Improving Attachments of Remotely-Deployed Dorsal Fin-Mounted Tags: Tissue Structure, Hydrodynamics, In Situ Performance, and Tagged-Animal Follow-Up

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LONG-TERM GOALS

We recently developed small satellite-linked telemetry tags that are anchored to the dorsal fin with small attachment darts. These tags have been remotely-deployed onto the dorsal fins of small- and medium-sized cetaceans, opening up the potential to monitor the movements of numerous species not previously accessible because they were too large or difficult to capture safely, but too small for tags that implant deeply within the body. Our main goal is to improve upon our existing tagging methodology to achieve longer, less variable attachment durations by carefully examining the factors that affect attachment success. We will design an improved barnacle-style tag shape for remote-deployment by assessing the hydrodynamic properties of our current tag shapes and new candidates that may reduce drag force, using computational flow dynamics and by creating physical models that are tested in a wind tunnel. We will conduct histological and material properties analyses on dorsal fins. We will determine the performance of our current attachment devices in order to design an improved system. Achieving more consistent and longer duration attachments, however, is not our only goal. Our key goal is to develop a method for attaching tags to cetaceans that provides the data needed to answer critical conservation and management questions without an adverse affect on the tagged animal. Therefore, we will also conduct follow-up studies of whales that have been tagged with a remotely-deployed dorsal fin-mounted tag to accurately quantify wound healing and the effects of tagging on whale survival, reproduction, and behavior. We will compare relative survival rates of tagged and non-tagged short-finned pilot whales within groups and assess survival in tagged false killer whales and beaked whales using photographic re-sightings. We will also assess female reproduction in previously tagged whales by examining long-term sighting histories pre- and post-tagging using photo-ID catalogs. The combination of these approaches will provide an improved understanding of some of the key factors affecting tag attachment duration as well as a more complete understanding of impacts to individuals due to tagging.

OBJECTIVES

1. Design an improved barnacle-style tag shape for remote-deployment by assessing the hydrodynamic properties of tag shapes
2. Examine the tissue structure of the dorsal fin and its material properties for better informed implanted attachment design.
3. Examine the in situ performance of our current attachment devices and then design and test improved retention systems
4. Conduct follow-up studies of tagged whales to accurately quantify wound healing and the effects of tagging on whale survival, reproduction, and behavior

APPROACH

To determine the most critical factors that may be affecting the consistency and reliability of attachment of remotely-deployed dorsal fin-mounted tags we have adopted a bio-engineering framework, addressed in Objectives 1 – 3. Our key goal, however, is to develop a method for attaching tags to cetaceans that provides the data needed to answer critical conservation and management questions without an adverse affect on the tagged animal. Therefore, it is essential to quantitatively measure such effects and demonstrate that our methodology does not significantly alter the behavioral parameters that we are studying and most importantly that this type of tagging does not reduce survival or reproductive rates.

1. Hydrodynamics of tag shape (Key individuals: Mittal, Howle, Andrews, Schorr, Hanson):
We will determine the drag load on the tag through numerical modeling and analysis, primarily computational flow dynamics. High fidelity numerical simulations, working in concert with physical experiments, are needed to establish qualitative as well as quantitative relationships between tag configuration and the associated flow structure and surface pressure distribution, which is ultimately the key to the force/moments on the tag. Numerical simulations can also be used to evaluate, in a relatively inexpensive manner, candidate tag configurations and guide experimental investigations and prototype development. We will determine how factors such as position on the fin affects the drag value. We will also assess modifications of the LIMPET tag shape to select a shape with lower drag. As a result of our CFD modeling, we will have a few candidate tag designs and detailed information about the effect of tag orientation on drag. However, due to the rather large uncertainty bounds that exist with CFD simulations of turbulent, separated flows, we will verify and extend the results of our CFD simulations with physical models and wind tunnel studies.

2. Dorsal fin tissue structure (Key individuals: Hanson):
In order to appropriately evaluate the factors influencing tissue degradation (and therefore attachment duration), it is first necessary to identify the attachment mechanism and assess the anatomical factors likely to influence long-term viability. Because the dorsal fin lacks skeletal support, its structural integrity is derived primarily from fibrous connective tissue. Most of the fibrous connective tissue is located in the ligamentous sheath and central core layers. To date, the harbor porpoise is the only species whose dorsal fin geometry and material properties have been fully described (Hanson 2001). Interspecific differences in these parameters may be an important factor in the variability we've seen in attachment duration, as might body size scaling effects. Consequently, we selected various species for examination based on differences such as size/shape of the dorsal fin (e.g., melon-headed versus killer whale), taxonomic grouping (i.e., odontocetes versus mysticetes), or dynamic behavior (e.g., beaked whale versus melon-headed whale). Our choices were also influenced by conservation issues (e.g., navy sonar - beaked whales; ship strikes - fin whales; ecological role – killer whales).

