NOAA's National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

Agencies:	NOAA's National Marine Fisheries Service-Office of Protected Resources-Permits, Conservation, and Education Division
Activities Considered:	Issuance of permit amendment to Brad Hanson, Northwest Fisheries Science Center, National Marine Fisheries Service (Permit number 781-1824-02)
Consultation Conducted by:	NOAA's National Marine Fisheries Service-Office of Protected Resources-Endangered Species Division
Approved by:	Kelly Noble for J. H. Lecky
Date:	Nov 22, 2011

Section 7(a)(2) of the Endangered Species Act (ESA)(16 U.S.C. 1531 *et seq.*) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat designated for them, that agency is required to consult with either the NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected. For the actions described in this document, the action agency is the NMFS' Office of Protected Resources-Permits, Conservation, and Education Division (Permits Division), which proposes to authorize tagging of southern resident killer whales in the Pacific Northwest. The consulting agency for these proposals is the NMFS' Office of Protected Resources – Endangered Species Division.

This document represents the NMFS' biological opinion (Opinion) of the effects of the proposed actions on endangered and threatened species and designated critical habitat and has been prepared in accordance with section 7 of the ESA. This Opinion is based on information provided in the application, draft permit, the southern resident killer whale recovery plan, monitoring reports from prior research, other information provided by the applicant, and other biological opinions involving research.

Consultation history

On November 9, 2010, the Permits Division published a Federal Register notice soliciting public comment on their intent to issue the proposed permit.

On May 23, 2011, NMFS' Endangered Species Division received a request for formal consultation from the Permits Division to authorize Permit Number 781-1824-02, Brad Hanson, Northwest Fisheries Science Center, National Marine Fisheries Service. Formal consultation was initiated on the same date.

Description of the proposed action

Dr. Brad Hanson and associated researchers propose to amend their current research permit (781-1824-01) to include implantable satellite dart tagging (on six individuals amongst three pods) and increase suction cup tagging (from 10 to 20 annually) of southern resident killer whales in Puget Sound and coastal regions of the Pacific Northwest. The purpose of this research is to characterize cetacean movement patterns, particularly southern resident killer whales during winter, and to clarify data gaps for designating critical habitat additional critical habitat. The researchers propose to deploy two tags per year in each of the three pods composing the southern resident killer whale DPS: J, K, and L. A given individual would be implantably tagged a maximum of once annually, with up to two tagging attempts per day and no more than four per year. Post reproductive females and adult males (qualifying individuals identified in Table 1) would be targeted whereas other age and sex classes would be avoided. Individuals that appear sick or emaciated may be targeted due to these conditions (allowing more information to be gained pre-mortem and better stranding information to be collected post-mortem). Tagging of southern resident killer whales is proposed to occur any time, although most tagging is expected to occur in fall. Applicants anticipate tags to remain attached for between three weeks and three months.

Table 1. Identity, sex, and age of possible target whales for implantable tagging.

Whale ID	Sex	Estimated age
J1	Male	59
J2	Female	99
J8	Female	77
J26	Male	19
J27	Male	19
J30	Male	15
K11	Female	77
K40	Female	47
K21	Male	24
K25	Male	19
K26	Male	17
L25	Female	82

L12	Female	77
L41	Male	33
L2	Female	50
L85	Male	19
L87[K]	Male	18
L79	Male	17
L89	Male	17
L78	Male	18
L88	Male	17
L26	Female	54
L92	Male	15
L7 [J]	Female	49
L53 [J]	Female	33
L27	Female	45
L5	Female	47
L73	Male	24
L74	Male	24
L84	Male	20

Suction cup tags would be similar or identical to those currently permitted for use on southern resident killer whales by the researchers. Implantable satellite tags would include a Wildlife Computers Spot-5 PTT or a VHF transmitter, or a similar configuration of size, shape, and weight to that proposed for use (Figure 1; 7 cm long, 3 cm wide, 2.2 cm high, 17 cm antenna, 44-47 grams, 7 cm-long titanium implantation darts). Modifications to prevent tag breakage would also be included.

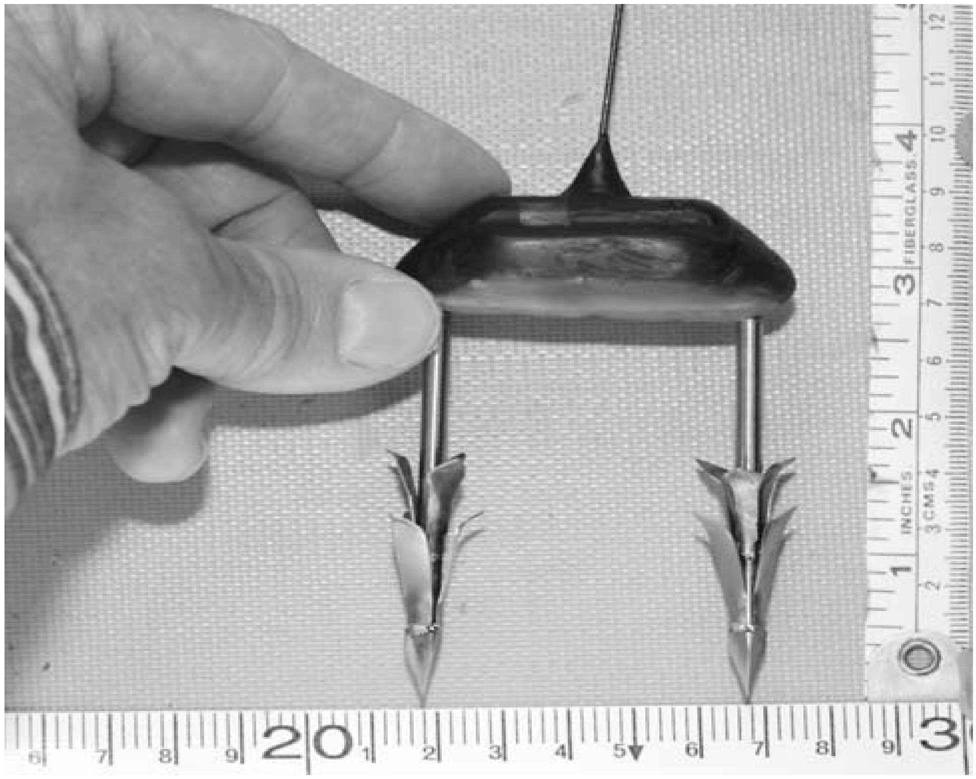

Figure 1. Implantable satellite tag proposed for use on southern resident killer whales.

Based upon previous work with killer whales and other odontocetes, tags should be expunged from the blubber via the healing process and hydrodynamic drag within three to twelve weeks post tagging (Andrews et al. 2008; Baird et al. 2010; Hanson et al. 2008; Schorr et al. 2010).

Methodology for approach, photography, and biopsy are included in the researchers' present permit and have already undergone consultation under the ESA. As the researchers do not propose any changes to these actions in association with the proposed tagging actions, approach, photography, and biopsy are outside the scope of the present consultation. Researchers will approach targeted individuals to within two to eight meters and deploy implantable tags with a pneumatic projector, crossbow, or pole. Tags will have previously been sterilized by a process of scrubbing with soap (removes oils), boiled and bleached (sterilization), soak in acetone (ensure dryness), soak in isopropyl alcohol (sterilization), and coated in antibiotic prior to storage in aluminum foil and a plastic bag. Researchers would aim for the middle of the dorsal fin, attempt to deploy the tag, and photograph the target site immediately after attachment.

Suction cups could also be deployed using a pneumatic projector, crossbow, or pole. Since no component would break the skin, no disinfection or pretreatment is proposed for suction cup tags. The target area is between the blowhole and dorsal fin, erring towards the dorsal fin so as not to risk obstructing the blowhole. Suction cup tags would be similar to those currently used ranging in size up to 20 cm long, 5 cm wide, and 500 grams. Suction cup tags typically remain attached for under 24 hours on killer whales (mean of 10 hours), but have remained attached for as long as 79 hours.

Approach to the assessment

The NMFS approaches its Section 7 analyses of agency actions through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The result of this step includes defining the *action area* for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *response analyses*).

The final steps of our analyses – establishing the risks those responses pose to listed resources – are different for listed species and designated critical habitat (these represent our *risk analyses*). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. The continued existence of these "species" depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them – populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individuals' "fitness," or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during our response analyses) are likely to have consequences for the individual's fitness.

When individual, listed plants or animals are expected to experience reductions in fitness in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (see Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (e.g., Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals is a *necessary* condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always *sufficient* to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established in the *Environmental baseline* and *Status of listed resources* sections of this Opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always *sufficient* to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of listed resources* section of this Opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on all of the evidence available to us. This evidence consists of monitoring reports submitted by past and present permit holders, reports from NMFS Science Centers; reports prepared by natural resource agencies in States and other countries, reports from non-governmental organizations involved in marine conservation issues, the information provided by the Permits Division when it initiates formal consultation, and the general scientific literature.

We supplement this evidence with reports and other documents – environmental assessments, environmental impact statements, and monitoring reports – prepared by other federal and state agencies like the Minerals Management Service, U.S. Coast Guard, and U.S. Navy whose operations extend into the marine environment.

During the consultation, we conducted electronic searches of the general scientific literature using search engines, including Agricola, Ingenta Connect, Aquatic Sciences and Fisheries Abstracts, JSTOR, Conference Papers Index, First Search (Article First, ECO, WorldCat), Web of Science, Oceanic Abstracts, Google Scholar, and Science Direct.

We supplemented these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically tried to identify data or other information that supports a particular conclusion as well as data that do not support that conclusion. When data were equivocal or when faced with substantial uncertainty, our decisions are designed to avoid the risks of incorrectly concluding that an action would not have an adverse effect on listed species when, in fact, such adverse effects are likely (i.e., Type II error).

