Australian Government
Department of Sustainability, Environment, Water, Population and Communities
Australian Antarctic Division

Report of the workshop on the satellite tracking of southern right whales in Australian waters

Melbourne, Australia 22-23 November 2012

AUSTRALIAN MARINE MAMMAL CENTRE

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1. WELCOME AND OPENING COMMENTS

Mike Double welcomed participants on behalf of the Australian Marine Mammal Centre (AMMC) and the Department of Sustainability, Environment, Water Population and Communities (DSEWPaC) and introduced the workshop. He discussed the potential for satellite telemetry to address or contribute to actions listed in the southern right whale conservation management plan (DSEWPaC). Throughout the two day workshop, the following questions were to be addressed:

1. What are the conservation management questions that could be addressed using satellite tracking of right whales?
2. What would be the priority questions to address?
3. What would be the most efficient approach to address the priority questions?
4. What would be the appropriate location(s), sample sizes and duration for any research effort?
5. What are the current limitations and concerns associated with the use of implantable tags on whales?
6. How would these limitations and concerns affect the research effort?

The output from the workshop, the workshop report, would be made publicly available on the AMMC website of the DSEWPaC.

2. ELECTION OF CHAIR, APPOINTMENT OF RAPPORTEUR/S

There were 9 attendees in total (see Appendix 1 for a list of participants) comprising federal and state government, consulting and research organisations from Western Australia, South Australia, Victoria and Tasmania. John Bannister chaired the workshop and Virginia Andrews-Goff acted as rapporteur.

3. DOCUMENTS

Additional documents relating to satellite tagging of southern right whales were made available by Simon Childerhouse and are listed in Appendix 2. Peter Best supplied a document updating published observations of tagged southern right whales off South Africa for discussion. Glenn Dunshea provided a project report on southern right whale stable isotope profiles.

4. BACKGROUND PRESENTATIONS

Background presentations were delivered throughout the first morning of the workshop. A summary of these presentations follows.

4.1 Southern right whales
Australia – western subpopulation
John Bannister

Since 1976, annual aerial surveys for southern right whales have been conducted along the south coast of Western Australia from Cape Leeuwin to as far west as Twilight Cove. These surveys were extended in 1993 to Ceduna, South Australia, covering the majority of the Australian 'western' subpopulation. Sightings data are held in two databases – 'sightings' (some 3000 sheets) and photographically identified individuals (1859) mostly from overhead (aerial) shots of head callosities. Animals are recorded in two main categories – cows with calves of the year ('cow-calf pairs') and others ('unaccompanied animals'), including non-breeding cows, males, and juveniles of both sexes. Cow-calf pairs are found in three main locations – the Doubtful Island Bay and Israelite Bay areas (Western Australia) and at Head of Bight (South Australia); 'unaccompanied animals' are more widespread and unpredictable with concentrations near Albany, at Doubtful Island Bay, Yokinup Bay and Israelite Bay (Western Australia), near Border Village and west of Head of Bight (South Australia). Analyses of annual counts carried out between 1993 and 2012 indicate that the western subpopulation is increasing at 6.8% (95% CI 4.56-9.23) for all animals and 7.28% (4.14-10.52) for cow-calf pairs. Using a simple model, the current size of the western subpopulation is estimated at circa 2800.

Based on head callosity 'matches,' individual whale movements have been recorded between the Antarctic and the West Australian/South Australian coast (15 animals), between 41-44°S and the West Australian/South Australian coast (2 animals), along the coast between Head of Bight (South Australia) and West Australia (mainly westward movement - 18/30 animals) and between the Auckland Islands (New Zealand subantarctic) and Head of Bight (3 animals). Two discovery mark returns show summer movement eastwards south of the Great Australian Bight and Tasmania (Tormosov et al., 1998). American whaling logbook data ('Townsend's Charts' - see Bannister, 2001) show a general movement southwards from the coast from September, with south easterly movement offshore in summer. In the 1840s, whalers were reported as believing that right whales moved northwards from the south early in the season, approaching Tasmania from about April and continuing on past Victoria and into the Bight. Southern right whales were also thought to approach the whole coast from the south, striking southward as a body from Cape Leeuwin and working south east, 2-300 miles from land in October/November. Such a generalised, almost circular, anti-clockwise pattern for right whales south of Australia was suggested by Burnell (2001) from intra-year (95% westerly) and inter-year (75% easterly) movements recorded mainly from Head of Bight.

4.2 Southern right whales in south east Australia
Mandy Watson

Southern right whales are considered critically endangered in Victoria (DSE Advisory List Threatened Vertebrate Fauna in Victoria, 2007) and listed under the Victorian Flora and Fauna Guarantee (FFG) Act 1988. They were recently upgraded from vulnerable to endangered in New South Wales and listed under Schedule 1 of the Threatened Species Conservation Act 1995.

