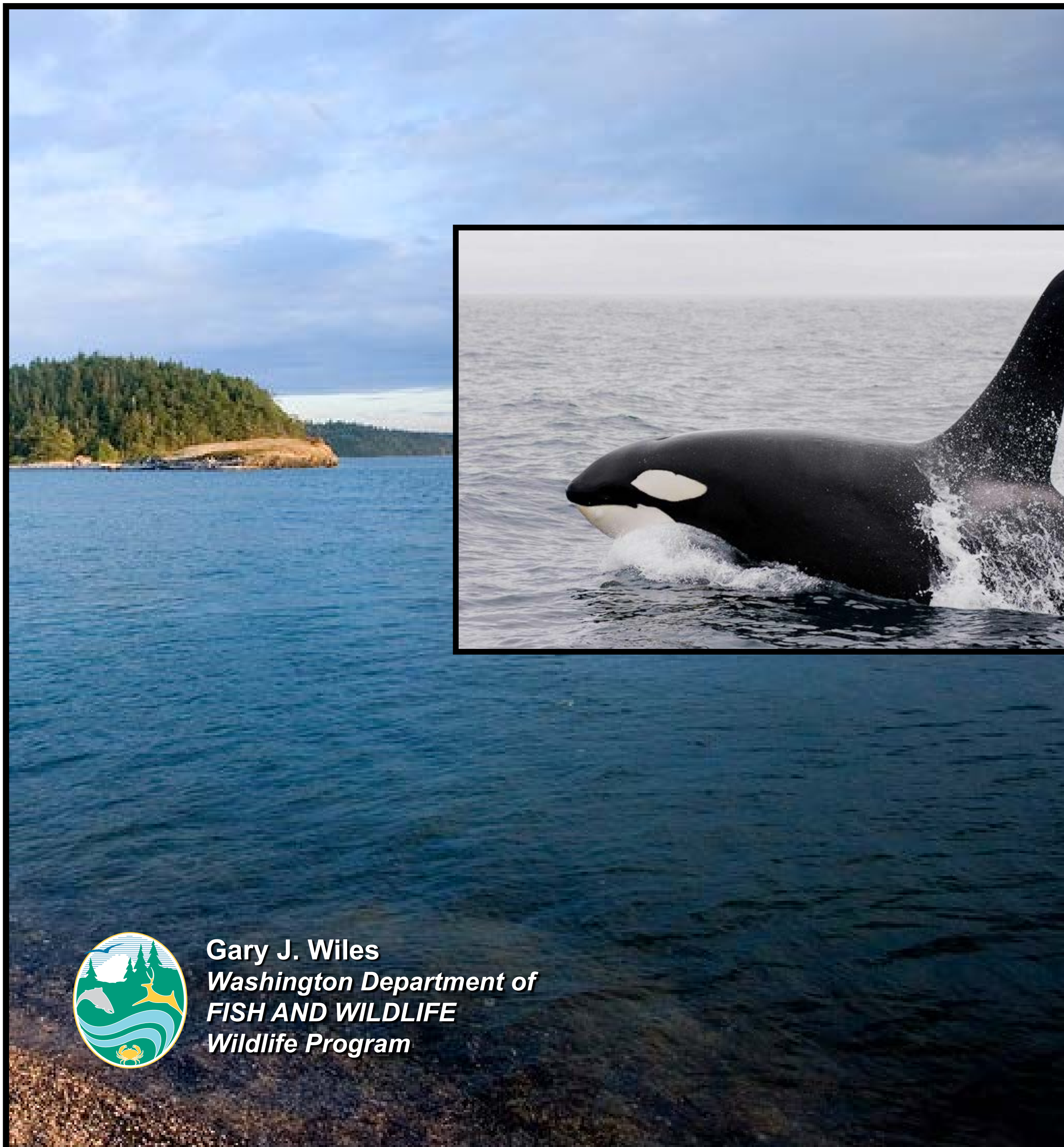
STATE OF WASHINGTON June 2016

Periodic Status Review for the Killer Whale



Gary J. Wiles

Washington Department of FISH AND WILDLIFE

Wildlife Program

The Washington Department of Fish and Wildlife maintains a list of endangered, threatened, and sensitive species (Washington Administrative Codes 232-12-014 and 232-12-011). In 1990, the Washington Wildlife Commission adopted listing procedures developed by a group of citizens, interest groups, and state and federal agencies (Washington Administrative Code 232-12-297. The procedures include how species listings will be initiated, criteria for listing and delisting, a requirement for public review, the development of recovery or management plans, and the periodic review of listed species.

The Washington Department of Fish and Wildlife is directed to conduct reviews of each endangered, threatened, or sensitive wildlife species at least every five years after the date of its listing by the Washington Fish and Wildlife Commission. The periodic status reviews are designed to include an update of the species status report to determine whether the status of the species warrants its current listing status or deserves reclassification. The agency notifies the general public and specific parties who have expressed their interest to the Department of the periodic status review at least one year prior to the five-year period so that they may submit new scientific data to be included in the review. The agency notifies the public of its recommendation at least 30 days prior to presenting the findings to the Fish and Wildlife Commission. In addition, if the agency determines that new information suggests that the classification of a species should be changed from its present state, the agency prepares documents to determine the environmental consequences of adopting the recommendations pursuant to requirements of the State Environmental Policy Act.

The draft periodic status review for the killer whale was reviewed by species experts and was available for public review from December 28, 2015, to March 27, 2016. All comments received were considered during the preparation of the final periodic status review. The Department presented the results of this periodic status review to the Fish and Wildlife Commission at the June 10-11, 2016, meeting in Olympia. The recommendation to keep the killer whale listed as endangered was affirmed by the Commission at this meeting.

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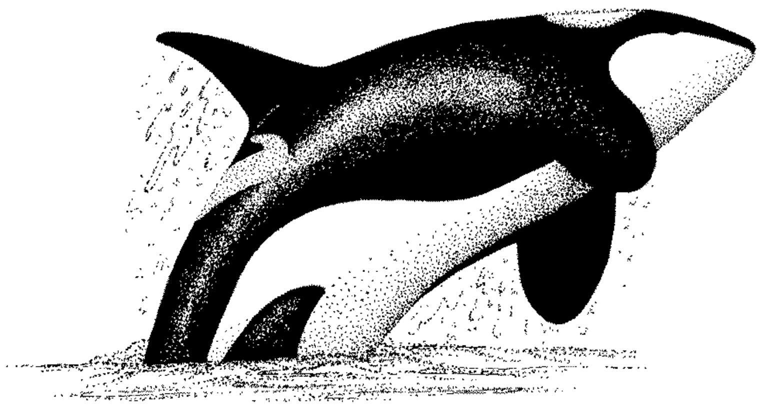
Periodic Status Review for the Killer Whale in Washington



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EXECUTIVE SUMMARY

Killer whales have been listed as a state endangered species in Washington since 2004. Three main populations known as the southern residents, west coast transients, and offshores occur in the state. While closely similar in appearance, these ecotypes differ in their biology, rarely interact with one another, and do not interbreed despite having largely sympatric year-round distributions ranging from California to Alaska. All three populations make extensive use of Washington's outer coastal waters, with the southern residents and transients also regularly visiting the Salish Sea. Southern resident killer whales prey primarily on chinook salmon, with chum and coho salmon also consumed during certain seasons, west coast transient whales feed primarily on harbor seals and other marine mammals, and offshore killer whales appear to prey mainly on sharks.

Southern residents totaled just 81 whales as of July 2015 and are the population of greatest concern. Numbers have been relatively stable since 2001, but remain 17% below their recent peak size recorded in 1995. In addition, the population's growth rate remains well below the downlisting and delisting goals established in the 2008 federal recovery plan. The recent lack of significant growth in the population also contrasts greatly with the continuing growth of two similar resident populations in British Columbia and Alaska, which have expanded at average annual rates of 2.9% and 3.5% in recent decades. The southern resident population faces significant potential threats from the reduced availability of chinook salmon, interactions with whale-watching vessels and human-generated marine sound, and factors associated with its small population size, including the recent skewing of births towards males, which will constrain productivity over the next few decades.

In contrast, the west coast transient population has shown considerable growth since the 1970s in response to the recovery of its marine mammal prey base, and is now estimated to number more than 500 whales and be near its carrying capacity. Offshore killer whales are estimated at 300 individuals and have a stable population trend. All three populations carry heavy loads of environmental contaminants, face a continuing risk of major oil spills in their ranges, are susceptible to a disease outbreak, and will likely experience the impacts of climate change in the future.

Various management activities have been taken since 2004 that directly or indirectly benefit killer whales in Washington, many of which are aimed at the southern residents. These include the preparation of conservation plans; designation of federal critical habitat for southern residents; implementation and enforcement of new whale-watching regulations; evaluation of chinook salmon abundance and marine fisheries on the southern residents; population monitoring; research; public outreach; salmon management and recovery; steps to enhance oil spill prevention and response, and to deter whales away from spills; and measures to reduce the input of environmental contaminants into marine waters. Nevertheless, expanded actions will very likely be needed to achieve recovery of the southern residents.

