefore simple accounting using the prior year's population size and the current year's number of births, deaths and missing animals may not always be equivalent to the best population size in the current census year. Note that previous NRKW catalogues and annual updates containing population size estimates (e.g., Ellis et al. 2011, Towers et al. 2015) typically reported minimum number, maximum number and the mean of these two values, and so the 'best' numbers we present here may not align with previous estimates.

Defining demographic categories:

- Calves are animals that are 0 or 1 y old in the given year (animals are considered 0 y old in their year of birth).
- Female juveniles are animals sexed as female that are 2-11 y old and have not yet given birth.
- Male juveniles are animals sexed as male, older than 1 y old, that have not yet shown physical signs of sexual maturation (i.e. 'sprouting'; see *Determining sexes*).
- Juveniles of unknown sex are animals between 2-11 y old that have not yet been sexed.
- Adults of unknown sex are animals between 12-14 y of age that have not yet been sexed. These animals will eventually be sexed retrospectively (through the means described in *Determining sexes*); because of this, animals of unknown sex only tend to appear in the population demographics for the most recent years of the study.
- Reproductive-age females are animals known to have given birth in the past or that are assumed female (see *Determining sexes*), and are no older than 41 y, as well as females between 42-47 y old that gave birth in the current census year[3].
- Post-reproductive females are females older than 42 y that have not given birth in the current year[2].
- Sexually mature males are those that have shown signs of accelerated dorsal fin growth (sprouting), where the growth is not yet asymptotic/complete (Bigg et al. 1990, see *Determining sexes* above).
- Physically mature males are those with fully developed dorsal fins, i.e., fins displaying asymptotic growth; the onset of physical maturity typically occurs at about 18.4 y (Bigg et al. 1990, Olesiuk et al. 2005).

Population update for 2018

The photo-identification census in 2018 accounted for 92% of the NRKW population. Total best population size was estimated at 302 individuals (range = 302-310), for a decrease of 1 animal (or -0.3%) compared to the previous survey year. Clan sizes in 2018 were 158, 94, and 50 individuals for A, G, and R clan, respectively. Annual NRKW population size estimates throughout the history of the photo-identification study are presented in Figure 1 and Table 1, and annual clan sizes are presented in Figure 2. Over the entire time series, the NRKW population has shown periods of growth and decline, but overall, it has grown at a mean annual rate of 2.2% (sd = 2.3%). G clan has grown the most since the study began in 1973, at a mean

[3] Based on 95% probability of reproductive senescence (42 y) (Stredulinsky 2016). No female older than 48 y has given birth to a calf in this population.

rate of 2.9% per year (sd = 4.2%), followed by R clan at 2.3% per year (sd = 4.1%) and A clan at 1.9% per year (sd = 2.8%). A proportional break-down of the population by demographic category throughout the time series is presented in Figure 3.

A total of eight calves were born in 2018, eight animals were considered missing (possibly dead), five animals were declared dead, and no new animals were discovered (aside from young-of-the-year, i.e., calves born in 2018).

- Identities of 2018 calves: A118 (mother: A54), A119 (mother: A79), D32 (mother: D13), G116 (mother: G48), I157 (mother: I21), R68 (mother: R50), R69 (mother: R22?), R70 (mother: R42)
- Animals missing (possibly dead) this year: D30 (sex: Unknown, age: 3), G41 (sex: F, age: 31), G111 (sex: Unknown, age: 2), I16 (sex: F, age: ~49), I78 (sex: M, age: 21), I154 (sex: Unknown, age: 2), I120 (sex: Unknown, age: 11), R28 (sex: M, age: 26)
- Animals declared dead this year: A115 (sex: F, age: 1), A71 (sex: M, age: 19), C24 (sex: M, age: 18), G27 (sex: F, age: ~44), I67 (sex: M, age: 27)[4]

Conclusions

The 2019 Science Response provides an update of total population size, numbers in each acoustic clan, births and deaths for the NRKW population in 2018. The population showed a decline of -0.3% from 2017 to 2018, the first negative population change since 2001. Annual NRKW population growth rates have slowed over the past 5 census years, from 5.1% in 2014 to -0.3% in 2018. The cause of this trend is not yet known; it is possible that this population may be experiencing a reduction in prey availability or is beginning to approach carrying capacity. However, periods with similar trends were observed before (e.g., 2004–2011), followed by periods of growth. Several more years of census data are required before this pattern can be confirmed or its cause investigated. It should also be noted that, of the three clans, only G clan decreased in size in 2018 (-4.1%, net loss of four animals), while R clan grew at a rate of 4.2% (net gain of two animals) and A clan grew 0.6% (net gain of one animal).

