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Developing a Better Method of Tag Attachment for Cetaceans

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LONG-TERM GOALS

The goal is to develop, test, and use some novel methods of tag attachments to cetaceans to (1) increase attachment duration, (2) minimize the negative effects to the individual, and (3) to increase types of tags thus broadening the options for tag deployment and duration of attachment.

OBJECTIVES

The primary goal was to increase the duration of tag attachment while limiting the detrimental effects of placing an anchoring device in or on animals. I proposed to develop and test some novel approaches for attaching instruments to marine mammals, especially large whales. Long-term attachment requires a firm and biocompatible anchor into the animal that causes the least amount of injury and infection and resists the tendency for rejection. I proposed a lateral movement of a prong (called an anchoring wing) after tag penetration that would be more effective as a deterrent to tag rejection and would also be coupled with antibiotic injection. The combination of a more secure anchor, more antiseptic deployment, and a smaller tag will increase the longevity of tag deployments. Also I proposed to develop and test small modifications to suction-cup attachments (i.e. post with barb) that will increase the duration of attachments of instruments via suction cups. Finally, I proposed a barb attachment with external tag that would minimize the implantable portion of the tag while allowing prolonged attachment (e.g. 1-4 weeks) beyond that afforded by suction-cup attachments (0-2 days). These attachments would be tested first on stranded marine mammal carcasses, then miniature renditions tested on live captive animals, and then tested and used on animals in the wild.

APPROACH

The first task was a thorough review of the literature and production of an annotated bibliography that would be made available to anyone that is considering tagging large whales. This document will allow others to quickly review who has tried what, and allow them access to these papers/reports so they can more efficiently and effectively design new tags. Secondly I will design and build three types of tags attachments: (1) implantable tag attachment that involves laterally spreading “wings”, (2) barb attachment with external tag, and (3) suction-cup attachment with external tag. The implantable tag attchment wings will deploy after the tag is imbedded in the whales tissue. This mechanism would greatly increase the holding power of the tag, decrease the amount of friction and drag during

deployment, and allow slightly greater penetration thus greater duration of attachment. I hope this type of design would allow tag attachments of 6-8 months to more than a year. The barb attachment will consist of a 6 -7 cm long barb that penetrates the whales skin and blubber and has small prongs that anchor the barb into the tissue. The external tag would be hydrodynamically shaped to minimize drag and increase downward force so the tag remian flush to the whale's surface. Additionally, a spring-loased hinge attaching the external tag to the barb would assist in keeping the tag flush to the whale. Theis type of desgin should allow attachments of 2-4 weeks and with a release mechanism allow recovery of the tag. The third attachment would be a test of various small barbs added to suction-cups. Suction cups have been used successfully to place small radio tags on whales and dolphins for periods of hours to a maximum of 2 days. To increase attachment duration, a small barb would penetrate the skin and blubber thus restricting the posterior movement of the tag as drag forces act laterally. I also will expermient with various methods that prolong or actively increase the vacuum inside the suction cup.

WORK COMPLETED

The publication review and resultant annotated bibliography has been completed. Most of the published works in the primary literature and some grey literature were reviewed and the salient points regarding tag design, placement, attachment, and longevity were summarized.

The attachment "wings" for the implantable have been designed (Fig. 1), a working model has been bench tested, and tested in whale blubber. The current model can fit inside a tube of 120 mm, but we want to reduce the size eventually so that it can fit inside a 190 mm ID tube that would be deployed in some of the standard implantable tag in use today (N. Gales, pers. comm.). The main challenge is to provide maximum wing surface area that can be deployed laterally from a small cylindrical housing. We have designed and tested two methods of deploying the anchoring wings, either by electric motor or spring (Fig. 1). Initially we had proposed using an electric motor but recently we discovered that these small motors could not produce the necessary torque and were susceptible to shock. Hence we have designed and tested a spring-loaded deployment that is simpler, is not affected by deceleration, and can create the necessary torque. A sleeve covers the spring-loaded wings, and when deployed in the whale is deflected posteriorly allowing the wings to spring outward to full deployment

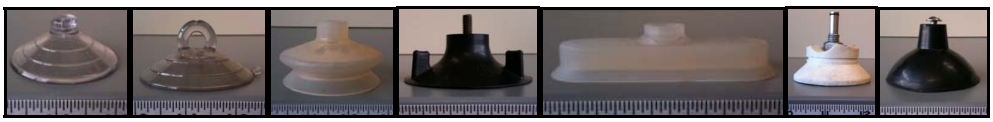
Fig. 1. The left panel is the original SolidWorks drawing of the spring-loaded anchoring wing design, the middle panel depicts the projectile point, the extended attachment wings, with the spring removed, whereas the right panel depicts the spring in the loaded position.