For these reasons, it is recommended that killer whales remain listed as a state endangered species in Washington. The protections associated with this listing apply to all populations of killer whale occurring in the state.

INTRODUCTION

This periodic status review summarizes the biology, population status, threats, and recent management actions directed at the three main populations of killer whales (*Orcinus orca*) occurring in Washington's marine waters. It also assesses whether the species should retain its current endangered status under state law or be reclassified to another status. Substantial new information has been published on killer whales since the state's last status review (Wiles 2004) and has greatly expanded the knowledge of these populations.

SPECIES BACKGROUND

Figure 1. Killer whales (photo by NOAA).

Description. Killer whales are the world's largest dolphin and feature a striking black-and-white appearance. Males are larger than females, with males averaging 6-8 m in length and 3,600-5,400 kg in weight and females averaging 5-7 m in length and 1,300-2,700 kg in weight (Center for Whale Research 2015). Males also have larger dorsal fins, pectoral flippers, and tail flukes than females. More detailed descriptions appear in Shirihai and Jarrett (2006) and Jefferson et al. (2008).

Taxonomy, ecotypes, and populations. Killer whales are the only species in the genus *Orcinus*. Taxonomy within the species remains unclear, but at least two unnamed subspecies have been distinguished, with one represented by resident killer whales and the other by transient (or Bigg's) killer whales (Committee on Taxonomy 2015). Other forms, or "ecotypes," of killer whales occurring elsewhere in the world may eventually be classified as separate subspecies or species (Foote et al. 2009, Morin et al. 2010, Riesch et al. 2012). Killer whale ecotypes display regional variation in a number of traits, such as body size, dorsal fin shape, coloration, vocalizations, genetics, social structure, and diet (Herman et al. 2005, Foote et al. 2009, Riesch et al. 2012, Parsons et al. 2013). These differences are maintained through a lack of interbreeding with other ecotypes, even when similar geographic ranges are inhabited (Morin et al. 2010, Riesch et al. 2012, Moura et al. 2014).

Three ecotypes of killer whale occur in the northeastern Pacific Ocean and are known as resident, transient, and offshore killer whales (Riesch et al. 2012, Ford and Ellis 2014). Within two of the ecotypes, multiple discrete populations (also referred to as stocks) are further recognized (Allen and Angliss 2015, Carretta et al. 2015). These include four resident populations (i.e., southern residents, northern residents, southern Alaska residents, and western Alaska residents) and five transient populations (i.e., west coast transients, Gulf of Alaska transients, AT1 transients, Aleutian transients, and Bering Sea transients) (Riesch et al. 2012, Ford and Ellis 2014). Only one offshore population is recognized (Dahlheim et al. 2008). Populations within ecotypes rarely interact and interbreeding between populations is generally thought not to occur (Barrett-Lennard 2000, M. J. Ford et al. 2011). Three killer whale populations (southern residents, west coast transients, and offshores) regularly occur in Washington. A fourth population (northern residents) occasionally enters the state's waters (Calambokidis et al. 2004, Oleson et al. 2009, Širović et al. 2012) and is not considered further in this report.

Distribution. Killer whales have a cosmopolitan distribution, giving the species the largest geographic range of any marine mammal. They are generally more common in coastal locations and at higher latitudes than in pelagic waters and tropical regions (Forney and Wade 2007). The three main populations occurring in Washington have the following distributions. The southern residents are found coastally from central Southeast Alaska to central California (NMFS 2008, Carretta et al. 2015), and the west coast transients occur from Southeast Alaska to southern California (Allen and Angliss 2015). Offshore whales range from the eastern Aleutian Islands to southern California and probably into Mexico, giving them the largest range of any killer whale population in the northeastern Pacific (Dahlheim et al. 2008, Ford et al. 2014). Both the southern residents and transients regularly use the inner marine waters of Washington and British Columbia, whereas offshores rarely do so (Ford and Ellis 1999, Ford et al. 2000, Wiles 2004).

NATURAL HISTORY

Killer whales are highly social marine mammals. Matrilines are the basic social unit within most populations and contain a female and her descendants of both sexes from up to three subsequent generations. Pods are comprised of groups of related matrilines and commonly hold from 2 to 35 individuals, but may occasionally reach 50 or more animals depending on the population (Dahlheim and Heyning 1999, Baird 2000, Ford et al. 2000). Larger aggregations of up to several hundred whales from multiple pods (referred to as super pods) sometimes form temporarily, usually near seasonal concentrations of prey, for social interaction, or for breeding. The species is long-lived and has a low reproductive rate, with one calf per birth. Mating is polygamous (Dahlheim and Heyning 1999).

Vocal communication is particularly advanced in killer whales and is an essential element of the species' complex social structure. Three main types of vocalizations (echolocation clicks, pulsed calls, and whistles) are produced and are useful in communication, navigation, and foraging (Ford 1989, Thomsen et al. 2002). Vocalizations show differences in structure between and within populations (Riesch et al. 2012).

Killer whales are the top predator of marine ecosystems. The species as a whole is versatile in its prey selection, with more than 120 species of fish, marine mammals, cephalopods, and sea turtles consumed (Ford and Ellis 2006). However, regional ecotypes usually possess specialized foraging strategies that allow them to focus on particular prey species, especially marine mammals or certain fish (Ford and Ellis 2014). To serve as a major type of prey for an ecotype, the prey must be reliably encountered, safely catchable, and have a relatively high energy value.

Many killer whale populations inhabit relatively large year-round home ranges that can approach or exceed 100,000 km^2 in size (Baird 2000). Pods commonly travel extensively over the course of a year, but frequently inhabit relatively small core areas for periods of a few weeks or months where favored prey concentrate seasonally (e.g., Jefferson et al. 1991, Nichol and Shackleton 1996). Animals can travel up to 160 km per day when swimming between areas (Erickson 1978, Baird 2000).

Southern residents. Matrilines within resident killer whale populations are highly stable, with members maintaining strong bonds and seldom straying from the group for more than a few hours or by more than a few kilometers (Ford et al. 2000, Ford and Ellis 2014). Long-term dispersal of individuals away from matrilines has never been recorded. The southern resident population is comprised of three pods, known as J, K, and L pods (Ford et al. 2000).

Diet of the southern residents is heavily dominated by chinook salmon (*Oncorhynchus tshawytscha*), which is the largest but least abundant species of salmon in the northeastern Pacific and has the highest nutritional quality of the different salmon species in terms of caloric content (J. K. B. Ford et al. 1998, Ford and Ellis 2006, Hanson et al. 2010, M. J. Ford et al. 2016). Mature chinook salmon in the 4- and 5-year age classes are most frequently captured (Ford et al. 2010). Fraser River chinook are mostly targeted by whales foraging in the Salish Sea (Hanson et al. 2010). The diet shifts to include more coho salmon (*O. kisutch*) in the late summer and more chum salmon (*O. keta*) in the fall (Ford et al. 2016; B. Hanson, pers. comm.). In some years, modest amounts of sockeye salmon (*O. nerka*) are consumed in mid-summer (Ford et al. 2016). Other fish (e.g., Pacific halibut [*Hippoglossus stenolepis*], Pacific herring [*Clupea pallasii*], rockfish [*Sebastes* spp.], lingcod [*Ophiodon elongatus*]), other salmonids, and squid are infrequently eaten (J. K. B. Ford et al. 1998, Ford and Ellis 2006, Hanson et al. 2010, M. J. Ford et al. 2016; Northwest Fisheries Science Center, unpubl. data). Diet along the outer coast is more poorly known, but also appears to be dominated by chinook salmon (Ford and Ellis 2014). Members of foraging groups often search for prey by spreading out across areas of one to several square kilometers. Echolocation is frequently used to locate prey (Barrett-Lennard et al. 1996). Prey captured by females and younger whales are brought to the surface and shared with related individuals, whereas males usually do not share prey (Ford and Ellis 2006).

From late spring to fall, the southern residents are regularly present in the U.S. and Canadian waters near the San Juan Islands, including Haro Strait, Boundary Passage, and the eastern portion of the Strait of Juan de Fuca (Hauser et al. 2007). However, K and L pods also commonly make trips lasting a few days to the outer coast of Washington and southern Vancouver Island during this period (Ford et al. 2000, Carretta et al. 2015). During the remainder of the year, K and L pods spend most of their time along the outer coasts of Washington, Oregon, and Vancouver Island, with movements sometimes extending as far south as Monterey Bay in California and as far north as Chatham Strait in Southeast Alaska (NMFS 2008, Hanson et al. 2013, Carretta et al. 2015, NOAA 2015a). The vicinity of the Columbia River mouth is a favored winter foraging site for both pods (Hanson et al. 2013). J pod tends to remain in the Salish Sea throughout the year, although regular trips are made to the outer coast of northern Washington and southern Vancouver Island during winter and spring (Hanson et al. 2013, NOAA 2015a). During autumn, all three pods expand their movements into Puget Sound, probably in response to migrating chum salmon (Osborne 1999).

