What is the objective of satellite tagging southern resident killer whales?

NOAA Fisheries is mandated under the Endangered Species Act to develop a Recovery Plan for listed species, and completed a plan for Southern Resident Killer Whales (SRKW) in 2008. The Recovery Plan identifies the threats, data gaps, and research priorities for the population. One of the highest priorities identified for SRKW was to determine their coastal distribution in the winter. Although their summer range in inland waters is well defined, their coastal distribution, during the winter months, where they spend the vast majority of their time, is uncertain.

NMFS is also mandated to designate Critical Habitat for listed species. A prerequisite to Critical Habitat designation is determination of the area occupied by species and collection of location and habitat use data that are sufficient to determine "those physical and biological features that are essential to the conservation of a given species and that may require special management considerations or protection." Habitat features may include, but are not limited to, the following: (1) space for individual and population growth, and for normal behavior; (2) food, or other nutritional or physiological requirements; (3) sites for breeding, reproduction, rearing of offspring; and generally; (4) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. The designation of Critical Habitat adds an increased threshold of protection under section 7 of the ESA. Once critical habitat is designated, section 7 of the ESA requires Federal agencies to ensure that they do not fund, authorize, or carry out any actions that will destroy or adversely modify that habitat. This is in addition to the requirement that Federal agencies ensure their actions do not jeopardize the continued existence of listed species. Examples of Federal actions that have been analyzed for impacts to SRKW critical habitat include fisheries regulations, in-water construction projects, wastewater treatment at Federal facilities, and issuance of scientific research permits. A 5-year review of the status of SRKW completed in 2011 recommended "Increasing knowledge of coastal distribution, habitat use, and prey consumption to inform critical habitat determination, identify any unknown threats, and assess and minimize impacts of ongoing and new coastal activities (i.e., fisheries, alternative energy projects)."

How might satellite tag-derived location data be used for Critical Habitat designation?

NMFS was able to partially designate Critical Habitat for SRKWs within the inland waters of Washington due to the very large data set (approximately 54,000 sighting reports collected over the last 20 years) from opportunistic sightings available from a long-term sighting network. However, the paucity of SRKW sighting data from the outer coast (less than 50 sightings over the past 20 years), combined with their wide-spread range, stretching from Monterey Bay, California to the north end of the Queen Charlotte Islands, British Columbia, precluded NMFS from designating appropriate areas along the Pacific coast. Because there are so few locations over this long period, there are no discernible patterns of habitat use to allow for determination of essential features. Collection of movement data with satellite tags can provide spatially

unbiased data over a short temporal scale to be able to assess occurrence and movement patterns that indicate specific areas of importance. Data from satellite tags can also fill in key data gaps, such as how far offshore the range of the SRKW extends, and data can direct studies, such as ship cruises, working to identify habitat features, including the specific prey the whales are eating in coastal waters.

An example of how satellite tagging information can help NMFS accomplish designating Critical Habitat in an effective manner was evidenced with Hawaiian Insular false killer whales. This small population is in the process of being listed under the ESA and a significant body of satellite tag location data has been obtained and was also used to inform the Critical Habitat designation process. NMFS has relied almost exclusively on this dataset from 23 satellite–tagged whales and is on track to designate Critical Habitat within the prescribed time limits mandated by the ESA. Although far fewer SRKWs will be tagged, we have found that a significant amount of new data can be gained from only a small number of tag deployments. An example of this is from recent tag deployments on a small number of Southeast Alaska resident-type whales. Like SRKW, despite extensive research efforts in the inland waters of Southeast Alaska and Prince William Sound, little was known of their coastal movements. With the deployment of only four tags to date, we have discovered that these whales range well to the west of Kodiak Island, which was completely unknown and this information will be important information to understanding their role in the Gulf of Alaska Ecosystem.

Why can't SRKW occurrence and movements be determined using non-invasive approaches?

