



Final Workshop Proceedings for

Cetacean Tag Design Workshop

Arlington, Virginia

16-17 March 2009

*Funded by the Office of Naval Research Marine Mammal and
Biological Oceanography Program*

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EXECUTIVE SUMMARY

The Office of Naval Research sponsored workshop entitled ‘Cetacean Tag Design Workshop’ was held in Arlington, Virginia, 16-17 March 2009. The workshop brought together over forty marine mammal researchers, veterinarians, tag manufacturers, and federal agency and other group representatives to discuss current technology and topics related to cetacean tag attachments (Appendix 1). The goal of the workshop was to review and evaluate past, present, and future tag attachment & delivery designs with a goal of identifying and collectively advancing designs and design ‘features’ that maximize tag attachment duration and data collection while minimizing potentially adverse risks to animals.

Workshop Objectives

The workshop format was a mix of presentations on various topics related to tag attachments combined with a ‘Show & Tell’ of tag attachment & delivery designs, and large and small group discussions with the following objectives:

- 1) Identify research needs related to further development of tag attachment designs or ‘features’ and prioritize research needs,
- 2) Identify research needs related to development of follow-up case studies to evaluate physical, physiological, and behavioral effects of tag attachment designs on animals,
- 3) Determine if there is community interest and how best to develop or establish peer-reviewed ‘*Guidelines for Cetacean Tagging Studies*’, and
- 4) Identify acceptable or ‘best’ practices and attachment designs and ‘features’ that are operational and considered ‘tools of the trade’ for cetacean tagging research that could be included in ‘*Guidelines for Cetacean Tagging Studies*’.

Research Recommendations

Workshop participants broke into small groups and were asked to make recommendations for research related to further development of tag attachment designs or ‘features’, and without prioritization included:

General Recommendations

- Develop a tagging database with complete summarization of date, species, tag type(s), attachment type and location on animal, animal identity (photos, marks, etc.), tag performance metrics, and make the database accessible to stranding/research groups and others.
- Develop a process for continued communication (i.e. secure website, meetings) among researchers to share experiences, details of attachment development, tag performance metrics.
- Assess hydrodynamics of tags and all tag attachment types: initially using computer models and then transition to wind tunnel/water flumes.
- Evaluate increased energetic requirements of animal due to increased drag for all tag designs using computer simulations and captive animal experiments.

Research Recommendations– Tag Type I - Penetrating body tag attachments

- Increase "reliability" and consistency of tag attachment duration through the investigation of causes of tag failure (rejection, loss) and tag success. Encourage repeated observations of animals post-tagging to assess tag performance and animal health.
- Examine performance of current tag attachment designs by assessing holding power and anchoring performance in carcasses using imaging (CT scans, X-Ray).
- Quantify delivery force of each delivery system as a function of attachment success and duration.
- Design physiology sensors (pH, temp) for the tip of tag attachment to collect information about wound healing/condition, and depth of tag penetration (myoglobin).
- Develop new antennae design to reduce vibration of the tag (antenna or exposed tag) - consider reducing coupling of antenna with tag body.
- Investigate tissue structure as tag substrate: investigate the structure, variability, strength, biomechanical aspects, and basic dimensions of the tissues (i.e. blubber thickness) into which we are implanting tags. Need to quantify the strength of the blubber and muscle layers and variability among individuals, seasons, demographic group, and species.

Research Recommendations– Tag Type II - Penetrating dorsal fin/ridge attachments

- Investigate variability of biofouling as a function of tag attachment materials.
- Determine bolt tightness for surgically placed dorsal fin tags to avoid pressure necrosis.
- Investigate reactions (e.g. abrasion and sensitivity) to different materials placed against the skin and other related issues (dead skin buildup) using captive animals.
- Assess effect of bolt size or shape on tag retention.
- Develop release mechanism for proper release of dorsal fin attachments (active and passive releases) – may be covered by STTR topic.
- Test positioning of tag on the dorsal fin using captive animal experiments.

Research Recommendations– Tag Type III - Non-penetrating attachments

- Test effects of tissue necrosis under suction cups using captive animal experiments.
- Investigate effects of temperature and pressure on suction cups.
- Investigate engineering/methods (i.e. suction cup type, material, size, number, configuration) for longer suction cup attachments.