During periods of population growth, demographic characteristics of the southern residents resemble those of the northern and southern Alaska residents (Olesiuk et al. 1990, 2005, Matkin et al. 2014). Annual survival rates are highest among juveniles and adults (96–99%), but are much reduced among small calves and old age classes, with as many as 37-50% of small calves dying. For individuals that survive their first six months, lifespan is longer in females (average = 46 years; maximum = probably about 80 years) than in males (average = 31 years; maximum = about 60–70 years) (Olesiuk et al. 2005; B. Hanson, pers. comm.). On average, females produce their first surviving calf at 14 years of age and give birth to 4.7 calves during their lifespan. The interval between calves averages about 5 years (range = 2-14 years). Most calving occurs from October to March, but births can happen during any month. Females stop reproducing upon reaching menopause at about 42 years of age. Males attain sexual maturity on average at 12-13 years of age.

The southern residents commonly occur in areas frequented by salmon, especially when salmon are migrating to their natal rivers (Heimlich-Boran 1988). In the Salish Sea, the whales generally spend more time in deeper water and only occasionally enter water less than 5 m deep (Heimlich-Boran 1988, Baird 2000, Hauser 2006). Several studies have reported that foraging occurs most frequently in areas characterized by high-relief underwater topography, such as subsurface canyons, seamounts, ridges, and steep slopes, which may serve to concentrate prey (Heimlich-Boran 1988, Felleman et al. 1991, Hauser 2006). Maximum dive depths reach 264 m in this region (Baird et al. 2005). Habitat use along the outer coast remains poorly described, although most sightings occur within 25 km of shore (NMFS 2006, 2015).

West coast transients. Transients display a much more fluid social organization than residents (Ford and Ellis 2014). They form fairly stable matrilineal groups that usually comprise an adult female and one or two of her offspring (Ford and Ellis 1999, Baird 2000, Baird and Whitehead 2000). Male offspring typically maintain longer lasting relationships with their mother than female offspring. However, unlike residents, transient offspring of both sexes commonly disperse away from natal matrilines either permanently or for extended periods (Ford and Ellis 1999, Baird 2000, Baird and Whitehead 2000). Some males live solitarily much of the time and occasionally join groups with potentially reproductive females (Baird 2000, Baird and Whitehead 2000). Transients usually occur in pods of 10 or fewer individuals, but larger groupings of up to 36 animals occasionally form and result from matrilines temporarily joining each other to forage or socialize (Baird and Dill 1996, Ford and Ellis 1999, Baird and Whitehead 2000, Saulitis et al. 2000, Houghton et al. 2015).

Diet is comprised of a variety of marine mammal species and squid. Harbor seals (*Phoca vitulina*) represent about half or more of the prey captured or attacked in British Columbia, Washington, and Southeast Alaska (Baird and Dill 1996, Ford et al. 1998, 2007, London 2006). Steller sea lions (*Eumetopias jubatus*), California sea lions (*Zalophus californianus*), Dall's porpoises (*Phocoenoides dalli*), harbor porpoises (*Phocoena phocoena*), and Pacific white-sided dolphins (*Lagenoryhncus obliquidens*) are other regular parts of the diet (Ford et al. 1998, 2007, Ternullo and Black 2002, Dahlheim and White 2010). Large whales (e.g., gray whale [*Eschrichtius robustus*] calves, minke whales [*Balaenoptera acutorostrata*]) are occasionally killed (Ford and Ellis 1999; Ford et al. 2005). A recent report of substantial numbers of squid remains in the stomachs of two west coast transients suggests that squid may be a larger component of the diet than previously recognized (Hanson and Walker 2014). Seabirds are also rarely taken (Ford et al. 1998). Transients vocalize minimally while foraging to avoid detection by their marine mammal prey (Barrett-Lennard et al. 1996, Deecke et al. 2005).

West coast transients are more mobile than residents, traveling greater distances and having larger home ranges (Goley and Straley 1994, Dahlheim and Heyning 1999, Baird 2000). Daily movements covering 75-150 km of shoreline are typical and presumably are required to achieve sufficient foraging success (Cascadia Research 2010, Ford et al. 2013). Extensive regional-scale movements have also been documented, with individuals recorded traveling between California, Washington, and Southeast Alaska (Black et al. 1997, Dahlheim et al. 1997, Ford and Ellis 1999).

Ford et al. (2007) reported average annual survival rates of 98% (95% probability interval = 97-99%) for adult females, 98% (95-99%) for juveniles, 97% (94-98%) for adult males, 95% (87-98%) for subadult males, and 92% (82-97%) for calves.

The west coast transient population consists of two presumed groups known as the inner coast and outer coast subpopulations (Ford et al. 2013). The first of these inhabits shallower waters (average depth = 98 m) usually within 6 km of the coast, whereas the second occurs primarily in deeper waters (average depth = 248 m) over the continental shelf, shelf edge, and beyond the shelf edge that can reach depths of at least 2,000 m (Cascadia Research 2010, Ford et al. 2013). Individuals foraging in nearshore areas closely follow the shoreline, enter small bays and narrow passages, circle small islets and rocks, and explore inter-tidal areas at high tides (Heimlich-Boran 1988, Felleman et al. 1991, Baird and Dill 1995). This use reflects the distribution of harbor seals. Although some individuals often closely approach seal haulouts during foraging, especially during the summer pupping and weaning season, other transients do not concentrate their activity near these sites (Ford et al. 2013, Houghton et al. 2015). Ford et al. (2013) reported that transients catch their prey at an average water depth of 93 m and at an average of 2.1 km from shore.

Offshores. Less information is available on offshore killer whales because of the many fewer observations of this population since its discovery in 1988 (Ford et al. 2014). Most records come from British Columbia, especially off Vancouver Island and Haida Gwaii (Queen Charlotte Islands), but this partly reflects the greater observer effort in these areas.

Social structure of this population is poorly known. Animals regularly travel in groups of 2-70 whales (average size = 32), although aggregations of up to 104 individuals have been observed (Ford et al. 2014). Large groups have fluid membership and may represent temporary aggregations of smaller social units. Individuals often travel with one or more preferred companions, but it remains unknown whether these associations represent matrilines (Ford et al. 2014).

Evidence suggests that offshore killer whales feed primarily on sharks (Dahlheim et al. 2008, J. K. B. Ford et al. 2011, 2014). Pacific sleeper sharks (*Somniosus pacificus*) are the most frequently documented prey, with Pacific spiny dogfish (*Squalus suckleyi*) and blue sharks (*Prionace glauca*) also eaten. Teleost fishes appear to comprise a much smaller portion of the diet and include chinook salmon, Pacific halibut, opah (*Lampris guttatus*), and sculpin (family Cottidae). Ford et al. (2014) speculated that offshores may prefer the livers of sharks, which are particularly large (about 20% of total body weight) and high in fat content. The heavily worn teeth of offshores also suggest extensive shark predation and may result from repeatedly grasping the abrasive skin of sharks (J. K. B. Ford et al. 2011, 2014). Other evidence of a fish diet comes from stable isotope and other chemical analyses (Krahn et al. 2007a); the highly vocal nature of offshores during foraging, which suggests that marine mammals are not hunted (Ford et al. 2000); and the indifference of marine mammals to the presence of offshores (Dahlheim et al. 2008).

Offshores are known to make extensive regional movements of more than 4,400 km (Dahlheim et al. 2008). Additionally, individuals have been recorded traveling several thousand kilometers between widely separated geographic regions during periods of several months (Dahlheim et al. 2008). A satellite-tagged animal traveled from off the central Washington coast to Hecate Strait, British Columbia, during a 7-day period, representing a minimum total distance of at least 670 km (G. Schorr, pers. comm., in Ford et al. 2014). There is some evidence suggesting that a partial seasonal shift in distribution to more northern locations takes place during the spring, summer, and fall (Ford et al. 2014).

Offshores inhabit waters over the outer continental shelf and shelf-edge, and show reduced use of shallower coastal waters, enclosed marine waters, and deep pelagic waters (Ford et al. 2014). Average water depth was 208 m for 157 encounters. Offshore whales visit the Salish Sea infrequently, with 31 sightings documented from 1992 to 2012 and the visits averaging 3 days in length (Ford et al. 2014). The extent of visitation to pelagic waters beyond the shelf-edge is unknown. When traveling in shallow coastal waters, offshore killer whales appear susceptible to mass stranding or natural entrapment (Ford et al. 2014).

POPULATION STATUS AND TREND

Photo-identification is the preferred method of surveying killer whale populations around the world and provides precise information on population size, demographic traits, and social behavior (Hammond et al. 1990). However, the method requires intensive effort spread over years and, due to the species' mobility, should be conducted over large geographic areas to obtain accurate results. Photographic surveys rely on recognition of individual animals through their distinctive dorsal fins, saddle patches, and sometimes eye-patch characteristics.