3. In situ behavior of retention system elements (Key individuals: Andrews, Schorr, Hanson, Howle, Mittal):
As discussed above, a key factor is the drag load imposed by the tag body but acting on the attachment elements implanted into the dorsal fin. Although we have a good idea of how the LIMPET retention system operates when first implanted, we unfortunately do not understand the mechanics once that tissue necrosis process begins and the surrounding tissues begin to lose their structural integrity. Therefore, we will simulate the tissue necrosis process and assess the performance of the retention system under steady state and high dynamic loads in tissue with reduced structural integrity. These results, along with those from the analysis of dorsal fin histology and material properties will inform modified designs that will be similarly tested.

4. Tagging effects - follow-up studies of survival, reproduction,& behavior (Key individuals: Baird, Schorr, Andrews, Hanson):
Our key goal is to develop a method for attaching tags to cetaceans that provides the data needed to answer critical conservation and management questions without an adverse affect on the tagged animal. More thorough assessments of the potential impacts on survival and reproduction of individuals, as well as assessment of healing of the tag attachment sites and potential behavioral changes associated with tagging, are needed to address concerns regarding sub-lethal and potentially lethal impacts of remotely-deployed tags. As part of an ongoing collaborative study, to date 78 satellite tags and 6 VHF tags have been remotely-deployed on seven species of odontocetes around the main Hawaiian Islands. Based on long-term photo-ID studies and on the results of the satellite tagging work, the majority of these tags have been deployed on individuals that are part of relatively small resident populations around the main Hawaiian Islands (McSweeney et al. 2007; Baird et al. 2008; Schorr et al. 2009). Re-sighting rates for the two species with the largest sample size of tag deployments, short-finned pilot whales (n = 34) and insular false killer whales (n = 16), are particularly high, as populations are small, individuals are relatively easy to approach, and there are sufficient encounters each year to have a high probability of re-sighting previously tagged whales. The purpose of this task is to assess impacts of remotely-deployed tags on tagged animals at a variety of levels: from wound healing and potential behavioral effects of tag attachment to reproduction and survival. Wound healing assessment will be undertaken by examination of high resolution photographs of tag attachment sites by veterinarians, FLIR imaging of tagged whales before and after tag loss at various time intervals post-tagging, and if possible collection of biopsy samples from tag attachment sites for histological examination. Assessment of reproduction and survival of tagged whales will utilize existing photographic datasets as well as additional photos taken during this project.

WORK COMPLETED

This project just began 3 months ago, so we are just getting underway. Our main progress has been on Objective #4, to compare relative survival rates of tagged and non-tagged whales using photographic re-sightings, and to assess female reproduction in previously tagged whales by examining long-term sighting histories pre- and post-tagging using photo-ID catalogs. The first task to achieve this goal is to review all photos of the tagged species of interest (short-finned pilot, pygmy killer, false killer, Cuvier's and Blainville's beaked whales) obtained since the start of the tagging work in 2006 and then to match them to the long-term photo-ID catalogs to generate re-sighting histories of tagged and matched untagged individuals, and reproductive histories of adult female individuals within the groups.

As part of this NOPP-funded project, additional photos were obtained by Wild Whale Research Foundation in July and August, 2010, as well as photos obtained during field projects undertaken by Cascadia Research Collective (funded by other sources) in December 2009 and April 2010. Since starting on this task in July, out of 192 pilot whale encounters, 59 pilot whale encounters have been completely sorted and added to the catalog and 65 encounters have been either partially or completely sorted but have not been added to the catalog yet. Those that have been fully sorted contain at least one individual that cannot be linked back to the catalog and have been kept separate in order to hopefully match the individual(s) rather than add them as new IDs. Sixty-eight encounters (36 from 2008 and 32 from 2009) are left to be sorted/matched to the catalog. There are over 35,000 photos just in the 2008 pilot whale archive, and ~70% of the encounters have been sorted and/or added back to the catalog, so ~ 25,000 photos have been matched from 2008 thus far. We have approximately 23,000 photos from 2009, so with ~45% having been sorted and/or matched back, over 12,000 photos have been matched from 2009 for a total of over 37,000 short-finned pilot whale photos sorted/matched thus far in this project. There are also over 13,000 pilot whale photos available from 2010 available for matching, with two additional field projects planned in Hawaii this year (funded by other sources) where additional photos will be obtained.