A suction cup replaces the spear tip for a less invasive attachment technique. The thrust and release technique is the same, however suction cups provide a less secure method of attachment on cetaceans

and generally fail within a few hours due to failure of the vacuum within the suction cup or slipping along the skin of the animal until it reaches a flex point that compromises the suction. We tested nine varieties of suction cups of different sizes and materials to determine the optimal diameter and material for short deployments.

We also conducted testing of the vertical tensile force of various suction cups (Tables 1 and 2). This test was conducted in the same manner as the horizontal test; however, force was applied in the vertical direction until vacuum failure was reached. Vacuum failure is defined as the moment at which the suction cup vacuum is compromised, and the cup detaches from the test surface. The weight on the spring scale was recorded when the failure point was reached. The final recorded measurements were then averaged from a set of three test measurements. In addition, both the horizontal slip and vertical failure tests were conducted over timed intervals. This measured the capacity of the suction cup to maintain its position and vacuum over time. The surface material was rubber, which best simulated the skin of a cetacean.

Table 1. Diameter and surface area of nine suction cups tested on rubber and the holding force (lbs) and slip force (lbs) measured horizontally for each type of cup.



Cup: A, B, C D E F G H I

Cup Type	Diameter (mm)	Surface Area (mm^2)	Holding Force (lbs)	Test Surface	Slip (lbs)
A	44.45	1551.8	25.9	Rubber	5
B	63.5	3166.9	72.1	Rubber	9
C	76.2	4560.3	103.9	Rubber	8
D	82.55	5352	141.4	Rubber	9
E	82.55	5352	141.4	Rubber	12
F	92.25	7125.5	162.3	Rubber	16
H	82.55	5352	141.4	Rubber	22
I	76.2	4560	103.9	Rubber	50

Table 2. Diameter and surface area of nine suction cups tested on rubber and the holding force (lbs) and slip force (lbs) measured vertically for each type of cup.

Cup Type	Diameter (mm)	Surface Area (mm^2)	Holding Force (lbs)	Test Surface	Failure (lbs)
A	44.45	1551.8	25.9	Rubber	20
B	63.5	3166.9	72.1	Rubber	22
C	76.2	4560.3	103.9	Rubber	20
D	82.55	5352	141.4	Rubber	34
E	82.55	5352	141.4	Rubber	32
F	92.25	7125.5	162.3	Rubber	50
H	82.55	5352	141.4	Rubber	24
I	76.2	4560.3	103.9	Rubber	50

We have developed a unique process by modifying several types of suction cups with the addition of a small barb embedded in the cups symmetrical center line and protruding below the suction cup's lip. The concept is to provide enough anchoring into the tissue to prevent the cup from horizontally slipping along the animal due to hydrodynamic drag. Ideally, this would provide a deployment time of 1 – 2 weeks instead of a few days. Custom adaptors were machined to fit into a 1.25 cm (1/2 inch) diameter center line hole which was drilled through the suction cup (Fig. 2). A hole was tapped on one end of the adaptor to allow a variety of barbed tips to be threaded tightly onto the bottom of the suction cup. This design allows for a variety of different barbs to be easily fitted and tested on all suction cup types. Silicon caulking was used to fill the gaps around the drilled hole and the barb adaptor, creating an airtight seal to ensure a solid vacuum. The barb tips were machined from 0.79 cm (5/16 in) x 3.81 cm (1.5 in) stainless steel bolts. A number of different designs were created, including a thin barbed tip with a single petal and a conical pointed barb. The barb protrudes 0.64 cm (1/4 in) past the bottom of the suction cup

Increasing the diameter therefore the holding force of the suction cup does increase its vertical failure point. This is most apparent in suction cup types F and I, which are both large cups, composed of stiff black rubber. The stiffness of the material allows the cups to generate an excellent seal; however, much more effort is required to push the stiff material down firmly. When using these types of suction cups, a pole spear adaptor design that allows for concentrated forceful delivery is recommended. Deploying tags using this type of cup will require a strong and steady push from the pole. Types H and I had the greatest horizontal slip point. Type H is a very flexible suction cup used for tagging cetaceans (produced by Cetacean Research) and used by ourselves to attach videocameras and tags to Leatherback turtles, whereas type I is the stiff black roof rack suction cup. These two cups are at the extremes of flexibility and stiffness of all the tested cups.