Southern residents. Annual surveys date back to 1974 and represent complete counts of the population (Balcomb et al. 1982). The southern resident population increased from 70 whales in 1974 (when it was depleted by the live-capture era; Olesiuk et al. 1990, Wiles 2004) to 98 whales in 1995, then rapidly declined to 80 animals by 2001 (Figure 2). Numbers grew to between 83 and 88 whales from 2004 to 2012, but fell to between 78 and 82 whales during 2013-2015 (Figure 2). A decline from 88 to 78 whales from 2011 to 2014 corresponded with the deaths of 13 animals and births of just two surviving calves. Results of the annual census in July 2015 indicated that the population stood at 81 whales. This excludes the birth of five calves and deaths of one adult female, one adult male, and one calf between July 2015 and June 2016, which bring the population's total to 83 whales as of June 2016 (Orca Network 2016). Nine calves have been born and catalogued since December 2014, with eight surviving to date.

Southern resident numbers have declined 17% (mean of -1.0% per year) since 1995, when the population reached its recorded peak. Each of the three pods has shown different trends during this period (Figure 2). Much of the overall decrease has been driven by L pod, which is the largest of the three pods. L pod numbers declined 40% (mean of -2.5% per year) from 58 whales in 1995 to 35 whales in 2015, and reached its lowest ever recorded size of 34 whales in 2014. In comparison, K pod has remained essentially unchanged during the past 20 years, with a net of gain of one individual (from 18 to 19 animals). J pod has grown from 22 to 27 whales (mean of 1.0% per year) since 1995, which continues an overall increasing trend dating back to the mid-1970s.

Based on the mean age of maturity (15 years for females, 13 years for males; Olesiuk et al. 2005), the southern resident population held 23 reproductive females (28% of the population), 12 juvenile females (15%), 8 post-reproductive females (10%), 17 mature males (21%), and 21 juvenile males (26%) as of July 2015. Probably the most noticeable change in the population's structure since 2007 (NMFS 2008) has been the increasing disparity between the number of juvenile males versus juvenile females. Fewer adult females entering the population over the next 15 years suggests an upcoming period of reduced reproductive output within the population. J pod is the only pod with a strong female bias in the sex ratio among animals younger than 34 years of age, indicating it is the pod with the highest reproductive potential over the next 30 years (Ward et al. 2013). If chinook salmon abundance remains steady during this period, J pod is predicted to double in size, K pod is predicted to increase by several individuals, and L pod is likely to decrease slightly (Ward et al. 2013).

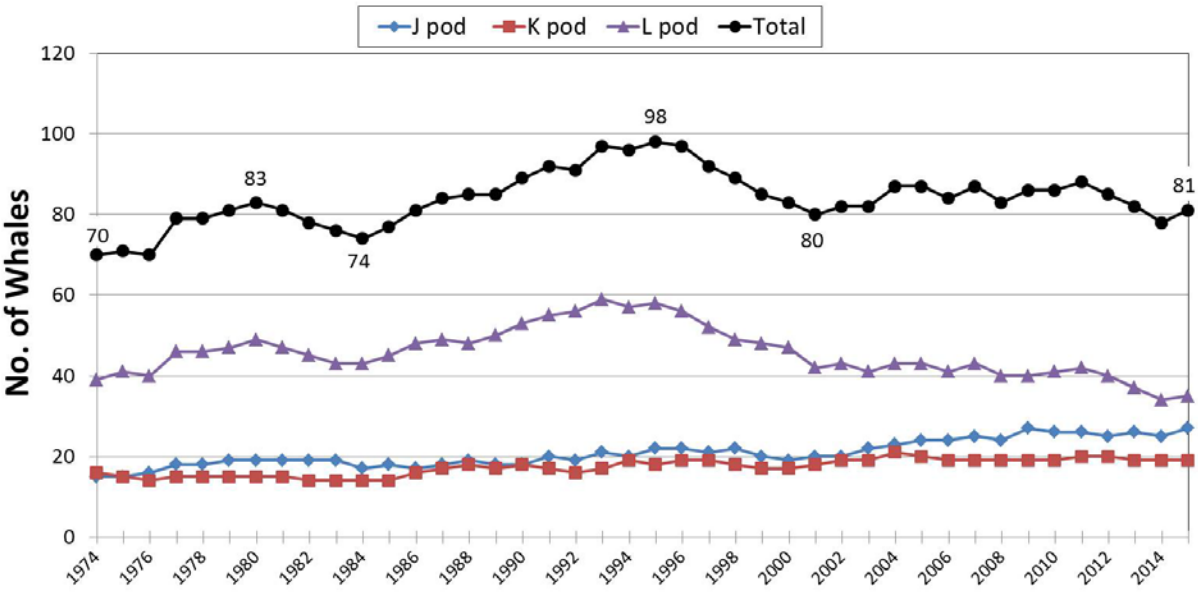

Figure 2. Population size and trend of southern resident killer whales and each of the three pods (J, K, and L), 1974-2015. Annual count data are mostly reported for the end of the calendar year (1974-2011) or for July 1 (2012-2015).

The trend in the southern resident population since 2001 (average increase of 0.1% per year) falls far below the recovery objectives established for the population in the federal recovery plan (i.e., means of 2.3% per year for 14 years and 28 years to achieve downlisting and delisting, respectively; NMFS 2008). It also contrasts greatly with that of the neighboring northern resident and southern Alaska resident populations, which grew at average annual rates of 2.9% and 3.5%, respectively, in recent decades (Matkin et al. 2014).

West coast transients. Previous size estimates of this population were placed in the range of 300-400 whales (Ford and Ellis 1999, Wiles 2004, NMFS 2008, Allen and Angliss 2011). Ford et al. (2007) produced an estimate of 243 (95% probability interval = 180-339) animals for the nearshore waters of northern Washington, British Columbia, and Southeast Alaska in 2006. High survival and recruitment rates allowed this portion of the population to increase rapidly at an average annual rate of 8-11% from 1975 to 1990, which coincided with a dramatic increase in harbor seal abundance (Ford et al. 2007). However, growth slowed to an annual average of 2% from 1991 to 2006, suggesting this segment of the population was approaching the carrying capacity of the prey resources in its range (Ford et al. 2007). Increased transient sightings in the Salish Sea since the 1990s are further evidence of population growth (Houghton et al. 2015).

Ford et al. (2013) recently separated the west coast transient population in northern Washington, British Columbia, and Southeast Alaska into two putative groups known as the inner coast and outer coast subpopulations. Estimated sizes of the two groups from 1990 to 2011 were 304 whales in the inner coast subpopulation and 217 whales in the outer coast subpopulation, for a total of 521 individuals. However, these estimates likely include some animals that are no longer alive. They also exclude most transients living off California, for which no recent estimates exist, thus the estimate of 521 whales is considered a minimum count for the entire west coast transient population (Allen and Angliss 2015).

Offshores. Past population estimates based on photo-identification or shipboard line-transects have variously ranged from about 200 to 365 whales (Ford et al. 2000, Carretta et al. 2002, 2004, 2009, 2015, COSEWIC 2008, DFO 2009; J. K. B. Ford, pers. comm. in Wiles 2004; M. E. Dahlheim, unpubl. data in NMFS 2008). All were considered underestimates of true numbers because they suffered from various biases or incomplete photo-documentation. Most recently, Ford et al. (2014) provided an estimate of 300 whales that was based on modeling of a larger photo-identification dataset. Population trend is considered stable (Ford et al. 2014). Because offshores often occur in large groups and travel widely, their abundance in Washington probably varies from a few to perhaps as many as 75-100 animals at any one time (D. K. Ellifrit, pers. comm. in Wiles 2004).

FACTORS AFFECTING CONTINUED EXISTENCE

Killer whale populations in the northeastern Pacific are variously affected by three primary threats: inadequate prey availability, elevated levels of environmental contaminants, and vessel effects and anthropogenic marine sound (NMFS 2008). Major oil spills, disease, and climate change are additional potential threats. The slow maturation and low reproductive rate of killer whales means the species is slow to recover from human-related mortality and other impacts (Matkin et al. 2014).

Adequacy of existing regulatory mechanisms. All three of the main killer whale populations visiting Washington are protected under the federal Marine Mammal Protection Act (MMPA). With a few exceptions, this law prevents the taking (defined as harassing, hunting, capturing, killing, or attempting to harass, hunt, capture, or kill) and importation of these animals and products derived from them (NMFS 2008). The southern residents were listed as endangered under the federal Endangered Species Act (ESA) in 2005, whereas the west coast transient and offshore populations are not federally listed. Federal endangered status includes prohibitions on take of listed species similar to those under the MMPA. In response to their endangered status, the National Marine Fisheries Service (NMFS) designated most of the U.S. portion of the Salish Sea as critical habitat for the southern residents in 2006 (NMFS 2006). Under section 7 of the ESA, all federal agencies must insure that any actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species, or destroy or adversely modify its designated critical habitat. Federal agencies must therefore consult with NMFS to avoid or minimize impacts of their activities on the southern residents. In 2011, NMFS implemented whale-watching regulations requiring that most vessels stay at least 200 yards from all killer whales in Washington's inner marine waters and not intercept the whales or park in their path (NMFS 2011).