Overview of Workshop

The workshop was organized and sponsored by the Office of Naval Research (ONR) - Marine Mammal and Biological Oceanography Program (MMB), which is part of the U.S. Department of Navy (DON). ONR is the Science & Technology branch of DON. The marine mammal part of MMB program is guided by, though not limited to, research and technology development related to the effects of sound on marine mammals. A key research topic in the MMB Program and central to marine mammal research is *Sensor & Tag Development*, including the issue of tag attachments.

Attaching instruments to individual marine mammals is the principal means of getting quantitative data about animal physiology and behavior, their use of the oceans, and how human activities affect these processes. The issue of the potential effects of anthropogenic sound on the behavior and physiology of marine mammals has been the stimulus for the development of a number of small, sensor-equipped and microcomputer-driven electronic tags. These tags have been providing sound producers, regulators, and the scientific community with valuable data on a variety of species for over 20 years, and have received a great deal of attention via targeted workshops, funding, and development efforts. Great strides are being made in capability – size, configuration, memory, and the number and type of sensors. However, keeping these loggers consistently and safely attached to animals for targeted time frames lags behind tag improvements and is the main technological constraint limiting further advances in this field. The top technological constraints identified that limit further advances in the field was tag attachment. Often tags, tag attachments, and tag delivery systems have been developed independently by investigators and labs around the world, and are only accessible to those individuals and/or labs. Components of the development and testing of tag attachment technology are best done on animals in captivity, but facilities and animals for such testing are limited and permits for this work have been difficult to obtain.

The goal of this workshop is to review and evaluate past, present, and future tag attachment & delivery designs with a goal of identifying and collectively advancing designs and design ‘features’ that maximize tag attachment duration and data collection while minimizing potentially adverse risks to the animal. To achieve this goal and facilitate sharing of ideas/concepts/designs and enhance communication/collaborations in the field we asked researchers and tag manufacturers that develop tag attachment and tag delivery systems to bring and share with workshop participants their equipment and tag attachment hardware. Tag attachment developers also presented the details of the development of tag attachment and delivery systems.

Ultimately, our interest was to have a collective identification and development of tag designs and ‘features’ by the experts in the field that can be used to establish *Guidelines for Cetacean Tagging Studies*. These guidelines can be used to inform tagging research and funding agencies on acceptable practices and ‘tools of the trade’. Funding agencies are discussing the establishment of a *Tag Development Research Fund* to support the development of tag designs and research recommendations identified in this workshop.

While the topic of cetacean tagging is of great interest to many, the purpose of this workshop was to provide a forum for tag attachment designers and veterinarians to have an open and honest discussion about tag designs with the goal of collectively advancing tag delivery mechanisms and tag design ideas and plans.

Organization of the Workshop

The workshop commenced with an introduction by Dr. Michael Weise of ONR with a brief overview of the ONR research program and how ONR interests in tags attachments fits into their research topic - *Sensor & Tag Development* (Agenda – Appendix 2). Dr. Weise gave a brief background on why tag attachments are a topical issue, a brief overview of the workshop goals and objectives, workshop structure and format, and ended with

participant introductions. This was followed by a discussion of an email survey of the data requirements related to cetacean tagging and development of tag attachments (Appendix 3).

The first portion of the workshop consisted of a series of presentations by researchers that have and are developing tag attachments for cetacean tagging studies. For organizational purposes and to facilitate discussion on related topics individual presentations were divided into three tag attachment types: I) Penetrating body tag attachments (i.e. saddle packs with embedded anchors, electronics package embedded in body of animal), II) Penetrating dorsal fin/ridge attachments (tags with the electronics package contained outside of the animal and anchors that penetrate, e.g. barnacle tags, tags surgically attached to captured animals, saddle packs with embedded anchors), and III) Non-penetrating attachments (i.e. suction-cups, and alternative designs such as peduncle belt tags). Each tag type is designed for a general attachment duration from hours (*Type III*) to weeks (*Type II - barnacle*), to months and even years (*Type II capture/surgically attached tags; Type I*). Each researcher was asked to give a detailed overview of their research on tag attachments, including materials used, a brief history of what worked and what failed, target species, attachment size and positioning on animal relative to animal anatomy, attachment statistics, and follow-up observations of the physical, physiological, and behavioral effects of the tag on animals, and ideas for improvements or future plans.

The second portion of the workshop was a series of small and large group facilitated discussions. The small group discussions, or break-out groups (Appendix 4), focused on 1) identifying best practices for *Guidelines Cetacean Tagging Studies*, and 2) identifying research needs and making recommendations for research on topics related tag attachment designs and delivery systems, and follow-up studies to evaluate the potential effects of tag attachments on the animals. Large group discussions focused on related topics and subsequent sections provide a summary of key discussion points.

