



CHINOOK SALMON ABUNDANCE LEVELS AND SURVIVAL OF RESIDENT KILLER WHALES

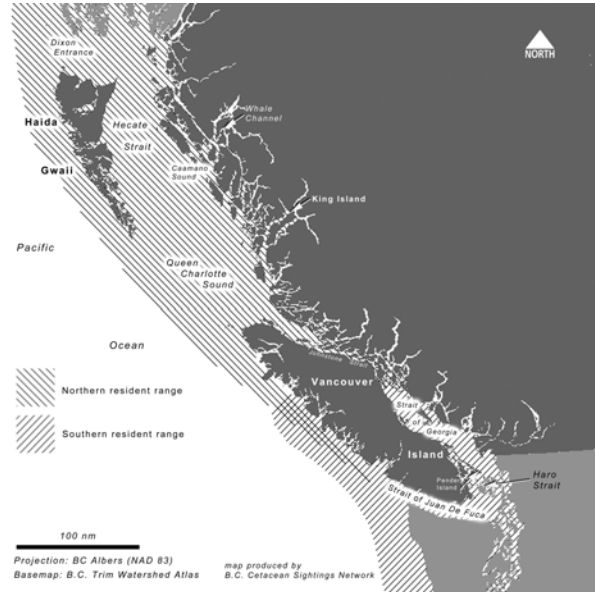
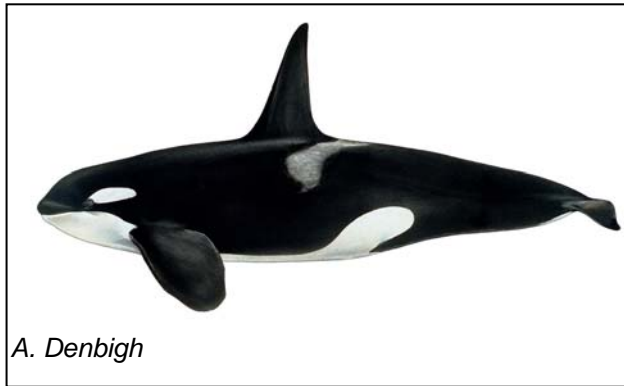


Figure 1: Range of Northern and Southern Resident Killer Whales in Canadian waters.

Context :

Two populations of resident killer whales, northern and southern, are listed under Canada's Species at Risk Act. Southern resident killer whales have declined to 87 with only 10 breeding females in the population. Nutritional stresses combined with immuno-suppressive effects from contaminant loads appear to be impacting these populations. The Pacific Salmon Commission's (PSC) Chinook Abundance Index values are significantly correlated with resident killer whale population health and the lower boundary of the PSC Chinook abundance index that ensures population growth needs to be determined for management purposes.

The goal of this Science Advisory Report is to provide an estimate of the Chinook salmon abundance levels required to prevent impacts on resident killer whale survival and productivity.

SUMMARY

- Resident killer whales (*Orcinus orca*) are salmonid specialists that feed preferentially on Chinook salmon. This prey species is larger and more energy-rich than other salmonids, and is also available to the whales throughout the year.
- Chinook salmon (*Oncorhynchus tshawytscha*) availability appears to be important to the survival and recovery of northern and southern resident killer whale populations. An

analysis of the relationship between mortality rates in resident killer whales and the Pacific Salmon Commission's Chinook salmon abundance index over the period 1979 to 2008 revealed a strong negative correlation.

- This analysis suggests that a total PSC Chinook abundance index value above 1.1 is necessary to permit the survival and recovery of resident killer whales.
- Assuming that about 70% of the annual nutritional needs of resident killer whales is obtained through Chinook salmon, total consumption by the two populations at their current size may exceed 1,000,000 fish annually.
- Chinook salmon comprise about 90% of resident killer whale diet in Critical Habitat areas during the summer months of July-August. Based on estimated prey energy requirements and the caloric value of Chinook salmon prey, approximately 1200-1400 Chinook per day, or 67,000-81,000 Chinook over the July-August period, would be required by southern resident killer whales in their Critical Habitat (in both Canadian and U.S. waters) based on their 2008 population size. For northern residents, about 420-500 Chinook per day would be required in their Critical Habitat, or 26,000-31,000 Chinook over the two month period.
- Genetic stock identification of Chinook salmon consumed by resident killer whales indicates that stocks originating from the Fraser River system are of the greatest overall importance in their diet, particularly in Critical Habitat areas off northeastern and southeastern Vancouver Island. Local Chinook stocks from other river systems may also be of importance in certain coastal areas.
- Different Chinook salmon stocks undertake their return migrations at different times and some may be of particular seasonal importance to the whales. It is important to ensure sufficient geographic and seasonal availability of Chinook salmon, as well as adequate overall abundance, to meet the whales' needs.