For the past seven years the NWFSC has actively used and supported (and will continue to support) several non-invasive approaches to assess the winter range of SRKW. Despite ongoing efforts to document the whales' winter distribution through an enhanced coastal sighting network, deployment of autonomous acoustic recorders, and dedicated research cruises, a significant information gap remains in their spatial and temporal distribution which has precluded delineating coastal Critical Habitat. The coastal sighting network has yielded fewer than 20 sighting over the past six years. While these are valuable data and represent a significant increase compared to previous years, the three to four sightings gained per year do not provide sufficient data by themselves or in combination with other recently derived data to allow for Critical Habitat determination. Although SRKW have been located on four to five NWFSC killer whale-focused survey cruises, as well as on a few other cruises, like the sighting network data, these data are too limited to provide more than just isolated snapshots of the whales' locations. Consequently, this hand full of sightings over the past seven years is insufficient to provide the data needed to fully assess essential habitat features, identify specific areas with those features, and designate additional Critical Habitat. While ocean-class vessel surveys offer the potential opportunity to follow the whales day and night to determine habitat use and possibly collect predation samples and feces for diet studies it is important to note that the

NWFSC is typically only allocated 10-20 sea days per year on NOAA's ocean class vessels. For the past two years the NWFSC has not been able to secure sea days due to funding cuts, and given ongoing fiscal constraints of the federal government it is likely that future opportunities will be extremely limited. Passive acoustic recorders have provided the greatest number of detections of SRKWs over the past six years. At the seven moorings that are currently deployed from Cape Flattery, Washington to Pt. Reyes, California we have detected SRKWs approximately 180 times. Despite this relatively large sample size there are numerous multi-week gaps in the locations of the whales, such that a high degree of uncertainty continues to exist with respect to their winter range. It also important to note that the latter method, while providing the most data to date, does not provide real time sightings. Therefore, the information gained is limited to location data after the recorder has been recovered such that there is no ability to respond to detections in order to conduct predation event collection, etc. It is important to note that all of these methods are limited by inclement weather which biases the data obtained and limits their effectiveness. These techniques are also location specific: where we locate the recorders and where the ship goes is based on past sightings, and visuals sightings are restricted to nearshore or areas of regular whale watch activity. The sighting data for SRKWs obtained to date are clustered based on effort more than anything else. These biases can be directly addressed by satellite tag data.

While it has been suggested that aerial surveys are a useful non-invasive technique, the NWFSC has not used this method due to the small benefit for the high costs incurred. Aerial surveys are expensive relative to the amount of information they return, i.e., although they have the advantage of covering a lot of area relatively quickly, even if a killer whale sighting is obtained we still may not be able to ascertain even the ecotype, much less photos suitable for individual ID, because of the need to maintain altitude for safety reasons. In addition, the prevalent inclement weather during winter severely restricts aerial operations, much more so than an ocean-class survey vessel. Aerial surveys have been attempted to assess the winter distribution of gray whales off the Washington coast in the 1990s and this approach was determined to be very limited.

In addition, although the NWFSC has approached the Navy about obtaining killer whale detections on its hydrophone systems to monitor SRKW movements, the Navy's response is that there is "no Navy environmental hydrophone network along the US West Coast". The Navy also noted that "Any other "Navy" system would be more operational and classified, in addition to not being used for environmental analysis."

What is the risk of satellite tagging to the whales?

We believe the risks to the whale's health, reproductive success, and survivorship to be extremely low, and are essentially insignificant. NMFS conducted an Environmental

Assessment on the effects of issuing the scientific research permit and concluded that there would not be a significant impact on endangered species. The Section 7 consultation on the research permit concluded that the effects of the proposed action would not likely jeopardize the continued existence of this ESA-listed species and would not likely destroy or adversely modify designated critical habitat. These assessments are based on extensive testing and evaluation of the tagging system - having been deployed on over 250 cetaceans of 16 different species during the past six years. To date, there is no indication of serious injury or mortality subsequent to tag implantation. The extent of impacts to the whales post tag-loss is typically a small raised area at the site of the dart penetrations on the dorsal fin and sometimes some depigmentation of the epidermis, all of which is within the range of naturally occurring marks.

For example, both cookie cutter shark bites and bites by conspecifics and other types of wounds frequently occur on the various killer whale eco-types in the North Pacific. SRKWs, due to limitations in their range do not incur cookie cutter shark bites. Over a quarter of SRKWs have definitive nicks on the trailing edge of their dorsal fin and although their source origin is unknown it is likely given the numerous rake marks on their bodies that these are bites from conspecifics. We do not consider any of these previously noted wound types as being substantial because they do not affect survival or reproduction.