All pygmy killer whale (29) encounters from 2008 and 2009 have been sorted/matched back to the catalog and two of the six 2010 encounters have been sorted completely but have not yet been entered into the catalog. There are a total of 5,685 files in the 2008 pygmy killer whale photo archive, 3,770 files in the 2009 archive and 5,654 files in the 2010 archive for a total of 15,109 files. The two sorted encounters together contain 4,013 file images. All Cuvier's beaked whale (28) and Blainville's beaked whale (31) encounters from 2008, 2009 and 2010 have been sorted/matched back to the catalog. There are a total of 2,765 files in the 2008 Cuvier's folder, 4,656 files in the 2009 folder and 1,049 files in the 2010 folder for a total of 8,470 photos. For Blainville's beaked whales, we have a total of 7,104 files in the 2008 Blainvilles' folder, 4,326 files in the 2009 folder and 609 files in the 2010 folder, for a total of 12,039 files. We have just begun the preliminary work on false killer whale encounters, checking for missed matches within the catalog and taking individual IDs through as they are sent from the field.

For Objective #2, examination of the tissue structure of the dorsal fin and its material properties, we have been soliciting contributions of dorsal fins from strandings, and so far we have already received a very fresh Blainville's beaked whale fin.

The other major task that we have accomplished at the beginning of our project was to hold our first "partners project kick-off" meeting earlier this month. Most team partners traveled to Friday Harbor, WA so that we could meet face to face for discussion of past work and preliminary results, planning experiments and analyses, and developing new attachment designs. The one partner that could not travel to Washington State joined us by video conference. We were also joined in person by three important collaborators: Dr. Stephen Raverty, veterinary pathologist and head of the of the pathology section of the provincial veterinary diagnostic laboratory in Abbotsford, British Columbia, Canada, and two principals from the commerical manufacturer that we have worked most closely with, Wildlife Computers.

RESULTS

After only a few months we believe that we have started off in a productive and positive manner. At our project kick-off meeting we accomplished a number of important goals: we were able to expose our mechnical engineers partners to the biology of the subjects were are studying and let them see a whale tagging operation first hand in Puget Sound; we polished up our objectives and refined our methods, and have come up with a fundamental shift in our understanding of the physical forces that are acting on the LIMPET tag/attachment design. We are in the process of working with Wildlife Computers to design a 3rd generation of the LIMPET SPOT5 tag that will incorporate these insights.

Since the proposal for this project was written (Nov. 2009), we have added substantially to the number of photos available to assess survival/reproduction, both through projects funded by other sources, and through funding provided to collaborator Dan McSweeney for his opportunistic work in this project. From the 6 sat-tagged species, we've added 60,346 new photos from 80 different encounters. Our ability to assess both survival and reproduction of tagged versus non-tagged individuals will be dependent to a large degree on sample sizes. When our proposal was submitted we hoped that several other funding sources for additional field work would come through and allow us to increase our sample size of both sightings and tagged animals. Since our proposal was funded Cascadia Research Collective has received funding both from the Naval Postgraduate School and the Pacific Islands Fisheries Science Center that has allowed for some work in 2010 and additional work later this year and in future years. The large number of additional photos that will be available as a result of these efforts will contribute substantially to our efforts, but additional funding will be required for matching purposes to allow all these photos to be completely incorporated into the catalogs and analyses.

IMPACT/APPLICATIONS

Understanding the potential for impacts of naval activities on protected species of marine mammals, as well as estimating the number of individuals potentially impacted, and mitigating such impacts, all requires information on movements and habitat use. The development of better tag technologies and deployment techniques will make a significant contribution to the ability of researchers to track movements, monitor behavior, and determine distribution of species of interest. The improvements that we made to our location-only satellite tag and attachment system with previous ONR funding have already resulted in attachment durations well beyond our expectations and are currently being shared with other researchers so that they also can benefit from these advances.

RELATED PROJECTS

The National Marine Fisheries Service Pacific Islands Fisheries Science Center is supporting research on false killer whale movements in Hawaiian waters (Baird et al. 2010), and the Naval Postgraduate School (with funding from N45) is supporting tagging studies of a variety of species. Tag and deployment developments from this work are being incorporated into these ongoing studies. See www.cascadiaresearch.org/hawaii/beakedwhales.htm and www.cascadiaresearch.org/hawaii/falsekillerwhale.htm .

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