The workshop was facilitated by Dr. Michael Weise (ONR), Dr. Jim Harvey (Moss Landing Marine Laboratories), Dr. John Hildebrand (University of California San Diego), and Dr. Doug Nowacek (Duke University). These discussions provided a forum for tag attachment designers and veterinarians and morphology experts to have an open and honest discussion about tag designs with the goal of collectively advancing tag delivery mechanisms and tag design ideas and plans.

Discussion - Review of the Potential Effects of Tagging on Animals

Following presentations, the first discussion was a brief round table by the veterinary/morphology group, that included Dr. Terrie Rowles with NOAA, Dr. Francis Gulland with TMMC, Dr. Michael Moore with WHOI, Dr. Ann Pabst with UNC-Wilmington, Dr. Joe Geraci with University of Maryland, and Dr. Dan Mulcahy with USGS. The goal of this discussion was to review potential physical, physiological, and behavioral effects of tagging, and identify and highlight issues and topics related to tag attachments that were relevant to developing research recommendations for further tag attachment development. This session ended with Dr. Frances Gulland's review of the recently released External Review of National Marine Fisheries Service (NMFS) *Dolphin Tagging in North Carolina 2006*. Many recommendations in the External Review were also highlighted during this discussion and noted below. Topics identified in the discussion included:

New precautionary approach to investigating the effects of tagging and tag attachments. The first recommended step was to do anatomical studies to understand key structures (i.e. vasculature, innervation, etc.) that might facilitate or degrade tag attachment performance, and potentially adversely affect animal health. The second recommended step was to test and collect baseline data on tag attachment performance and animal effects in a controlled setting using captive or possibly rehabilitated animals (also in the External Review). The need for using captive animals was highlighted throughout

the workshop, as well as the regulatory hurdles required for this approach. All agreed that modifications of the permitting systems to allow experimentation on captive animals would greatly facilitate the development and testing of tag attachments. The third recommended step was the use of wild animals, in accessible populations that are routinely resighted or recaptured to monitor potential tag attachment performance issues and/or effects on the animal (also in External Review). For new or modified tag attachments designs, it was recommended to start with only a few tags and then increase use only if few or no problems were observed (also in External Review).

- Safe development of tag attachments is important, however, it is equally important to encourage innovation in new tag attachment developments and operations.
- Use of infrared or thermal imagery may enhance our ability to evaluate condition of tag attachment site, and if swelling/divots are a sign of infection.
- Potential physical, physiological, and behavioral effects of tag attachment will vary by individual. Important to get health assessment pictures of individual animal before, during, or shortly after tagging and to resight animal after tagging to do a follow-up health assessment. Need to explore and develop ways to evaluate *a priori* and *post hoc* health assessment related to tagging, including a central ‘tagging database’ of tagging data that includes information on individual animals, health assessments, tag data, and photo identification. Post hoc analysis of potential tag attachment effects would benefit from connecting ‘tagging database’ with existing stranding networks and other researchers and databases.
- Further investigation of the benefits and potential deleterious effects of antibiotics and other agents (i.e. coatings, NSAIDS) is required.
- Assess hydrodynamics of tags and all tag attachment types initially using computer models, then transition to wind tunnel/ water flumes. (also in NMFS Report)

Discussion - Tag Attachment Design and Delivery System Development

From small and subsequent large group discussions there were a number of research needs and recommendations identified for the development of tag attachment designs. The goal of this session was to identify research needs as they relate to further development of existing tag attachment designs and features and delivery systems, and/or new directions to address data requirements. Aside from specific tag attachment research needs identified during discussions, there were a number of community needs identified during discussions, some of which may require additional research, and others that may require infrastructure development. These recommendations are listed first under General Research Recommendations and include general recommendations for tag attachment design developments that apply to all three attachment types. This is followed by research needs related to development of specific tag attachment designs for each of the type attachment types, followed by research needs related to follow-up studies. Recommendations include:

General Research Recommendations

- Develop tagging database with complete summarization of date, species, tag type(s), attachment type and location on animal, animal identity (photos, marks, etc.), tag performance metrics, and make database accessible to stranding/research groups/and others.

