10 Years of Research & Conservation

Southern Resident Killer Whales

NOAA FISHERIES

OUR PARTNERS

PARTNERS AND COLLABORATIONS

Front cover photo: Southern Resident killer whales with the NOAA ship Bell M. Shimada on the outer coast. Opposite page: Southern Resident killer whales in front of Seattle skyline. NWFSC/NOAA Fisheries.

This document summarizes 10 years of work made possible through funds appropriated by the U.S. Congress to NOAA Fisheries. This work would not be possible without the hard work and expertise of our many partners. Every project, scientific discovery, and management action listed in this document is the result of successful collaborations with multiple entities. In some cases NOAA provided funding to groups to conduct an action or research project; in others partners provided critical expertise, advice, or consultations. Due to space constraints and to aid readability, we cannot list every partner on each accomplishment. Our major partners are listed here. We are indebted to our regional partners and look forward to building upon our past success and together recovering Southern Resident killer whales.

Institutions

- American Cetacean Society
- Beam Reach (BR)
- Biowaves
- Cascadia Research Collective (CRC)
- Center for Whale Research (CWR)
- Concurrent Technologies Corporation (CTC)
- Department of Fisheries and Oceans, Canada (DFO)
- Global Research and Rescue
- Industrial Economics
- Killer Whale Tales (KWT)
- Orca Network
- OrcaSound (OS)
- Pacific Salmon Commission
- Pacific Whale Watch Association
- Peak Internet
- Puget Sound Partnership
- Resolve
- San Juan County Sheriff's Office
- Soundwatch Boater Education Program
- TerraMar
- The Bridge Group
- The Mediation Institute
- The Port Townsend Marine Science Center
- The Seattle Aquarium
- The Whale Museum (TWM)
- The Whale Trail
- University of California at Davis, SeaDoc Society
- University of Washington (UW)
- Washington Department of Fish and Wildlife (WDFW)

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NOAA FISHERIES

INTRODUCTION

"Over the last decade, we have come a long way…[but] our research has inspired new important questions."

The endangered Southern Resident killer whale *(Orcinus orca)* is an icon of the Pacific Northwest and inspires widespread public interest, curiosity, and awe around the globe. These striking black and white mammals are recognized for their cultural and spiritual importance to coastal tribes and communities, their value as a keystone species in the marine ecosystem, and their starring role in our region's ecotourism industry. But the Southern Residents are also among the most contaminated marine mammals in the world. Noise and overcrowding from boat traffic, as well as a scarce supply of their preferred food—salmon—pose serious threats to this endangered population.

Over the last decade, we have come a long way in our understanding and ability to protect this unique population. Through the work of our scientists and regional partners, we have made significant progress on many of the key questions that were asked a decade ago when the whales were first considered for listing under the U.S. Endangered Species Act (ESA). For example, we know a lot more about:

- Where the whales spend their time during the winter months;
- What species and stocks of fish they eat, and how this changes throughout the year;
- How the population reacts to changes in abundance of their prey;
- Which chemical contaminants are most affecting the whales; and
- How they react to the presence of boat traffic and noise.

NOAA Fisheries has used these new findings to increase protections for the whales. These include developing new rules for boat operations in the vicinity of the whales, evaluating how fishing and habitat loss affects whales through changes in prey abundance, and developing proactive plans to protect whales in the event of a major oil spill.

Although many key questions have been answered, the population continues to struggle to recover. Consequently, our research has inspired new questions, such as whether competition with other marine mammals might be limiting the population's recovery. Our research has also shown that some of the most important factors affecting the population, such as lack of adequate prey, cannot be addressed through simple actions, but instead will require a long-term commitment to rebuilding and enhancing depleted salmon stocks. In this document you will find a summary of research and conservation accomplishments made possible by 10 years of Congressional funding (FY 2003 to FY 2012) and our plans for future actions to protect the Southern Resident killer whales.

KILLER WHALES

Killer whales are found in every ocean. In the Northeast Pacific Ocean, there are three main groups, or "ecotypes," of killer whales whose ranges overlap, but that differ in their ecology, behavior, diet, and genetics.

- **Residents**, which include the Northern and Southern Resident killer whale populations along with additional populations around the Pacific Rim, occur in large social groups called pods. Residents eat fish, particularly salmon.

- **Transients**, sometimes called Biggs killer whales, are also found throughout the Pacific Rim, often in long-term stable social units of less than 10 whales – smaller than the social groups of residents. Transients feed almost exclusively on marine mammals like seals, sea lions, whales, dolphins, and porpoises.

- **Offshores** are believed to feed primarily on fish, squid, and sharks. These whales often occur offshore but also enter coastal and protected inshore waters. Offshores congregate in groups of 25 to 75 animals and sometimes have been sighted in larger groups of up to 200 whales. Offshores are the least studied of the three ecotypes.

2001

2002

Center for Biological Diversity and others petition agency to list Southern Residents under the ESA.

Determined Southern Residents ineligible for protection under the ESA.

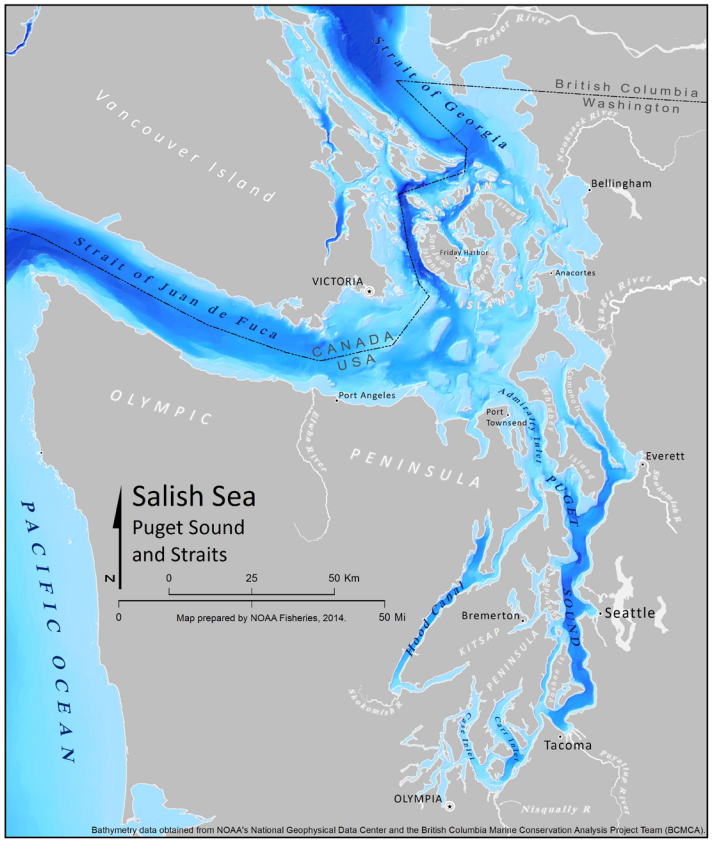
2003

Completed Southern Resident Status Review.

Formed scientific team to study Southern Resident risk factors and data gaps.

The Southern Resident killer whale population is comprised of three pods, designated J, K, and L. Whales from the same pod tend to spend the majority of their time together, and consist of multiple matrilines – female whales and their descendants.

During the spring, summer, and fall months, the Southern Resident population can be found in the Salish Sea, which includes the inland waters of Puget Sound, the Northwest Straits, and southern Georgia Strait. Until recently, little was known about where whales go in the winter months, although Southern Residents had been sighted as far south as Monterey Bay, CA and as far north as Chatham Strait in southeast Alaska. As we describe later, thanks to federal funding and collaboration with regional partners, we now have a much more detailed, if still incomplete, picture of their coastal distribution.



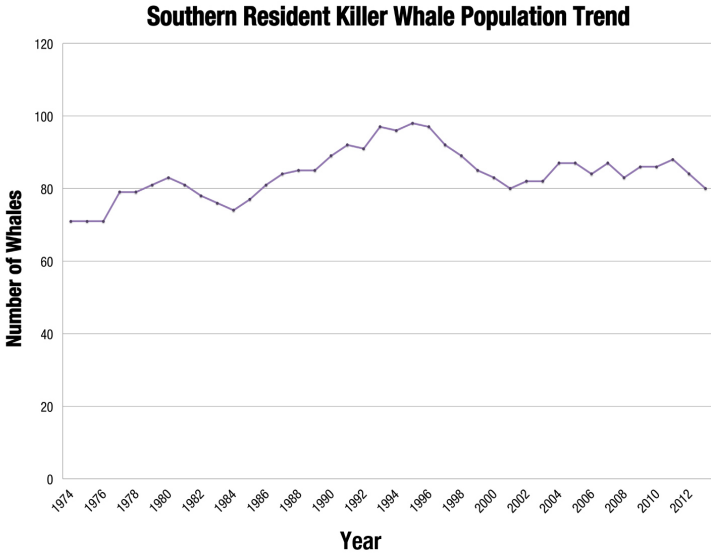
Map by: Damon Holzer. NWFSC/NOAA Fisheries.