Under Washington state law, all forms of killer whales were listed as endangered in 2004 (WAC-232-12-014). This prohibits the hunting, possession, malicious harassment, and killing of the species (RCW 77.15.120). Killer whales also receive protection under WAC 232-12-064, which prohibits the capture, importation, possession, transfer, and holding in captivity of most wildlife in the state. Additionally, the Washington Legislature passed a law (RCW 77.15.740) in 2008 placing legal restrictions on the activities of vessels near southern resident whales. This law was updated in 2012 to correspond with current federal regulations (see above). The law may also give some indirect protection to transient and offshore killer whales because of their strong similarity of appearance with southern residents, making it difficult for most boaters to distinguish the three types of whales.

Canada's federal Species at Risk Act (SARA) classifies southern resident killer whales as endangered and the west coast transient and offshore populations as threatened. Under this regulation, the killing, harassment, and possession of killer whales are prohibited. Critical habitat has been established for the southern residents (DFO 2008) and is recommended for the west coast transients (Ford et al. 2013). Canada has not adopted a whale-watching law similar to the U.S. and Washington regulations and continues to promote voluntary guidelines recommending vessels remain at least 100 m from the whales. The cross-border inconsistency in legal protection for the whales adds confusion for vessel operators and complicates enforcement efforts in U.S. waters.

Prey availability. Viable killer whale populations are dependent on adequate prey levels. Southern resident killer whales have experienced widespread reductions in their primary prey, chinook salmon, throughout much of their range since the mid-19th century due primarily to degradation of aquatic ecosystems resulting from modern land use changes (e.g., agricultural, urban, industrial, hydropower development, and resource extraction), overharvesting, hatchery production, and other causes (National Research Council 1996, Lichatowich 1999, Gustafson et al. 2007, Myers 2011). Reductions in chinook salmon abundance have been greatest in the Columbia River and California's Central Valley, and less severe but still significant elsewhere in the range, including the Fraser River and Puget Sound (Myers 2011). Reductions exist despite the addition of hatchery fish to stocks, which contribute more than 50% of the run sizes in much of Washington, Oregon, and California (Myers 2011). Decreases in spring-run populations are most prominent (Myers 2011). Declines have continued through recent decades, with total combined abundance of wild and hatchery chinook salmon from British Columbia to California declining by an estimated 16% from 1979 to 2010 (although escapement to terminal areas increased 37% overall due to improved harvest management of ocean fisheries; Ward et al. 2013).

Concurrent with declines in abundance, many chinook populations have experienced long-term reductions in body size and age (with age-5 and age-6 fish now rare in some stocks) and altered timing of runs (NMFS 2008, Myers 2011). This has further contributed to both the lower availability of prey biomass and changes in seasonal prey occurrence for the southern residents. Reductions in prey availability may force whales to spend more time foraging and traveling between feeding locations (McCluskey 2006), is correlated with reduced reproductive rates and higher mortality (Ward et al. 2013), and may reduce social cohesion (Parsons et al. 2009, Foster et al. 2012).

In contrast to the southern residents, west coast transients have experienced significant increases in prey availability across their range over the past few decades. Populations of harbor seals, California sea lions, Steller sea lions, harbor porpoises, and gray whales have doubled or more in size following improved legal protections in the 1970s (Jeffries et al. 2003, DFO 2010, NMFS 2013, Carretta et al. 2015, Wiles 2015; J. Evenson, pers. comm.).

Information is limited or lacking on the abundance and population trend in Washington of most shark species eaten by offshore killer whales (PFMC 2011; K. Hughes, pers. comm.). An exception is the Pacific spiny dogfish, which remains abundant in the waters off Washington and British Columbia despite some fishing harvest (Gertseva and Taylor 2012). Dogfish population trend off the outer British Columbia coast is considered stable (Wallace et al. 2009). At least five shark species (Washington species include the blue shark, common thresher shark [*Alopias vulpinus*], and shortfin mako shark [*Isurus oxyrinchus*]) are harvested in fisheries off the U.S. West Coast (PFMC

2011). In general, most shark species are vulnerable to decline because of their slowness to reach sexual maturity and low reproductive output.

Environmental contaminants. Like other marine mammals, killer whales are susceptible to a variety of environmental contaminants that bioaccumulate upward through marine food webs to high-level predators. These substances include organochlorines (e.g., polychlorinated biphenyls [PCBs], dioxins, dichloro-diphenyl trichloroethane [DDT] and its derivatives, and various other pesticides and herbicides), polybrominated diphenyl ethers (PBDEs), trace metals (e.g., mercury, copper, selenium, zinc), and other established or emerging pollutants (O'Shea 1999, O'Hara and O'Shea 2001). Organochlorines and PBDEs enter marine ecosystems through atmospheric transport, runoff, and point source pollution; they persist in the environment for very long periods and accumulate in fatty tissues. High levels of organochlorines and PBDEs in marine mammals can interfere with reproduction, immune and endocrine function, and gene expression, whereas elevated concentrations of metals can variously produce neurotoxic effects and harm organ function (O'Hara and O'Shea 2001, Buckman et al. 2011, Mongillo et al. in press). Resulting effects from contaminants are typically chronic and sublethal, but nevertheless may have population-level impacts. Risk in killer whales is probably highest during periods of food scarcity, when animals draw upon blubber reserves, thereby releasing fat-soluble contaminants into the full body and perhaps causing a decline in immune function (Krahn et al. 2009). As in other marine mammals, female killer whales transfer much of their fat-soluble contaminant burden to their calves (especially first-born calves) during nursing and therefore generally have lower to much lower levels than their weaned offspring or adult males of similar age (Ross et al. 2000, Ylitalo et al. 2001, Krahn et al. 2009, Mongillo et al. in press).

Southern resident, west coast transient, and offshore killer whales are among the world's most contaminated marine mammals (Ross et al. 2000, Ylitalo et al. 2001, Krahn et al. 2007a). This reflects the high (transients, offshores) or relatively high (southern residents) trophic levels of the three populations, their more urbanized distributions along the West Coast, and their long lifespans. Studies have documented high to very high concentrations of the following chemicals in these populations: southern residents, PCBs, DDTs, PBDEs, and other chemicals (Ross et al. 2000, Rayne et al. 2004, Krahn et al. 2007b, 2009); transients, PCBs, PBDEs, and others (Ross et al. 2000, Rayne et al. 2004, Buckman et al. 2011); and offshores, PCBs, DDTs, and others (Herman et al. 2005, Krahn et al. 2007a). Detected PCB and PBDE levels typically exceed the thresholds associated with toxicity in other marine mammals (Krahn et al. 2007b). Pollutant levels vary with pod in the southern residents, with L and K pods having relatively high amounts of DDTs and J pod having relatively high amounts of PCBs and PBDEs, reflecting differences in foraging areas (Krahn 2007b, 2009). Modeling projections indicate that PBDE levels will continue to increase in the southern residents, whereas PCBs will gradually decline and perhaps fall below the threshold for harmful effects in the next few decades (Hickie et al. 2007, Mongillo et al. 2012). Declining trends in several contaminant types, including PCBs and possibly PBDEs, in harbor seals suggest that transient whales are already experiencing reduced exposure to these pollutants (Ross et al. 2013).

Environmental pollutants also may affect the southern residents by causing potential declines in prey. Research has linked elevated concentrations of metals and petroleum hydrocarbons (such as from urban runoff) to reduced survival of chinook and other salmon (e.g., Meador et al. 2006, Spromberg et al. 2016).

Oil spills. Exposure to petroleum hydrocarbons released into the marine environment via oil spills and other discharge sources represents another potentially serious health threat for killer whales in the northeastern Pacific. Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but acute or chronic exposure poses greater toxicological risks (Grant and Ross 2002). Unlike humans, cetaceans have a thickened epidermis that greatly reduces the likelihood of petroleum toxicity from skin contact with oiled waters (Geraci 1990, O'Shea and Aguilar 2001). Inhalation of vapors at the water's surface and ingestion of hydrocarbons during feeding are more likely pathways of exposure. Transient killer whales may be especially vulnerable after consuming prey debilitated by oil (Matkin and Saulitis 1997). Matkin et al. (2008) reported that killer whales did not attempt to avoid oil-sheened waters following the *Exxon Valdez* oil spill in Alaska. In marine mammals, acute exposure to petroleum products can cause changes in behavior, reduced activity, and a host of health problems (Geraci and St. Aubin 1990). Evidence of adverse impacts on killer whales from spills comes from the *Exxon Valdez* spill, where single resident and transient pods experienced significant loss of members, reduced or no reproductive recruitment, and altered population structure after the spill (Matkin et al. 2008). Oil spills are also potentially destructive to prey populations (e.g., Incardona et al. 2015) and therefore may adversely affect killer whales by reducing food availability.