- Develop a process for continued communication (i.e. secure website, meetings) among researchers to share experiences, details of attachment development, tag performance metrics.
- Evaluate increased energetic requirements of animal due to increased drag for all tag designs using computer simulations and captive animal experiments.
- Assess hydrodynamics of tags and all tag attachment types (I, II, III) initially using computer models, with possible transition to wind tunnel/ water flumes.
- Quantify delivery force for all tag attachment types (I, II, III) and correlate with attachment success and duration.
- Investigate biocompatibility and reaction (e.g. abrasion and sensitivity) to different tag attachment materials against skin using captive animals and related issues (e.g. dead skin buildup).

Research Recommendations – Tag Type I and II

- Increase "reliability" and consistency of tag attachment duration through the investigation of causes of tag failure (rejection, loss) and tag success.
- Examine performance of current tag attachment designs by assessing holding power, anchoring performance and depth of Type I and II penetrating tags in carcasses (ie. using imaging - CT scans and X-Ray).
- Evaluate retention systems or tag attachment anchors for Type I and II penetrating tags, including prong design, number, material, shape, flexibility, and deployment strategy.
- Investigate tissue structure as tag substrate for Type I and II attachments: what are the structures, variability, basic dimensions of tissues (i.e. blubber thickness), strength, and biomechanical aspects of the substrate into which tags are implanted. Quantify the retention strength of the blubber, fascia, and muscle layers (body and dorsal fin) and variability among individuals, seasons, demographic group, and species.
- Develop new antennae design for Type I penetrating tag attachments to reduce vibration of embedded or exposed tag body (i.e. decoupling antenna and tag attachment body).
- Quantify delivery force of each delivery system and determine whether attachment success and duration is related to force.
- Design physiology sensors (pH, temp) for the tip of tag attachment to collect information about wound healing/condition, and depth of tag penetration (myoglobin)

Research Recommendations – Type III

- Investigate engineering/methods to maximize Type III suction cup attachment duration and consistency (e.g. suction cup type, material, size, number, configuration, flexibility, holding power, and sensitivity to temperature and pressure).
- Determine the effects of tissue necrosis under suction cups on attachment duration using captive animal experiments

Discussion - Follow-up Studies to Evaluate Potential Tag Effects on Animals

Also from small and subsequent large group discussions research needs and recommendations were identified for follow-up studies to evaluate the potential of physical, physiological, and behavioral effects of tagging on animals. In this context, physical signs of tag effects will vary by tag attachment type, but may include overall skin condition (i.e. swelling, divots, pock marks, bumps, ulcerations, barnacles, and scarring) and coloring, skin sloughing, evidence of serious injury (any type), evidence of human impact (entanglement, vessel), and fin condition. In wild populations, signs of physical tag attachment effects may be obtained through longitudinal visual and/or photographic resighting of animals. Physiological effects of tag attachments may include, but not be limited to localized wound healing or encapsulation, or increased drag (e.g. energetic consequences, changes in foraging efficiency). Behavioral responses may include, but not be limited to, any signs of avoidance of tagging area, sudden high-speed movement away from the tagging area, anomalously slow movements post-tagging, and aggressive behavior (i.e. tail slapping, lunging).

The specific goal of these discussions was to identify case studies for testing the effects of tag attachment designs on animals in captivity and/or candidate species and/or populations in the wild that have good follow-up opportunities. Many tagging studies target species or populations that may not be conducive to close follow-up to evaluate the effects of tag attachments (i.e. offshore, remote locations); therefore, case studies for each tag attachment design need to be developed to evaluate potential effects of tag attachments. These case studies will enable tag attachment designers to quantify and minimize potentially adverse risks to the animal from tagging activities, and enable safe deployments on more sensitive or remote species or populations. Research recommendations for topics of follow-up studies included:

- Need to establish more detailed criteria to evaluate physical, physiological, and behavioral effects of tags rather than simply using mortality as a success/fail criteria
- Investigate factors that inhibit or facilitate wound healing and encapsulization of Type I and II penetrating tag attachments (e.g. salt water ingress, tag movement, penetration depth).
- Compare detailed health assessments of animals before/after tagging with Type I and II penetrating tag attachments, including weight, photographs, and collection of samples for toxicology studies, (whole blood, serum, plasma, blubber biopsy).
- For case study related to specific tag attachment development optimal monitoring schedule of tagged animals to evaluate tag effects (e.g. 0.5 week, 1 week, 2 weeks, 4 weeks, etc).
- Evaluate efficacy of coatings (antibiotics, anti-inflammatories) and biocoatings (chitosan) in tag attachment types I and II in promoting wound healing and tag retention.
- Evaluate increased energetic requirements of animal due to increased drag for all tag designs (I, II, III) using computer simulations and captive animal experiments.
- Design physiology sensors (pH, temp, light) for the tip of Type I penetrating tag attachments to collect information about wound healing/condition and depth of tag penetration (myoglobin). Test effects of tissue necrosis under suction cups using captive animal experiments.