STATUS AND TRENDS

Scientists estimate the minimum historical population size of Southern Residents was about 140 animals. Beginning in the late 1960s, a live-capture fishery removed nearly 50 whales for display at marine parks and resulted in an immediate steep decline in the population. The decline was steepest among the juveniles in the population, because smaller animals were targeted for capture. By 1974, the population consisted of 71 whales.

Live captures of this population ended in the early 1970s, and since that time the population has gone through several periods of growth and decline. In the mid 1980s, Southern Residents entered an 11-year growth period peaking at 98 animals in 1995. From 1996 to 2001, the population experienced a renewed decline of almost 20% and was reduced to 80 whales in 2001 before increasing somewhat to 88 whales in 2005 (including an orphaned whale, L98, who later died from a collision with a tugboat).

As a result of the steep decline in abundance, in 2005 the population was listed as an endangered distinct population segment (DPS) under the ESA. The major threats to the population's survival identified at the time were prey availability, pollution and contaminants, and effects from vessels and sound. In addition, small population size and vulnerability to oil spills and disease were identified as significant concerns. The population has declined since 2005 and consisted of 82 whales in the summer of 2013.



Hosted first science workshops to identify research needs on prey relationships and vessel interactions.

Court orders NOAA to reconsider eligibility of Southern Residents for ESA listing.

Southern Residents are declared "depleted" under the Marine Mammal Protection Act.

RECOVERY PLANNING

"While we have made progress toward meeting the recovery goals, there is still more work to do."

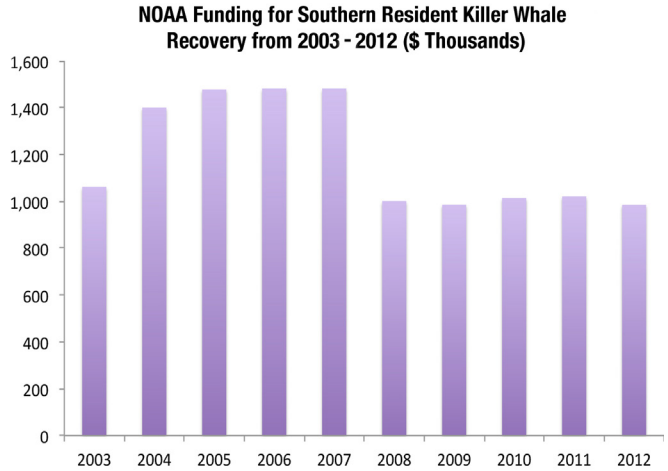
With extensive input from the public, NOAA Fisheries completed a recovery plan for Southern Residents in January 2008. Based on the best available information, it was clear that the population faced multiple potential threats and that we had many gaps in our understanding, but it was not clear which threats were most responsible for limiting the population's recovery. The plan, therefore, identified the specific aspects of the potential threats to address based on the best available science. The plan also identified important data gaps to fill.

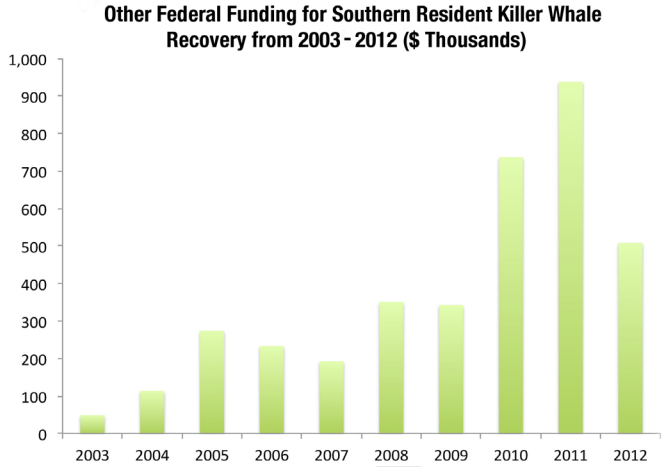
Even before the recovery plan was finalized, many efforts were underway by local and regional partners, and state and federal groups to conserve and protect Southern Resident killer whales. In 2003, the U.S. Congress allocated specific funding for killer whale research and management. From 2003 to 2012, NOAA spent $15.7 million dollars on research and conservation projects focused on or supporting recovery of Southern Resident killer whales.

Coastal communities in the Pacific Northwest have shown a commitment to recovery of the Southern Resident killer whales by implementing a number of actions in the recovery plan. Recovery is a long-term effort and will require cooperation, coordination, and dedication of resources in the years to come. The Southern Residents have long lifespans, low reproductive rates, and a small number of reproductive individuals, so a recovery strategy should ensure that the whales' population growth is on a positive trend over a long period of time. Therefore, our recovery criteria require a high degree of confidence that the population has been growing for at least several decades.

While we have made progress toward meeting the recovery goals, there is still more work to do. Over the past decade, scientists have advanced our knowledge about the biology of the whales, the threats they face, and other information guiding conservation of this endangered species. But Southern Residents still face an uncertain future. Research and conservation activities remain important to learn more about the whales and inform actions to protect them.

A key to the continued success of research and conservation programs is leveraging resources and maximizing impact through partnerships. For example, the whales spend significant time in Canadian waters and are listed as endangered under the Canadian Species At Risk Act, so transboundary coordination has, and will continue to be, important to recovery.





From 2003 to 2012, $15.7M in federal funding has been provided to support Southern Resident killer whale recovery activities. NOAA Funds are those directed by Congress to be used for this purpose. Other federal funds represent additional funds contributed by NOAA and other federal agencies for specific projects.

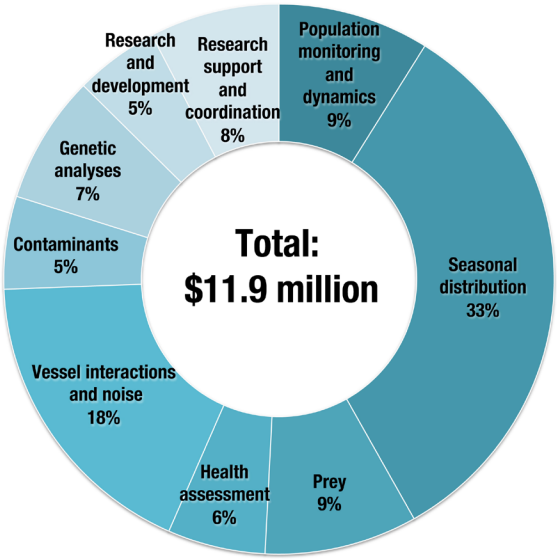
2004

Washington Department of Fish and Wildlife completes Washington State Status Report for Southern Residents.

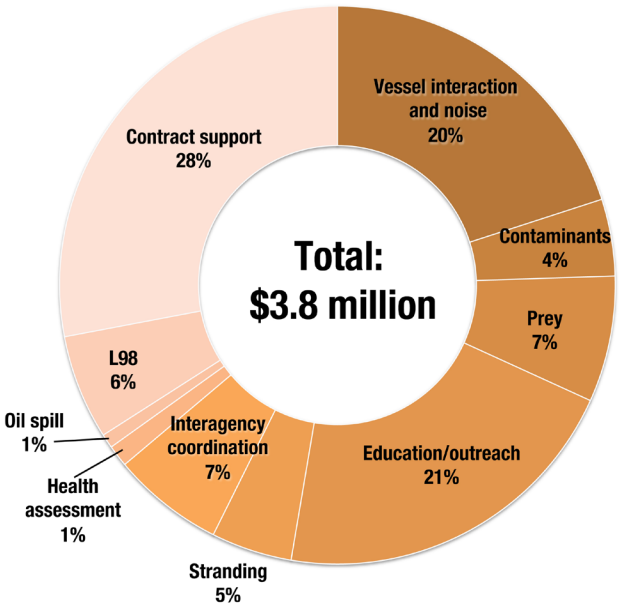
Completed first Southern Resident winter distribution survey cruise (PODS) and confirmed coastal habitat use by L pod.

Hosted additional science workshops about behavioral data collection and identification of Southern Resident subspecies.