BACKGROUND

So-called 'resident' killer whales are one of three sympatric ecotypes of *Orcinus orca* found in the coastal waters of the cold-temperate northeastern Pacific. Each ecotype is ecologically specialized and has a distinct diet. Resident killer whales are fish feeders and, in particular, specialize on Pacific salmon. Field studies of foraging behaviour and diet have shown that although most available salmonids are consumed by resident killer whales, Chinook salmon, the largest but also one of the least abundant species, is the whales' primary prey. Chum salmon is an important prey species for a period in the fall, but the smaller pink and sockeye salmon are not significant components of the whales' diet despite great seasonal abundance in some years.

Chinook salmon appears to be of such importance as primary prey of resident killer whales that its availability plays a role in their population dynamics. A previous study (Ford et al. 2005) showed that mortality rates of resident killer whales were negatively correlated with Chinook salmon abundance over a 25-year period, from 1979-2003. In particular, a sharp decline in Chinook abundance during the late 1990s was associated with killer whale mortality rates up to 2-3 times greater than expected, which resulted in population declines in both northern and southern resident killer whale populations. Calving rates showed a weaker, but still significant, positive correlation with Chinook salmon abundance.

Resident killer whales are listed under the Species at Risk Act in Canada, with the northern population designated as threatened and the southern population as endangered. The southern resident population is similarly listed as endangered under the U.S. Endangered Species Act. A primary objective in the Recovery Strategy for resident killer whales is to ensure that resident killer whales have an adequate and accessible food supply to allow recovery. Since Chinook salmon is the primary prey of resident killer whales and its abundance may directly affect survival and recovery, it is important that an improved understanding of the seasonal and geographic importance of this prey resource is obtained. In particular, information is needed on the specific Chinook salmon populations that are exploited by resident killer whales at different times of the year and in different parts of their range, and the overall abundance of Chinook that may be needed to support the existing resident killer whale population and to provide for sustained growth and recovery.

ANALYSIS

Since the last assessment of the diet of resident killer whales (Ford and Ellis 2005), the dataset on salmonids identified from feeding events has doubled in size, from 396 to 806 samples. Larger sample sizes are now available for most coastal regions, especially for important feeding areas for southern residents off southwestern Vancouver Island. Although few in number, prey samples have also been collected from resident feeding events during the winter months. This much larger dataset provides further support for previous conclusions – that Chinook salmon is clearly the preferred and most important prey of resident killer whales and that the smaller pink and sockeye salmon are insignificant prey despite their greater seasonal abundance. Chum salmon is also an important prey species, particularly during the fall as these fish migrate through inshore waters. Coho salmon make up a small portion of the whales' catches in some regions, but represent only 2.5% of prey items overall. Feeding events sampled in December-March mostly involved Chinook salmon.

Chinook salmon are not only the species consumed most frequently by killer whales in most months, they are larger in average body size than other salmonids. Killer whales appear to select large Chinook, that is 4-5 year old fish which have mean body masses of 8-13 kg. This size is considerably larger than mature chum salmon (4.0-5.5 kg) and more than double the typical size of coho, pink and sockeye salmon. As Chinook salmon also tend to have the highest lipid content of salmonids, the energy content per fish is considerably greater than for other salmonids.

An updated assessment of the relationship between mortality rates of resident killer whales and coast-wide Chinook salmon abundance (Figure 2) has confirmed that there is a significant long-term negative correlation. The correlation is not as pronounced in recent years, due primarily to low mortality and continued growth in the northern resident population despite relatively low Chinook abundance since 2006. On-going annual monitoring will determine whether this trend continues.