- Evaluate the effects of Type II surgically placed dorsal fin tags on thermoregulation and vascularity of the fin using remote sensing and thermal imaging in captive or dolphins tagged in rehabilitation, and pre/post tag application to dolphins in the field.

Discussion - Guidelines of Practice for Telemetry Studies of Cetaceans

Marine mammals are considered charismatic megafauna and the general public is very enamored with these animals and interested in scientific research on this group of animals. The general public and some scientists in the field do not always believe that tagging is the best way to gather data on these animals. While outreach to the public about the benefits of tagging research is needed, it is incumbent upon researchers in the field using tag technology to use the best practices when handling and attaching various instrumentation packages. For new biologists moving into the field of cetacean tagging or biologists working in more remote areas of the world the best practices for cetacean tagging may not be available and/or may not be obvious.

A key objective of this workshop was to gauge the level of interest in the field for establishing *Guidelines for Cetacean Tagging Studies*, and as we discussed equipment and field protocols participants began to identify best practices as it related to applying the three tag types - I) Penetrating body tag attachments, II) Penetrating dorsal fin/ridge attachments, and III) Non-penetrating attachments. Given the experience and perspective of several workshop participants, it quickly became apparent that there was not sufficient time at the workshop to fully develop guidelines. A clear outcome from this workshop was a strong interest in developing more formal and detailed *Guidelines for Cetacean Tagging Studies*, a list of participants interested in writing the guidelines, and an outline of topics. Therefore, what follows can be considered as just the beginning of an attempt to formulate comments or general recommendations for 'Best Practices' for tagging cetaceans based on the three tag types discussed, although time ran out before Tag Type III was discussed in detail.

Best Practices - General Recommendations

There were several recurring themes that presenters mentioned as important considerations or research needs that arise when using all three tag types:

- Establish screening criteria for animal selection based on animal size, physical condition, signs of parasitism, skin condition, mother-calf pairs, species-specific considerations. Avoid poor tagging opportunities or tagging animals in poor body condition or more vulnerable age classes, such as calves or older animals.
- Identify tagged individual (*e.g.* photo ID, genetic sample) to assist in resighting efforts to assess potential tag effects. It was recognized that this was difficult at times due to funding constraints, remote field sites, and limited personnel; however all recognized that this is a high priority as the field moves forward.
- Integrate the electronic components to minimize tag size and improve performance of all aspects of the tag (*i.e.* attachment, hydrodynamics, etc).
- Follow up with photographs of the tag attachment site to assess animal health and tag performance. Best to test tags on populations that are not listed as threatened or endangered and are easily observed (*i.e.* reduced distribution or movements).
- Use well developed and tested tagging protocol, experienced boat driver/tagging team and delivery system that is appropriate for target species.

- Make sure the tag is transmitting before it is deployed and that the electronics package is doing what it is supposed to before deployment
- Justify the sample size before conducting the research

Best Practices - Tag Type I

- Design attachment with a “stop plate” to prevent deeper penetration into blubber or muscle than desired and/or inward migration of the tag over time.
- Choose the appropriate tag attachment size based on the species selected (i.e. length of the dart/barb).
- During tag attachment design and construction additional attention needs to be paid to issues such as biocompatibility of materials, corrosion, dissimilar metals, temperature cycling, and minimizing infection via sterile techniques and materials
- Avoid placing tag in flexing regions (i.e. caudal peduncle) and it needs to be high on the animal for adequate radio transmission (near and forward of the dorsal fin).

Best Practices - Tag Type II

- For tag attachments with multiple points or attachments or bolts consider an inner liner and synchronize releases of all attachment points
- Consider VHF radio transmitter with tag to allow relocation to collect the tag
- If an animal is handled for tag attachment, a basic health assessment should be conducted that could include blood collection, body morphometrics, and skin samples for genetics.