Total Funding for Science and Research 2003-2012 by Category



Total Funding for Management and Conservation Actions 2003-2012 by Category



The pie charts include all expenses associated with each category, including supplies, equipment, travel, and federal and contractor labor and overhead costs. Federal labor costs were not tracked to the project level, but are applied proportionally across all categories.

NOAA Fisheries

Learning from Springer and Luna

NOAA has worked with Canada and many partners to respond to two lone killer whales that were separated from their families.

A73, (also known as Springer and pictured above), a Northern Resident calf found alone in Puget Sound, was returned to her family group in 2002 and has successfully reintegrated there. She had her first calf in 2013.

L98 (also known as Luna), a lone Southern Resident juvenile in Canadian waters, was killed by a vessel in 2006 before he could be returned to his family group.

These unique situations provided new insight into the challenges these whales face in their environment. Working with Springer taught us successful reintroduction strategies for young orcas with an absent mother, and gave us useful health insights through disease and blood screenings. The experience with Luna highlighted risks of interacting with boats and humans. The diverse transboundary partnerships formed as a result of these efforts continue to benefit recovery efforts for Northern and Southern Resident killer whale populations. Springer's rescue was supported by emergency funds through the John H. Prescott Marine Mammal Rescue Assistance Grant Program.

Washington State designates killer whales in Washington State as endangered.

Completed an updated Southern Resident status review.

Collected first fecal sample from a Southern Resident to identify diet.

What Does It Mean for Southern Resident Killer Whales to Be Endangered?

Look for the different icons throughout the report to see how research supports implementation of the protections under the Endangered Species Act.

Protections under the Endangered Species Act (ESA)		Date Completed	Icon
ESA Listing	When a species is listed, "take" is prohibited without a permit. Take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct.	November 2005	L
ESA Section 7 – Reviewing federal activities	Federal agencies must ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify critical habitat. NOAA Fisheries consults on federal actions under section 7 to reduce or mitigate impacts and ensure the survival and recovery of Southern Resident killer whales.	Ongoing	Section 7
ESA Section 10 permits – Reviewing scientific research activities	Permits can be issued for scientific research or to enhance the survival of a species; permits can also be issued for takes that are incidental to an otherwise lawful activity (such as construction projects with pile driving). Issuing a section 10 permit is a federal action so we also conduct section 7 consultations to ensure issuing permits will not reduce survival or recovery.	Ongoing	Section 10
ESA Critical Habitat	For listed species, NOAA Fisheries must designate critical habitat — specific areas within their occupied range that contain the physical and biological features essential for conservation and that may require special management considerations or protection. Critical habitat is protected from destruction or adverse modification by federal actions (see section 7 above).	November 2006 (Summer range only)	CH
ESA Recovery Plan	NOAA Fisheries is required to develop and implement recovery plans, which include site-specific management actions, objective, measurable recovery criteria, and estimates of time and cost to carry out recovery actions.	January 2008	RP
ESA 5-year Review	NOAA Fisheries must conduct a review of all listed species at least once every 5 years to determine if the listing status should be changed.	January 2011	5-yr Review
ESA Protective Regulations	NOAA Fisheries shall issue regulations as deemed necessary and advisable for the conservation of listed species.	April 2011 (Vessel regulations)	PR

2005

Southern Resident killer whale distinct population segment listed as endangered under ESA.

First paper from Southern Resident killer whale program characterizing diving behavior of Southern Residents in the summer range.

2006

Co-hosted a symposium with the Department of Fisheries and Oceans Canada to share new research results.

Reducing Threats to Southern Resident Killer Whales

Federal agencies must insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify critical habitat. NOAA Fisheries consults on federal actions under section 7 of the Endangered Species Act to reduce or mitigate impacts and ensure the survival and recovery of Southern Resident killer whales. Section 7 consultations are an important and effective management tool to reduce impacts on Southern Residents.

	Types of Actions	Mitigation/Conservation Measures
Actions that affect the salmon prey of Southern Residents	• Harvest management, such as fisheries regulations or fishery management plans • Hydropower operations • Hatchery production and management • Freshwater and estuary habitat projects	• Risk analysis to assess salmon abundance levels and relationships to killer whale survival and recovery. • Identify workgroups and research projects to address data gaps. • Minimize occurrence of derelict gear. • Protective measures for salmon habitat, populations, and hatchery operations.
Actions that affect contaminant levels	• Wastewater treatment plants • Sewer outfalls • Dredge disposal of contaminated sediments • Creosote piling removal	• Monitor input levels of harmful contaminants. • Identify workgroups and research projects to address data gaps. • Implement adequate mixing zones to limit accumulation in local prey. • Required threshold levels for at sea disposal. • Spill prevention and emergency clean-up plans.
Actions that may produce sound and/or cause disturbance	• In-water construction, pile driving • Docks, marinas, terminals that increase vessels traffic • Tidal and wave energy projects • Navy and Coast Guard operations • Research on Southern Resident killer whales	• Protective monitoring zones to avoid exposure to high levels of sound. • Responsible slow, safe vessel operation to reduce risk of strikes. • Adaptive management approaches for new technology, including required monitoring and feedback to evaluate protections. • Terms and conditions to minimize impacts of research activities (such as limits on repeated approaches or restricted age/sex for sampled individuals). • Track individual project effects to assess cumulative impacts.

Collected first contemporary biopsy sample from a Southern Resident to quantify contaminant loads, infer diet preferences, and collect DNA for pedigree analysis.

Completed Southern Resident killer whale Research Plan.

Proposed potential areas for Southern Resident critical habitat.

MAJOR THREATS TO RECOVERY

PREY AVAILABILITY

Recovery Goal: Rebuild depleted populations of salmon and other prey to ensure an adequate food base for recovery of the Southern Residents.

Southern Residents are fish-eating whales that rely on echolocation to detect their prey, primarily Pacific salmon. One species, Chinook salmon, make up a majority of their summer diet. In the fall and spring the whales eat a wider variety of salmon species, including coho, chum, and steelhead. Their winter diet remains relatively unknown, but recent investigations by NOAA Fisheries and collaborating scientists suggest it also consists largely of Chinook salmon. In the Pacific Northwest, many Chinook salmon populations have declined substantially from historical levels of abundance and are listed as threatened or endangered under the ESA. Ensuring that salmon populations are healthy and sustainable is an important part of achieving recovery for the whales.

Science and Research

Research prior to 2003 suggested that the whales prefer Chinook salmon, but these studies were largely focused on Northern Resident whales. The diet of Southern Residents may be different because the two killer whale communities occupy different ranges. To better understand the Southern Resident whales' diet, NOAA researchers have collaborated with experts over the past 9 years, collecting fecal material and prey remains from the whales to determine what they eat. With partners, we modeled the daily food requirements of the whales, investigated relationships between population sizes of salmon and whales, and examined the relationship between the whales' movement patterns and prey availability.

Major Findings and Milestones:

Food Preferences

- We confirmed that Chinook salmon are the whales' preferred prey, particularly in the summer. To a lesser extent, the whales also consume other salmon species and groundfish, such as halibut and lingcod. In Puget Sound, chum salmon appear to be a particularly important prey item during the late fall.
- Fraser River Chinook salmon make up the bulk of the whales' summer diet while they are in the Salish Sea. From our sampling in coastal waters we learned that they also consume Chinook from the Columbia, Sacramento, Klamath, and other coastal river systems.
- Research we funded showed that the backscatter patterns of fish air bladders are unique for each salmon species, and these unique patterns likely allow the whales to distinguish Chinook salmon from other species using echolocation.

Feeding Behavior

- We estimated the daily energy requirements of the whales, and based on these numbers, calculated that whales consume hundreds of thousands of adult salmon each year.
- Several methods have shown that the west side of San Juan Island is a foraging "hot spot" for Southern Residents during the summer.
- Studies showed that the whales travelled over a greater area and their movement patterns were more complex in the late 1990s, when prey availability was low.

Impacts on Population

- We found that survival and birth rates in the Southern Resident killer whale population are correlated with coast-wide abundance of salmon.
- An analysis of hormones in the feces of Southern Residents showed that reduced prey availability has a greater effect on these whales than vessel traffic, though during years of very poor food availability the presence of vessels likely contributes to stress.

2006

Designated final Southern Resident critical habitat in inland Washington waters.