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[4] A46 and I153 were also declared dead in 2018, but their deaths were retroactively assigned to 2017.

Approved by

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Tables

Table 1: Northern resident killer whale population size by census year. Size change and percent growth are based on the best population estimate.

Year	Minimum	Maximum	Best	Size change	% growth
1973	113	120	117	n/a	n/a
1974	120	123	122	5	4.3
1975	128	131	129	7	5.7
1976	125	131	130	1	0.8
1977	129	134	131	1	0.8
1978	131	136	132	1	0.8
1979	138	142	140	8	6.1
1980	147	149	147	7	5.0
1981	150	151	150	3	2.0
1982	152	154	152	2	1.3
1983	154	156	155	3	2.0
1984	156	156	156	1	0.6
1985	163	163	163	7	4.5
1986	170	170	170	7	4.3
1987	176	177	177	7	4.1
1988	180	183	180	3	1.7
1989	185	185	185	5	2.8
1990	192	194	193	8	4.3
1991	196	198	197	4	2.1
1992	199	206	203	6	3.0
1993	197	203	199	-4	-2.0
1994	199	208	206	7	3.5
1995	205	213	207	1	0.5
1996	209	219	212	5	2.4
1997	215	219	215	3	1.4
1998	214	217	214	-1	-0.5
1999	210	222	211	-3	-1.4
2000	208	209	208	-3	-1.4
2001	200	201	200	-8	-3.8
2002	202	203	202	2	1.0
2003	204	206	205	3	1.5
2004	220	224	221	16	7.8
2005	232	236	232	11	5.0
2006	238	239	239	7	3.0
2007	241	246	244	5	2.1
2008	252	255	252	8	3.3
2009	258	258	258	6	2.4
2010	262	266	263	5	1.9

Year	Minimum	Maximum	Best	Size change	% growth
2011	266	267	266	3	1.1
2012	272	279	272	6	2.3
2013	275	279	275	3	1.1
2014	289	290	289	14	5.1
2015	297	298	297	8	2.8
2016	301	302	301	4	1.3
2017	303	307	303	2	0.7
2018	302	310	302	-1	-0.3