Appendix 1 - Cetacean Tag Design Workshop - Participant List

Veterinary & Morphology Group

Terrie Rowles – NOAA	Teri.Rowles@noaa.gov
Francis Gulland - TMMC	Gullandf@TMMC.org
Michael Moore - WHOI	mmoore@whoi.edu
Ann Pabst, UNC-Wilmington	pabsta@uncw.edu
Joe Geraci - University of Maryland	jrgeraci@sbcglobal.net
Dan Mulcahy - USGS	Daniel_mulcahy@usgs.gov

Tag Type I - Penetrating body tags

Bruce Mate - OSU	bruce.mate@oregonstate.edu
Nick Gales - Australian Gov	Nick.Gales@aad.gov.au
Jim Harvey - MLML	Harvey@mlml.calstate.edu
Rui Prieto - University of Azores	rui@portulano.org
Alex Zerbini - NOAA	alex.zerbini@noaa.gov
Mark Baumgartner - WHOI	mbaumgartner@whoi.edu
Rod Hobbs - NMML	Rod.Hobbs@noaa.gov

Tag Type II - Penetrating dorsal fin/ridge attachments

Russ Andrews - AK Sealife Center	RussA@alaskasealife.org
Robin Baird - Cascadia	RWBaird@cascadiaresearch.org
Greg Schorr - Cascadia	GSchorr@cascadiaresearch.org
Andrew Westgate - UNC-Wilmington	westgatea@uncw.edu
Forrest Townsend - Fort Walton Beach, FL	bayvet@bha.gccoxmail.com
Brad Hanson - NOAA	Brad.Hanson@noaa.gov
Michael Scott - IATTC	mScott@iattc.org

Tag Type III - Non-penetrating

Mark Johnson - WHOI	majohnson@whoi.edu
Becky Woodward - WHOI	bwoodward@whoi.edu
Jeremy Winn - WHOI	jwinn@whoi.edu
John Calambokidis- Cascadia	Calambokidis@cascadiaresearch.org
Doug Nowacek – Duke University	dpn3@duke.edu
John Hildebrand - SIO	jhildebrand@ucsd.edu

Hydrodynamics Expert

Laurens Howle - Duke University	laurens.howle@duke.edu
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Tag Manufacturers

Roger Hill – Wildlife Computers	roger@wildlifecomputers.com
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Colin Hunter – Sirtrack	HunterC@sirtrack.com
Frank Deckert - TRAC PAC, Inc.	elldeck@cox.net
Joe Olson - Cetacean Research Technology	crinfo@cetaceanresearch.com

Participating Agencies and Groups

Mike Weise – ONR

Jim Eckman - ONR

Dana Belden - ONR

Sevgi Bullock - ONR

John Hall - SERDP

Amy Scholik-Schlomer - NOAA

Carrie Hubard - NOAA

Bob Gisiner - MMC

Robin Brake - SECNAV

Frank Stone - N45

Roger Gentry - JIP

Jim Price - MMS

Bob Houtman - NSF

Appendix 2 - Workshop Agenda

Day 1 – 16 March

0800 Registration and Coffee

0830 Introductions

- Brief overview of Navy needs / ONR program
- Why tag attachments, why now
- Workshop goals / objectives
- Workshop structure
- Introductions

0900 Data Requirements – Review email survey results

- Identify science questions/conservation issues that drive tag development
- Identify critical gaps and data/research needs

0915 Tag Type I - Penetrating body tags (i.e. saddle packs with embedded anchors, embedded electronics)

0915 Bruce Mate (30 min + 5 min questions)

0950 Nick Gales (20 min + 5 min questions)

1015 Jim Harvey (10 min + 5 min questions)

1030 Coffee Break

1045 Tag Type I continued

1045 Rui Prieto (10 min + 5 min questions)

1100 Rod Hobbs (10 min + 5 min questions)

1115 Mark Baumgartner (10 min + 5 min questions)

1130 Alex Zerbini (10 min + 5 min questions)

1145 Tag Type II - Penetrating dorsal fin/ridge attachments (i.e. barnacle tags, surgically attached tags)

1145 Russ Andrews (20 min + 5 min questions)

1210 Lunch

1310 Tag Type II - Penetrating dorsal fin/ridge attachments (i.e. barnacle tags, surgically attached tags)

1310 Robin Baird / Greg Schorr (20 min + 5 min questions)

1335 Brad Hanson (20 min + 5 min questions)

1400 Andrew Westgate (20 min + 5 min questions)

1425 Forrest Townsend / Frank Deckert (20 min + 5 min questions)

1450 Michael Scott (20 min + 5 min questions)

1515 Tag Type III - Non-penetrating (i.e. suction-cups, and alternative designs)

1515 Mark Johnson (20 min + 5 min questions)

1540 Joe Olson / John Hildebrand (10 min + 5 min questions)

1555 Becky Woodward / Jeremy Winn (10 min + 5 min questions)

1610 Review potential of physical, physiological, and behavioral effects of tagging

- Round table from veterinary/morphology group
- Focus on scientific/medical judgment based on findings/data