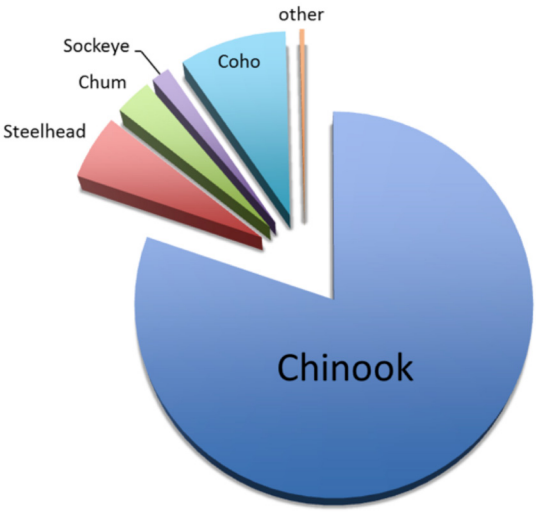
2007

Requested public input on potential vessel regulations.

Published paper showing high levels of toxics in Southern Residents, raising concerns about health, especially for juveniles with highest levels of PBDEs.

- We funded a study that estimated killer whale body size from photographs taken above whales using a helicopter. This novel method has promise for helping us understand how food availability impacts whale body condition and growth.

Composition of the Southern Residents' Summer Diet



Scientists collected individual prey samples in the Southern Residents' summer range, including the Western Juan de Fuca Strait and San Juan Island, from May to September 2004-2008. More than 75% of the whales' summer diet is Chinook salmon. Data from Hanson et al. 2010.

Management Activities

Biological Opinions

Under section 7 of the ESA, NOAA reviews all federal actions to ensure that endangered species, as well as their primary food source, are not put in jeopardy. Since listing in 2005, we have evaluated federal actions that directly affect the Southern Residents. We have also evaluated the effects of actions on their prey – namely salmon – and their habitats. For example, we know that the whales eat Columbia River and Sacramento River salmon, so we have included the Southern Residents in our assessment of the Federal Columbia River Power System (FCRPS) and the state and federal water projects in California, which affect multiple species of ESA-listed salmon and steelhead. Actions in these opinions benefit the salmon, and therefore the whales, including habitat, hatchery, predation management, and harvest actions to mitigate for the adverse effects of hydrosystems. The opinions also include numerous research, monitoring, and evaluation actions to support and inform adaptive management decisions.

Salmon Fisheries

The management of commercial and recreational salmon fisheries can affect the amount of food available to sustain the endangered Southern Resident killer whale population. It is essential to understand what the whales eat, how much they need, and where they are feeding in order to ensure we have a healthy and sufficient source of food to support the recovery of the whales.

As part of an ongoing evaluation of salmon fisheries, NOAA and the Department of Fisheries and Oceans Canada appointed an independent science panel to review salmon harvest actions and to inform recovery of Southern Residents in the U.S. and Canada. The panel held three workshops in 2011 to 2012 to rigorously explore the evidence available to answer the following key question:

> *To what extent are salmon fisheries affecting recovery of Southern Resident killer whales by reducing the abundance of their available prey, and what are the consequences to their survival and recovery?*

The science panel reviewed all available information, including new research called for by the outcomes of the first two workshops, and provided a final report in November 2012. The panel concluded that at a broad scale, salmon abundance will likely influence the recovery of the whales, but that there was a great deal of uncertainty about whether current fisheries remove enough salmon to have a meaningful influence on the whales' status.

The report also provided valuable recommendations on future analysis and research that could be done to fill data gaps and reduce uncertainty. The report will continue to be used to inform the management of salmon fisheries and assess impacts of actions that may alter the abundance of salmon available to the whales as part of the recovery programs for Southern Residents in the U.S. and Canada. Background information on the science panel process, workshop materials, and the final report are available at: http://www.westcoast.fisheries.noaa.gov/

Completed first stock identification of Southern Resident killer whale prey, shedding light on importance of salmon in whale diet.

Completed final Southern Resident killer whale Recovery Plan.

2008

First fecal samples collected from Southern resident killer whales to identify stress hormones, genetic identify, and diet.

POLLUTION AND CONTAMINANTS

Recovery Goal: Minimize pollution and chemical contamination in Southern Resident habitats.

Southern Resident killer whales are long-lived, top predators in the marine ecosystem, which make them vulnerable to pollutants that can accumulate up the food chain and negatively affect their health. This endangered population is exposed to contaminants from urban areas such as Puget Sound, where they and their prey spend much of their time.

Chemical pollutants of concern for killer whales include the pesticide DDT and chemicals found in industrial coolants and lubricants (known as PCBs), as well as flame-retardants (PBDEs). A large body of evidence links pollutant exposure to disease and reproduction problems in marine mammals. For example, chemicals in flame-retardants can potentially affect thyroid hormone levels, mimic or offset reproductive processes, and alter immune disease response in many species.

High levels of pollutants may be keeping the whale population from increasing at the rate required for recovery of the population. It is hard to study how these pollutants affect wild whales, so we often rely on information from other species and lab experiments. Working to reduce chemical contamination in the whales' habitat and food, however, will help slow the accumulation of these chemicals in the whales over their long lives, which may help their long-term prospects of survival.

Science and Research

U.S. and Canadian researchers first measured chemical pollution in the whales in the early 1990s. They found that the whales had high levels of PCBs but did not measure some other important contaminants such as DDT and flame-retardants. Over the past decade, NOAA Fisheries' researchers have collected many more biopsy samples from the whales in order to measure current levels of a number of pollutants.

Major findings and milestones:

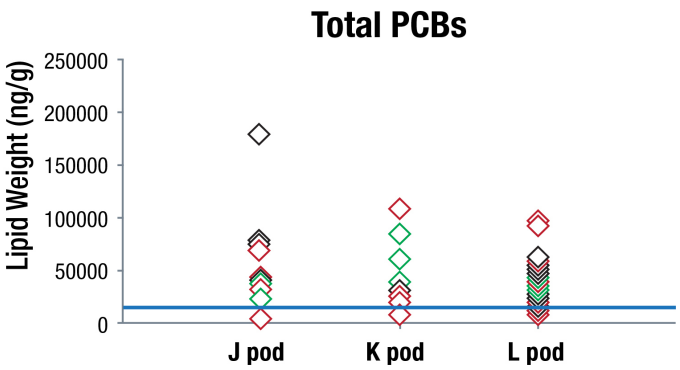
- We discovered that young whales have particularly high levels of certain pollutants.
- All of the whales in the population, including young whales, have high levels of pollutants that were banned long ago, like PCBs (legacy pollutants). The levels of PCBs found in their blubber exceed those we know to affect the health effects of other marine mammals. Section 7
- The population's three pods differ greatly in the types of pollutants found in their blubber. L and K pod have higher levels of pollutants, such as DDT found mostly near the California coast, suggesting that the whales eat prey from that area.
- Computer models showed that banned pollutants like PCB will slowly decline in the environment. However, because of high contaminant levels in currently reproducing females, young whales will continue to be exposed to these pollutants for several generations. Section 7
- These same computer models also predicted that the newer pollutants, like those found in flame retardants, will increase rapidly in the environment. This means that even though accumulation of banned contaminants will slowly decline in the whales, newer contaminants will increase, possibly resulting in continued health risks for the whales. Section 7

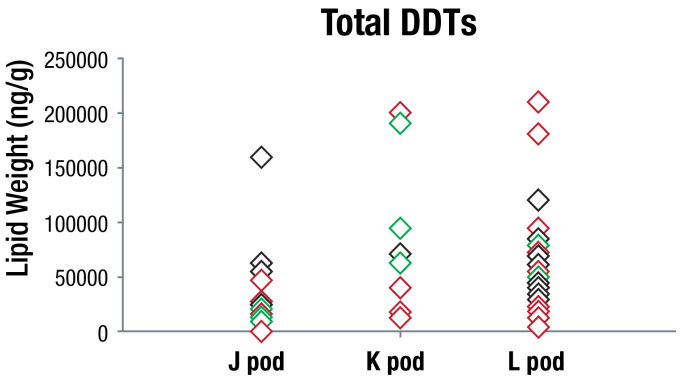
2009

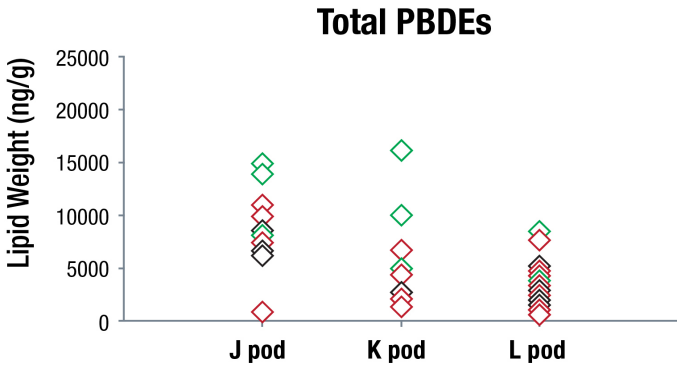
Co-hosted Southern Resident killer whale Naturalist Workshop with The Whale Museum for whale-watch operators and naturalists to learn about U.S. and Canadian management efforts and research results.