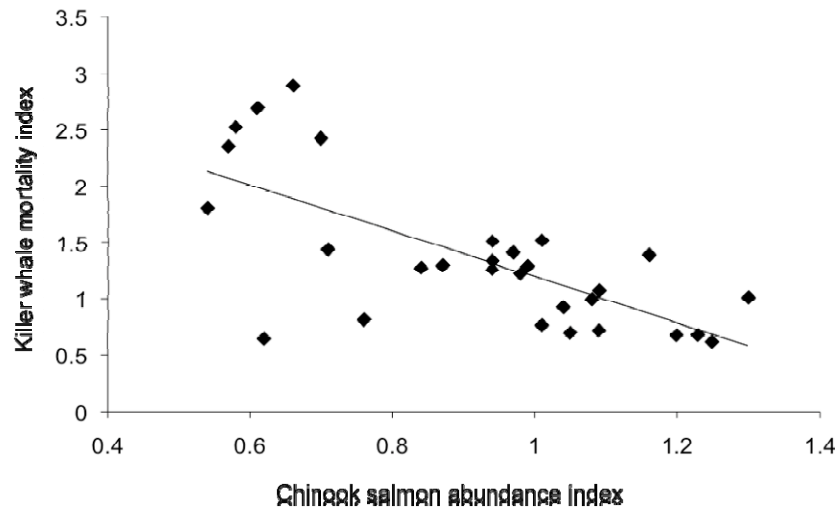


Figure 2. Relationship between annual indices of Chinook salmon abundance (total Pacific Salmon Commission Chinook abundance Index) and resident killer whale mortalities, 1979-2008. Killer whale mortality index values are the ratio of observed to expected deaths in the population for each year. Mortality indices are lagged one year following Chinook salmon abundance ($y = -2.0x + 3.2$, $r^2 = 0.49$).

Genetic stock identification from remains of Chinook salmon collected during resident killer whale feeding events indicates that resident killer whales consume fish originating from a wide variety of coastal regions, some quite distant from the feeding location. For example, almost one-quarter of Chinook taken by residents off the northern Queen Charlotte Islands originated from the Columbia River, the mouth of which is located over 1000 km to the south. Stocks from the Fraser River system were represented most frequently in feeding events in most parts of the coast, and comprised 58% of samples overall. This is not unexpected given that the Fraser River system is the largest producer of Chinook salmon in Canada. The predominance of Fraser River Chinook was particularly notable in samples collected from feeding events in Critical Habitat areas off northeastern and southwestern Vancouver Island. Fraser River stock regions comprised 64% of Chinook consumed by northern residents in their Critical Habitat, and 75% of Chinook taken by southern residents in their Critical Habitat. South Thompson was the most prevalent of the Fraser River stock regions.

Although the Fraser River system may be the most important source of Chinook salmon for resident killer whales overall, other stock regions are also likely important at certain times of year. Chinook originating from smaller, local river systems were significant prey of resident killer whales along the north and central mainland coasts. Many of the northern resident groups feed in these areas early in the summer, before moving south to the Critical Habitat area off northeastern Vancouver Island later in the summer. Thus, whales may rely on a range of Chinook stocks at different times of year and in different parts of the coast. The results presented here are preliminary – further effort is needed to determine the seasonal importance of particular Chinook salmon stocks to whales in different geographic areas, and the conservation status of these stocks should be evaluated in this context.

Assessment of the quantity of Chinook salmon needed to sustain current resident killer whale populations indicates that a substantial number of fish are consumed each year. Although there is considerable uncertainty in the actual proportion of the whales' year-round diet that is comprised of Chinook, a reasonable conservative estimate is that about 70% of their nutritional needs may be provided by this species. If this is the case, consumption by the current resident

populations may be over 1,000,000 fish per annum (range of estimate 1,124,400 to 1,349,400). This is roughly equivalent to the total combined commercial and recreational harvest of Chinook salmon in marine waters between Southeast Alaska and Oregon in recent years.