The Victorian sightings database spanning 1985 – 2012 is summarised below:

- Logans Beach - 64 calves recorded, with up to 6 in one year, average 2 per year, no detectable increase.
- Remainder of Victoria - up to 74 calves in total, locations highly variable and short residency periods.
- Incidental sightings distribution maps indicate areas of highest density are Portland, Port Fairy and Warrnambool (Logans Beach).
- Earliest sighting on record is 22nd of April at Portland (2006), latest sighting on record is 5th of November at Point Hicks in East Gippsland (1990).
- Majority of first sightings occur in May (54%) and June (42%) in western Victoria.
- Majority of last sightings occur in September (50%) and October (38%) in western Victoria – but increasing trend towards October (7 out of last 10 years).
- First sightings of the season are more spread out than last sightings of the season.

New South Wales sightings are summarised below:

- New South Wales sightings are concentrated along the southern and central coasts (south of Newcastle).
- Estimated to be less than 10 individuals per year using the New South Wales coast.
- However, 14 individuals were recorded between Moruya and Narooma during an opportunistic photo - ID flight in 2010.

The *South East Australia Southern Right Whale Photo Identification Catalogue* (SEA SRW PIC) project was initiated by Mandy Watson in 2001. To date, 225 different whales (eastern South Australia, Victoria, New South Wales and Tasmania) have been identified including 29 (13%) breeding females. The year 2009 is considered a “big year” with 43 whales catalogued. Thirty eight whales have been catalogued in 2012 with approximately 20 yet to be matched. Very few matches (approximately 3%) have occurred between New South Wales and Victorian sightings (one confirmed, five unconfirmed).

Potential impacts on the southern right whale population in south east Australia include offshore and coastal development encompassing seismic and drilling exploration, wave energy installations, port development, shipping, whale watching, aquaculture and commercial fishing. For the south east population, particular knowledge gaps are population size and trend, distribution, migratory patterns, seasonal coastal distribution and use, impacts of noise and cumulative impacts.

4.3 Southern right whales - Tasmania
Rosemary Gales

Southern right whales are listed as an endangered species in Tasmania and are the focus of a program which seeks to better understand the status of the south eastern Australian subpopulation. Historically southern right whales were abundant in inshore Tasmanian waters, until they became the foundation of the shore based whaling industry in the early 1800s. Over the next 70 years, in excess of 7750 right whales were killed, driving the population close to extinction. In recent decades sightings of southern right whales have been recorded around the coastline of Tasmania with most sightings occurring on the east coast, particularly in the south east region. The areas of most frequent use are consistent with the locations of the whaling stations and reflect the areas of sheltered bays and shallow water where the whales used to congregate and breed in large numbers.

Southern right whales have been observed in Tasmanian waters in all months of the year, but are most frequently seen between June and October. The numbers of reports of southern right whales in Tasmania shows an overall increase in recent years, not withstanding significant inter annual variation. The 2012 season has seen the highest number of reports of southern right whales in Tasmania for many years. There are also increasing observations of aggregations of whales which are remaining in the area for increasing periods, and also increasing observations of feeding and highly active and social behaviours. The number of individuals identified each year from callosity images is also increasing, with images of 33 new individuals acquired in 2012. Cow-calf pairs are recorded in low numbers in Tasmania in most years.

In October 2010, in collaboration with AMMC, a satellite transmitter was attached to a single southern right whale in south east Tasmania. The whale was tracked until February 2011 (115 days) during which time it travelled over 9000 km through the southern ocean into Antarctic waters. Transmission ceased when the whale was travelling northwards towards more temperate waters. Priorities for research for southern right whales in Tasmania include increasing an understanding of their numbers, trends and at-sea distribution.

4.4 Previous satellite tagging studies of northern and southern right whales and the current state of tagging techniques
Simon Childerhouse

Simon Childerhouse presented the findings of previous studies that employed satellite tags to determine the movements of northern and southern right whales. The abstracts of the published papers detailing this research are given below and these references are included in Appendix 2.