Published trio of papers on how Southern Residents modify their behavior in presence of vessels.

Proposed new vessel regulations to protect killer whales.







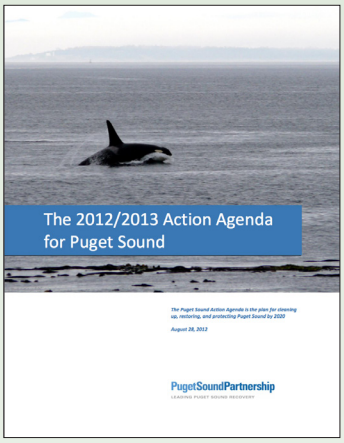
The concentrations of PCBs, DDTs, and PBDEs found in the whales' blubber vary by pod, sex, age, and pollutant, but all of the whales in the population, including young whales, have high levels of pollutants that were banned long ago (known as legacy pollutants), like PCBs. The levels of PCBs found in their blubber exceed the levels we know to cause poor health effects in other marine mammals. Figure generated using data from Krahn et al. 2007, Krahn et al. 2009 and NWFSC unpublished data.

Legend:
Black- Maturing and adult males 13 years and older
Red – Adult females 12 years and older
Green – Juvenile and sub-adult whales
Blue line – the level we know generates negative health effects in other marine mammals

Management Activities

Partnering with Puget Sound Partnership

Contaminants are a threat to healthy marine ecosystems, not just Southern Resident killer whales. In order to address the threat of pollution and contamination in critical habitat for the whales, we work with the Puget Sound Partnership; the state agency leading the cleanup of Puget Sound. We collaborate with them in their efforts to clean up, restore, and protect Puget Sound by 2020. For more information on efforts to address pollution and contaminants, please visit http://www.psp.wa.gov/.



Convened PBDE Working Groups

We have focused our recent management efforts on one emerging contaminant, flame-retardants, also known as PBDEs, in Puget Sound. With the discovery of relatively high levels of these chemicals in Southern Resident killer whales, the recovery plan identifies actions to monitor and mitigate effects from these newly emerging contaminants. Discharge of treated wastewater is one of the primary sources of PBDEs in Puget Sound. We worked with the U.S. Environmental Protection Agency to establish working groups composed of state and local managers and the research community to evaluate data gaps and make recommendations on the following topics:

- PBDE removal efficiency in wastewater treatment plants
- PBDE modeling in Puget Sound (fate, transport, and bioaccumulation or food web modeling)
- Toxicological thresholds for PBDEs in killer whales
- Effects of mixtures of persistent pollutants

The working groups have completed a report of recommendations to help inform policy makers, conservation groups, agencies that issue permits and regulate contaminants, and the Puget Sound Ecosystem Monitoring Program. Background information on the working groups, and the report are available at: www.westcoast.fisheries.noaa.gov.

Added killer whale response plan to the Northwest Area Contingency Plan for oil spill response.

2010

Published two papers, one on the identification of species and stocks of prey consumed and one on prey consumption requirements by Southern Residents, providing much needed information on Southern Resident predator/prey relationships.

2011

Completed 5-year Status Review; no change to status needed.

VESSELS AND NOISE

Recovery Goal: Minimize disturbance of Southern Resident killer whales from vessels.

The inland waters of Washington state and British Columbia are highly urbanized areas with significant vessel traffic from container ships, ferries, tugboats, recreational boats, and fishing vessels, and are also where the whales spend much of their time in the summer and fall. Southern Resident killer whales are also the focus of considerable recreational and commercial whale watching. The cumulative impacts from vessels may interfere with the whales' ability to communicate and find food, affecting their health and survival. Quantifying the amount and types of marine traffic, as well as the whales' responses to vessels, has helped us understand the effect of vessels on killer whale behavior and determine the best ways to protect whales and allow for human uses of the marine environment.

Science and Research

Working with our partners, we have completed studies providing insights into the trends in vessel activity and how the whales react to vessels. The results helped the agency create new regulations for vessel activities in areas frequented by Southern Resident killer whales.

Major findings and milestones:

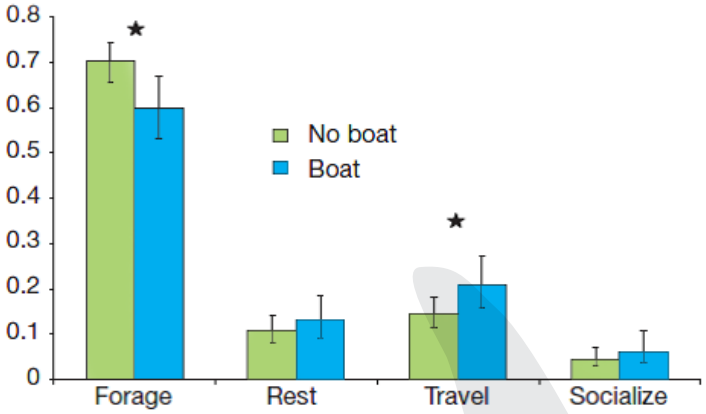
Vessel activity and ongoing monitoring PR

- With our partners, we monitored the vessels in the vicinity of the whales annually and observed compliance with the whale watch guidelines and regulations. Recreational boaters are the most common vessel type observed out of compliance.
- In collaboration with our partners, we documented summer vessel traffic in the San Juan Islands, including the western shore of San Juan Island, a high-use area for Southern Residents. We detected a higher vessel presence on weekends and holidays and a small increase in overall vessel traffic in 2010 compared to a similar 2006 study.
- We completed a detailed survey of the whale watching industry to evaluate how future regulations might affect employment and participation in this important tourist activity.

Noise and impacts on communication PR

- A study we funded quantified the level of noise produced by a variety of vessel sizes, propulsion systems, and operational speeds in Haro Strait.
- Average noise levels in Haro Strait are strongly influenced by large vessels such as commercial ships, according to a NOAA-funded study.
- NOAA-funded scientists constructed and validated models that predicted received levels of sound from large vessels that killer whales experience in the main shipping lanes of Haro Strait.
- We determined that noise from motoring vessels at distances of up to 400 meters has the potential to affect echolocation abilities of foraging whales.
- We confirmed that ambient noise levels increase as the number of vessels increase.
- Our studies documented particularly high noise levels experienced by whales in close proximity to certain types of vessels such as small recreation and commercial whale watch boats.

Southern Resident Behavior Changes With Boat Presence



This figure shows the amount of time Southern Residents from J, K, and L pod spent foraging, resting, traveling, and socializing with and without the presence of boats in two areas near San Juan Island. When vessels were present, the whales foraged significantly less and travelled more. Data from Lusseau et al. 2009.

2011

Published scientific paper showing reproductive success appears to increase with male age and size and that Southern Residents do not breed outside of their small population.

Announced new vessel regulations to protect killer whales.

First of three NOAA-DFO Bilateral Scientific Workshops to Evaluate Effects of Salmon Fisheries on Southern Residents.

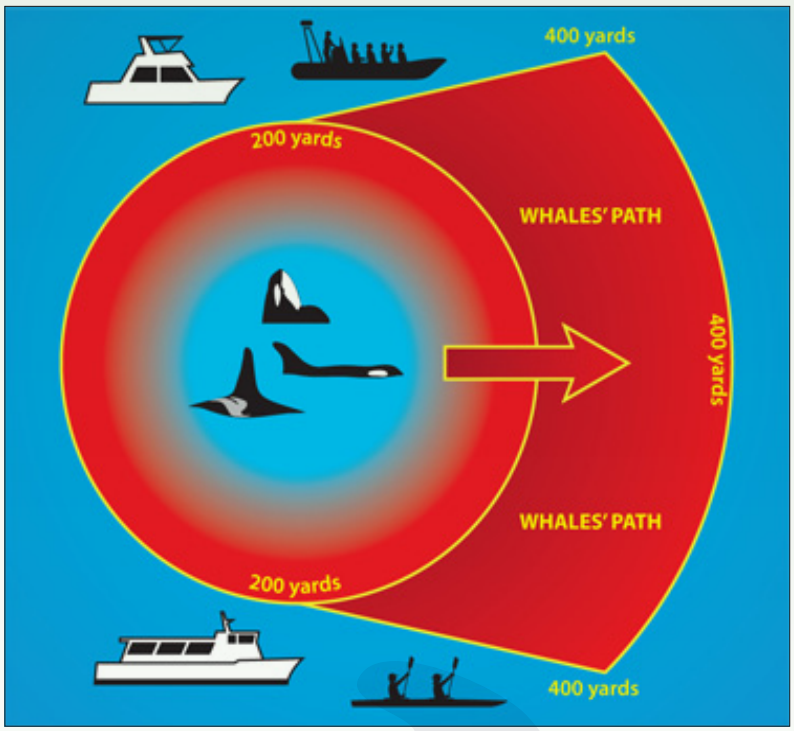
Management Activities

NOAA Fisheries announced new regulations to protect killer whales in Washington State from vessel impacts in April 2011. The rule prohibits vessels from approaching any killer whale closer than 200 yards, and prohibits vessels from intercepting or parking in the path of the whales.