In this particular assessment, we identified the stressors associated with the action and evaluated which had a significant possibility of occurring based upon previous research. Of the probable stressors, we identified the species that were expected to co-occur with the effects of the action.

Action area

The applicant proposes to undertake tagging wherever the opportunity arises, including shore-based day operations as well as research cruises. This means that tagging could occur anywhere in the southern resident killer whale's range, including waters as far north as the Queen Charlotte Islands and as far south as Monterey, California. However, sightings in these Pacific-coast locations are rare and we expect most or all tagging to occur in waters of Puget Sound, the San Juan Straits, and adjacent inland waters of the U.S. and along the nearshore Pacific coast of Washington State.

Status of listed resources

The only listed resources that would co-occur in time and space with the tagging action are southern resident killer whales, which are listed as endangered, and their critical habitat. The primary constituent elements of the critical habitat are: water quality to support growth and development, prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth, and passage conditions to allow for migration, resting, and foraging. As we were unable to identify any stressor associated with the proposed action that could affect these aspects of critical habitat, we discount the possibility of the proposed action affecting critical habitat for southern resident killer whales.

Southern resident killer whale

Description of the species. Southern resident killer whales compose a single population that occurs primarily along Washington State and British Columbia. The listed entity consists of three family groups, identified as J, K, and L pods.

Distribution. Occurrence is throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as the Queen Charlotte Islands, British Columbia. However, there is limited information on the range of southern residents along the outer Pacific Coast, with only 25 confirmed sightings of J, K, and L pods between 1982 and 2006 (Krahn et al. 2004a).

Movement and habitat. Southern residents are highly mobile and can travel up to 160 miles per day (Baird 2000a; Erickson 1978a). Members of K and L pods once traveled a straight line distance of 940 km from the northern Queen Charlotte Islands to Victoria, Vancouver Island, in seven days. Movements may be related to food availability.

Southern resident killer whales spend a significant portion of the year in inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound, particularly during the spring, summer, and fall, when all three pods are regularly present in the Georgia Basin (defined as the Georgia Strait, San Juan Islands, and Strait of Juan de Fuca) (Felleman et al. 1991; Heimlich-Boran 1988; Olson 1998; Osborne 1999). Typically, K and L pods arrive in May or June and primarily occur in this core area until October or November. Late spring and early fall movements of southern residents in the Georgia Basin have remained fairly consistent since the early 1970s, with strong site fidelity shown to the region as a whole (NMFS 2005b). During late fall, winter, and early spring, the ranges and movements of the southern residents are less well known. Offshore movements and distribution are largely unknown for the southern resident population.

While the southern residents are in inland waters during the warmer months, all of the pods concentrate their activities in Haro Strait, Boundary Passage, the southern Gulf Islands, the eastern end of the Strait of Juan de Fuca, and several localities in the southern Georgia Strait (Felleman et al. 1991; Ford et al. 2000; Heimlich-Boran 1988; Olson 1998). Individual pods are similar in their preferred areas of use, although there are some seasonal and temporal differences in certain areas visited (Olson 1998). For example, J pod is the only group to venture regularly inside the San Juan Islands. The movements of southern resident killer whales relate to those of their preferred prey, salmon. Pods commonly seek out and forage in areas where salmon occur, especially migrating salmon (Heimlich-Boran 1986; Heimlich-Boran 1988; Nichol and Shackleton 1996).

Members of different pods do interact, but members generally remain within their matrilinear groups (Parsons et al. 2009). However, additional interaction between pods has occurred over the past two decades, possibly in association with the decline of the southern resident population as a whole (Parsons et al. 2009).

Feeding. Southern resident killer whales are fish eaters, and predominantly prey upon salmonids, particularly Chinook salmon but are also known to consume more than 20 other species of fish and squid (Ford and Ellis 2005; Ford and Ellis 2006; Ford et al. 2000; Ford et al. 1998; Saulitis et al. 2000; Scheffer and Slipp 1948). Killer whales show a strong preference for Fraser River Chinook salmon (78% of identified prey) during late spring to fall (Ford and Ellis 2006; Hanson et al. 2010b; Hanson et al. 2005). Chum salmon are also taken in significant amounts (11%), especially in autumn. Chinook are preferred despite much lower abundance in comparison to other salmonids (such as sockeye) presumably because of the species' large size, high fat and energy content, and year-round occurrence in the area. Killer whales also captured older (i.e., larger) than average Chinook (Ford and Ellis 2006). Throughout inland waters from May to September, southern resident killer whale diet is approximately 88% Chinook (Hanson et al. 2007; Hanson et al. 2010a), with a shift to chum salmon in fall. Little is known about the winter and early spring diet of southern residents. Recent studies suggest that members of L pod have undergone dietary shifts from Chinook salmon during fall months over the past decade (Krahn et al. 2009). Southern resident killer whales appear to be more sensitive to vessel disturbance while feeding than during other activities (Ashe et al. 2010). An area to the southwest of San Juan Island appears to be a foraging "hotspot" (Ashe et al. 2010)

Growth and reproduction. Female southern resident killer whales give birth to their first surviving calf between the ages of 12 and 16 years (mean ~ 14.9 years) and produce an average of 5.4 surviving calves during a reproductive life span lasting about 25 years (Matkin et al. 2003; Olesiuk et al. 1990a). Females reach a peak of reproduction around ages 20-22 and decline in calf production gradually over the next 25 years until reproductive senescence (Ward et al. 2009a). Older mothers tend to have greater calving success than do their younger, less-experienced counterparts (Ward et al. 2009b). Calving success also appears to be aided by the assistance of grandmothers (Ward et al. 2009b). The mean interval between viable calves is four years (Bain 1990). Males become sexually mature at body lengths ranging from 17 to 21 feet, which corresponds to between the ages of 10 to 17.5 years (mean ~ 15 years), and are presumed to remain sexually active throughout their adult lives (Christensen 1984; Duffield and Miller

1988; Olesiuk et al. 1990a; Perrin and Reilly 1984). Most mating is believed to occur from May to October (Matkin et al. 1997; Nishiwaki 1972; Olesiuk et al. 1990a). However, conception apparently occurs year-round because births of calves are reported in all months. Newborns measure 2.1-2.7 m long and weigh about 200 kg (Clark et al. 2000; Ford 2002; Nishiwaki and Handa 1958; Olesiuk et al. 1990a). Mothers and offspring maintain highly-stable, life-long social bonds and this natal relationship is the basis for a matrilineal social structure (Baird 2000a; Bigg et al. 1990; Ford et al. 2000). Some females may reach 90 years of age (Olesiuk et al. 1990a).

Diving. Killer whales tend to make relatively shallow dives. Of 87 tagged individuals in the Pacific Northwest, 31% of dives were less than 30 m deep (Baird et al. 2003a). However, a free-ranging killer whale was recorded to dive to 264 m off British Columbia (Baird et al. 2005). The longest duration of a recorded dive was 17 minutes (Dahlheim and Heyning 1999).

Status and trends. Southern resident killer whales have been listed as endangered since 2005 (70 FR 69903). In general, there is little information available regarding the historical abundance of southern resident killer whales. Some evidence suggests that, until the mid- to late-1800s, the southern resident killer whale population may have numbered more that 200 animals (Krahn et al. 2002a). This estimate was based, in part, on a recent genetic study that found that the genetic diversity of the southern resident population resembles that of the Northern residents (Barrett-Lennard 2000; Barrett-Lennard and Ellis 2001), and concluded that the two populations were possibly once similar in size. Unfortunately, lack of data prior to 1974 hinders long-term population analysis (NMFS 2005b). The only pre- 1974 account of southern resident abundance is from Sheffer and Slipp (1948) and merely notes that the species was “frequently seen” during the 1940s in the Strait of Juan de Fuca, northern Puget Sound, and off the coast of the Olympic Peninsula, with smaller numbers along Washington’s outer coast. Olesiuk et al. (1990a) estimated the southern resident population size in 1967 to be 96 animals. Due to demand for marine mammals in zoos and marine parks, it is estimated that 47 killer whales, mostly immature, were taken from the southern resident population for public display between 1967 and 1973. By 1971, the level of removal decreased the population by about 30% to approximately 67 individuals (Olesiuk et al. 1990a). The population then went through periods of decline and expansion for more than two decades. At the end of an 11-year growth cycle in 1995, the three southern resident pods – J, K, and L, reached a peak of 98 animals (NMFS 2008b).

More recently, the southern resident population has continued to fluctuate in numbers. After growing to 98 whales in 1995, the population declined by 17% to 81 whales in 2001 (-2.9% per year) before another slight increase to 84 whales in 2003 (Carretta et al. 2005; Ford et al. 2000). The population grew to 90 whales in 2006, although it declined to 87 in 2007 (NMFS 2008b). A recent population abundance estimate of 87 southern residents consists of 25 whales in J pod, 19 whales in K pod, and 43 whales in L pod (NMFS 2008b). Surveys during July 2010 support 88 individuals currently in the population (Balcomb 2010).

Natural threats. The recent decline, unstable population status, and population structure (e.g., few reproductive age males and non-calving adult females) continue to be causes for concern. Moreover, it is unclear whether the recent increasing trend will continue. The relatively low number of individuals in this population makes it difficult to resist/recover from natural spikes in mortality, including disease and fluctuations in prey availability (NMFS 2008b). Although disease outbreaks have not been identified in this population, increased contaminant load (see below) may increase the susceptibility of individuals to disease.

Anthropogenic threats. Numerous threats to the continued survival of southern resident killer whales have been identified (NMFS 2008b). Many of these are human in origin. The primary prey of killer whales, salmon, has been severely reduced due to habitat loss and overfishing of salmon along the West Coast (Gregory and Bisson 1997a; Lackey 2003; Lichatowich 1999; NRC 1996; Pess et al. 2003; Schoonmaker et al. 2003; Slaney et al. 1996). Several salmon species are currently protected under the ESA, and are generally well below their former numbers. A 50% reduction in killer whale calving has been correlated with years of low Chinook salmon abundance (Ward et al. 2009a).