MATE BR, NIEUKIRK SL, KRAUS SD. 1997. SATELLITE-MONITORED MOVEMENTS OF THE NORTHERN RIGHT WHALE. JOURNAL OF WILDLIFE MANAGEMENT 61(4):1393-1405**.**

The northern right whale, *Eubalaena glacialis*, remains the most critically endangered of the large cetaceans despite international protection since 1936. We used satellite-monitored radiotags to identify the late-summer and fall habitat use patterns of right whales in the western North Atlantic. We tagged 9 whales in the Bay of Fundy (BOF) and successfully tracked them for a total of 13,910 km (f = 1,546 km) in 195 whale-tracking days (range 7-42 days each, i = 21.7 days). Individuals tracked for more than 12 consecutive days (N = 6 whales) left the BOF at least once and had higher average speeds (Y = 3.5 km/hr) than those that stayed within the bay (Y = 1.1 km/hr). Three of the tagged whales not only left the BOF, but traveled more than 2,000 km each before returning to the general tagging area. One adult female with a calf went to New Jersey and back to the BOF (3,761 km) in 42 days. Most locations were along bank edges, in basins or along the continental shelf. Eighty percent of locations were in water <182 m (100 fathoms [F]) deep. All of the tagged whales were located in or near shipping lanes. Right whale distribution coincided with areas intensively used by humans for fishing, shipping, and recreation. Individuals moved rapidly among areas previously identified as right whale habitat. Whale locations plotted on sea surface temperature (satellite infrared) images suggest that one whale spent time at the edge of a warm core ring and others spent extended periods in upwellings. Observations of whales surfacing with mud on their heads suggest that these whales fed near the BOF seafloor. Satellite telemetry is a useful means of tracking cetacean species that are difficult to view, move long distances, and might be too expensive to monitor by other means.

BEST PB, MATE B. 2007. SIGHTING HISTORIES AND OBSERVATIONS OF SOUTHERN RIGHT WHALES FOLLOWING SATELLITE TAGGING OFF SOUTH AFRICA. JOURNAL OF CETACEAN RESEARCH MANAGEMENT 9(2):111-114.

In September 2001, satellite tags were deployed on 21 southern right whales in South African coastal waters including eight cows accompanied by newborn calves. To date, there have been 26 re-sightings of 11 of these individuals (or their calves) at intervals of 27-1,502 days. So far, 85.7% of the females with calves have been resighted with a second calf, at intervals comparable to those that the same individuals showed before tagging. All tags seem to have been shed between 27 and 36 months of tagging. Superficial and remote examination of wound sites indicated the frequent formation of divots with accompanying scarring and cyamids, but little sign of localised (and none of regional) swellings.

MATE, B. R., BEST, P. B., LAGERQUIST, B. A. AND WINSOR, M. H. 2011. COASTAL, OFFSHORE, AND MIGRATORY MOVEMENTS OF SOUTH AFRICAN RIGHT WHALES REVEALED BY SATELLITE TELEMETRY. MARINE MAMMAL SCIENCE 27(3): 455-476.

In September 2001, 21 satellite-monitored radio tags were deployed on southern right whales in South African waters, 15 of which transmitted for 25–161 d. Most coastwise movement on the south coast occurred in a westerly direction with cow- calf pairs moving slowest. Three whales tagged on the west coast and one tagged on the south coast moved north into St Helena Bay, a probable feeding ground, where residence times were 36–100 d. Five animals tracked after leaving the coast maintained a bearing of 201°–220° before branching out over the southeast Atlantic from 37° to 60° S and between 13° W and 16° E, traveling 3,800–8,200 km over

the ensuing 53–110 d before transmissions ceased. Their locations were categorized as migrating or nonmigrating based on the relative orientation of the track and net speed. An average of 42% of nonmigrating locations were between 37° S and 45° S, and 53% were south of 52° S, possibly associated with the Subtropical Convergence and Antarctic Polar Front, respectively. Whaling data suggest right whales fed largely on copepods at the former and euphausiids at the latter. If the nonmigrating locations represented feeding at these frontal zones, switching between them would seem to have obvious cost-benefit implications.

CHILDERHOUSE SJ, DOUBLE M, GALES N. 2010. SATELLITE TRACKING OF SOUTHERN RIGHT WHALES (EUBALAENA AUSTRALIS) AT THE AUCKLAND ISLANDS, NEW ZEALAND. IWC PAPER SC/62/BRG19

We attached satellite tags to 6 southern right whales off the Auckland Islands in sub-Antarctic New Zealand during July and August 2009. The tags lasted for an average of 75 days (range: 1-167 days) and provided data on migratory movements of three individuals between the Auckland Islands and assumed feeding areas south of Australia.

4.5 Southern right whales and stable isotopes: Towards defining southern right whale habitat and trophic ecology
Glenn Dunshea, presented by Simon Childerhouse

Stable isotope abundances of carbon (13C) and nitrogen (15N) were measured in 476 southern right whale (*Eubalaena australis*) skin samples from south east Australia (SEA, n = 16), the New Zealand (NZ, n =36) mainland and the Auckland Islands (AI, n = 424). These data were used to infer trophic processes and the broad geographic location of austral summer foraging habitat in the Southern Ocean and whether these vary according to calving ground, demographic class, matri-lineage determined from mitochondrial DNA (mtDNA) haplotype or inter-annually. These results were then related to known natural gradients in the distribution of 13C and 15N; namely the latitudinal gradient of 13C that exists in the Southern Ocean in relation to oceanographic features and the trophic gradient in15N, where 15N abundance increases with increasing trophic level. The abundance of 13C was significantly lower in samples from SEA compared to AI (but not NZ), indicating that SEA whales may feed further south overall than most AI whales.