As a shipping and oil-refining hub, Washington experienced seven major oil spills ranging from 0.1-2.3 million gallons along the outer coast, the Strait of Juan de Fuca, and the lower Columbia River between 1964 and 1991 (Neel et al. 2007). It is unknown whether any of these harmed killer whales. Increased safety measures and prevention programs since the 1990s have helped reduce the number and scale of vessel spills in Washington, where no spills exceeding 100,000 gallons have occurred since 1991 (Etkin and Neel 2001, Neel et al. 2007). However, the sheer volume of shipping traffic (i.e., >6,600 vessel transits in 2015; WSDOE 2016) makes oil spills a persistent threat in the state. Shipping routes for major ports in Seattle, Tacoma, and Vancouver, B.C., as well as several major oil refineries and the third largest naval base in the U.S., all traverse waters used by killer whales in Washington. A 2014 risk assessment of oil spills from vessels transiting the Salish Sea and northern outer coast of Washington found that the region remains at risk of a large spill (Van Dorp and Merrick 2014). Spill risk in Washington's marine habitats (including Haro Strait, an area frequently used by the southern residents) is expected to increase in the next several decades as tanker traffic from ports in British Columbia and possibly Washington increases due to expanded oil and natural gas production in the interior of North America and as offshore oil and gas development likely begins off Vancouver Island (NMFS 2013).

Effects of vessels and sound. Killer whales in the northeastern Pacific are exposed to increasing levels of underwater sound from vessels and numerous other anthropogenic sources (e.g., military sonar, seismic surveys, and marine construction; NMFS 2008). Vessels (including kayaks) also have the potential to affect killer whales through the physical presence and activity of the vessel. Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. Significant levels of anthropogenic sound can mask echolocation and other signals used by the species, as well as temporarily or permanently damage hearing sensitivity. A number of studies have reported behavioral differences in resident killer whales in response to vessel traffic and increased underwater noise levels. These can include more evasive swimming paths, changes in diving rates, increased surface activity (e.g., tail and pectoral fin slapping, breaching, spy hopping), reduced foraging time, increased travel time, and increased calling amplitude (Williams and Ashe 2007, Holt et al. 2009, Lusseau et al. 2009, Noren et al. 2009, Williams et al. 2009). Such behavioral changes are usually subtle and probably result in minor increased energy expenditures by the whales (e.g., see Holt et al. 2015). Under certain conditions, the whales may also occasionally inhale harmful levels of exhaust fumes produced by whale-watching vessels (Lachmuth et al. 2011). Based on fecal levels of stress hormones, Ayres et al. (2012) concluded that the impacts of vessel traffic had a lesser physiological impact on the southern residents than changes in the availability of chinook salmon.

Extensive whale-watching activity in the San Juan Islands, Puget Sound, and southern Strait of Georgia is one of the major sources of vessel interactions with the southern residents (NMFS 2008, Seely 2015). West coast transients are also affected, but to a much lesser extent. Most viewing activity by commercial and private whale-watching vessels takes place from May to September. Vessels cluster around groups of whales throughout the day during this period, especially from 10 a.m. to 5 p.m., when an average of 16-22 (maximum = >50) vessels is present within 0.8 km of targeted whales (Seely 2015). Infractions of whale-watching regulations and guidelines frequently occur (average = 4.2 incidents per hour in 2015), especially in the absence of enforcement and outreach vessels (Seely 2015; R. Mullins, pers. comm.). Infractions mainly consist of vessels approaching within 200 yards of the whales or parking in their path. Compliance levels are by far the lowest among private recreational boaters (Seely 2015), who are often unfamiliar with proper viewing etiquette.

Small population size. The small number of southern resident killer whales, which currently includes just 40 members of breeding age, brings additional risks to this population, such as an increased likelihood of inbreeding, loss of genetic variability, genetic drift, demographic fluctuations, and declining opportunities for cooperative behavioral interactions (Courchamp et al. 1999, NMFS 2008, M. J. Ford et al. 2011). In contrast to the northern resident population (Barrett-Lennard 2000), paternity analysis indicates that southern resident members regularly breed within their own pod (but not within their own matriline), which may result from the limited mate choice within the population (M. J. Ford et al. 2011). M. J. Ford et al. (2011) reported that the population has experienced a recent population bottleneck that probably predates the population's decline during the 1900s.

Disease. A variety of pathogens have been identified in killer whales, although none are known to have caused epidemics or limit populations (Gaydos et al. 2004). Additional pathogens, several of which are highly virulent, have been detected in other sympatric marine mammal species and may therefore be transmittable to killer whales. Of particular concern for killer whales are several types of virus of the genus *Morbillivirus* that have caused mass mortalities in other marine mammals (see NMFS 2008). Among Washington's killer whales, the southern residents may be at the greatest risk of a serious disease outbreak due to their gregarious behavior, smaller population, seasonal concentration near the San Juan Islands, and high contaminant levels (Gaydos et al. 2004). Reduced prey abundance and increasing ambient noise are additional stressors that increase the vulnerability of this population to a major disease event (J. P. Schroeder, pers. comm. in NMFS 2008).

Climate change. Global climate change is predicted to be the largest threat to most species of marine mammals in the coming decades (Kovacs et al. 2012) because of its capacity to alter marine ecosystems through changes in ocean temperatures, currents, stratification, and nutrient cycling, and by causing increased acidification, higher sea levels, and increased occurrence of unusual and extreme environmental conditions such as strong El Niño events (Hoegh-Guldberg and Bruno

2010, Doney et al. 2012, Gattuso et al. 2015, Nagelkerken and Connell 2015). Climate change will likely impact all three ecotypes of killer whales in the northeastern Pacific through alterations in prey abundance (i.e., availability of salmon, marine mammals, sharks, and other prey) resulting from (1) changes in marine food webs, (2) alterations in freshwater habitats occupied by salmon, and (3) rising sea level, which may submerge or render unsuitable some traditional pinniped rookeries and haulouts, and some nearshore habitats required by salmon. Climate change effects will probably occur unevenly within the region, with some areas affected more severely than others (Doney et al. 2012, Gruber et al. 2012, Iles et al. 2012). Few impacts to killer whales have been documented thus far, but are expected to increase in the future as climate change progresses.

MANAGEMENT ACTIVITIES

NMFS and Fisheries and Oceans Canada are the lead entities promoting killer whale conservation along the North American west coast, but numerous other agencies, conservation organizations, and tribes participate in actions that directly or indirectly benefit the species.

Management plans. A U.S. federal recovery plan for the endangered southern residents was published in 2008 (NMFS 2008). Recommended conservation actions in the plan included (1) increasing prey availability, (2) minimizing chemical contaminants in the whales' habitat, (3) reducing disturbance from vessels, (4) preventing oil spills and improving spill responses, (5) enhancing public awareness of the whales' status and threats, (6) responding to stranded, sick, or injured whales, (7) increasing transboundary and interagency cooperation in managing the population, and (8) expanding research to better address conservation concerns. Similar federal conservation plans have not been prepared for the west coast transient or offshore populations because they are not listed under the Endangered Species Act. Canada has completed or is preparing its own federal recovery strategies or management plans for each of the three populations (DFO 2007, 2008, 2009, 2015). These identify many of the same conservation actions listed in the U.S. recovery plan.

WDFW has never prepared a state recovery plan for killer whales, in part because WDFW participated in development of the U.S. recovery plan for the southern residents. The species is considered a priority species under WDFW's Priority Habitats and Species (PHS) program, but specific management recommendations have not been developed under this program.

Critical habitat. NMFS designated critical habitat for the southern residents in 2006 (NMFS 2006). This designation includes Puget Sound, the San Juan Islands, and the U.S. waters of the Strait of Juan de Fuca, but excludes waters shallower than 6.1 m (20 ft) deep and 18 military sites. A review of whether to expand critical habitat to include the outer coastal waters from Cape Flattery, Washington, to Point Reyes, California, out to a distance of 76 km (47 mi) offshore is underway and should be completed by 2017 (NMFS 2015).

Vessel regulations. Federal and state whale-watching regulations require most vessels to stay at least 200 yards from the whales and forbid vessels from intercepting the whales or parking in their path. Both laws are primarily enforced by WDFW through major funding from NMFS. The NMFS Office of Law Enforcement also conducts patrols and coordinates with the U.S. Coast Guard to enforce the federal law. WDFW's primary focus during patrols has been outreach to recreational boaters, but it also issues citations for serious violations. From July 2013 through fall 2015, officers contacted more than 7,000 boaters on the water for both educational and enforcement reasons, which included giving more than 350 warnings and 40 citations. The Soundwatch Boater Education Program monitors boater compliance with the regulations and the Be Whale Wise viewing guidelines, and documents levels of vessel activity near the whales (Seely 2015).

Impacts of chinook salmon abundance and harvest on southern resident killer whales. In 2011-2012, NMFS and Fisheries and Oceans Canada convened a scientific panel of experts to evaluate the effects of chinook salmon abundance and marine fisheries on the southern residents. The panel's final report (Hilborn et al. 2012) agreed with previous research linking southern resident survival rates to some indices of chinook salmon abundance, thus increases in chinook abundance would result in higher survival and population growth in the southern residents. However, there was considerable uncertainty about the nature of the relationships (Hilborn et al. 2012, Ward et al. 2013), meaning that reductions in chinook harvest would not necessarily result in equivalent increases in prey availability for the whales or their population growth. Separate analyses by Vélez-Espino et al. (2015) reached a similar conclusion. The recommendations and conclusions from the studies continue to inform salmon and killer whale management and coordination in the U.S. and Canada. To date, salmon managers have not placed any additional restrictions on chinook salmon harvest in response to the studies' findings (K. Hughes, pers. comm.).

