To: NMFS, Office of Protected Resources, Permit and Conservation Division

From: Brad Hanson, Leader, Marine Mammal and Seabird Ecology Team, NWFSC

Subject: Permit 16163 Incident Report - Satellite tag attachment breakage in a Southern Resident Killer Whale and mortality of a previously satellite tagged Southern Resident killer whale

Description of Events

Per section E.2. of Research Permit 16163 issued to Dr. Brad Hanson of the Northwest Fisheries Science Center we are filing an incident report which describes the circumstances surrounding: 1) a satellite-linked tag attachment failure, and 2) the subsequent mortality of the tagged whale 4-5 weeks post-tagging, the cause of which is still under investigation.

On the afternoon of Tuesday, 23 February 2016, L pod was encountered during the NWFSC winter killer whale cruise on the NOAA R/V Bell M. Shimada off the northern coast of Washington, near La Push. Twenty-year-old adult male L95 appeared to be in good health based on general body condition and behavior when he was initially approached (Figure 1). A LIMPET tag was deployed on the right side of the dorsal fin by experienced staff (Figure 2). The tag, equipped with 6.3 cm darts, was deployed with a pneumatic dart protector at the typical distance of approximately 8m and placement was at the insertion of the dorsal fin to the body, slightly posterior to the mid-point point of the fin. The whale exhibited no reaction to tagging. In addition, the angle of the deployment was approximately perpendicular, although we unable to confirm the flushness of the fit at the time of deployment. The deployment was routine in all regards and close examination of the photos post-deployment did not indicate any breakage of the tag body during the deployment process.

We observed L95 at close range again from our work boat on Thursday, 25 February, near the Columbia River and although the anterior end of the tag appeared to have lifted slightly, such lifting a few days after deployment is routine such that we didn’t have any concerns about the tag detaching prematurely. In addition, although we did note that a slight outline of his ribs could be discerned from a view from behind the whale (Figure 3) there were no immediate health concerns as we also noted that others in this group (L72 and L105) also had rib outlines showing. The last satellite tag signal received from L95’s tag was the next morning Friday, 26 February, suggesting premature tag detachment. We last observed L95 on Saturday, 27 February, from the Shimada (Figure 4) but the only photos we were able to collect were of the left side preventing a view of the tag site. There was nothing from this encounter to suggest a change in health status.

On 30 March 2016 the carcass of an adult male killer whale carcass was discovered floating at 49°32.5’N, 127° 13.8’W, west of Nootka Island by Brian Gisborne during a DFO Cetacean Research Program survey and towed to Tahsis for necropsy. Although the advanced state of decomposition precluded identification from photos, the presence of two small holes at the base of the dorsal fin suggested a LIMPET tag had been recently attached to the animal (Figure 5). This was determined to be the attachment location of the LIMPET tag deployed on L95. Upon further inspection of the site it was apparent that some of the dart attachment petals remained after the tag was lost. X-rays of the site
indicated that although the darts had pulled free of the tissue, 7 of the 12 of retention petals (likely the base row on each dart and one from the secondary row) had broken off the dart shaft and were retained (Figure 6a, b).

LIMPET tag systems are designed to slowly pull out and detach from the animal due to extended frictional drag from water passing over the unit during normal swimming activity. The breakage that occurred was unexpected because the tag used was the latest design from Wildlife Computers. This tag system has undergone a number of modifications to address issues that had been manifested on previous deployments. A complete redesign of the tag body to reinforce its structural integrity at the attachment dart mounting sites on the tag body was undertaken following the observation of breakage on four deployments on transient killer whales (T30, T123A, T90, and T86a). An additional modification that was made following the orphaning of a dart on a long-term deployment on a Southern Resident killer whale (K25) was the addition of a titanium flange attached to the dart shaft base against the base of the tag to prevent migration into the tissue and add additional drag to an orphaned dart to facilitate out-migration and detachment. A change was also made as to how retention petals are fastened to the dart shaft to improve their structural integrity. In the past, single petals were cut from Ti-6Al-4V (Grade 5) sheet and individually welded to the dart shaft. The heat from the weld created a weak point at the junction of the petal and the shaft where the petals sometimes broke. In the new process, triplets of petals are cut from the Ti sheet, and then rolled around a jig to make the petal assembly. This assembly is slipped down the dart shaft and then welded at the seam, which is at a point between two petals. This prevents weakening of the area where the petal bends back when the tag is pulled out. This most recent design had received extensive lab and ballistics testing that resulted in no attachment failures, nor had there been any apparent failures in field deployments. Only one attachment failure at the time of deployment has been documented since the redesign, involving a pilot whale in Hawaii. In this instance, unlike the K25 deployment, there was immediate evidence of attachment failure, possibly due to an interaction with a conspecific.

**LIMPET tag performance**

Out of the 533 satellite tags that our research collaboration group has deployed in the LIMPET configuration on 19 cetacean species, 7 have been documented with a dart remaining (1.3%, with the caveat as below that re-sighting rates are low for a number of species, so this may be negatively biased).

A total of 59 LIMPET tag deployments have transmitted for less than 7 days (11%), 5 of which were caused by tag integrity issues (documented breakage), 6 of which were due to documented conspecific interaction (physical removal of tag), and 12 of which were deployed below the base of the fin.