- Review Recommendations NMFS Tagging NC Report (Gulland)

1730 Adjourn

1830 Social and Dinner

Day 2 – 17 March

0800 Discussion – Guidance and Objectives for Break-out Groups

0815 Discussion –Break-out Groups (each group will cover all topics for all tag types)

Topics:

1. **Tag Attachment & Design** (& identify uncertainties with each attachment design)
 - Materials – durability, biocompatibility issues
 - Size of attachment and positioning on animal
 - Consistency of design – attachment & transmission duration
 - Delivery system (boat/drivers, airgun, cross bow, pole, capture)
 - Related electronic data logger issues – acceleration/deceleration, antennas, materials, connecting to attachments (requirements)
 - Battery life
 - Predeployment testing
2. **Effects** - Physical, physiological, and behavioral effects of the tag on animals
 - Status
 - Amount of data (# deployments, # resights, etc.)
 - Scope of data (behavioral, wound healing, health status)
 - Identify/recommend follow-up data needs
3. **Recommendations**
 - Identify/recommend approaches and specific tag designs and/or features that are ‘operational’, and can be used to establish ‘*Guidelines for the Practice of Telemetry Studies of Cetacean*’
 - Identify/recommend specific tag designs and/or features to consider for further development

1015 Discussion - Large group - Break-out group chairs report back.

- Identify areas of uncertainty with each tag type
- Identify/recommend follow-up data needs for each tag type
- Identify/recommend approaches and tag designs for ‘*Guidelines ...*’
- Identify/recommend tag designs and/or features for further development

1115 Prioritize Research & Development Needs for Tag Attachments & Delivery Systems

1200 Lunch

1300 Discussion Topics: (Identify issues, research needs)

1300 Factors Affecting Attachment Durations (all tag types)

- Hydrodynamics
- Implant design: shape / function of retention devices, material choice and biocompatibility issues
- Foreign body response / wound healing / encapsulation

1430 Follow-up Studies (based on data needs from earlier discussion)

1430 Overview (Calambokidis)

1445 Tag Types

- I – Identify candidate species/pops, objectives, & study design
- II – Identify candidate species/pops, objectives, & study design
- III – Identify candidate species/pops, objectives, & study design

1545 Initial proof-of-concept tag attachment & delivery system testing

- Determine Requirements (i.e. biocompatibility, engineering approach, flow tanks & tissues, captive animals, wild animals)

1600 Recommendations for developing:

‘Guidelines of Practice for Telemetry Studies of Cetaceans’

1645 Recommendations to make technology available to research community

1715 Wrap-up / Adjourn

Meeting Location:

Qinetiq

4100 North Fairfax Drive

Suite 800

Arlington VA 22203

Main line phone 703.741.0300

Appendix 3 - E-mail Survey Results – Data Requirements

Table. Email survey results submitted prior to the workshop of the major science questions facing the marine mammal community that drive the use and need for tagging technology and approaches, and research needs related to development of tag attachments and technology. Science gaps and research needs were broken down by research topic, and the attachment duration, spatial scales, tag type, and target species required to address topics are listed.