Concerns have been raised about how tagging might exacerbate the potential for SRKW to be further immuno-compromised due to their relatively high contaminant burdens. The extent to which SRKW are immune-compromised due to toxin loads is unknown. It has been documented that they are above levels that harbor seals have been shown to be immune-compromised. However, even if individuals were immune-compromised the wound caused by dart penetration is minor, and based on veterinarian assessment, to date; these would be unlikely to be of significant risk to the animal's health.

We have worked to address the potential for tagging to exacerbate decreased immune-competence due to high contaminant levels with tags deployed on other species. For example, the contaminant levels in Hawaiian Insular false killer whales are between those of SRKWs and Alaska resident killer whales. This similarity to SRKW contaminant loads is due to life history characteristics and feeding at a similar trophic level. In addition, transient killer whales have far higher contaminant burdens than SRKWs. For neither false killer whales nor transient killer whales have there been what would be interpreted as infected tissue during or following dart out-migration. However, based on consultation with veterinarians, even if a localized infection were to occur, it is extremely unlikely that this infection would become systemic.

We recognize that the risk to whale health is not zero, but rather it is extremely small, such that we do not believe that tagging any individuals will directly or indirectly result in serious injury, decreased reproductive output (no reproductive age SRKW females will be tagged) or mortality. We have examined the resighting rates of tagged and non-tagged pilot whales and false killer whales, (which were tagged opportunistically, i.e., there were not tagged based sex or age) and

we did not find a reduction of resighting rates. NMFS has issued several permits for dart and other forms of implantable tagging of multiple endangered species with no mortalities or serious injuries documented. In fact, NMFS has issued permits for tagging other small, endangered cetacean populations; i.e., North pacific right whales. However, it is important to note that many of the SRKWs we are proposing to tag are likely near the end of their natural life span, such that it is anticipated that some tagged animals may disappear from the population post-tagging. Consequently, it is important to note that should tagged-animals disappear during, or shortly after post-tagging, this occurrence should not be interpreted as a direct consequence of tagging.

How are you minimizing potential impacts to the whales and population?

Following a very small number of tag attachment failures that were detected in 2010, the tags and darts were redesigned to reduce the likelihood of breakage on impact. The redesigned tags have been thoroughly tested and all have worked well. been available for about six months. None of the several redesigned tags that have been deployed have failed.

We are authorized to tag a very limited number of SRKWs – a maximum of two per pod per year, for a total of six per year. However, we expect the reality of the logistics associated with deploying this many tags to substantially constrain these efforts, and result in fewer deployments than what are authorized. Because we are only interested in winter movements our only opportunities will be when the whales enter Puget Sound in the late winter or we encounter them on the outer coast. These very limited opportunities will be further constrained by workable conditions (day length and sea state) for small boat operations.

In addition, close proximity access to the small number of whales that are designated eligible for tagging will further limit opportunities. Consequently, based on previous encounter experience, we consider it likely that we will only tag a couple of whales/year.

Which whales will be tagged?

Part of the mitigation is to err on the side of caution by selecting animals that do not contribute directly to the reproductive potential of the population (i.e., reproductive females) regarding the animals that will be considered for tagging. Consequently, only adult, whales; post-reproductive females and adult males will be tagged.

What tags will be used?

The remotely deployed satellite-linked tags were originally developed by Russ Andrews (of the University of Alaska Fairbanks and the Alaska SeaLife Center) to examine movements of killer whales in Alaska and the Antarctic.

Other researchers are also using these tags in Alaska and California to study movements of both fish-eating and mammal-eating killer whales as well as to study the study movements of cetaceans in Hawaiian waters (see more information at http://www.cascadiaresearch.org/hawaii/satellite.htm) and off the coasts of California, Washington and Alaska.

The tags are comprised of a transmitter (which is about the size of a standard 9- volt battery) that will uplink to System Argos receivers mounted on weather satellites (see more info below) and two short (about 6 cm) retention darts.

How are the tags deployed and how do the whales react?

The tags are deployed with a Pneumatic dart projector from about 4-12 meters. The darts penetrate the fin tissue and the retention petals secure the transmitter to the fin.