After taking into account recaptures of the same individual using genetic data, sample sizes were only sufficient in the AI sample set to examine demographic class, mtDNA haplotype and inter-annual effects on isotope abundances and the extent of co-variation with the other isotope. No differences in either 13C or 15N abundances were apparent for different mtDNA haplotypes, in contrast to findings from Argentinean southern right whales. Additionally there was less variation in both 13C and 15N for samples used in this study compared with those from Argentinean whales, indicating a relatively more latitudinal restricted geographic area used for foraging by Oceania whales. There was a non-linear effect of 15N on AI 13C abundances and inter-annual changes varied according to different demographic classes: in 2007 there was no difference between the demographic classes, in 2008 cow 13C abundances were lower than other females and males with the same pattern in 2009 although less pronounced. This indicated that the different demographic classes respond to different environmental conditions (for example, prey availability) in different ways, either physiologically or with distributional changes. For 15N there was a significant difference between demographic classes in 15N abundances with cows having consistently lower values compared with other females and males. The effect of 13C values on 15N also differed between demographic classes with cows showing a relatively strong effect compared with no effect in males and females. These results may be due to the energetics of pregnancy and lactation influencing nitrogen isotope fractionation processes.

Based on previously described 'isoscapes' of the Southern Ocean, the 13C abundances for all samples appear to indicate that the majority of Oceania whales (particularly AI whales) feed at latitudes above 50°S, probably in association with convergence of different oceanic water masses such as the sub-tropical convergence. This is consistent with some satellite tracking data showing austral summer positions of three AI whales between 40 - 50°S below Australia. Comparison of the 15N data with other Southern Ocean fauna indicated that Oceania whales likely feed on zooplankton (copepods and krill) at the lower end of the 15N spectrum. Compared to the limited data available on Southern Ocean predators, Oceania southern right whales have an isotopic niche closest to that of other major pelagic mid-latitude consumers of zooplankton, the crested penguins.

4.6 Concerns and limitations associated with the use of implantable tags
Virginia Andrews-Goff

(References that were discussed and referred to during this presentation are given in Appendix 2)

Satellite tags have the ability to provide information important for the conservation and management of whales. This movement information can range from short term to long term and fine scale to coarse scale depending on the satellite tag employed. Suction cup tags (such as the DTAG in fig. 1a) attach directly to the dermis and provide fine scale information over a time period of hours. DTAGS can collect information on body orientation and depth in addition to recording sounds made by the whale over a number of hours and have been successfully deployed on right whales (Nowacek et al., 2001). Tags that penetrate skin and blubber such as the LIMPET (Low Impact Minimally Percutaneous External-electronics Transmitter; Andrews et al., 2008; fig. 1b) and the Z-tag (Zebedee tag under development by Michael Noad from the University of Queensland and the AAD; Baker et al., 2012 fig. 1c) offer the capacity for medium range deployment (days for Z-tags to around a month for LIMPETs) potentially describing fine scale (GPS locations – Z-tag) to medium or large scale movements. Deep implantable tags (fig. 1d) penetrate through skin and blubber to anchor in the blubber muscle interface – an attachment that is secure enough to result in tag attachment spanning months to years. Deep implantable tags have been successfully deployed on right whales (for example, Baumgartner and Mate, 2005; Best and Mate, 2007; Childerhouse et al., 2010; Zerbini et al., 2010; Mate et al., 2011). This long term attachment potential is essential for the study of large- scale migrations (Mate et al., 2011), site fidelity (Baumgartner and Mate, 2005) and dispersal patterns (Gales et al., 2009), stock structure (Heide-Jorgensen et al., 2006) and relating movement to environmental variables (Baumgartner and Mate, 2005). However, the invasive nature of attachment raises concerns over deep-tissue damage and potentially infection (Weller, 2008).