These regulations were developed and informed by public input, scientific results from research we conducted or funded, and data from the Soundwatch Boater Education Program that monitors boat activity around the whales. We also considered the potential costs of the regulations to various stakeholder groups, including the whale watching industry and fishing communities.

The regulations strike a balance by providing protection for endangered Southern Resident killer whales while still allowing for educational and economically viable whale watching. The new 200-yard approach rule was a change from a previous 100-yard guideline. Our final assessment concluded that the new regulations would provide a net benefit to whales by reducing risk of vessel strikes and behavioral and acoustic disturbance, but would have no significant impacts to socioeconomics or recreational opportunities. The new regulations called for additional education, enforcement, and monitoring activities, which are currently underway. In 2013, the Washington Department of Fish and Wildlife received a NOAA endangered species grant to support enforcement.

For more information on the regulations and the "Be Whale Wise" guidelines, please visit: http://www.bewhalewise.org/.



WCR/NOAA Fisheries

Impacts on behavior

- Research we funded demonstrates that killer whales spend a greater proportion of time traveling and less time foraging in the presence of vessels, including kayaks.
- Results from our research as well as research we funded show that Southern Residents modify their behavior by increasing surface activity (breaches, tail slaps, and pectoral fin slaps) and swimming in more erratic paths when vessels are close.
- We found that Southern Resident killer whales increase the amplitude (loudness) of their calls when noise levels in their environment are high.
- We estimated the potential energetic impact of increased surface activity and louder calls in wild killer whales by quantifying the energetic cost of the same activities in trained bottlenose dolphins.

Deployed first satellite tag on a Southern Resident (adult male J26) to determine winter distribution.

Longest Southern Resident satellite tag deployment to date (>3 months) provided information on winter habitat use and allowed researchers to collect the most offshore prey samples in one research cruise.

2012

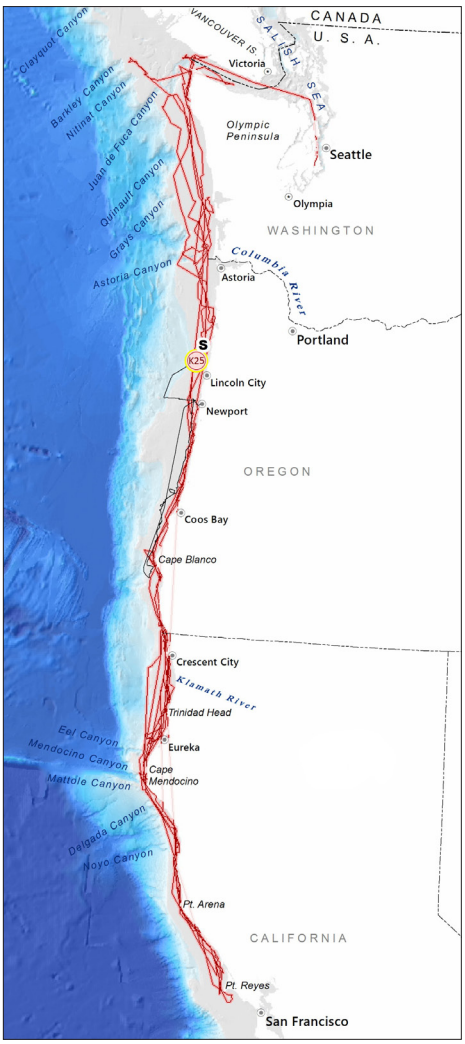
2013

Second and third NOAA-DFO Bilateral Scientific Workshops to Evaluate Effects of Salmon Fisheries on Southern Residents.

FILLING CRITICAL INFORMATION GAPS

WINTER DISTRIBUTION

In 2003 we knew very little about the whales' winter habitat and their distribution along the West Coast. This was a large information gap, since the whales spend well over 50% of their time on the outer coast where they are difficult to observe. Understanding more about the whales' coastal habitat has helped us learn what they are eating, what threats they face in this part of their habitat, and how to protect this important part of their range.



Movements of satellite-tagged Southern Resident killer whale K25 from 29 December 2012 to 3 April 2013. NWFSC/NOAA Fisheries.

Science and Research

Prior to 2003, data on the whales' winter distribution and movement patterns were limited to a handful of sightings off the West Coast over several decades. A series of workshops identified winter distribution as a primary data gap. To determine where the whales spend their time outside of the inland waters of Washington and British Columbia, we used a variety of technologies, including passive acoustic monitoring, a land-based sighting network, coastal research cruises, and most recently satellite-linked tags.

Major findings and milestones:

- We located and recorded the location of Southern Residents off the Washington and Oregon coasts on 6 of 7 NOAA cruises to study the whales since 2004.
- With partners we expanded the sighting network in inland Washington waters and along the West Coast.
- We greatly expanded the use of passive acoustic monitoring to study the whales' coastal habitat use. Acoustic recorders deployed at 7 sites off the West Coast detected dozens of Southern Resident calls, providing an improved understanding of where the whales go along the coast.
- We implemented a satellite-linked tagging program to directly determine whale movements. We collected 93 days of winter location information for K pod in 2013 and a month of locations for J pod in 2014.
- In 2013, researchers used satellite tagging information to follow the whales along the coast for 8 days, allowing nearly continuous investigations of behavior and habitat use. Scientists also collected numerous prey and fecal samples to learn more about winter diet, and oceanographic data helped them understand features of their environment on the outer coast of Oregon.
- Prey and fecal samples collected during coastal cruises suggest that Southern Residents consume Chinook, steelhead, chum, lingcod, and halibut during winter and spring months.

Southern Resident killer whale male, K25, with satellite tag attached. NWFSC/NOAA Fisheries.

Management Activities

NOAA Fisheries designated critical habitat for Southern Resident killer whales in 2006. Three specific areas were designated which together comprise approximately 2,560 square miles (6,630 square kilometers) of marine habitat in inland waters of Washington:

1. the Summer Core Area in Haro Strait and waters around the San Juan Islands;
2. Puget Sound; and
3. the Strait of Juan de Fuca.

At the time, we did not include any areas off the coast because of the limited information regarding the whales' distribution along the coast, as well as the uncertainty regarding the important habitat features in the coastal areas. In January 2014, the Center for Biological Diversity submitted a petition to NOAA Fisheries requesting an expansion of the critical habitat to include offshore waters of the Pacific Ocean. New information from the current research activities will inform future consideration of critical habitat along the coast.