We typically only see a "flinch" by the whale and a more rapid than normal dive. In some cases there was no observed response. In most cases we are able to re-approach the whale for photographs within a few minutes of tagging.

How do the tags work?

Satellite-linked tags transmit a signal to a satellite, and position data is then relayed to the researcher. The Argos system functions very differently than the Global Positioning System (GPS) most people are familiar with. The transmitter on the whale emits a signal when the whale is at the surface and during the specific hours of the day when the transmitter is programmed to be on (to conserve battery life). The signal the transmitter emits is received by System Argos receivers on NOAA's polar orbiting weather satellites (the transmitter produces a quarter watt signal that has to be detected by a satellite 800 miles above). Weather satellites orbit overhead about every 90 minutes, are overhead for only about 8-14 minutes and are generally most directly overhead during the morning hours to give weather forecasters a first look at cloud cover and/or environmental data the satellites collect. Assuming the satellite is overhead when the tag is turned on and the whale is at the surface, several signals are sent by the transmitter to the satellite receiver. When tag transmissions are received, these signals are then sent to a ground station which sends the entire transmitter ID and frequency information to Argos headquarters in

France for processing. Getting an estimated location requires the emission and receipt of a series of signals from a very stable frequency of the transmitter, and using a principle known as Doppler shift (this is what occurs when you hear a train horn sounding lower at the instant it passes by) a series of algorithms are applied to the signal data to estimate the transmitter signal's location. Each location we receive has a location quality rating which estimates the amount of error associated with it. Argos has seven location quality ratings, four of which have no error estimate associated with it – in other words the location may be correct or may be off by dozens of miles. For the three ratings that have error estimates assigned to them the actual locations are generally accurate within a couple of miles. Determination of the final set of locations requires the use of a filtering program to select those points that have the highest probably of being correct, based in part on the speed between consecutive locations. The result is a detailed and relatively accurate track of the whale's movements for the time the tag was on during the day.

We receive the location information once a day in the form of an e-mail from ARGOS, and can also access it on-line, although there is a delay (anywhere from 20 minutes to several hours) before the information is available on-line. We will periodically post maps of the whale's movements.

When would tagging occur?

Tagging will only be conducted in the early winter to early spring – late December through April, in order to determine winter movements. Tagging would occur when the whales come into Puget Sound or during coastal surveys. This tagging will be timed to maximize chances for follow up/sample collection on NOAA ocean-class vessel surveys or other survey efforts. If tags are deployed during ocean-class vessel surveys we will attempt to track the whales for the duration of the cruise with the goal of collecting a variety of data including predation event samples and feces to determine winter prey selection and stress hormones. To the extent feasible, but recognizing the substantial constraints associated with lack of daylight and persistently inclement weather, coastal small boat operations will be undertaken on an opportunistic basis.

How will you assess if there are any effects to the whale?

During all encounters of populations of whales that may have been tagged, most if not all of the individuals in the group are photographed. In many cases, previously tagged animals are identified during the encounter. We do look for both physical (e.g., is the animal emaciated or how has the tagging site healed?) and behavioral (e.g., does the animal surface/dive/swim normally, is it associating with conspecifics?) cues to assess potential effects.

Over the past six years a total of over 250 tags have been deployed on 16 species. We have conducted both dedicated and opportunistic resighting efforts. Despite the challenges associated with resighting animals that can range widely, a substantial number of the tagged animals have been resighted both during the time the tag was attached as well as post-tag loss. In no instance have we observed any anomalous behaviors or change in overall health status of the animals.

In fact we have noted that one of the transient killer whales that was tagged gave birth post-tagging, as has a Cuvier's beaked whale.

How much data do you expect to obtain?

The median duration of signal contact for tagged killer whales is approximately 31 days with some deployments exceeding 3 months. We typically receive several reliable locations/day. Consequently, for each deployment we expect to acquire several hundred new locations.

What organizations will be involved in tagging project?

The project will be led by the NWFSC with logistical support from Cascadia Research Collective due to their extensive of experience in the deployment of satellite tags. We will provide location data from the satellite tags in a timely manner to the Center for Whale Research and DFO Canada and other researchers so that they have the opportunity to locate the whales to obtain resighting data that will be used to assess the whale's condition and the condition of the fin tissue at the tag attachment site.