The possible physical impacts of implantable tags are initially related to the blunt trauma associated with deployment followed by the maintenance of an open wound in salt water (Weller, 2008). Physical impacts described in published scientific literature and observations from an ongoing study of tagging impacts to humpback whales in the Gulf of Maine indicate that blubber extruding from the tagging site, scar tissue, cyamids at the tagging site, development of a depression at the tagging site, local swelling and regional swelling are common to a range of tagged cetaceans (Mate et al., 1983; Kraus et al., 2000; Best and Mate, 2007; Mate et al., 2007; Weller, 2008; Mate, 2009; Baker et al., 2012). Veterinarian assessment of the humpback whales tagged in the Gulf of Maine has indicated that this range of symptoms is unlikely to cause long term or systemic damage (Frances Gulland, pers. comm.). However, if a swelling were to increase in size, be accompanied by a discharge at the tagging site and/or be accompanied by a behavioural change (such as a lack of feeding), further action may need to be taken which would likely be administration of an antibiotic. To date, all evidence suggests that tagging impacts do not affect reproductive success and survival but continued assessment is required to improve our understanding of these impacts as satellite tagging technology and attachment techniques evolve and improve. In addition, clear and directed research questions will enable an informed approach to the programming of tag settings (see Breed et al., 2011) and will result in data suitable for a range of analytical techniques (see Jonsen et al., 2012). The choice of an appropriate tag duty cycle and resulting analyses will differ according to the spatial and temporal scale of the movements of interest and the quality of location data received.

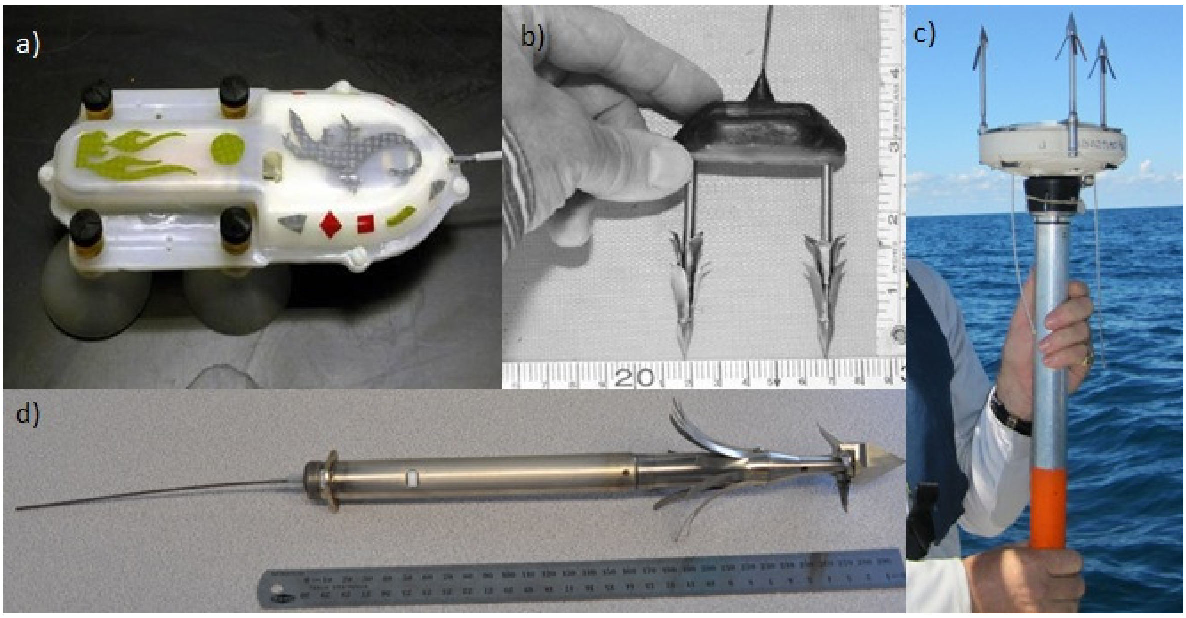

Figure 1: Satellite tags deployed on cetaceans. a) The Digital Acoustic Recording Tag or DTAG as developed by Mark Johnson and Peter Tyack, WHOI. Image sourced from www.whoi.edu/page.do?pid=39337. b) The Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET tag) as developed by Russel Andrews, Alaska SeaLife Center. Image sourced from Andrews et al. 2008. c) The Zebedee or Z-tag (white body and darts) mounted on a tagging bolt (long cylinder) as developed by Michael Noad, University of Queensland and the AAD. Image courtesy of Michael Noad. d) Deep implantable satellite tag as developed by the AAD. Image: Virginia Andrews-Goff

4.7 The South African experience – a document supplied for discussion by Peter Best Presented by Simon Childerhouse

This note presents data from 44 resightings of 15 southern right whales that were satellite-tagged on the South African coast in September 2001. Tag performance in terms of number of days with locations received was significantly higher in males than females, and lowest in cows with calves, and attributed to behavioural differences leading to variable degrees of tag antenna damage. Resightings occurred from 27 to 4,041 days after tagging: tags were retained in all whales seen within 27 months, but were apparently shed in all but one individual seen within 36 months of tagging. The exception was a whale that still had the tag present 11 years after tagging. Healing at the tag site occurred gradually and within five years of tagging (and two years after tag shedding), leaving a circular depression about 15-20 cm in diameter but little swelling. Although sample sizes were small, no significant effects on the frequency of calving were detected in mature females before and after tagging. The death of one female three years after tagging was more likely attributable to a ship strike on an animal debilitated by a prolapsed uterus.