If resident killer whales are near the carrying capacity of their habitat and if that capacity is determined by the availability of Chinook salmon (as the correlation between mortality and Chinook abundance suggests), then greater numbers of Chinook salmon will be required to provide for recovery of the killer whale populations. Assuming that resident killer whale populations grow at their maximum rate of 2.6% over the next 10 years, an estimated 1.5-1.8 million Chinook may be needed annually to support these populations by 2018.

Critical Habitats that have been designated for northern and southern resident whales under Canada's Species at Risk Act and the U.S. Endangered Species Act are prime feeding areas during the peak of the summer salmon migration period. It is thus essential that sufficient prey resources be available to the whales in these areas at this important time of year. Extensive prey sampling in Critical Habitats suggests that Chinook salmon provide about 90% of resident killer whale diet during July-August. Southern residents foraging in Critical Habitat would thus require approximately 1200-1400 Chinook salmon per day, or roughly 67,000-81,000 over the two month period. On average, only 14.5% of the northern resident population use their designated Critical Habitat on a daily basis during July-August. As a result, Chinook salmon requirements in this area are less than for southern resident Critical Habitat – about 420-500 fish per day, or 26,000-31,000 in total over the two months. As the great majority of Chinook taken in both Critical Habitat areas are Fraser River stocks, it can be concluded that adequate Chinook production in this river system is essential to the continued function of resident killer whale Critical Habitats.

CONCLUSIONS AND ADVICE

Resident killer whales are salmon-feeding specialists that forage primarily for Chinook salmon. Past studies have shown a strong relationship between killer whale survival and Chinook salmon abundance. A high-priority objective in the Recovery Strategy for resident killer whales is to “Ensure that resident killer whales have an adequate and accessible food supply to allow recovery”.

An updated analysis confirmed the highly significant correlation between resident killer whale survival and range-wide abundance of Chinook salmon. The regression between Chinook abundance and resident killer whale mortalities during 1979-2008 indicates that a mortality index value of 1 – that is, the observed mortality rate in the killer whale populations equals that expected – is associated with a total PSC Chinook abundance index of 1.1. This analysis suggests that a PSC Chinook abundance index value above 1.1 is necessary to permit the survival and recovery of resident killer whales.

Chinook salmon consumption has been well documented during the summer months of July-August, when resident killer whales congregate in their Critical Habitat areas to intercept migrating salmon. Observations of prey capture and identification of prey remains suggest that 90% of resident killer whale diet is composed of Chinook salmon during these months. If so, approximately 1200-1400 Chinook per day, or 67,000-81,000 Chinook over the July-August period, would be required by southern resident killer whales in their Critical Habitat based on their 2008 population size. For northern residents, about 420-500 Chinook per day would be required in their Critical Habitat, or 26,000-31,000 Chinook over the two month period. Genetic stock identification of prey samples has shown that the majority (65-75%) of Chinook salmon

consumed by killer whales in these areas originate from stocks in the Fraser River system. It can be concluded that adequate Chinook production in this river system is essential to the continued function of resident killer whale Critical Habitats. It is thus advisable that Chinook salmon fisheries management plans for these stocks take such predation levels into account in order to ensure adequate Chinook availability for the whales in their Critical Habitats.

Although there is uncertainty about the diet of resident killer whales in the winter, if it is assumed that year-round diet is similar to that in the summer, it can be assumed that the whales' annual diet may be composed of 70% Chinook salmon. Estimated consumption rates of resident killer whales based on their daily energetic prey requirements and the caloric value of their Chinook salmon prey suggest that the two resident killer whale populations may require over 1 million Chinook salmon annually. This predation level is in the range of the total marine harvest by commercial and recreational fisheries in the region.

Resident killer whales range widely at different times of year, and genetic stock identification indicates that they consume Chinook salmon originating from a diversity of regional populations. Local stocks may be of considerable importance to the whales in certain coastal areas and, given that different stocks undertake their return migrations at different times, some may be of particular seasonal importance to the whales. It is thus important not just to ensure an adequate overall abundance to meet the whales' needs, but also to ensure adequate geographic and seasonal availability.

SOURCES OF INFORMATION

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ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)
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La version française est disponible à l'adresse ci-dessus.

**CORRECT CITATION FOR THIS PUBLICATION**

DFO. 2010. Chinook salmon abundance levels and survival of resident killer whales. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2009/075.