Critical habitat. Critical habitat for the DPS of southern resident killer whales was designated on November 29, 2006 (71 FR 69054). Three specific areas were designated; (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, which comprise approximately 2,560 square miles of marine habitat. Three essential factors exist in these areas: water quality to support growth and development, prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth, and passage conditions to allow for migration, resting, and foraging. Water quality has declined in recent years due to agricultural run-off, urban development resulting in additional treated water discharge, industrial development, and oil spills. The primary prey of southern residents, salmon, has also declined due to overfishing and reproductive impairment associated with loss of spawning habitat. The constant presence of whale-watching vessels and growing anthropogenic noise background has raised concerns about the health of areas of growth and reproduction as well.

Environmental baseline

By regulation, environmental baselines for Opinions include the past and present impacts of all state, federal, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR §402.02). The *Environmental baseline* for this Opinion includes the effects of several activities affecting the survival and recovery of ESA-listed species in the action area.

Climate change

In general, based on forecasts made by the Intergovernmental Panel on Climate Change (IPCC), climate change is projected to have substantial effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the near future (IPCC 2000; IPCC 2001a; IPCC 2001b; IPCC 2002). From 1906 to 2006, global surface temperatures have risen 0.74º C and continue to rise at an accelerating pace; 11 or the 12 warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed species occur) is warming faster than the Southern Hemisphere, although land temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). Climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown.

Climate change has been linked to changing ocean currents as well. Rising carbon dioxide levels have been identified as a reason for a poleward shift in the Eastern Australian Current, shifting warm waters into the Tasman Sea and altering biotic features of the area (Poloczanska et al. 2009). Similarly, the Kuroshio Current in the western North Pacific (an important foraging area for juvenile sea turtles and other listed species) has shifted southward as a result of altered long-term wind patterns over the Pacific Ocean (Poloczanska et al. 2009).

Climate change would result in changes in the distribution of temperatures suitable for whale calving and rearing, the distribution and abundance of prey and abundance of competitors or predators. For species that undergo long migrations, individual movements are usually associated with prey availability or habitat suitability. If either is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). Although effects to southern resident killer whales are not known, impacts to other marine mammals have been documented. Climate change can influence reproductive success by altering prey availability, as evidenced by low-success of northern elephant seals during El Niño periods, when cooler, more productive waters are associated with higher first year pup survival (McMahon and Burton. 2005). Reduced prey availability resulting from increased sea surface temperatures has also been suggested to explain reductions in Antarctic fur seal pup and harbor porpoise survival (Forcada et al. 2005; Macleod et al. 2007). Polygamous marine mammal mating systems can also be perturbated by rainfall levels, with the most competitive grey seal males being more successful in wetter years than in drier ones (Twiss et al. 2007). Sperm whale females were observed to have lower rates of conception following unusually warm sea surface temperature periods (Whitehead 1997). Marine mammals with restricted distributions linked to water temperature may be particularly exposed to range restriction (Issac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based upon expected shifts in water temperature, 88% of cetaceans would be affected by climate change, 47% would be negatively affected, and 21% would be put at risk of extinction. Of greatest concern are cetaceans with ranges limited to non-tropical waters and preferences for shelf habitats, such as southern resident killer whales (Macleod 2009). Variations in the recruitment of krill and the reproductive success of krill predators correlate to variations in sea-surface temperatures and the extent of sea-ice cover age during winter months. Although the IPCC (2001b) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran et al. (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20% since the 1950s.

Climate change poses significant hazards to salmonids along the west coast, which are the primary prey of southern resident killer whales. Paleoecological data (which exclude anthropogenic influences) suggest regional and global climate factors on decadal, centennial, and millennial time scales are tied to abundance patterns of Pacific salmonids (Finney et al. 2009). Increases in global temperatures are likely to have profound effects on salmonids directly and indirectly through altered hydrological regimes. Increases in instream temperatures may decrease habitat available for refugia, increase species interactions and competition, accelerate incubation timing and premature emergence, increase susceptibility to parasites and disease, reduce fry survival, delay migration and spawning, and accelerate loss of energy reserves. Using emission scenarios from the IPCC, O'Neal (2002) estimates that direct thermal changes in freshwater temperatures could cause the loss of between 4-20% of existing salmon and trout habitat by the year 2030, 7-34% by 2060, and 14-42% by 2090, depending on the trout or salmon species, IPCC emission scenario considered, and the model used. Projected salmon habitat loss would be most severe in Oregon and Idaho, with losses of 40% or greater of 2007 habitat estimates. While the predicted losses are substantial, the estimates may underestimate the overall effect global climate change will have on salmon and trout abundance since these models do not consider the related effects from changes in seasonal hydrological patterns and water volumes that result from altered weather patterns and precipitation (O'Neal 2002).

Changes in hydrological regimes are closely linked to salmon abundance (Hicks et al. 1991). From studies that have examined the effects of timber harvest and other changes in land use patterns, we know that changes in hydrology (i.e., increased peak flows, decreased low flows, altered timing discharge events, and rapid fluctuations in flows) can profoundly affect salmon abundance and the amount and availability of quality habitat. Hydrology is strongly correlated to in-redd and young-of-the-year survival, can lead to the displacement of young fish, alter immigration and emigration timing, affect the volume of available habitat by affecting channel structure (e.g., pool to riffle ratios, debris loading, substrate composition, erosion and sediment loading) and the relative abundance of salmon and trout species within a watershed, as well as the relative abundance of age-classes (Gregory and Bisson 1997b; Hicks et al. 1991).

Upstream changes in riverine habitat can affect downstream estuarine ecosystems through alterations in sediment delivery (timing and volume), and changes in freshwater volumes and timing can influence the volume of the spring/summer salt-wedge (O'Neal 2002). In turn, changes in the trophic dynamics of the estuary may occur. At the same time, physical changes in the ocean associated with warming include increases in temperature, increased water column stratification, and changes in the intensity and timing of coastal upwelling. These changes will alter primary and secondary productivity, the structure of marine communities, and, in turn, the growth, productivity, survival, and migration of salmonids. Changing ocean temperatures may alter salmonid behavior, distribution, and migration, increasing the distance from home streams to ocean feeding areas. If salmon migrate farther to the north and/or food is less available, longer times may be required to reach maturity, delaying return of adult migrations into coastal water and rivers. Energetic demands increase at warmer temperatures, requiring increased feeding to maintain growth. This could lead to intensified competition for food and/or reduction in growth rates, further exacerbating the prey/predator relationship. Increasing concentrations of carbon dioxide in the oceans lowers pH, which reduces the availability of carbonate for shell-forming marine animals. Pteropods, which can comprise more than 40% of some salmon diets, are expected to be negatively affected.

Foraging is not the only potential aspect that climate change could influence. Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence. Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Simmonds and Eliott. 2009). It has also been suggested that increases in harmful algal blooms could be a result of increases in sea surface temperature (Simmonds and Eliott. 2009).

Species that are shorter-lived, have larger body sizes, or are generalist in nature are liable to be better able to adapt to climate change over the long term versus those that are longer-lived, smaller-sized, or rely upon specialized habitats (Brashares 2003; Cardillo 2003; Cardillo et al. 2005; Issac 2009; Purvis et al. 2000). Climate change is likely to have its most pronounced effects on species whose populations are already in tenuous positions (Isaac 2008). As such, we expect the risk of extinction to listed species to rise with the degree of climate shift associated with global warming.

Naturally-occurring climatic shifts, such as the Pacific Decadal Oscillation, El Niño, and La Niña can strongly influence marine productivity, including southern resident killer whales and the prey they rely upon (Beamish et al. 1999; Benson and Trites. 2002; Francis et al. 1998; Hare et al. 1999; Mantua et al. 1997). Cooler periods appear to promote coastal biological productivity in the action area and warmer phases have the opposite effect (Hare et al. 1999; NMFS 2008c). Changes in ocean temperature also directly influence salmon abundance in the Strait of Juan de Fuca and the vicinity of the San Juan Islands. In years when ocean conditions are cooler than usual, the majority of sockeye salmon returning to the Fraser River do so via this route, but when warmer conditions prevail, migration patterns shift to the north through Johnstone Strait, altering the value of foraging habitat for southern resident killer whales from year-to-year (Groot and Quinn 1987). Southern residents and their prey are also likely to experience impacts from human-induced climate change, including alteration of snowfall, rainfall, and stream flow patterns, oceanic winds and currents, and higher sea levels (altering estuarine ecology; critical for salmonid transition from freshwater to marine habitats; (Glick 2005; NMFS 2008c; Snover et al. 2005). At present, salmonid abundance within Puget Sound appears to be stable or increasing largely due to the strong performance of pink and hatchery-raised chum salmon, which are at or near historic levels of abundance for the past 20-25 years (Hard et al. 1996; Johnson et al. 1997; NMFS 2008c; WDFW 2004).

Naval activities

The Puget Sound area is home to a naval training range and a large number of naval vessels. However, Navy vessels only constitute <1% of the radiated engine sound inside the western half of the Strait of Juan de Fuca and off the Washington coast (NMFS 2006b). Although naval vessels represent a small fraction of the total sound level and are designed to operate quietly, these ships are large and equipped with high-output sonar equipment such as ANISQS-53C tactical sonar, which produces signals at source levels of 235 dB re 1 μPa_{rms} at 1 m. The signals emitted from these devices have the potential to affect killer whales in the action area; however, empirical data are limited. An event that occurred in the Strait of Juan de Fuca and Haro Strait on May 5, 2003 demonstrates the potential for naval activities to impact southern resident killer whales. The U.S. Navy guided missile destroyer U.S.S. *Shoup* passed through the strait operating its mid-frequency sonar during a training exercise. Members of the southern resident killer whale J pod were in the Strait at the same time and exhibited unusual behaviors coincident with exposure to the sonar, as reported by local researchers (Commander U.S. Pacific Fleet 2003; NMFS 2005a; NMFS 2006b). Based on the duration of exposure, the received levels experienced by the whales, and information on sound levels known to cause behavioral reactions in other cetaceans, NMFS concluded J pod was exposed to levels likely to cause behavioral disturbance, but not temporary or permanent hearing loss (NMFS 2005a; NMFS 2006b).