Topic	Required attachment duration	Required spatial scales	Current tag attachment design & duration	Current species tagged	What are critical science gaps and data/research needs that can be addressed with tagging?	What are critical gaps and data/research needs related to tagging and attachments?
Migration	months, seasons, years	ocean basin	Type I and II	large whales	1. What is the tag design lifetime vs. reality? 2. What are the effects of implanted tags? 3. What are the best deployment techniques? 4. How can we expand data telemetry/tag recovery options? 5. Can we create a safe & reliable tag to use on small cetaceans?	1. What are implications of migration/movements for stock structure? 2. Are there differences in movements associated with seasons, age, or sex? 3. Should we think of creating species specific systems?
Movements - seasonal or short term	days to months	10s of kilometers to 100s of kilometers	Type I and II	large whales delphinids	1. What is the tag design lifetime vs. reality? 2. What are the effects of implanted tags? 3. What are the best deployment techniques? 4. How can we expand data telemetry/tag recovery options? 5. Can we create a safe & reliable tag to use on small cetaceans?	1. What is the range of the stock or population? the home range of individuals? 2. Are there differences in movements associated with seasons, age, or sex? 3. Should we think of creating species specific systems?
Habitat use & foraging (listed species*)	hours / days/ months	10s of meters to 100s of kilometers	Type II and III	large whales delphinids	1. What are the effects of suction cups and why do they fall off? 2. How can we extend the duration of suction cup tags. 3. What are the best deployment techniques for both types of tags? 4. How can we expand data telemetry/tag recovery options? 5. Can we create a longer term non-invasive tag attachment? 6. Can we create a safe & reliable tag to use on small cetaceans?	1. Integrating physical oceanography w/ prey field & whale behavior. 2. When do the animals feed? How deep do they feed? travel? 3. Should we think of creating species specific systems?
Diving behavior	hours to weeks	10s of meters to 100s of kilometers	Type II or III	beaked whales	1. What are the effects of suction cups and why do they fall off? 2. What is the best deployment technique for these tags? 3. How can we expand data telemetry/tag recovery options? 4. Can we create a longer term non-invasive tag attachment? 5. Can we create a safe & reliable tag to use on small cetaceans?	Needs: heart rate, heat exchange, gas management, vocalization, received sounds, and blood gases. 1. Are there differences in movements associated with seasons, age, or sex? 2. Should we think of creating species specific systems?
Effects of sound - BRS, CEE	hours to days	10s of meters to 100s of kilometers	Type II or III	beaked whales killer whale sperm whales	1. How do marine mammals respond to vessel, air gun, and sonar noise? 2. Do we need to rethink how species are grouped together or should we look at species specific reactions?	1. What are the effects of implanted tags?
Industrial conflicts	weeks	10s of meters to 100s of kilometers	Type II	large cetaceans delphinids	1. How do marine mammals respond to vessel, air gun, and sonar noise? 2. Do we need to rethink how species are grouped together or should we look at species specific reactions?	1. What are the effects of implanted tags?
Post release tracking of relocated stranded animals	months	100s of kilometers	Type II	sperm whales mid to small delphinids	1. What is the survivability of released animals? 2. What are the daily movement and diving patterns? 3. What are the longer-term ranging patterns?	1. What are the effects of dorsal fin tags?
Disentangle ment Case Management	months	ocean basin	towed PCCS buoy - months	large cetaceans: right and humpback	1. What does the drag do to entanglement embeddings? 2. Is there a lower drag alternative (this is grossly underinstrumented - many kinds of sensors could be included)? 3. Could it be attached with a lasso to normal animals?	
Sedation Monitoring	hours	small scale	none	right whale	Needs: real time feedback to enable better case management. 1. How do heart & breath rates vary with levels of sedation? 2. Does the locomotory pattern change with sedation?	
Calibrating passive acoustics	months	ocean basin	none		1. What are vocalization rates of different life stages in different habitats?	

Appendix 4 - Break-out Groups

Group 1

Joe Geraci - Univ. Maryland (Chair)
Becky Woodward – WHOI (Rappateur)
Terrie Rowles – NOAA
Bruce Mate - OSU
Greg Schorr - Cascadia
Andrew Westgate
Joe Olson - CRT
Vince Janik - SMRU

Group 2

Jim Harvey – MLML (Chair)
Mark Baumgartner – WHOI (Rappateur)
Francis Gulland - TMMC
Forrest Townsend - Fort Walton Beach
Alex Zerbini - NOAA
Mark Johnson (Dtag) - WHOI
Laurens Howle - Duke
Colin Hunter – Sirtrack

Group 3 (Restricted Room)

Dan Mulcahy – USGS (Chair)
Jeremy Winn - WHOI (Rappateur)
Michael Moore - WHOI
Rod Hobbs - NMML
Russ Andrews – AK Sealife Center
Brad Hanson - NOAA
John Calambokidis - Cascadia
Frank Deckert - TRAC PAC INC

Group 4

Michael Scott - IATTC (Chair)
Doug Nowacek - Duke (Rappateur)
Ann Pabst, UNC- Wilmington
Nick Gales – Australian Gov
Robin Baird - Cascadia
Rui Prieto - University of Azores
John Hildebrand - SIO
Roger Hill – Wildlife Computers