5. ETHICAL CONSIDERATIONS

Following the background presentations, workshop participants discussed the ethical considerations related to implantable satellite tags. The workshop recognised that the physical impacts of tagging to southern right whales are concerning and felt that researchers must only employ the use of satellite tags if essential to addressing a research question that is central to important conservation management decisions. The workshop recognised that tagging presents little or no threat to reproductive success and survival as indicated by the 11 year southern right whale study presented in Peter Best's document (section 4.7). However, some workshop participants were concerned about the shorter term physical impacts revealed through the study of humpback whales tagged in the Gulf of Maine (as discussed in Baker et al., 2012). The workshop encouraged researchers undertaking the tagging of whales to provide the most current information regarding tagging impacts to ethics committees so that the importance of the proposed research can be assessed relative to potential tagging impacts.

In principle, and where they are applicable, the workshop strongly supports the implementation of safeguards such as those proposed below by (Weller et al., 2009) for the deployment of satellite tags on Western Pacific gray whales:

- *the work should be carried out by experienced investigators using tested techniques;*
- *tag design and deployment methodology should be of best-practice standard, including:*
  - *tag length being the minimum possible to achieve a pre-determined attachment duration*
  - *use of sterile techniques to minimise infection*
- *the work should be restricted to known males in good body condition and identified in 'real time' (i.e.in the field while tagging is being attempted) from previous photo-id and genetic studies) ;*
- *field protocols to minimise risks and limit the time spent with individuals should be developed and presented for review by the co-ordination group in advance of fieldwork;*
- *follow-up work on the potential effects of tagging should be a key part of any programme, and in particular every effort should be made to resight tagged whales during the period of the study;*
- *tracking data should be available to the IWC in as near 'real time' as possible.*

The workshop strongly recommends that a dedicated and comprehensive follow-up study to assess the possible impacts of tagging of southern right whales must be included with any satellite tagging project proposal. A follow-up study should include, but not be restricted to, methodologies proposed to address the following elements:

- Collection of photo-ID at time of tagging to allow cross referencing with photo identification catalogues and to assist individual identification pre and post tagging
- Collection of biopsy at time of tagging to allow individual identification
- High quality photographs of the tag site and general photos to assess the health and condition of the whale over time
- Resighting of the tagged individual over the short term, ideally including
    - At least 1-2 weekly sightings within the first several months (e.g. three months)
- Resighting of the tagged individual over the medium to long term, ideally including
    - At least monthly resightings while the tag is transmitting and accessible (i.e. not offshore or in remote areas)
- Consideration of the collection of photos from the individual once the tag is no longer transmitting, for example
    - Development of collaborations and networks to facilitate the sharing of photo-IDs and information about tagged whales (i.e. real time tracking so that researchers can locate and access the tagged individual)
- Future surveys in areas where the individual may be seen subsequently
- Development of a process to ensure the long term continuation of this follow up study (e.g. centralised reporting of photos)
- Involvement of experts with expertise in the assessment of tag healing

6. CONSERVATION MANAGEMENT QUESTIONS THAT CAN BE ADDRESSED WITH SATELLITE TAGGING

Southern right whales (*Eubalaena australis*) are currently listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) because they have undergone a severe reduction in numbers as a result of commercial whaling. An initial recovery plan for southern right whales was developed for the period 2005 to 2010. A review of that plan found that despite progress on many recovery actions and evidence of population increase in south-west Australian waters, southern right whale habitat occupancy is still constrained in comparison to historical occupancy, and current abundance is still well below estimated historic abundance. The review recommended an updated recovery plan for the southern right whale be developed to reflect new knowledge and prioritise research needed to monitor population recovery and better predict the impacts of threats such as climate change. Therefore, a recovery plan for the southern right whale has been developed which conforms to the International Whaling

Commission's 'Conservation Management Plan' format, while meeting the requirements of a recovery plan under the EPBC Act.