Only a few Navy vessels operating in the greater Puget Sound area are equipped with mid-range frequency active sonar. Typically, use of this sonar in Puget Sound is limited to pier-side system maintenance and training on designated ranges (NMFS 2006b). As a precautionary measure, any ship, submarine, or unit interested in using active mid-frequency sonar in Puget Sound, including the Strait of Juan de Fuca, is required to obtain prior permission from the Commander, U.S.

Pacific Fleet (NMFS 2006b). The Canadian military also uses this area for ordnance training and testing operations, at a munitions testing area near Bentinct Island and Peddler Bay at the southern tip of Vancouver Island (NMFS 2006b). Underwater detonations are sometimes performed at this site and there was an occasion when J pod was less than 1.5 km away when a blast occurred, which caused the whales to suddenly change their direction of travel (NMFS 2006b). The U.S. Navy also maintains and operates several ordnance training locations in Puget Sound; however these activities include procedures for ensuring that marine mammals are not in the vicinity activities are likely to have little effect on these species (NMFS 2008c).

During a year of activities, naval vessels undertake roughly 7,000 steaming hours in the Northwest Training Range (northern California to Washington, including Puget Sound), of which ~2,600 is during training activities (Commander U.S. Pacific Fleet 2010). Although this is a small component of the total vessel traffic in the Puget Sound and Juan de Fuca Straits, this does add to the ambient noise of the region, which as a whole can impact foraging efficiency, communication, energy expenditure, as well as effects from chronic stress responses such as reduced immune function (Gordon and Moscrop. 1996; Holt 2008; NMFS 2008c). Approximately 150 items of explosive ordnance (30 bombs and missiles and 124 explosive sonobuoys) would be used in the training area each year (Commander U.S. Pacific Fleet 2010). These explosive devices produce shockwaves that at close to intermediate range can cause mortality, serious injury, or changes in hearing (permanent or temporary) and cause behavioral changes in listed species further out from the blast (Commander U.S. Pacific Fleet 2010). Aircraft (which generate noise that can be transmitted into water and startle whales, possibly through the sudden presence of a shadow) fly roughly 6,800 sorties annually (Commander U.S. Pacific Fleet 2010). Seven different sonar systems are used in the Northwest training range by the Navy, ranging from 42 to 896 hours of use for each system and totaling roughly 1,400 hours of total use (Commander U.S. Pacific Fleet 2010).

Habitat degradation and loss

The Puget Sound area has experienced severe and widespread habitat loss since European settlement began; 60% of intertidal habitats have been eliminated in Puget Sound and another 20% in the Haro Straits (Hutchinson 1988). The Duwamish, Lummi, Puyallup, and Samish river deltas have lost 90% of their marshland; 75% of marshes in the greater Puget Sound area are gone (Schmitt et al. 1994; Simenstad et al. 1982). Significant declines have also occurred for mudflat and sandflat habitats (Levings and Thom 1994).

Numerous projects are currently underway that may further degrade local habitat, or serve to recover it. The Hood Canal Bridge has been undergoing replacement and retrofitting since 2006 (Commander U.S. Pacific Fleet 2010). Public boat ramps at Point Whitney are being upgraded and expanded by the Washington Department of Fish and Wildlife (Commander U.S. Pacific Fleet 2010). This project has the potential to impact Pacific herring and epibenthic organisms and infauna that utilize eelgrass habitat in the boat ramp area (Commander U.S. Pacific Fleet 2010). Fred Hill Materials is proposing to construct a shipping facility and loading dock along the western shore of Hood Canal. Apart from the destruction of shoreline habitat, this would also increase the amount of vessel traffic in Hood Canal (Commander U.S. Pacific Fleet 2010). A 253-acre, 1,090 unit, 18-hole golf resort and community, including boat ramp, is also planned for construction near Brinnon and Babob Bay (Commander U.S. Pacific Fleet 2010). A 200-acre restoration project for Crescent Harbor marsh (Whidbey Island) is underway that will, in part, restore significant amounts of juvenile salmon habitat (Commander U.S. Pacific Fleet 2010).

In-water construction activities (e.g., pile driving associated with shoreline projects) in both inland Washington waters as well as coastal waters in the action area can produce sound levels sufficient to disturb marine mammals under some conditions. Pressure levels from 190-220 dB re 1 μPa were reported for piles of different sizes in a number of studies (NMFS 2006b). The majority of the sound energy associated with pile driving is in the low frequency range (<1,000 Hz) (Illingworth and Rodkin Inc. 2001; Illingworth and Rodkin Inc. 2004; Reyff 2003). Dredging operations also have the potential to emit sounds at levels that could disturb marine mammals. Depending on the type of dredge, peak sound pressure levels from 100 to 140 dB re 1 μPa were reported in one study (Clarke et al. 2003). As with pile driving, most of the sound energy associated with dredging is in the low-frequency range, **<**1000 Hz (Clarke et al. 2003).

Several measures have been adopted to reduce the sound pressure levels associated with in-water construction activities or prevent exposure of marine mammals to sound. For example, a six-inch block of wood placed between the pile and the impact hammer used in combination with a bubble curtain can reduce sound pressure levels by about 20 dB (NMFS 2008c). Alternatively, pile driving with vibratory hammers produces peak pressures that are about 17 dB lower than those generated by impact hammers (Nedwell and Edwards 2002). Other measures used in the action area to reduce the risk of disturbance from these activities include avoidance of in-water construction activities during times of year when marine mammals or listed salmon may be present; monitoring for marine mammals during construction activities; and maintenance of a buffer zone around the project area, within which sound-producing activities would be halted when marine mammals enter the zone (NMFS 2008c).

Acoustic harassment devices

Acoustic harassment devices (AHDs) are another source of underwater sound that may occur in the action area and may be disruptive to southern resident killer whales. AHDs used at salmon aquaculture farms emit "loud" signals intended to displace harbor seals and sea lions and thereby reduce depredation (Petras 2003; NMFS 2008). However, these signals can also cause strong avoidance responses in cetaceans (Olesiuk et al. 2002). Morton and Symonds (2002) describe one AHD model that broadcasts a 10 kHz signal at 194 dB re 1 μPa at 1 m and was potentially detectable above ambient levels in open water for up to 50 km. Activation of AHDs at an aquaculture farm near northeastern Vancouver Island corresponded with drastic declines in the presence and use of nearby passages and inlets by both resident and transient killer whales (Morton and Symonds 2002. The only AHD still in use in Washington State operates at the Ballard locks in Seattle, where NMFS uses it to deter sea lions (NMFS 2008).

Fishing, entanglement, and shooting

The waters surrounding Washington State host extensive commercial and recreational fishing; in 2007, 180 million pounds of fish and invertebrates were harvested from state waters; of this, 15% was salmon (Commander U.S. Pacific Fleet 2010). Although closely regulated, there is the potential for overfishing, especially considering the selective nature of southern resident killer whale diets (Fraser River populations of Chinook salmon). Lost gill nets, purse seines, and longlines may foul and disrupt bottom habitats as well as create the potential for “ghost fishing,” where marine animals are continually trapped and die in derelict gear. Recent reports of entanglement are unknown, but Sheffer and Slipp (1948) documented several deaths of animals caught in gillnets between 1929 and 1943. Typically, killer whales are able to avoid nets by swimming around or underneath them (Jacobsen 1986; Matkin 1994). Recreational fishing also has the potential to affect fish habitats because of the large number of participants and the intense, concentrated use of specific habitats. Historically, killer whales have commonly been subject to shooting (some likely fatal) by fisherman due to perceived competition for target fish resources (Baird 2001; Haley 1970; Olesiuk et al. 1990b; Pike and Macaskie. 1969; Scheffer and Slipp. 1948). This practice has largely abated in the past few decades and is unlikely to occur today (Carretta et al. 2001; Young et al. 1993).

Vessel traffic

The action area experiences very high levels of vessel traffic from both commercial and recreational sources, producing the potential for ship strike, high ambient noise levels, and behavioral harassment of southern resident killer whales. Commercially, a quarter million vessels move within the Puget Sound region annually, with the Ports of Seattle and Tacoma combining to be the third largest port in the U.S. (www.washingtonports.org). These vessels include tankers, tugs, cargo containers, ferries, and a variety of other vessel types. Several cruise ships are also based out of Seattle. Recreationally, 244 marinas, nearly 40,000 moorage slips, and 331 boat launches are located within the Pacific Northwest, servicing 180,000 registered recreational vessels and countless vessels not requiring registration (WSDE 2006). Haro Strait, one of the regions primary shipping lanes, is frequently used by southern resident killer whales.

Ship strike

The presence of whales in shipping lanes leads to the potential for ship strikes of listed individuals. A total of six instances have been documented of northern and southern resident killer whales being struck by vessels since the 1990s, including lethal interactions (Baird 2001; Carretta et al. 2001; Carretta et al. 2004; Visser 1999; Visser and Fertl. 2000). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs.