Figures

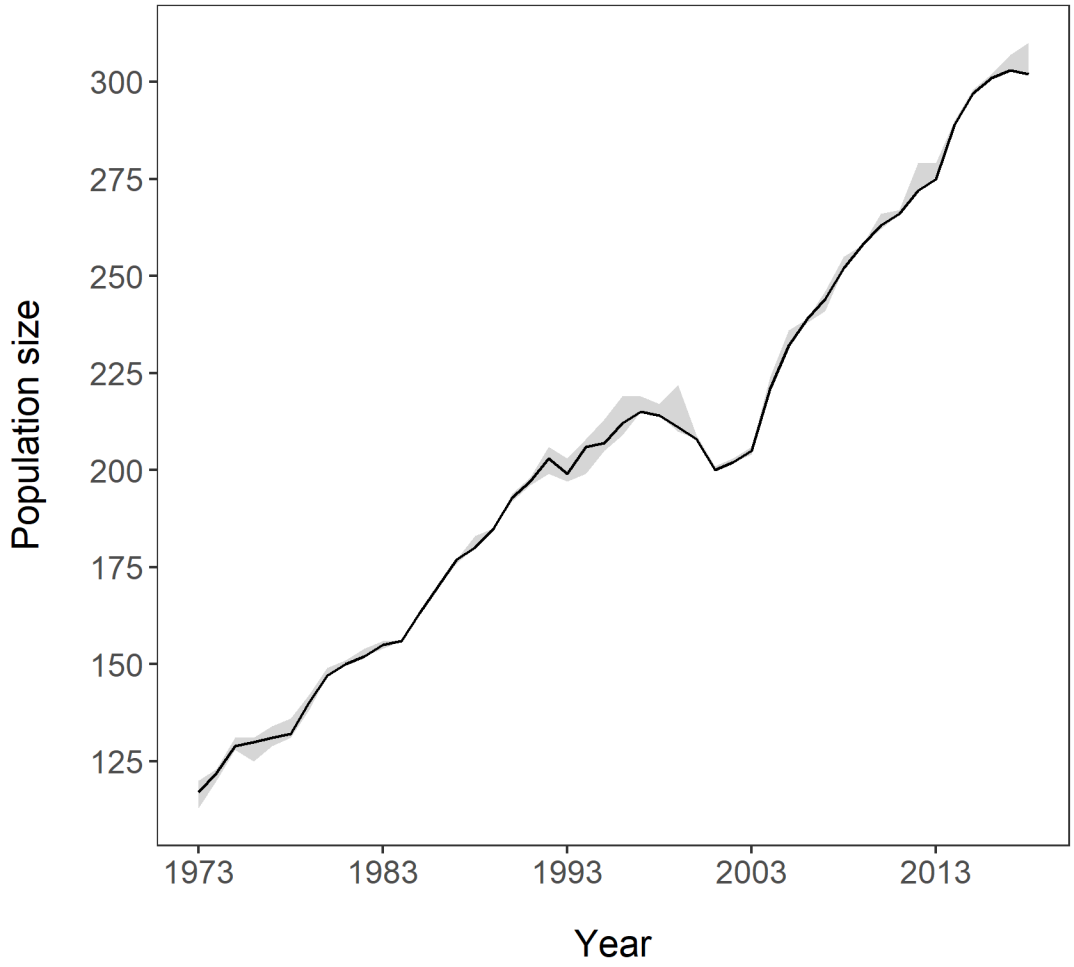

Figure 1: Northern Resident Killer Whale population size by census year. Grey shaded band represents range of minimum and maximum population size estimates. Black line indicates the best population size estimate.