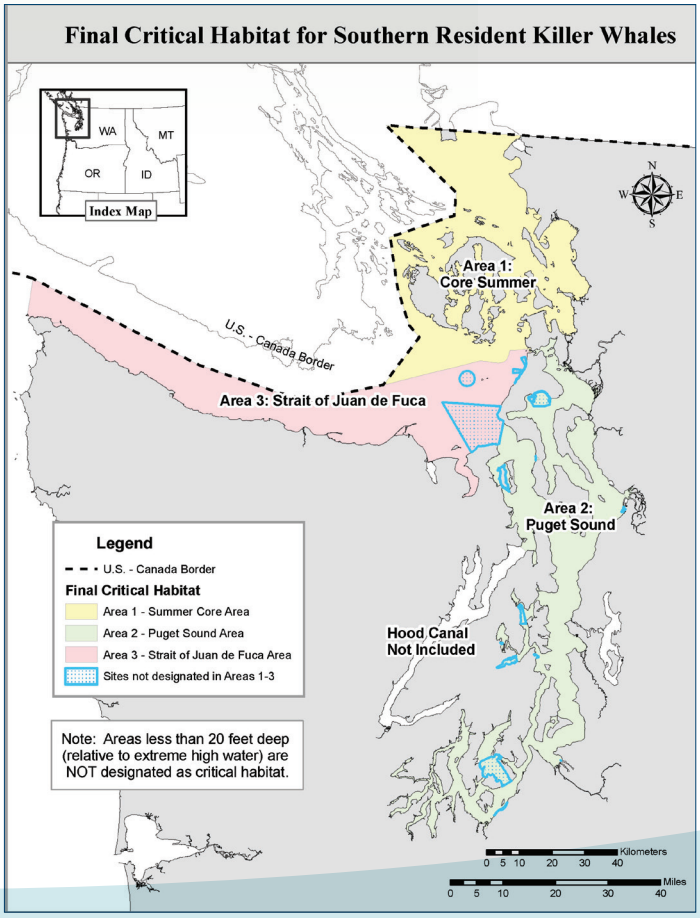
MATING PATTERNS AND RELATIONSHIP TO OTHER KILLER WHALE POPULATIONS

In its listing of the Southern Resident killer whales under the ESA, NOAA Fisheries determined that the whales are a distinct population within a sub-species of killer whales consisting of fish-eating resident killer whales of the North Pacific Ocean. The taxonomy of killer whales remains uncertain, however. To help reduce this uncertainty, NOAA Fisheries has funded and conducted research on the genetic relationships of different groups of killer whales in the Pacific and worldwide. We have also used genetic information to evaluate patterns of mating and inbreeding within the Southern Resident whale population. This information is useful for evaluating whether the population is suffering adverse effects from inbreeding.

Science and Research

Major findings and milestones:

- Genetic analysis of historical samples from museum collections revealed that the historical range of Southern Residents is similar to what it is today.
- Genetic data show that the resident and transient killer whale ecotypes in the North Pacific diverged from each other at least 20,000 years ago, and possibly much earlier, with almost no interbreeding between the ecotypes.
- Paternity analysis revealed that the oldest and largest males are the most successful breeders in the population.
- This paternity analysis also showed that sometimes Southern Residents mate with whales in their own pod, a behavior not seen in other killer whale populations. Despite this mating within pods, the overall level of inbreeding within the population appears to be low.



Management Activities

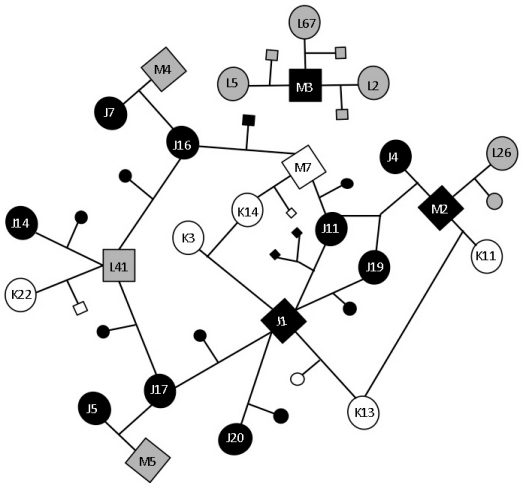
In 2012 NOAA received a petition asking us to remove the Southern Resident killer whales from the list of endangered species. Based on the best available information, including new genetic information released since the ESA listing in 2005, we reaffirmed that the North Pacific Residents are likely a sub-species and that the Southern Residents are a distinct population segment of that sub-species. In 2013 we found that delisting was not warranted and the Southern Residents maintained their endangered status under the ESA.

NOAA FISHERIES

FILLING CRITICAL INFORMATION GAPS (cont.)

DEMOGRAPHICS

One of the most important methods for assessing the status of this endangered population is the annual census, which has been conducted every year since 1976. NOAA Fisheries has funded the Center for Whale Research to complete the annual survey each year from 2003 to 2013. The data collected provide managers with current information on Southern Resident population status and trends, updates to photo-identification guides, relationships among individual whales, and valuable data for advancing scientific research that help predict population-level responses to environmental change.



A partial family tree of the Southern Resident killer whale community, based on observed mother-offspring pairs and a genetic paternity analysis. Males are represented by squares, females by circles, and a line connecting a male and a female indicates they are parents of an offspring. Researchers found that only a few older males, such as J1 and L41, are the fathers of many of the offspring in the population. They also found that unlike what has been seen in other killer whale populations, some males mated with females in their own pod, potentially leading to future inbreeding problems. Individuals labeled "M" are fathers that were not sampled, most likely because they died prior to the study. Source: Ford et al. 2011.

Science and Research

Major findings and milestones from studies using the census data:

- The ongoing census provides accurate demographic information, including births, deaths, and the numbers of whales by age and sex.
- Despite an overlapping range and a similar diet, annual survival and birth rates of Southern Residents are depressed compared to Northern Residents. For example, over her full reproductive lifetime, a Northern Resident female produces on average one more calf than a Southern Resident female. Over time this results in a major difference in the populations' growth rates.
- The census data also showed that survival rates for calves born to older mothers were 10% higher than other calves, possibly because older mothers may be more experienced.
- Census studies showed that the small size of the population makes it difficult to forecast how alterations in Chinook salmon fishing might impact the population.
- Data from the annual census helped us confirm that individual whales prefer to spend most of their time with their own pods and close relatives, although the amount of time varies annually.
- The whales spend less time in large social groups during times of population decline and potentially low prey abundance. This suggests that their environment influences their social structure, and such changes in social groups can affect other behaviors such as patterns of mating, group foraging, and social care of calves.

Southern Resident killer whales with young calf. NWFSC/NOAA Fisheries.

MANAGING FOR RECOVERY

In addition to addressing the three primary threats to the Southern Resident killer whales and prioritizing additional research studies to fill critical information gaps, we have taken additional conservation actions to protect the whales and raise awareness. We are working to reduce future impacts and increase their chances of recovery through contingency response planning for impacts from possible oil spills, coordinating stranding responses for injured or dead whales, and supporting education and outreach about the science and management of these animals.

OIL SPILL PREPAREDNESS

All of the Southern Residents are periodically in the same location at the same time (known as a "super pod"), making the whales very vulnerable to a catastrophic event like an oil spill during such times. Many efforts are underway to prevent oil spills, but in the event they do occur, we are working on plans to reduce their impacts.

NOAA Fisheries worked closely with partners to develop a killer whale-specific oil spill response plan. Together with the University of California at Davis, we hosted a workshop with researchers, oil spill responders, and oil industry representatives and developed a draft oil spill response plan for killer whales. Working with the Washington Department of Fish and Wildlife, the Region 10 Regional Response Team and the Northwest Area Committee, we completed the plan, and it was adopted in 2010 as part of the Northwest Area Contingency Plan.

STRANDING RESPONSE

We can protect the whales by rescuing sick or injured whales and by learning about what may be causing death in the animals that wash up on our shores. Responding to stranded killer whales is an important data source for learning about the threats to the whales.

As part of NOAA Fisheries' role in coordinating the West Coast Marine Mammal Stranding Network, we work with network members to prepare for and respond to stranded killer whales. We developed an initial stranding protocol for killer whales, and our partners developed a detailed Killer Whale Necropsy and Disease Testing Protocol. In partnership with University of California at Davis and the Northwest Marine Mammal Stranding Network, we provided funding support to ensure prompt and thorough examinations of every stranded killer whale carcass. Stranding response along the West Coast is also supported through the John H. Prescott Marine Mammal Rescue Assistance Grant Program.

Necropsy of stranded killer whale neonate calf. WCR/NOAA Fisheries.

EDUCATION AND OUTREACH

Education and outreach about recovery of Southern Resident killer whales raises public awareness and knowledge about the whales, the threats they face, and actions people can take to support recovery.

We work closely with museums and aquariums, non-profit groups, researchers, and schools to raise awareness and show how individuals and organizations can contribute to conservation. A few examples of our partnerships and education and outreach programs include:

- The Seattle Aquarium created an Orca Family Center and killer whale trading cards to inspire conservation of our marine environment.
- The Whale Museum on San Juan Island helped to establish the Salish Sea Hydrophone Network and features conservation messages in its educational programs, exhibits, and the Soundwatch Boater Education Program.
- Killer Whale Tales inspires students to take an active role in conservation of the whales and their habitat.
- Orca Network connects whales and people in the Pacific Northwest and collects sighting information.
- The Whale Trail inspires appreciation and stewardship of whales and our marine environment by establishing a network of land-based viewing sites.
- NOAA Fisheries' high school curricula on killer whale recovery aligns with state learning requirements and is available for use in Washington State public schools.
- The Port Townsend Marine Science Center inspires conservation of the Salish Sea with their Orca Project and as part of the Salish Sea Hydrophone Network.