Whale watching

It is difficult to precisely quantify or estimate the magnitude of the risks posed to southern resident killer whales by whale watching and recreational vessels in the coastal portion of the action area (NMFS 2008c). Commercial whale watching in Washington State has increased dramatically from small scale operations during the late 1970s to early 1980s to 13 vessels by 1988 and a total of 76 vessels (and over 500,000 people) in 2006 (Koski 2006; Koski 2007; NMFS 2008c; Osborne 1991). Most companies belong to the Whale Watch Operators Association Northwest, which has established whale viewing guidelines for commercial operators (WWOANW 2007). Currently, over 50% of vessels involved with whale watching are commercially owned, with the San Juan Islands and adjacent area also attracting large numbers of private boaters for recreational activities such as opportunistic viewing of killer whales (Koski 2007; NMFS 2008c). In addition, private floatplanes, helicopters, and small aircraft regularly take advantage of whale watching opportunities (MMMP 2002). Weather conditions in the Pacific Ocean in winter limit whale watching during winter months and activity is greatest during summer (NMFS 2008c). From May to September 2005, an average of over 19 boats (up to 94) surrounded southern resident killer whales on a daily basis (Koski 2006). In Washington State, southern resident killer whales are the primary target species, particularly in Haro Strait (Hoyt 2001; Hoyt 2002; NMFS 2008c).

The increase in whale watching traffic over the past two decades has resulted in increased exposure of southern resident killer whales to vessel traffic and sound emitted by it. Whale watching activities have the potential to affect southern resident killer whales in the action area, resulting in possible disturbance or displacement. Increasing anthropogenic sound levels in the Puget Sound region have been associated with increased call duration by southern resident killer whales when vessels are present (Erbe 2002; Foote et al. 2004). Vessels also appear to cause whales to alter their direction of travel (Williams et al. 2002a; Williams et al. 2002b). Furthermore, vessel presence has been linked to reduced foraging success and/or inhibiting foraging all together (Bain et al. 2006; Williams et al. 2006). Based on a study in Johnstone Strait, British Columbia, northern resident killer whales decreased feeding behaviors significantly and increased time engaging in behaviors which required less energy such as resting and socializing (Williams et al. 2006).

There is also concern that whales may habituate to increased vessel traffic and become more vulnerable to ship strikes (Swingle et al. 1993; Wiley et al. 1995). Whale watching activities have been cited as a possible important factor in the recent decline of southern resident killer whales (Bain 2002; Baird 2000b; Krahn et al. 2002c; NMFS 2008c; Wiles 2004). Whale watching activity may be an important habitat issue as well, given the high seasonal density of whale watching vessels targeting southern resident killer whales. The commercial whale watching season usually runs from April through October (with peak activity May through September), but small levels of whale watching occur year-round (Koski 2004; Koski 2007; Koski et al. 2005; NMFS 2008c).

Several studies have specifically examined the effects of whale watching on marine mammals, and investigators have observed a variety of short-term responses from animals, ranging from no apparent response to changes in vocalizations, duration of time spent at the surface, swimming speed, swimming angle or direction, respiration rate, dive time, feeding behavior, and social behavior (NMFS 2006b). Responses appear to be dependent on factors such as vessel proximity, speed, and direction, as well as the number of vessels in the vicinity (Au and Green. 2000; Corkeron 1995; Erbe 2002; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Watkins 1986; Williams et al. 2002a; Williams et al. 2002b). Foote et al. (2004) reported that southern resident killer whale call duration in the presence of whale watching boats increased by 10-15% between 1989-1992 and 2001-2003 and suggested this indicated compensation for a noisier environment. Finally, disturbance by whale watch vessels has also been noted to cause newborn calves to separate briefly from their mothers' sides, which leads to greater energy expenditures by the calves (NMFS 2006b).

Although numerous short-term behavioral responses to whale watching vessels are documented, little information is available on whether long-term negative effects result from whale watching, including for southern resident killer whales (NMFS 2006b). Both resident communities have shown strong site fidelity to their traditional summer ranges despite nearly 30 years of whale watching operations (NMFS 2006b).

Pollution

Due to rapid human population growth and urban development in the Puget Sound region (Grant and Ross. 2002), significant pollutant loads have led to generally poor water quality in the region, including Puget Sound itself (Grant and Ross. 2002; Long et al. 2001; NMFS 2008c). Some of these pollutants have apparently bioaccumulated in southern resident killer whales, with persistent organic pollutants now being found in high levels in killer whales along British

Columbia and Washington State (Koski 2007) and considered to pose the greatest pollution threat to southern resident killer whales (CBD 2001; Koski 2007; Krahn et al. 2002c; NMFS 2008c; Ross et al. 2000c). These pollutants have the potential to cause immune, endocrine, and reproductive system effects in killer whales; concern has been expressed by researchers that these pollutants may be a factor in the decline of southern resident killer whales (Baird 2001; Calambokidis et al. 1984; Darnerud 2003; de Wit 2002; Hall et al. 2003; Hayteas and Duffield. 2000; Krahn et al. 2004b; Krahn et al. 2007b; Krahn et al. 2004c; Krahn et al. 2002c; NMFS 2008c; Ross et al. 2000b; Ross et al. 2000c; Waring et al. 2004; Ylitalo et al. 2001). Exposure is believed to be primarily through diet (Hickie et al. 2001); salmon preyed upon by southern resident killer whales may also be at risk. In addition, several hundred new chemicals enter the global marine environment annually; many of these chemicals have unknown effects to any lifeform (Grant and Ross. 2002; NMFS 2008c). Encouragingly, many persistent organic pollutants have been banned in the U.S. and, over the past few decades, regulatory actions, Superfund clean-up, improved waste handling, and ongoing cleanup efforts have led to improvements in regional water quality (NMFS 2008c). This has led to decreasing levels of many organochlorine residues in the environment (EVS Environmental Consultants 2003; Grant and Ross. 2002; Gray and Tuominen 2001; Mearns 2001), although it may take up to 60 years for some chemicals to fall below levels known to cause health effects in marine mammals (Hickie et al. 2001).

Another significant form of pollution is from the petrochemical industry utilizing the Puget Sound region for transport and refining. Puget Sound is one of the leading petroleum refining centers in the U.S. with about 333 million barrels of crude oil and refined petroleum products transported through it annually (Puget Sound Action Team 2005). Inbound oil tankers carry crude oil to five major refineries in the sound, while outbound tankers move refined oil products to destinations along the U.S. west coast (Neel et al. 1997). In 2005, a total of 716 oil tankers passed through Washington's waters bound for ports in Puget Sound, Canada, and along the Columbia River (WSDE 2006). In general, the Strait of Juan de Fuca and areas near Washington's major refineries (located in Anacortes, Ferndale, Blaine, and Tacoma) are considered the locations most at risk of major spills in the action area (Neel et al. 1997; NMFS 2008c). Since the 1960s, there have been at least nine major oil spills of at least 2,222 barrels; the largest was over 50,000 barrels (Neel et al. 1997; Puget Sound Water Quality Action Team 2002).

In addition to the substantial volume of shipping traffic and the prevalence of petroleum refining centers in the action area, of equal or perhaps greater concern are the chronic small-scale discharges of oil, which together can be substantial (Clark 1997). These discharges originate from numerous sources, including the dumping of tank washings and ballast water by tankers, the release of bilge and fuel oil from general shipping, and the disposal of municipal and industrial waters. Chronic oil pollution kills large numbers of seabirds (e.g., (Wiese and Robertson 2004)); however, its impact on southern resident killer whales and other marine mammals is poorly documented (NMFS 2008c). In addition, the long-term effects of repeated ingestion of sub-lethal quantities of petroleum hydrocarbons on marine mammals are not well understood. As a result, the magnitude of the risks posed by oil discharges in the proposed action area is difficult to precisely quantify or estimate.

Live-captures for aquaria

Killer whales have been displayed in aquaria worldwide since the early 1960s. For 15 years, killer whales were collected from the wild to populate display facilities; all but one individual came from Washington State or British Columbia until 1976, when local laws banned captures (Hoyt 1990; NMFS 2006b). During this time, from 275-307 killer whales were captured, of which 55 were sent to aquaria, 12-13 died, and 208-240 were released or escaped. Of the individuals captured and displayed or killed, 70% (47 or 48 individuals) were southern resident killer whales, including 17 immature males, 10 immature females, nine mature females, and seven or eight mature males; 15 individuals were from K pod, five from L, and one from J (Baird 2001; NMFS 2006b; Olesiuk et al. 1990b). The selective removal of younger animals and males produced a skewed age and sex composition in the southern resident killer whale DPS, which probably affected its ability to recover (Olesiuk et al. 1990b).

Scientific and research activities

Scientific research permits issued by the NMFS currently authorize studies on listed species in the Pacific Ocean, including portions of the action area. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, suction cup tagging, and breath sampling. Research activities involve non-lethal "takes" of these whales by harassment, with none resulting in mortality. Since these "takes" have been authorized, we must assume that they will actually occur. However, monitoring of prior research activities suggests that only a fraction of the potential "takes" will actually occur.

Table 2 describes the cumulative number of takes for each listed species in the action area authorized in scientific research permits.

Table 2. Southern resident killer whale takes authorized in the Pacific Ocean.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Breath sampling
2009	3,050	45	45	0	105
2010	3,200	55	45	0	105
2011	2,160	35	45	0	105
2012	270	10	0	0	0
2013	270	10	0	0	0
Total	8,950	155	135	0	315

Permit numbers: 10045, 14097, 532-1822, 540-1811, 731-1774, 774-1714, 781-1824, 782-1719, and 965-1821.

Effects of the proposed action

Pursuant to section 7(a)(2) of the ESA, federal agencies must ensure, through consultation with the NMFS, that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed issuance of permit 781-1824-02 would authorize "takes" by harassment of southern resident killer whales during the proposed research by Brad Hanson and associated researchers by directed suction cup and implantable satellite tagging. In this section, we describe the potential physical, chemical, or biotic stressors associated with the proposed actions, the probability of individuals of listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (given probable exposures) based on the available evidence. As described in the *Approach to the Assessment* section, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the listed species those populations represent. The purpose of this assessment and, ultimately, of this Opinion is to determine if it is reasonable to expect the proposed action to have effects on listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

For this consultation, we are particularly concerned about behavioral, stress-based physiological disruptions, and pathology that may result in animals that fail to feed or breed successfully or fail to complete their life history because these responses are likely to have population-level consequences. The ESA does not define harassment nor has the NMFS defined the term pursuant to the ESA through regulation. For this Opinion, we define harassment similar to the U.S. Fish and Wildlife Service's regulatory definition of "harass": an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

Our analysis considers that behavioral harassment or disturbance is not limited to the "take" definition and may in fact occur in many ways. Fundamentally, if our analysis leads us to conclude that an individual changes its behavioral state (for example, from resting to traveling away from the approaching vessel or from traveling to evading), we consider the individual to have been harassed or disturbed. In addition, individuals may respond in a variety of ways, some of which have more significant fitness consequences than others. For example, evasion of an approaching vessel would be more significant than slow travel away from the same stressor due to increased metabolic demands, stress responses, and potential for habitat abandonment that this response could or would entail. As described in the *Approach to the assessment*, the universe of likely responses is considered in evaluating the fitness consequences to the individual and (if appropriate), the affected population and species as a whole to determine the likelihood of jeopardy.