Salmon management and recovery. Extensive conservation efforts aimed at chinook and other Pacific salmon are being conducted along the West Coast by agencies, tribes, and conservation groups (see NOAA 2015b), and focus mainly on habitat restoration, harvest management, hatchery practices, and hydropower management. However, salmon management and recovery remains a complex and difficult undertaking because of increasing human pressure on the landscape, natural variability in ocean conditions, and other factors (Lackey et al. 2006).

Monitoring and research. Photo-identification work is continually conducted for the southern residents, with the Center for Whale Research providing a complete annual count of the population and a record of births and deaths. Transients and offshores are also catalogued by this method, but efforts are much reduced.

Numerous research projects involving the southern residents have been completed in the past decade or are underway. These include studies of seasonal distribution and movements; impacts from vessels; health (i.e., energetics, stress, disease, and contaminant loads); diet and foraging behavior; whether chinook salmon abundance is a limiting factor; population dynamics; and genetic analyses (see NOAA 2011, 2014). Transient and offshore populations are less studied, but recent investigations have involved some of the same topics (e.g., Ford et al. 2014, Houghton et al. 2015).

Outreach. A few of the many ongoing outreach and education efforts include the Soundwatch Boater Education Program and its Canadian counterpart program, Straitwatch, which promote responsible boating and kayaking practices near the southern residents. Orca Network posts online sightings of killer whales in the Salish Sea and information about the species. Work continues on The Whale Trail, which is a series of more than 50 sites in Washington and other West Coast locations where the public can watch for killer whales and other marine wildlife from shore or aboard Washington ferries. The environmental education program Killer Whale Tales is operated by a non-profit and provides storytelling, lectures, and hands-on classroom exercises about killer whales for school children. The Seattle Aquarium, The Whale Museum, and the Port Townsend Marine Science Center also conduct educational programs and have exhibits on killer whales. The

NMFS West Coast Regional Office has developed 10 classroom lesson plans on killer whales that are available online.

Oil spill prevention and response. State and federal agencies, industry, and other stakeholders continue their efforts to prevent oil spills from occurring in Washington. In 2010, a rescue tug was permanently deployed at Neah Bay with funding provided by the petroleum and shipping industries under a new state law. Presence of the tug greatly reduces the threat of spills associated with impaired vessels and barges in killer whale habitat near the entrance of the Strait of Juan de Fuca. Use of single-hull tanker vessels and barges was completely phased out in the U.S. in January 2015 to reduce the risk of spills. Spill response planning, participation in oil spill drills, and outreach are ongoing. A protocol to haze killer whales away from oil spills has been developed (NMFS 2012). In 2015, the Washington Legislature passed an oil transportation safety bill that includes new safety requirements and mandatory response planning for oil shipments by rail. Canada has also instituted regulations and measures to minimize the risk of accidental spills (e.g., Transportation of Dangerous Goods Act).

Environmental contaminants. Numerous efforts by governments, businesses, and citizens are underway to improve water and sediment quality in marine and freshwater habitats in coastal western North America. These include regulation and restrictions on use of certain known contaminants, treatment of industrial and municipal sewage, measures to reduce non-point source pollution, remediation of contaminated sites, and monitoring of water and air quality. Despite this work, expanded long-term programs will be required to achieve reduced contaminant loads in killer whales and other marine fauna.

CONCLUSIONS AND RECOMMENDATION

Of the three main killer whale populations occurring in Washington, the southern residents remain the one of greatest concern. Numbering just 81 whales in July 2015, their population has remained essentially stable since 2001 and is 17% below its recent peak size in 1995. Population growth rate also remains well below the downlisting and delisting goals established in the 2008 federal recovery plan. The lack of significant growth in the population contrasts greatly with the ongoing growth of the similar northern resident and southern Alaska resident populations to the north. Additionally, recent births in the southern resident population have been skewed towards males, which will continue to constrain growth over the next several decades. The population faces significant potential threats from the reduced availability of chinook salmon, interactions with whale-watching vessels and human-generated marine sound, and its small population size. In contrast, the west coast transient population has shown considerable growth since the 1970s in response to the recovery of its marine mammal prey base, and is now estimated to number more than 500 whales and be near its carrying capacity. Offshore killer whales are estimated at 300 individuals and have a stable population trend. All three populations carry high levels of environmental contaminants, face a continuing risk of major oil spills in their ranges, are susceptible to a disease outbreak, and will likely experience the impacts of climate change in the future.

Because of the significant conservation concerns associated with the southern resident population, it is recommended that killer whales remain listed as a state endangered species. However, the protections associated with this listing apply to all populations of killer whale occurring in the state.

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Appendix A. WDFW responses to public comments received during the 90-day public review period for the draft *Periodic Status Review for the Killer Whale in Washington* conducted from December 28, 2015, to March 27, 2016. The comments presented here are summaries of the remarks provided by one or more people.

Report Section	Comment and Response
General comments	1. I support the continued listing of killer whales as a state endangered species in Washington.
	WDFW recommends that killer whales should remain on the state list of endangered species for the reasons given in the periodic status review.
	2. Why are you recommending that the west coast transient population continue to be listed as endangered when it appears to have recovered?
	State law (WAC-232-12-297) allows wildlife to be listed at either the species or subspecies level, but not at the population level. In 2004, when killer whales were state listed as endangered in Washington, no subspecies had been formally designated. Because of this, all types of killer whales in Washington were covered under the listing. Since then, two unnamed killer whale subspecies have been suggested, with one representing all North Pacific resident killer whales and the other all North Pacific transient killer whales. However, because neither subspecies has been formally described yet, they were not adopted for this periodic status review. Although the west coast transient population may be near its ecological carrying capacity, the population nevertheless faces several threats. These include heavy loads of environmental contaminants, a continuing risk of major oil spills in its range, and the likelihood of negative impacts from future climate change. Because of this, Canada continues to list this population as threatened. For these reasons and until further taxonomic review is completed, WDFW considers it appropriate to retain all killer whale populations in Washington under a single listing unit that is legally classified as endangered.
	3. WDFW should develop its own killer whale recovery plan with specific management recommendations, including wild Chinook salmon recovery.
	WDFW hasn't prepared a state recovery plan for killer whales, in part because WDFW was highly involved in development of the U.S. recovery plan for the southern residents.
	4. The report should use the common name "orca" instead of "killer whale." The name killer whale carries too many negative connotations.
	The periodic status review uses the common name killer whale because of its widespread use by the scientific community.
Factors affecting continued existence	5. The report does not mention anything about Washington's abundant seal and sea lion populations competing with southern resident killer whales for Chinook salmon.
	Considerable uncertainty exists about the extent of competition for food between seals, sea lions, and the southern residents. The National Marine Fisheries Service is currently developing an advanced food web model that will include killer whales, salmon, other salmon predators, and different types of fisheries. This should help inform what, if any, impacts that seals and sea lions may be indirectly having on the southern residents.

Report Section	**Comment and Response**
Management activities	6. WDFW should support the expansion of federal critical habitat for southern resident killer whales along the outer coasts of Washington, Oregon, and California.
	The National Marine Fisheries Service is currently evaluating a proposal to expand federal critical habitat for the southern residents to include the outer coasts of these states. WDFW awaits the outcome of that evaluation. WDFW fully supports federal efforts to protect the southern resident population and in the past has expressed its strong support for the designation of critical habitat in the Salish Sea for the whales.
	7. Restoration of Chinook salmon populations is needed to recover southern resident killer whales. WDFW has a key role to play in responsible fishery management and in working with private and public partners to support the removal of dams blocking salmon passage, especially those along the lower Snake River.
	WDFW agrees that Chinook salmon recovery is an important aspect of killer whale recovery. The agency and its partners are working throughout the Columbia Basin on the restoration of these and other salmon runs and have achieved some success. Although WDFW does not currently maintain a position on the removal of the four lower Snake River dams, it is working on several other Chinook salmon recovery activities, including experimenting with increased spill at dams, large-scale Columbia River estuary restoration (including on WDFW lands), modifying hatchery operations for genetic management, and upstream fish passage in tributary habitats.
	8. Restoration of Chinook salmon populations is needed to recover southern resident killer whales. In particular, the Skagit River and its estuary, which is the largest river system in Puget Sound, should be restored to its natural channel conditions.
	WDFW agrees that the Skagit River system is an important basin to restore Chinook salmon. WDFW has sought to restore many of the original channel conditions in the Skagit River estuary, and has worked extensively over the past decade to improve and expand nearshore and estuary habitat conditions for Chinook salmon through other means. These include, for example, a number of projects funded under the Estuary and Salmon Restoration Program, Puget Sound Nearshore Ecosystem Restoration Project, and Puget Sound Marine and Nearshore Grant Program. WDFW also conducts large-scale restoration on its own lands to accomplish estuarine restoration goals, including Wiley Slough and Fir Island Farms.
	9. Hatchery production of salmon could be expanded to increase food availability for southern resident killer whales.
	Hatchery-reared salmon can have negative effects on the production of wild salmon stocks. Hatchery production can harm wild stocks through the impacts of mixed stock fishing, physical and genetic interactions between wild and hatchery salmon, competition for food and other resources, predation by hatchery fish, and transfer of disease. To avoid these problems and to assist in the recovery of wild salmon stocks, hatchery reform has been widely undertaken in recent years to review hatchery programs involving the breeding, culture, and release practices of hatchery fish, including suitable production levels. One goal of hatchery reform is to eliminate overproduction of hatchery fish that can interfere with overall salmon restoration.