NOAA FISHERIES

THE NEXT 10 YEARS

The many accomplishments described in this document were made possible through federal funding provided by Congress from FY 2003 to FY 2012. NOAA Fisheries and its partners have used this funding to conduct the innovative research needed to understand what factors are most affecting the whales and to implement targeted actions addressing those factors.

As a result of reductions in federal funding in FY 2012 and FY 2013, NOAA Fisheries was forced to temporarily eliminate or scale back important parts of the Southern Resident recovery program, such as aspects of the annual population census, visual monitoring of the whale health, satellite tag research and deployment, and coastal sighting network along the West Coast. Funding levels also prevented us from starting new studies assessing their health using breath analysis and reduced support for education and outreach. The graphic on the right highlights the critical research and management actions we plan to accomplish in the next ten years and beyond as resources allow.

We remain committed to increasing cooperation and coordination, both within NOAA and with our partners. Together we will continue to apply cutting-edge science techniques to explore killer whale biology and interactions with humans and the environment, and use the best available science to guide our management and recovery efforts for Southern Resident killer whales.

Prey Availability

Science & Research

- Study competition between other salmon predators including seals and seal lions, Northern Resident killer whales, and fisheries.
- Continue research on whale health related to diet.
- Continue to study what whales eat in the winter.
- Investigate inter-year variability in killer whale diet.

Conservation & Management

- Continue to evaluate relationships between salmon abundance and whale health and minimize effects of actions that reduce salmon abundance.

Pollution & Contaminants

Science & Research

- Monitor levels of new and emerging contaminants in the whales.
- Test and refine models to predict future contaminant loads.
- Investigate whether high contaminant loads have direct impacts on health and reproduction.

Conservation & Management

- Evaluate and minimize effects of actions that increase contaminants in the whales and their prey.
- Support oil spill prevention.
- Continued readiness in the event of a potentially catastrophic oil spill.

Vessels & Noise

Science & Research

- Investigate whether noise and vessels prevent whales from foraging efficiently.
- Measure the impacts of behavior change due to vessel presence and noise.
- Conduct field studies to evaluate effectiveness of new vessel regulations.
- Quantify sources of human-generated noise throughout the Southern Resident killer whales' range and assess their impacts.

Enforcement

Conservation & Management

- Continue to enforce vessel regulations.

THE NEXT 10 YEARS

Genetics & Population Structure

- Continue to collect and analyze data to inform killer whale taxonomy and breeding patterns.
- Collect data needed to estimate historical abundance.

- Use taxonomic and genetic information to assess the status of population and recovery criteria during reviews of listing status and in response to petitions.

Demographics

- Continue to monitor population size and response to changes in salmon abundance.
- Improve our estimates of the carrying capacity of the environment for the whales.
- Study how the population responds to seasonal changes in prey abundance and competition with other salmon predators.

- Conduct periodic reviews under the ESA to assess progress toward recovery goals.

Winter Distribution

- Address many questions about their life during the winter (diet, behavior, threats) to assess which risk factors may be impacting the whales in this portion of their range.

- Evaluate expanding critical habitat areas to include waters along the west coast where they range.

Health Assessment

- Combine health information for individuals from data collected to date (biopsies, feces, imagery, etc.).
- Conduct new nutritional studies and breath analyses to understand conditions that may contribute to killer whale mortality.
- Investigate stranded animals and other samples to understand the risk disease poses to these animals.

- Use health assessment and stranding investigation results to help prioritize recovery actions.

Science & Research

Conservation & Management

Opposite page: Southern Resident killer whale near a ferry in Puget Sound. This page: Southern Resident killer whale with salmon. NWFSC/NOAA Fisheries.

NOAA FISHERIES

LOOKING AHEAD

With 10 years of funding, collaboration, and ingenuity we have made substantial and important steps to aid Southern Resident killer whale recovery. Research projects have illuminated new aspects of killer whale biology, behavior, and ecology and helped us better understand the challenges this population faces. Targeted management actions, informed by research, have been taken to secure protections for the whales and their habitat. We have much better information to guide our decisions than we did 10 years ago, and this research continues.

While we can celebrate important successes, the key threats remain challenging to understand and manage. In particular, the past decade of research has shown that some of the most important threats facing the whales, such as prey limitation and high contaminant levels, cannot be addressed without a long-term commitment. Recovery of threatened salmon, for example, is a monumental task in itself and is expected to take many years. The threat of contaminants is also challenging, particularly considering that the whales remain contaminated by chemicals that were banned decades ago.

There are also mysteries that persist. For example, will increases in salmon abundance benefit the Southern Resident whales, or will any increases be consumed by other populations such as the Northern Resident killer whales? Are there health issues, like disease, which we have not yet uncovered? We also must consider new threats and actions as we look to a future with climate change, new alternative ocean energy projects, and continuing development along our coasts and in our ports.

In the next 5 to 10 years, there are several high priority projects planned to help answer these remaining questions and inform management actions to advance their recovery. Understanding the factors that affect the whales' health will help us identify the most important threats, how they interact, and what we can do to reduce their impacts. New technologies are being developed to better understand disease threats, assess individual body condition and health of individuals for example, via collection of breath samples, and gain a better understanding of the health effects of carrying large contaminant burdens.

We also plan to explore additional management actions outlined in the recovery plan. New information on coastal distribution and habitat use will inform designation of additional critical habitat for the whales. Seasonal health assessments, habitat use, and potential times and places with prey limitations or vessel impacts that affect health or feeding will be taken into consideration when determining the need for additional conservation actions, such as a protected area.

Recovery of the Southern Residents and their preferred salmon prey, as well as protection of their broad and diverse habitat, is a long-term process that requires support over a large geographic area, from California to Southeast Alaska. Our recovery criteria are built around a timeframe of 14 to 28 years based on the biology of these long-lived animals. It will take at least that long for us to evaluate the effectiveness of the protective measures put in place in the last several years. The last 10 years of federal funding and effort have secured a strong foundation of research and conservation, which we can build on to secure recovery of this iconic species for future generations.

Boater watching Southern Resident killer whales near San Juan Island, WA. NWFSC/NOAA Fisheries.

PUBLICATIONS

Included in this section are scientific articles resulting from work funded by federal Southern Resident killer whale funds. Most, if not all, of these articles are the result of successful collaborations with our regional, national, and international partners.

Genetics

Ford, M. J., M. B. Hanson, J. Hempelmann, K.L. Ayres, C.K. Emmons, G.S. Schorr, R.W. Baird, K.C. Balcomb, S.K. Wasser, K.M. Parsons, K. Balcomb-Bartok. 2011. Inferred Paternity and Male Reproductive Success in a Killer Whale *(Orcinus orca)* Population. Journal of Heredity 102(5): 537-553.

Hoelzel, A.R. 2004. Report on killer whale population genetics for the BRT review on the status of the Southern Resident population. Unpubl. Report submitted to the NWFSC, Seattle, WA.

Hoelzel, A.R., J. Hey, M.E. Dahlheim, C. Nicholson, V. Burkanov, and N. Black. 2007. Evolution of population structure in a highly social top predator, the killer whale. Molecular Biology and Evolution 24: 1407-1415.

Morin, P.A, F.I. Archer, A.D. Foote, J. Vilstrup, E.E. Allen, P. Wade, J. Durban, K.M. Parsons, R. Pitman, L. Li, P. Bouffard, S.C. Abel Nielsen, M. Rasmussen, E. Willerslev, M.T. Gilbert, and T. Harkins. 2010. Complete mitochondrial genome phylogeographic analysis of killer whales *(Orcinus orca)* indicates multiple species. Genome Research 20(7): 908-916.

Morin, P.A., R.G. LeDuc, K.M. Robertson, N.M. Hedrick, W.F. Perrin, M. Etnier, P. Wade, and B.L. Taylor. 2006. Genetic Analysis of killer whale *(Orcinus orca)* historical bone and tooth samples to identify western U.S. ecotypes. Marine Mammal Science 22(4): 897–909.

Reeves, R.R., W.F. Perrin, B.L. Taylor, C.S. Baker, and M.L. Mesnick. (eds.). 2004. Report of the Workshop on Shortcomings of Cetacean Taxonomy in Relation to Needs of Conservation and Management, 30 April to 2 May, La Jolla, California. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-363, 94p.

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Ward, E.J., E.E. Holmes, and K.C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. Journal of Applied Ecology 46(3): 632-640.

Ward, E.J., E.E. Holmes, K. Parsons, K.C. Balcomb, and J.K.B. Ford. 2009. The role of menopause and reproductive senescence in a long-lived social mammal. Frontiers in Zoology 6(4).

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