The potential for satellite tagging to address or contribute to each action area as outlined in the southern right whale conservation management plan was discussed and is presented in Table 1. The workshop recognised that less invasive tags such as Z-tags can provide valuable information on very short term (only a few days), fine scale movements. Z-tags could be employed, when appropriate, as a method with fewer physical impacts as compared to deep implantable satellite tags. The workshop noted that a reasonable amount of information on the distribution, especially inshore distribution, of southern right whales exists. However much movement information and in particular movements

Table 1: Assessment of the suitability of satellite tagging studies to address or contribute to action areas identified in the southern right whale conservation management plan

Action area	Research question	Tag type	Location**	Are there any viable alternative techniques?	Impact on management actions	Potential for follow up study on tagging impacts	How can tagging answer this question?
Assessing and addressing anthropogenic noise	What levels of anthropogenic noise impact on the behaviour of SRWs?	Z tags or other short term satellite tags (controlled exposure experiments)	Doubtful Island Bay, Israelite Bay HoB (optimally)	Possible surveys from land but much lower quality data	Feed directly into referral process – mitigation zones, reassess sound models, guidelines	Within year (3 months) then three years for cow/calves	Yes by analysing tagging data to assess behavioural response to noise
Reducing commercial fishing entanglements	Do whales occur where the threat of entanglement exists? e.g. cray pots	Deep implantable satellite tags	TAS, VIC, WA	Aerial survey and sightings data but only in waters of high visibility	Could inform spatial or temporal closures (low likelihood)	If tag is transmitting locations or potentially via aerial survey	Yes by creating outputs such as maps to overlay whale location with fishing effort but not likely to drive instigation of a tagging program
Assessing impacts of climate variability and change	Are whales vulnerable to climate change?	Deep implantable satellite tags	Locations with large population late in the season	Ship based surveys	Climate change policy	Immediate follow up possible, long term follow up unlikely	Yes by analysing tagging data to identify feeding activity and the location of potential foraging grounds as an indicator of climate mediated prey availability/quality
Addressing vessel collisions	Do whales occur where the threat of ship strike exists? e.g.	Deep implantable satellite tags	Northerly migrating animals off TAS which will pass through	Passive acoustics*	Placement of shipping lanes, regional ship speed adjustments	Intrayear	Yes by creating outputs such as maps to overlay whale location with shipping activity but not likely to drive instigation

	Bass Strait		Bass Strait				of a tagging study
Addressing infrastructure and coastal development impacts	Do inshore developments displace whales?	Deep implantable satellite tags	Throughout distribution – low priority for NSW & WA	Passive acoustics*, aerial survey	Feed directly into the referral process, guidelines, adaptive management, fish farm placement	Within TAS, VIC, SA	Yes by using tagging data to create outputs such as a time series of maps or animations depicting movement indicating a change in occupancy or use around developments
Understanding offshore distribution and migration	Do offshore developments impact whales?	Deep implantable satellite tags	TAS (northwardly migrating animals) Any likely concentrated areas (southwardly migrating animals)	Passive acoustics*	Feed directly into the referral process, guidelines, adaptive management	No	Yes by using tagging data to create outputs such as a time series of maps or animations depicting dispersal and migration route changes in relation to offshore development locations but timing of tag deployment will be challenging, tag life may not be long enough leading to poor representation of northward movements

* Passive acoustics in relation to satellite tagging will provide presence only information and is highly restricted geographically and therefore is unlikely to deliver sufficient information to guide broad scale management action.
** Locations listed are not necessarily the location under threat. Rather the locations specified are likely to provide adequate southern right whale numbers and conditions where a research study can be carried out successfully.

that connect breeding and feeding grounds is lacking, therefore the ability to assess vulnerability to threats is compromised by the inability to establish baseline movements.

7. WHAT WOULD BE THE PRIORITY QUESTIONS TO ADDRESS FOR CONSERVATION MANAGEMENT

The workshop prioritised the action areas identified in the southern right whale conservation management plan (as presented in Table 1) into two categories. Higher priority category A incorporates action areas where satellite tagging directly contributes to the investigation of identified threats. Category B details action areas that would benefit from information collected by satellite tags.

A – Addressing infrastructure and coastal development impacts
A – Assessing and addressing anthropogenic noise
A – Understanding offshore distribution and migration

B – Impacts of climate variability and change
B – Reducing commercial fishing entanglements
B – Addressing vessel collisions

The workshop acknowledged that the size of the south east Australian southern right whale population is unknown, but agreed that numbers are possibly in the low hundreds (i.e. minimum of 225 over the last 10 years, SEA SRW PIC); the Western Australian subpopulation comprises approximately 2800 individuals (J. Bannister pers. comm.). Further, unlike the west Australian subpopulation, there is no information on population trend for the south east subpopulation. The vulnerability of the south east subpopulation is further exacerbated by threats that may impact on these animals and their low numbers. The threats that likely impact the south east subpopulation at a moderate to major level include acute and chronic industrial noise, interactions with commercial fisheries and aquaculture equipment and vessel collisions (DSEWPaC, 2012). These are in addition to the threats posed by seismic activity and climate change, which may impact both the south east and south west southern right whale subpopulations. The combination of these factors underscore the need for research that focuses on the south east Australian subpopulation to progress effective conservation management of this subpopulation.