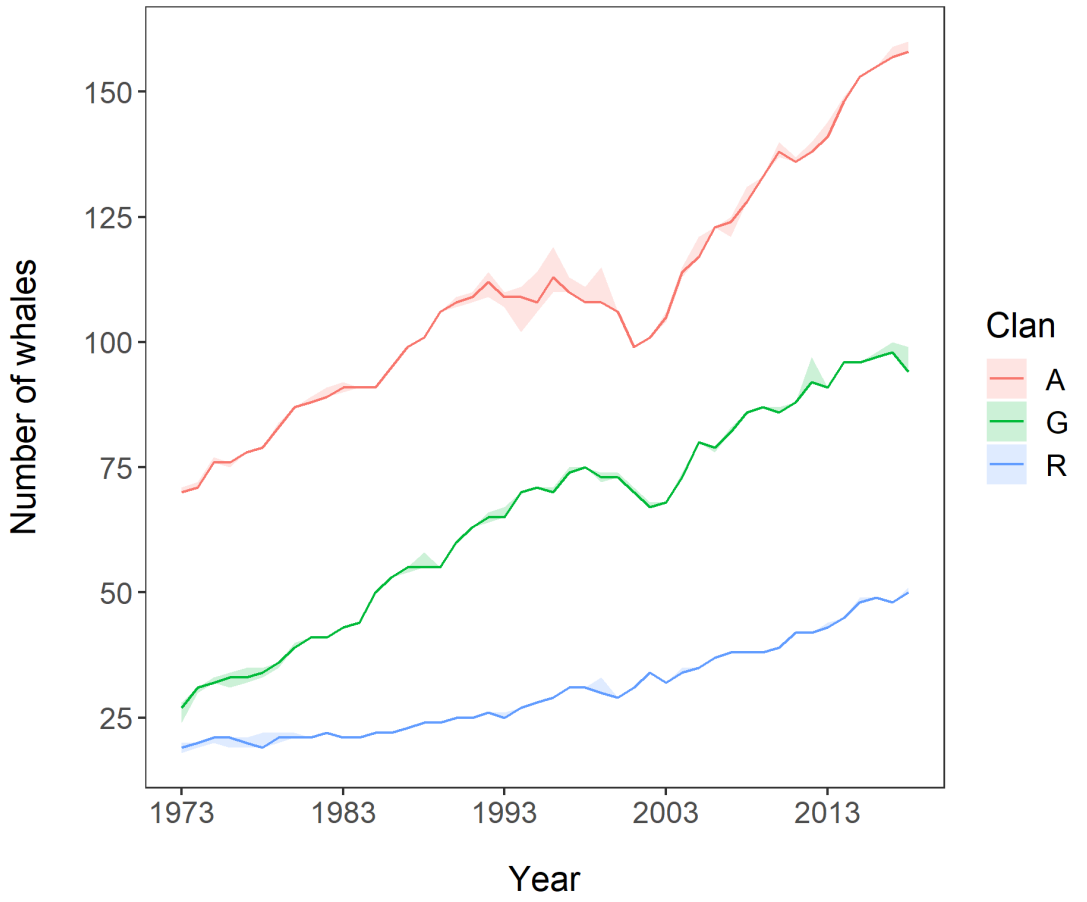

Figure 2: Northern Resident Killer Whale clan sizes by census year. Shaded bands represent range of minimum and maximum clan size estimates. Coloured lines indicate the best clan size estimates.

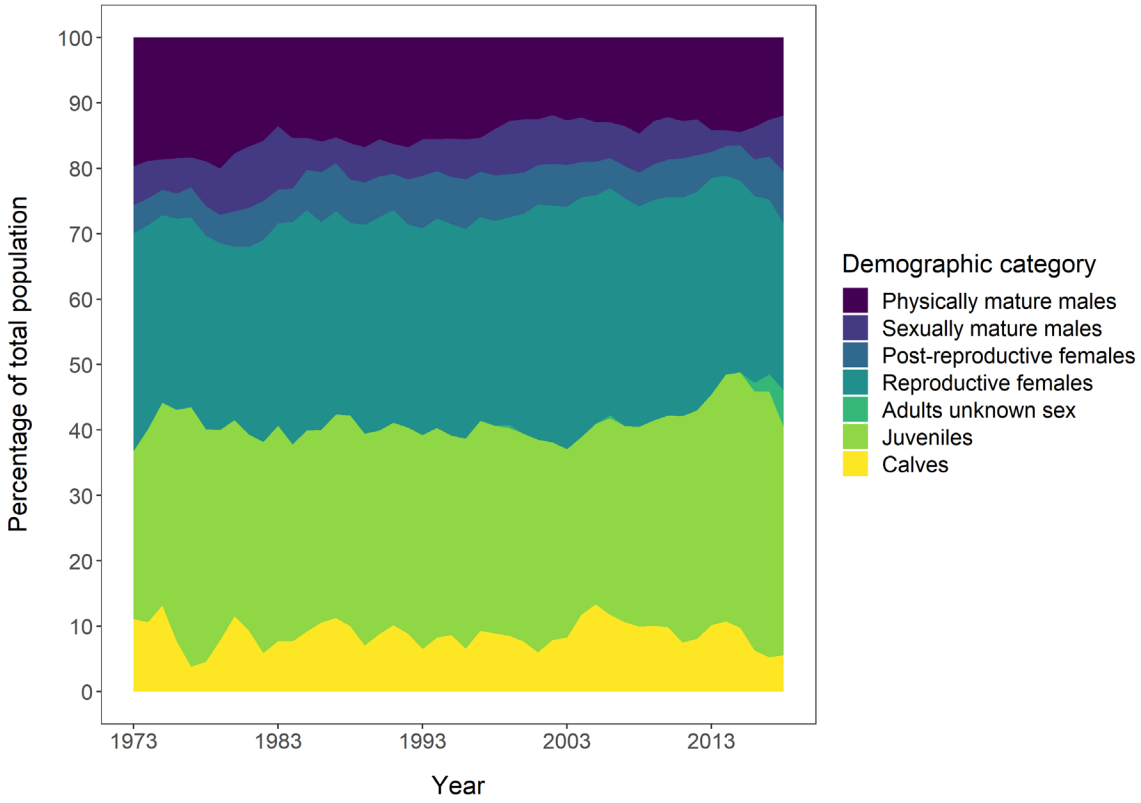

Figure 3: Proportion of individuals in each demographic category by census year. Calf counts do not include non-viable calves (calves that survive less than 1 y).

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