Report Section	**Comment and Response**
	10. Selective harvest of salmon that allows the safe release of wild fish should be expanded.
	Selective fishing is the ability of a fisher or fishing operation to avoid non-target species or stocks, or when caught, to release those fish at a high rate of survival. Washington's commercial fishing fleets are already intensively managed by area and time closures that restrict fleets to particular areas or times so that they avoid salmon stocks of concern. This type of avoidance is considered very effective in meeting conservation goals for specific non-target stocks. For commercial fisheries that do capture non-target species or stocks, efforts are underway to modify fishing gears and practices so that these fish can be sorted and released with a high likelihood of survival. In many areas of Washington (including Puget Sound), recreational anglers are required to release wild salmon, which are recognizable by the presence of an adipose fin (unlike hatchery fish that have had their adipose fin removed).
	11. Commercial harvest of forage fish in Washington should be curtailed to boost prey for salmon, thereby increasing salmon numbers for southern resident whales to eat.
	Commercial fisheries currently target several species of forage fish in Washington, but are much reduced from their historical peaks and, at current levels, are likely to have only a limited role in reducing current prey availability for salmon. Open ocean fisheries for sardines and anchovies are already managed by the Pacific Fishery Management Council with a priority for maintaining their ecosystem functions, primarily as a food source for salmon, marine mammals, seabirds, and other predators.
	12. Given the ongoing problems with pollution in the Salish Sea, the state of Washington should pressure the city of Victoria, British Columbia, to stop dumping its untreated sewage into the Strait of Juan de Fuca.
	The state of Washington has expressed its continuing concern over this source of pollution in the Strait of Juan de Fuca. This concern dates back to at least 1993 and has involved multiple governors of Washington and the state legislature.
Other comments	13. The report should include a paragraph on the live capture of killer whales for aquaria in the 1960s and 1970s.
	The live-capture era had a major negative impact on the southern resident population. The periodic status review gives very brief mention of this on page 6, but does not go into further detail for the sake of brevity. Readers are referred to the citations provided on page 6 for more detailed information on this topic.

WASHINGTON STATE STATUS REPORTS, PERIODIC STATUS REVIEWS, RECOVERY PLANS, AND CONSERVATION PLANS

Status Reports

2015 Tufted Puffin
2007 Bald Eagle
2005 Mazama Pocket Gopher, Streaked Horned Lark, and Taylor's Checkerspot
2005 Aleutian Canada Goose
2004 Killer Whale
2002 Peregrine Falcon
2000 Common Loon
1999 Northern Leopard Frog
1999 Olympic Mudminnow
1999 Mardon Skipper
1999 Lynx Update
1998 Fisher
1998 Margined Sculpin
1998 Pygmy Whitefish
1998 Sharp-tailed Grouse
1998 Sage-grouse
1997 Aleutian Canada Goose
1997 Gray Whale
1997 Olive Ridley Sea Turtle
1997 Oregon Spotted Frog
1993 Larch Mountain Salamander
1993 Lynx
1993 Marbled Murrelet
1993 Oregon Silverspot Butterfly
1993 Pygmy Rabbit
1993 Steller Sea Lion
1993 Western Gray Squirrel
1993 Western Pond Turtle

Periodic Status Reviews

2016 Killer Whale
2016 Streaked horned Lark
2016 Greater Sage-grouse
2016 Snowy Plover
2016 Northern Spotted owl
2016 Western Gray Squirrel
2015 Brown Pelican
2015 Steller Sea Lion

Recovery Plans

2012 Columbian Sharp-tailed Grouse
2011 Gray Wolf
2011 Pygmy Rabbit: Addendum
2007 Western Gray Squirrel
2006 Fisher
2004 Sea Otter
2004 Greater Sage-Grouse
2003 Pygmy Rabbit: Addendum
2002 Sandhill Crane
2001 Pygmy Rabbit: Addendum
2001 Lynx
1999 Western Pond Turtle
1996 Ferruginous Hawk
1995 Pygmy Rabbit
1995 Upland Sandpiper
1995 Snowy Plover

Conservation Plans

2013 Bats

Status reports and plans are available on the WDFW website at:
http://wdfw.wa.gov/publications/search.php

References Reviewed for the *Periodic Status Review for the Killer Whale in Washington*

Table B presents the 148 references cited in the *Periodic Status Review for the Killer Whale in Washington*. Each reference is categorized for its level of peer review pursuant to section 34.05.271 RCW, which is the codification of Substitute House Bill 2661 that passed the Washington Legislature in 2014. A key to the review categories under section 34.05.271 RCW is provided in Table A.

Individual papers cited in the *Periodic Status Review for the Killer Whale in Washington* cover a number of topics discussed in the report, including information on: 1) the species' taxonomy, distribution, and biology; 2) habitat requirements; 3) population status and trends; 4) conservation status and protections; 5) management activities; and 6) factors affecting the continued existence of the species.

Table A. Key to 34.05.271 RCW Categories:

Category Code	34.05.271(1)(c) RCW
i	(i) Independent peer review: review is overseen by an independent third party.
ii	(ii) Internal peer review: review by staff internal to the department of fish and wildlife.
iii	(iii) External peer review: review by persons that are external to and selected by the department of fish and wildlife.
iv	(iv) Open review: documented open public review process that is not limited to invited organizations or individuals.
v	(v) Legal and policy document: documents related to the legal framework for the significant agency action including but not limited to: (A) federal and state statutes; (B) court and hearings board decisions; (C) federal and state administrative rules and regulations; and (D) policy and regulatory documents adopted by local governments.
vi	(vi) Data from primary research, monitoring activities, or other sources, but that has not been incorporated as part of documents reviewed under the processes described in (c)(i), (ii), (iii), and (iv) of this subsection.
vii	(vii) Records of the best professional judgment of department of fish and wildlife employees or other individuals.
viii	(viii) Other: Sources of information that do not fit into one of the categories identified in this subsection (1)(c).

Table B Reference	34.05.271 RCW Review Category
Allen, B. M. and R. P. Angliss. 2011. Alaska marine mammal stock assessments, 2010. NOAA Technical Memorandum NMFS-AFSC-223, Alaska Fisheries Science Center, Seattle, Washington.	i
Allen, B. M. and R. P. Angliss. 2015. Alaska marine mammal stock assessments, 2014. NOAA Technical Memorandum NMFS-AFSC-301, Alaska Fisheries Science Center, Seattle, Washington.	i
Ayres, K. L., R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, and S. K. Wasser. 2012. Distinguishing the impacts of inadequate prey and vessel traffic on an endangered killer whale (*Orcinus orca*) population. PLoS ONE 7(6): e36842. doi:10.1371/journal.pone.0036842	i
Baird, R. W. 2000. The killer whale: foraging specializations and group hunting. Pages 127-153 *in* J. Mann, R. C. Connor, P. L. Tyack, and H. Whitehead, editors. Cetacean societies: field studies of dolphins and whales. University of Chicago Press, Chicago, Illinois.	i
Baird, R. W. and L. M. Dill. 1995. Occurrence and behaviour of transient killer whales: seasonal and pod-specific variability, foraging behaviour, and prey handling. Canadian Journal of Zoology 73:1300-1311.	i
Baird, R. W. and L. M. Dill. 1996. Ecological and social determinants of group size in *transient* killer whales. Behavioral Ecology 7:408-416.	i
Baird, R. W. and H. Whitehead. 2000. Social organization of mammal-eating killer whales: group stability and dispersal patterns. Canadian Journal of Zoology 78:2096-2105.	i
Baird, R. W., M. B. Hanson, and L. M. Dill. 2005. Factors influencing the diving behaviour of fish-eating killer whales: sex differences and diel and inter-annual variation in diving rates. Canadian Journal of Zoology 83:257-267.	i
Balcomb, K. C., III, J. R. Boran, and S. L. Heimlich. 1982. Killer whales in greater Puget Sound. Report of the International Whaling Commission 32:681-685.	i
Barrett-Lennard, L. G. 2000. Population structure and mating patterns of killer whales as revealed by DNA analysis. Ph.D. thesis, University of British Columbia, Vancouver, British Columbia.	i
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Carretta, J. V., J. Barlow, K. A. Forney, M. M. Muto, and J. Baker. 2002. U.S. Pacific marine mammal stock assessments: 2001. NOAA Technical Memorandum NMFS-SWFSC-317, Southwest Fisheries Science Center, La Jolla, California.	i
Carretta, J. V., K. A. Forney, M. M. Muto, J. Barlow, J. Baker, and M. Lowry. 2004. U.S. Pacific marine mammal stock assessments: 2003. NOAA Technical Memorandum NMFS-SWFSC-358, Southwest Fisheries Science Center, La Jolla, California.	i

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