For many of the animals tagged to date, it is not possible to fully assess whether the whales have gone missing or occur primarily outside study areas as our resighting rate of a number of species is low and photo-ID often lags behind by a year or more. Research has found survivorship of tagged and non-tagged false killer whales and short-finned pilot whales in Hawaii to be the same:  
A total of 56 killer whales have been tagged (including California transients, offshores, and pelagic ecotype in Hawaii). L95 was the eighth SRKW tagged since tagging of this population began in 2012. Using the available re-sighting data (for which California transients, offshores, and pelagic eco-types have a low re-sighting rate, and which is not current for Alaska residents, or SRKW in terms of duration between tagging and re-sight); 37 individuals (66%) have been re-sighted, with re-sightings occurring from 2.5 to 1,994 days post tagging. There are likely some longer re-sighting dates but we have not updated re-sighting data in the last year or two. All other previously tagged SRKW have been frequently re-sighted, their dorsal fin tissue has healed, and were all alive as of March 2016, including K33 who was tagged in December 2015.

Ten of the 56 tagged killer whales have had durations of attachment of 8 days or less, three of which were SRKW. Premature tag loss on J26 appeared to be due to a high impact load, likely associated with contact with another whale. This conclusion is based on the documentation of vertical scrape marks, likely from the retention petals, on the epidermis of the dorsal fin, observed a few days after tag loss. The tag loss L95 experienced is suspected to be due to a similar type of high impact load event.

Of the five killer whales documented to retain orphaned darts (T30, T123A, T90, T86a, K25), two (K25 and T90) have been documented to have shed the darts and of the resighting data we have obtained to date, all appear to have followed he expected tissue response.

**Examination of LIMPET tag attachment sites from stranded animals**

This is only the third LIMPET-tagged whale of any species that we have been able to examine post-mortem. The first was the North Atlantic right whale Eg3911, the severely entangled whale that had been sedated, partially disentangled, and tagged, and then it died about 1 week later. Michael Moore wrote that case up in a Marine Mammal Science paper. That whale retained 9 of the petals, but it was tagged with the previous version of darts that were constructed by welding each individual petal to the shaft. We assumed that the petals broke off when the tag was torn out of the blubber as the whale’s body was towed up onto the beach.

The second case was the Alaska western transient WT54, which had been tagged in May 2008 and was found dead in October 2011 up the Nushagak River near Dillingham, Alaska. X-rays and CT scans conducted on this whale’s fin showed no retained petals, and no signs of any abnormal healing.

**Natural mortality rate of adult male SRKWs**

To estimate the survival probabilities for L95 and similar males, we used flexible generalized additive models to model the inter-annual variability (year-to-year variation representing environmental variability, such as prey availability) and age effects (allowing survival probabilities to decline with age). We fit these models to all male whales born since 1976 to either the Southern Resident, or neighboring Northern Resident population (including population effects that allow the general shape of survival-at-age to be similar, but offset for each population). Using the output from the full dataset, we calculated the life-expectancy of males born about the same time as L95 in the Southern Resident population; this calculation involved using the estimated year effects since L95's birth (1996). The median life
expectancy, or age at which half of the males of this cohort would have died, are between 22-23 years old (Figure 7).

A primary question, then, is what is the probability of survival for a 20-year old male in 2016, given that he lives to age 19? Again, using output from the full model, we calculated the estimated survival probability for a 20 year old male in 2015-2016. This survival probability was estimated to be in the range of approximately 92.5%. Another way to look at this probability is in terms of coin flips or binomial draws; if there were 10 males of the same age, we'd expect 0-3 to die out of 10 this year and still be within what we would consider to be the 'normal' range.

Steps to reduce the potential for additional serious injury and research-related mortality or exceeding authorized takes

As required by our section A.2. of our permit, the NMFS permit office was notified this situation within 2 days. In addition, as required by our permit we have halted tagging activities on southern resident killer whales until a full reassessment of the tag and attachment system is completed to reduce risk of a similar incident happening again.

I have advised the AKFSC /NWFSC Institutional Animal Care and Use Committee (IACUC) of the situation. I also immediately contacted my researcher collaborators on tag development to advise them of the circumstances associated with the attachment failure and outline plans to mitigate this issue in the future. We have also notified the tag manufacturer of the problem we experienced with the attachment. We will work with them to review possible sources of tag attachment failure and potential design changes for mitigating future breakage. We will develop and submit a mitigation plan to address these issues.
Figure 1. 2/23/2016 – L95 on initial encounter on day of tag deployment. Photo by NWFSC
Figure 2. 2/23/2016 – Tag deployment on L95. Photo by NWFSC
Figure 3. 2/25/2016 – Behind view of tag deployed on SRKW L95 2 days after deployment. Note that flank region below the dorsal appears to be sunken in and outlines of 3 ribs can be seen near the posterior region of the thorax. Photo by NWFSC
Figure 4. 2/27/2016 (4 days post-day of tag deployment) – Sighting of L95 (on right) with other K and L pod whales from the Bell M. Shimada near the Columbia River. Photo by NWFSC

Figure 5. 3/31/2016 (37 days post-day of deployment) – LIMPET tag attachment site being removed from L95. Photo by DFO.
Figure 6a. Dorsal-ventral view of titanium dart retention petals in connective tissue of L95. BC Animal Health Ministry photo.

Figure 6b. Lateral view of titanium dart retention petals in connective tissue of L95. BC Animal Health Ministry photo.
Figure 7. Density plot of known ages of death for SRKW males (based on Sept 2015 dataset).