Potential stressors

The assessment for this consultation identified several possible stressors associated with the proposed research activities; for the present permit amendment, this is limited to the application of suction cup and implantable tags.

Exposure analysis

Exposure analyses identify the ESA-listed species that are likely to co-occur with the actions' effects on the environment in space and time, and identify the nature of that co-occurrence. The *Exposure analysis* identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the actions' effects and the population(s) or subpopulation(s) those individuals represent. The proposed permit identifies these parameters and would allow for 10 suction cup tag deployments and six implantable tag deployments on southern resident killer whales annually. Post-reproductive females and adult males would be targeted for tagging. The same individuals targeted for tagging would also be exposed to other previously authorized activities, such as close approach and possibly biopsy, and breath sampling. A given individual would be implantably tagged a maximum of once annually, with up to two tagging attempts per day and no more than four per year.

Response analysis

As discussed in the *Approach to the assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after exposure to an action's effects on the environment or directly on listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (physiological), or behavioral responses that might result in reducing the fitness of listed individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

There is mounting evidence that wild animals respond to human disturbance in the same way that they respond to predators (Beale and Monaghan 2004; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). These responses manifest themselves as stress responses (in which an animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response or more serious physiological changes with chronic exposure to stressors), interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses (Frid 2003; Frid and Dill 2002; Romero 2004; Sapolsky et al. 2000; Walker et al. 2005). These responses have been associated with abandonment of sites (Sutherland and Crockford 1993), reduced reproductive success (Beale and Monaghan 2004; Giese 1996; Lordi et al. 2000; Mullner et al. 2004), reduced energy budget (Frid 2003), and the death of individual animals (Bearzi 2000; Daan 1996; Feare 1976). Stress is an adaptive response and does not normally place an animal at risk. However, distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal (HPA) axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Busch and Hayward 2009)(Gulland et al. 1999; Morton et al. 1995; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Thomson and Geraci 1986)(Gregory and Schmid 2001). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch and Hayward 2009; NMFS 2006g)(Cattet et al. 2003; Delehanty and Boonstra 2009; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancia et al. 2008; Moe and Bakken 1997; Noda et al. 2007; Thomson and Geraci 1986)(Dierauf and Gulland 2001; Omsjoe et al. 2009). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2008). In highly-stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Cowan and Curry 2008; Herraez et al. 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the HPA axis may persist for weeks (Dierauf and Gulland 2001).

Repeated exposure to stressors can negatively impact the health and viability of populations (Gregory and Schmid 2001).

Although external transmitting devices have been used by many researchers, few studies examine the possible effects of these devices (Culik et al. 1994; Hawkins 2004; Murray and Fuller 2000; White and Garrot 1990; Wilson and McMahon 2006). For example, Murray and Fuller (2000) surveyed a sample of articles in which vertebrates had been marked, covering nine journals that publish studies on a broad range of taxonomic groups, and found that in most instances (90% of 238 articles surveyed), the articles did not address potential effects of marking, or at least did not report that such effects had been considered. However, the attachment of a device has the potential to generate physiological and behavioral effects, depending on factors such as device weight, shape, and attachment location (Hawkins 2004; White and Garrot 1990). Effects of attached devices may range from subtle, short-term behavioral responses to long-term changes that affect survival and reproduction; attached devices may cause effects not detectable in observed behaviors, such as increased energy expenditure by the tagged animal (White and Garrot 1990; Wilson and McMahon 2006). Walker and Boveng (1995) concluded the effects of devices on animal behavior are expected to be greatest when the device-to-body size ratio is large. Although the weight and size of the device may be of less concern for larger animals such as cetaceans, there is still the potential for significant effects; for example, behavioral effects that may cause reduced biological performance, particularly during critical periods such as lactation (Walker and Boveng 1995; White and Garrot 1990).

Tagging has been conducted on a variety of marine mammal species, including pilot whales (Mate 1989), blue whales (2003; Calambokidis et al. 2001; 2007; Lagerquist et al. 2000; Mate et al. 2007), North Atlantic right whales (Goodyear 1993; Mate et al. 1997; Nowacek et al. 2001; Slay and Kraus 1998), southern right whales (Best and Mate 2007); humpback whales (Goodyear 1981; Goodyear 1989; Goodyear 1993; 2007; Mate et al. 1998; Watkins 1981b), fin whales (Mate et al. 2007; Mikkelsen et al. 2007; Panigada et al. 1999; Watkins 1981b; Watkins et al. 1984), sei whales (MAR-ECO 2005), sperm whales (Madsen et al. 2002; Watkins and Tyack 1991), beluga whales (Martin and Smith 1992), northern bottlenose whales (Hooker et al. 2001), Hector's dolphins (Stone et al. 1994), bottlenose dolphins (Schneider et al. 1998), Dall's porpoises (Baird and Hanson 1996), harbor porpoises (Eskesen et al. 2009), and narwhals (Martin et al. 1994). Dart tagging studies have not been well documented on southern resident killer whales; however, implanted or dart tagging studies have been conducted on other killer whale populations and ecotypes (Andrews et al. 2005; 2007 unpubl. data; Erickson 1978b), and suction cup tagging studies have also been conducted on killer whales (Baird 1994; 1998; Baird et al. 2003b; 2005). Although several tagging studies have been conducted on marine mammals, few have systematically investigated or recorded the effects on cetaceans from tagging, and available investigations into instrument effects on marine species are often limited to visual assessments of behavior (Walker and Boveng 1995). In addition, reactions to tagging are difficult to differentiate from reactions to close vessel approaches, because in all cases it is necessary to closely approach the whale to ensure proper tag placement.

Although satellite dart tags have not previously been widely used on the southern resident killer whale DPS, similar tags have been recently deployed on other populations of killer whales, and the results of those studies inform this assessment. Data on responses of killer whales to tagging are available from studies conducted on 32 individuals from four different lineages (Antarctic Type A and Type B, North Pacific residents and Transients) between January 2006 and

September 2007 (unpublished data from Andrews et al. cited in (NMFS 2008a)). Most of the tagged whales were adult or sub-adult males, and more than half (18) were reported to exhibit no immediate reaction to tagging. Nine whales exhibited a slight or very slight startle or shake in response to tagging. A moderate startle reaction was observed in two whales (both transients), and three whales responded to tagging by either a startle response (no magnitude noted) or a startle response combined with a roll or dive. Of these 32 whales, 13 individuals were resident ecotype killer whales. The reactions noted for the resident whales were consistent with the range of reactions noted for the larger data set encompassing all 32 killer whales (i.e., 7 no reaction, 5 slight or very slight startle, 1 startle and dive). The duration of tag attachments averaged 29 days up to a maximum of 65 days, similar to what is anticipated during the proposed study. Since this tagging work, follow-up studies in Alaska have re-photographed previously tagged individuals over periods ranging from days to two years. Researchers report the available data from tagged whales indicate no long-term behavioral reactions and negligible scarring that is difficult to detect at the tag site (unpublished data from Andrews et al.; K. Balcomb, personal communication cited in (NMFS 2008a)). For example, photographs of whale AK1 which was tagged twice – once on August 9, 2006 and again on June 12, 2007 – indicate that tags sites completely healed, with small localized swelling that eventually subsided leaving no visible irregularities on the dorsal fin (unpublished data from Andrews et al cited in (NMFS 2008a)).

Andrews et al. (2005) also used satellite dart tags on five resident killer whales in southeastern Alaska. Tags were deployed using a similar crossbow and with similar tags as the proposed study, but with one dart for attachment and a penetration depth of 3 cm. In September 2004, three killer whales were tagged in various locations on the dorsal fin and flank; the authors observed no reactions to tagging. Three weeks later one of the tagged whales was resighted and a small (1-cm or 0.4-in) but healed spot was observed at the tag site. The authors concluded this suggested minimal tissue reaction and quick healing time. In October 2004, two killer whales were tagged and no reaction was noted from either whale. The authors used video playback to confirm the absence of an observable behavioral response to tagging. Both of these whales were followed for approximately 2.5 hours after tagging during which they exhibited apparently normal behavior. The authors also noted that no bleeding was observed when tags struck the dorsal fin.

Erickson (1978b) reported on an earlier use of attached radio packages on the dorsal fin of two killer whales in the Pacific Northwest. Although these whales were equipped with a much larger radio package (1.4 kg) than the proposed satellite tags (40 g), information from this study informs our assessment of anticipated effects. The radio packages were affixed to the base of each dorsal fin using four surgical pins that pierced the fin. The author noted that attachment of the tag elicited no noticeable reaction from the whales, no bleeding from the pin sites, and no flinching or thrashing at any time during the attachment process. Whales were observed afterward to determine if disturbed by the package; however no behavioral aberrations were seen and the whale did not attempt to rub the transmitter or try to remove the package (Erickson 1978b). The two whales were later recaptured and examined; there was no evidence of tissue edema, skin irritation, or discharge suggestive of infection. The author also noted that blood samples showed no significant change in the blood characteristics of either whale, particularly the white blood cell count, coincident with the attachment of the radio package.