The suction cups were also tested for vertical failure on a rubber and plexiglass surface over a timed interval. Use of the rubber surface led to a vertical failure of less than an hour for all suction cup types. Vertical failure tests were conducted on an hourly interval. All suction cups except for types H and I failed within one hour, whereas H and I lasted over 24 hours. Suction cup materials that contain either properties of extreme flexibility or extreme stiffness appear to form the best long-term seals. In future applications, the use of suction cup I is recommended due to its high horizontal slip / vertical failure points and low cost. The use of a single pedal barb was tested on suction cup type E and H. This increased the horizontal slip to 50 lbs, but did not increase the vertical failure point. The use of a prong may stop the suction cup from sliding on the horizontal plane, effectively locking the cup in the desired position. Future development and testing of using pronged barbs with suction cup types H and I will be conducted, along with the further development of removable adaptors to fix the suction cups onto the pole spear for tag deployment. We also plan to develop a suction cup that contains a small hand pump. When the animal dives, the increased pressure causes the hand pump to close, resealing the vacuum of the suction cup. We have developed a full deployment kit for the suction cup pole spear, and are ready for in-field testing on carcasses and live animals.

We have designed and constructed a number of possible modifications to the suction-cup attachment that mostly involve the use of a small barb attached to the base of the suction cup (Fig. 2). We have bench tested this design and realize that the barb must be at least 2 cm in length to properly penetrate the skin and blubber and allow the suction cup to properly deploy. The next step is to test the barbed suction cup attachment with the eventual deployment method (e.g. pole, cross bow, and air gun).

Figure 2. Suction cup attachment with central barb. The barb is 2-4 cm in length, and has a cone shaped barb to allow the suction cup to spin so the tag can be oriented parallel to the direction of water flow.

RESULTS

We have completed almost all of the objectives outlined in the original proposal other than testing some of the prototype tag attachments (wing-tagged and barbs) in dead beachcast whales. We had the opportunity to conduct these experiments on one dead beachcast humpback whale, however, the advanced decomposition of the carcass did not provide adequate conditions for experimentation. Ballistic tests have been conducted using simulated blubber but nothing actually can adequately portray actual whale blubber as far as texture, density, resistance, and flexibility. We will be conducting tests of the suction cup and barbed attachments this winter under permits and collaborations with John Calambokidis (Cascadia Research Collective).

IMPACT/APPLICATIONS

Modifications to pervious tag attachments for large whales are being developed with the goal of increasing the duration of attachment, decreasing harmful affects to the individuals, and possibly increasing the easy of attachment. If successful, these concepts would be useful for all researchers placing tags on large whales. These developments would be applicable for short-term (1-6 days) attachments using suction cup and an external tag, moderate-term (1-4 weeks) attachments and recoveries of tags using a barb attachment and external tags, and long-term (1-12 months and possibly longer) attachments of implantable tags. These could be used on all studies of large whales throughout the world.

RELATED PROJECTS

We also sponsored a workshop of whale tagging experts at MLML on 16 March 2009, and the summary of those discussions were completed and distributed to participants.

Invitees:

John Calamabokidis (Cascadia Research Collective – Tacoma WA)
Dave Casper (veterinarian – UC Santa Cruz, Santa Cruz CA)
Francis Gulland (veterinarian – The Marine Mammal Center – Sausalito CA)
Jim Harvey (Moss Landing Marine Laboratories – Moss Landing CA)
Mads Peter Heide-Jorgensen (Denmark)
Bruce Mate (Oregon State University – Newport OR)

Mike Weise (ONR – Arlington VA) – Mike by phone (weather did him in)
Alex Zerbini (National Marine Fisheries Service – Seattle WA)

Funds from this project were used to support the travel of a few of the participants. The discussion centered on various issues with large whale tagging and tag design. For instance we discussed:

1. General discussion of current tags and techniques being used by participants
2. Specific topics:
    - Tip design and cutting, wound healing, use of antibotics
    - Anchor design, housing materials, and performance
    - Force of delivery
    - Antenna wobble
    - Encapsulation or not
    - Tag movement (antenna mountings)