Although dart tagging studies on killer whales are limited, several studies using suction-cup attached tags on killer whales are available. These studies do not involve the use of invasive tags; however, whales are documented to respond to the strike of a tag and the results of these studies are also informative for this consultation. Baird (1994) attached suction cup TDR tags to three killer whales using a pole, noting that two reacted with a low-level response (flinch and roll) and one by swimming away. Using crossbow deployment, the author also tagged seven killer whales and noted no reaction in 43% of the whales and a low-level reaction in 57%. The author reported that whales were not more difficult to approach after tagging than before, and suggested their behavior was not greatly modified due to tagging. Baird (1998) reported on additional tagging studies using a crossbow-deployed, suction-cup tag on killer whales. Of over 160 attempts (41 successful), the author noted that responses were either no reaction or low-intensity and short duration responses such as flinching. Baird et al. (2003b) tagged eight southern resident killer whales with suction-cup tags and characterized killer whale behavior during the study as including social and travel behaviors; however, no description of behavioral or other responses to tagging were noted. Baird et al. (2005) reported on tagging studies of 34 southern resident killer whales using a suction-cup TDR tag. Males between 3–42 years of age and females between 3–60 years old were tagged at distances of approximately three to seven meters from the whale, using a crossbow. Immediate reactions included no reaction (24% in U.S. waters from 1997-2002) and low-to-moderate behavioral reactions consisting of a fast dive and a flinch or tail flick (76% in U.S. waters 1997-2002). No strong behavioral reactions were observed, and no changes in general behavioral state (e.g., travel, foraging) were seen immediately following tagging (Baird et al. 2005). In addition, acoustic monitoring of one event documented no change in sound production associated with the tagging.

Because implantable tags would penetrate the skin of targeted killer whales, their use poses a risk due to infection at the tag site. We assume that southern resident killer whales might respond separately to the strike of the dart tag and infection at the point of penetration. Limited information exists on the potential for infection at tag sites, which has not been the subject of much focused study in whales. However, some information from observations of tagged killer whales days to years after the use of implanted tags indicates complete healing with no signs of infection and negligible scarring (see Figures 3-5) (Brad Hanson, Cascadia Research Collective, pers. comm.). The only close study of a wound after tagging was based upon a gray whale that stranded dead 18 days post tagging; although the animals was decomposed, investigators found no evidence of infection at the tag site or other findings that suggested the tag/tagging process resulted in the animal's death (Weller 2008). Humpback whale survival does not appear altered by invasive tagging; seven individuals tagged in Alaska 20-30 years ago have been reidentified in recent years also in Alaska (Mizroch et al. 2008). We expect that southern resident killer whales would heal similar to other populations and ecotypes of killer whales. Disinfectants can be used to minimize risk of infection (Aguilar and Nadal 1984), and tag tips used in the proposed studies would be cleaned with acetone, iodine solution, and a topical antibiotic ointment would be applied to reduce the risk of infection. While it is recognized that there is a risk of infection at the tag site, this would be minimized by the use of sterile procedures at all times and the smallest tag possible.

Figure 3. Tagging site on pilot whale tagged 41 days after tagging with similar implantable tag as that proposed by the applicants. Photo credit: Dan McSweeney under permit 782-1719.

Figure 4. Tagging site of same pilot whale 138 post-tagging. Photo credit: Dan McSweeney under permit 782-1719.

Figure 5. Tagging site on transient killer whale tagged 547 days after tagging with similar implantable tag as that proposed by the applicants. Photo credit: Maya Sears under permit 781-1824-02.

Risk of significant bleeding during the tagging of killer whales is thought to be minimal. Andrews et al. (2005) concluded that the vasculature in the dorsal fin is likely controlled by sphincters and that the clotting and vessel healing properties would prevent any significant bleeding. Redundancy of vessels in the dorsal fin is expected to ensure thermoregulatory function even if a central vessel is compromised (Andrews et al. 2005). In addition, the account in Erickson (1978b) indicated that even after four surgical pins pierced through the base of the dorsal fin, no bleeding occurred at the pin sites. Bleeding during invasive techniques has occurred, though. Andrews et al. (2005) reported that killer whales in Norway and Iceland that had holes drilled into their dorsal fins sometimes experienced profuse bleeding; however, the bleeding ceased very quickly.

Whether any long-term effects resulting from tagging remain largely unknown and available information is limited. No research has been done to specifically assess the long-term impacts of tagging on killer whales. However, as described above, data from the resighting of previously tagged killer whales in Alaska days to years after tagging suggest no long-term behavioral reactions or physical damage (unpublished data from Andrews et al. K. Balcomb, personal communication cited in (NMFS 2008a)). For other whales, Goodyear (1989) noted that humpbacks monitored several days after being suction-cup tagged did not appear to exhibit altered behavior. In addition, Mate et al. (2007) found that tagged whales resighted up to three years later did not appear in poor health and did not appear to behave differently than untagged whales. Best and Mate (2007) used resighting data for previously tagged southern right whales to suggest that no major impact on reproductive output or short-term survival had occurred due to implanted tags.

To minimize the effects of dart tagging on southern resident killer whales, the permit requires researchers to only tag a killer whale in the dorsal fin, and to disinfect and sterilize tag barbs prior to and between each use. In addition, if a tag site becomes infected or does not heal properly, that animal may not be re-tagged at any time. A tagging attempt must be discontinued if an animal exhibits a strong adverse reaction to the activity or the vessel (such as breaching, tail lobbing, underwater exhalation, or disassociation from the group). Researchers would also apply "good practice" measures to minimize potential risks associated with tagging. Only qualified, experienced personnel with sufficient experience would perform the attachment of intrusive tags; that the attachment of invasive scientific instruments include the use of stoppers (in this case the tag itself acts as a stopper) to reduce the force of impact and limit the depth of penetration; and the use of the smallest possible tag size to minimize the potential for increased energetic costs of or behavioral responses to larger tags. Permit conditions to minimize the effects of tagging also address the potential for repeat disturbance of these species. The proposed permit limits tagging attempts on an individual to no more than twice daily and four times a year. The permit also requires coordination of the proposed activities with other permit holders conducting similar activities on the same species in the same locations or times of year.

Although not observed in southern resident killer whales, cetaceans of other social odontocete species have been known to remove tags from conspecifics or otherwise manipulate the tags (Irvine et al. 1979; Scott et al. 1990; White Jr. et al. 1981)(Robin Baird, Cascadia Research Collective, pers. comm.). This introduces the possibility of breakage of the tag and/or possible tag/component ingestion. We are not aware of a tag or its components being ingested, but we also lack information that documents this possibility. However, southern resident killer whales and virtually all other odontocete species are regularly exposed to marine debris of various types (both floating on the surface and items on the seafloor) that can be a proxy for the species propensity to ingest foreign objects. Ingestion of marine debris has not been documented in killer whales of the Pacific Northwest apart from ingestion of tags presumably attached to seals that were predated upon by transient killer whales (Brent Norberg, Lynne Barre, and Kristin Wilkinson, NMFS, pers. comm..s) and, based upon this, we expect the possibility of an individual removing and ingesting a telemetry tag to be very small.

We expect tag breakage may occur in some cases or situations. This is not unique to southern resident killer whales and was documented in other marine mammal taxa (Irvine et al. 1979; Scott et al. 1990). Although portions of the tags sometimes remained in the individual, where this has been investigated, the pieces were encapsulated and did not become infected (White Jr. et al. 1981). In another individual there was concern that a barb (unlike that proposed for use by the applicant) migrated further into the individual after its external components broke off, but no evidence to support or refute this was evident (White Jr. et al. 1981).

Two transient killer whales tagged with similar dart tags as those proposed for use under the proposed permit in 2010 have experienced significant wounds as a result of tagging and subsequent tag breakage. Follow-up photographic monitoring and review by expert marine mammal veterinarians, pathologists, and clinicians supports regional infection on the tag site over several months. The ultimate fate of broken tag components and, ultimately, the fate and fitness of the tagged individuals remains unclear at present, although poor overt health has not yet been observed and reproductive impacts are unknown. As a result of these instances, the manufacturer developed additional titanium plates and titanium nuts that tags proposed for use under the permit amendment. Testing by the manufacture has shown significant reductions in breakage potential of barbs compared to previous models. As a consequence, we do not expect breakage of barbs to occur under the permit amendment.

After reviewing available information on the responses of killer whales to both implanted and suction-cup tagging procedures, we do not expect any mortality to occur due to the tagging under permit amendment 781-1824-02. Injury from the implantable tags would be small and localized on the dorsal fin of targeted whales and is expected to heal completely and not result in any permanent scarring or other long-term physical damage. Rates of wound healing are expected to vary across regions and are not easily predicted in advance of the proposed tagging studies; however, photo and video monitoring would be conducted simultaneously and aid in determining wound healing or infection rates during the proposed studies. Resighting of tagged whales is expected to occur multiple times during the year, facilitating monitoring of tag sites for years afterwards. Individuals in this DPS are typically monitored and photographed dozens of times each year, allowing substantial opportunity for post-tagging monitoring.

Although tags have the potential to create hydrodynamic drag, which may have an effect on the tagged animal (Hooker et al. 2007), the proportion of the proposed tags to be used under permit amendment 781-1824-02 relative to the size and weight of the targeted whales is such that the energetic demand on the animal would likely be insignificant. We also believe there is minimal risk of non-target whales being hit with a dart tag given the close proximity of researchers to the targeted whale, the experience of researchers in positioning the vessel around this species, and the very low likelihood that a non-target whale would surface between the vessel and the target animal during a tagging attempt. In addition, due to the precision needed to obtain a successful tag attachment for maximum attachment time, tags would likely only be deployed under ideal circumstances. If the targeted whale is not in a good position, it is unlikely the tag would be deployed. This should also minimize the risk of any non-target whales being affected. A tether will not be employed for this research, so no entanglement risk exists.

Based on the available evidence, we would expect most killer whales exposed to tagging under the proposed permit to exhibit either no visible reaction or short-term low-level to moderate behavioral responses. We expect the short-term responses to tagging conducted under this permit amendment to last no more than a few minutes, and we do not anticipate that any behavioral changes would have long-term consequences for individual whales. Although the duration of tag attachment under permit amendment 781-1824-02 is expected to be an average of three weeks to three months, and perhaps longer, any disturbance of a tagged whale would be expected to occur during the approach of the researchers and during the delivery of the satellite tag (NMFS 2006a). Based on the available evidence, including the use of similar tags on other populations and ecotypes of killer whales in the North Pacific, we do not anticipate any strong behavioral responses to the use of the proposed tags. However, a substantial assumption is that southern resident killer whales will respond similarly as other populations of killer whales described above. Given that reactions of whales to activities can be highly context-dependent, and the fact that southern resident killer whales face conditions that are distinct from other ecotypes of killer whales, we assume that strong behavioral responses to the proposed tagging are possible but not likely.

Under permit amendment 781-1824-02, southern resident killer whales would be exposed to tagging between late fall and early spring in waters off the U.S. west coast and inland marine waters of Washington State. These areas include important foraging grounds for this species, and the proposed satellite tagging activities have the potential to interrupt foraging behaviors.

However, we expect any behavioral responses to tagging to be short-term, and accordingly we do not anticipate that responses to tagging conducted under this permit would result in reduced foraging opportunities for individual whales. Similarly, we do not anticipate that the short-term behavioral responses to tagging would result in any reduced opportunity for reproduction. In addition, the tagging studies, themselves, necessitate a tagged animal returning to its normal behavior after being tagged, because the purpose of these studies is to examine behavioral patterns such as whale distribution, movement, and habitat use.

Our use of behavior as an indicator of a whale's response to tagging may or may not accurately reflect the whale's experience, and we cannot definitively know whether such behavioral responses have long-term consequences. Responses to human disturbances, such as tagging, may manifest as stress responses, interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combination of these responses. Consistent with the findings of Andrews et al. (2005) described previously, we expect over half of the tagged whales would exhibit no observable reaction to tagging, and that at most a moderate behavioral response may occur for a smaller portion of tagged whales. Weinrich et al. (1992) associated "moderate" responses with alarm reactions and "strong" behavioral reactions with stress responses. Wild harbor porpoises restrained and tagged did not show consistent elevations in cortisol nor did heart rate change in ways consistent with a stress reaction (Eskesen et al. 2009); these actions are much more invasive that those proposed for southern resident killer whales. We do not expect any strong behavioral responses to result from tagging; however, permit conditions are expected to minimize risk in the event such a response should occur. Moderate responses might also be associated with a stress response, given that certain behavioral responses may have metabolic consequences. As a result, we assume the proposed tagging could be stressful for a small portion of the whales; however, the significance of this stress response and its consequences, if any, on the fitness of individual whales are not definitively known. However, the limited information available from Erickson (1978b) indicates that for a more invasive radio package attachment on the dorsal fin, the blood parameters of killer whales showed no significant change. Recognizing the conditions of the proposed permit and the evidence indicating that behavioral responses would be short-lived, we provisionally assume that the tagging activities could produce short-lived stress responses in some individuals, but would not lead to reduced foraging opportunities or negatively affect an individual's growth, survival, annual reproductive success, or lifetime reproductive success.

In summary, based on the evidence available, the experience of researchers; the proposed research protocol including the limited number of tags to be deployed, the absence of re-tagging within the same year, and the time interval between any re-tagging; as well as the permit conditions to be implemented with the proposed tagging studies, we expect all whales tagged under permit amendment 781-1824-02 would exhibit either no visible reaction or short-term behavioral responses to tagging. Strong behavioral responses are not expected during the proposed tagging studies, nor is significant bleeding or infection. We assume short-lived stress responses are possible in a few individuals as are short-term interruptions in behaviors such as foraging; however, we do not expect these responses to lead to reduced opportunities for foraging or reproduction for tagged individuals. Because any responses to tagging are expected to be short-lived, and assuming an animal is no longer disturbed after it returns to its pre-tagging behavior, we do not expect significant long-term consequences for tagged whales.

Cumulative effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered by this SEA. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Sources queried for the information herein include the State of Washington Department of Ecology and Office of Financial Management, NOAA's State of the Coast, the U.S. Census Bureau and Department of Labor, as well as Lexis-Nexis information system. With the latter (which was our source for state legislation), we reviewed bills passed in 2010 and pending bills under consideration were included as further evidence that actions "are reasonably certain to occur". Bills that died in process or were vetoed are not included in our review.

During the coming decades, increased human population growth, urbanization, and intensified land use are projected for western Washington and southern British Columbia adjacent to waters frequented especially by gradually expand and continue to reach the open North Pacific and the U.S. Pacific Northwest (NMFS 2008c). Environmental contamination is a persistent and long-term health risk for southern resident killer whales (Krahn et al. 2007a; NMFS 2008c; Ross et al. 2000a). In 2010 the Washington state legislature passed a bill limiting the use of copper in vehicle brake pads which is significant source of that contaminant found in Puget Sound. Overall, exposure of southern resident killer whales to most contaminants in the action area is not expected to appreciably decrease in the foreseeable future (Grant and Ross 2002; Krahn et al. 2002b; NMFS 2008c).

The U.S. Census Bureau projects the population of Washington State (the vast majority of which lives along Puget Sound, the San Juan Strait, or coastal Pacific waters where southern resident killer whales occur) is growing at an accelerated rate of 1.1% annually by 2010, 1.4% between 2010 and 2020, and 1.6% between 2020 and 2030 (USCB 2005a; USCB 2005b; USCB 2005c). Oregon should experience similar, although slower growth. Specifically, NOAA's State of the Coast which summarizes United States census data for coastal regions, indicates that all counties within the Washington and Oregon coastal watershed will show significant increases in population, with counties along the southern resident killer whale critical habitat having some of the largest growth (http://stateofthecoast.noaa.gov/). Washington's Office of Financial Management estimates an additional 700,000 people will be living in the Puget Sound Region over the next 10 years With this growth comes the related concern of increased toxic runoff and increased hard surface area that facilitate the runoff, reduced oxygen levels in the sound due to waste discharge, loss of habitat, and increased shoreline development.

The state of Washington has implemented a strategy to restore Puget Sound to a healthier condition in 2020. A Puget Sound Partnership was created by the governor and in 2008 the Puget Sound Action Agenda was released by the partnership. During the legislature's 2009 session, $78.5 million dollars was earmarked for various projects that would support the action agenda, indicating a concerted effort by the state to improve the Puget Sound environment.

Any future scientific studies targeting these species and contributing to their conservation or recovery will require consultation under the ESA and such studies, therefore, are not included in the *Cumulative Effects* section of this Opinion. Similarly, alternative energy projects such as ocean current, wave, and tidal energy projects are expected to increase within the action area and will require federal permits (e.g., Federal Energy Regulatory Commission (FERC)), so these actions are not included in the *Cumulative Effects* section of this Opinion. After reviewing available information, NMFS is not aware of effects from any additional future non-federal activities in the action area that would not require federal authorization or funding and are reasonably certain to occur during the foreseeable future.

Integration and synthesis of effects

As explained in the *Approach to the assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the population(s) those individuals represent or the species those populations comprise (Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if the assessment indicates that listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment. If possible, reductions in individuals' fitness are likely to occur, the assessment considers the risk posed to population(s) to which those individuals belong, and then to the species those population(s) represent.

The *Status of listed resources* discussion describes how southern resident killer whales affected by the actions outside the action area have been adversely affected by human-induced factors such as vessel activity, contaminants, and habitat loss of salmonid prey. Similarly, the actions discussed in the baseline, as well as those considered under *Cumulative effects* all pose the potential to result in take of southern resident killer whales resulting in stress or adverse sub-lethal impacts.

The research activities that would take place under the permit are not expected to result in mortality, but are likely to cause temporary stress to the animal, which is not expected to have more than short-term effects on individual whales. These non-lethal interactions will not affect a whale's ability to reproduce and contribute to the maintenance or recovery of the species. These effects are expected to be short-term because previous experience with the type of proposed research activities has demonstrated that it is reasonable to expect that effects will be minimal. This research will affect the whales by harassing individuals during the research thus raising levels of stressor hormones. Based on past observations of similar research, these effects are expected to dissipate within minutes. The NMFS does not expect any delayed effects on any individuals following tagging as a direct result of the research based on past research efforts by other researchers and adherence to certain protocols identified in the proposed action.

Conclusion

After reviewing the current status of southern resident killer whales; the *Environmental baseline* for the action area; the anticipated effects of the proposed activities; and the *Cumulative effects*, it is the NMFS' Opinion that the action (the Permits Division's issuance of a permit amendment for research activities on southern resident killer whales in the Pacific Northwest) is likely to adversely affect, but not likely to jeopardize the continued existence of this species or destroy/adversely modify designated critical habitat.

Incidental take statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibits the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

As discussed in the accompanying Opinion, only the target species will be harassed as part of the proposed actions. Therefore, we do not expect incidental take of threatened or endangered species as a result of the proposed actions.

Conservation recommendations

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

At this time, the Endangered Species Division has no conservation recommendations that would provide information for future consultations involving the issuance of permits that may affect listed resources as well as reduce harassment related to research activities.

In order for NMFS Endangered Species Division to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Permits Division should notify the Endangered Species Division of any conservation recommendations they implement in their final action.

Reinitiation notice

This concludes formal consultation on NMFS' proposal to issue Permit 781-1824-02 to Brad Hanson of the NMFS, Northwest Fisheries Science Center, pursuant to the provisions of section 10 of the ESA and MMPA. As provided in 50 CFR '402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of authorized take is exceeded, NMFS Permits, Conservation and Education Division must immediately request reinitiation of section 7 consultation.

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