8. GUIDING PRINCIPLES FOR ANY RESEARCH EFFORT

The following section outlines the principles that the workshop considered to be important to addressing priority actions in the southern right whale conservation management plan relevant to satellite tagging (see above) and would expect to see in any funding applications. A comprehensive and large scale approach to the projects outlined below may not always be possible due to funding or logistical issues. Where researchers and funding bodies cannot deliver the proposed project as a whole, consideration should be given to delivering a part of the project which would therefore contribute to completing the project as a whole. The workshop strongly encouraged researchers to implement projects that address more than one of the high priority action areas if possible.

8.1 Addressing infrastructure and coastal development impacts

Location
South east Australia (New South Wales, Western Australia lower priority). Potentially a sequential, longitudinal tagging program relative to established movements early in the season where the earliest opportunity to tag inshore will occur in Tasmania, followed by Victoria then South Australia. Likely to provide important information on movement through the Bass Strait.

Type
Deep implantable satellite tags deployed on unaccompanied adults to obtain an adequate tag deployment period (as presented in section 4.7, tags deployed on adult males demonstrated significantly higher tag performance in terms of the number of days on which locations were received than those deployed on adult females and tag performance was lowest for cow/calf pairs).

Sample sizes
10s eventually – 5 tags per site, per year would be ideal however tag deployment will need to be adaptive, addressing tagging issues as they arise.

Timing
Early season

Duration
Ideally at least 3 years to encompass a breeding cycle and deploy a sufficient number of tags.

Follow up
Information gained from any inshore research project is likely to inform offshore projects later in the season and will enable a thorough follow up program (as per section 5). Collaboration between researchers and states is fundamental so that any inshore research effort can include inshore development threats throughout the Australian population's range. This collaboration should be detailed in any funding application so that funding bodies are aware of the increased sample sizes/statistical power that this collaboration allows.

8.2 Assessing and addressing anthropogenic noise

A project of a similar nature to BRAHSS (Behavioural Response of Australian Humpback Whales to Seismic Surveys) could be considered for southern right whales. This project would deliver important information to assess the impact of anthropogenic noise to southern right whales. BRAHSS is a four year project aimed at understanding how humpback whales respond to the sounds of seismic surveys and to provide the information that will allow these surveys to be conducted efficiently with minimal impact on whales. The main objectives are to study the behavioural reactions of humpback whales to seismic air guns to determine if these have longer term biological effects, and also to determine whether ramp-up of air guns at the start of a survey is effective as a mitigation measure. To do this, BRAHSS utilizes both DTAGS (suction cap tags) and Z-tags. For further details on BRAHSS methodology see: http://www.brahss.org.au/pages/the-project/methodology.php

Location
Multiple sites across southern Australia where adequate sample sizes can be obtained

Type

DTAGs and Z-tags

Sample sizes
10+ per year as tags are likely to be reused

Timing
Early season

Duration
3+ years

Follow up
Tag deployment is short term and follow up can be integrated into methodology, for example during focal follows

8.3 Understanding offshore distribution and migration

Location
Multiple sites across Australia where adequate sample sizes can be obtained

Type
Deep implantable satellite tags deployed on unaccompanied adults to obtain an adequate tag deployment period (as presented in section 4.7, tags deployed on adult males demonstrated significantly higher tag performance in terms of the number of days on which locations were received than those deployed on adult females and tag performance was lowest for cow/calf pairs).

Sample sizes
10s eventually. Tag deployment will need to be adaptive, addressing tagging issues as they arise. Tagged individuals from inshore studies may potentially be included assuming ongoing functioning of the satellite tag.

Timing
Late season

Duration
3 years

Follow up
Upon tagging and while tagged animals are inshore, follow up on tagging impacts may be possible as discussed for the inshore research project. Once whales move offshore, the potential for follow up is limited.

9. OTHER CONSIDERATIONS

Collaborative research is key to the success of satellite tagging of Australian southern right whales. Whales tagged early in the season may travel between jurisdictions and so collaborations may result in increased sample sizes as well as the capacity to share knowledge and skills. It is strongly recommended that tagged animals are identified by photo ID and biopsy at the time of tagging and this information be shared throughout the southern right whale network in Australia so that tagging impacts may be monitored immediately post tagging and upon each resight thereafter. The workshop noted that tags with no duty cycles will maximize the probability of successful follow up studies. Researchers should exercise extreme caution when employing coarse duty cycles that may results in large gaps in the data received.

Researchers attempting tagging for the first time are expected to consult and collaborate with those experienced in tagging techniques such as:

- Russel Andrews, Alaska SeaLife Centre – LIMPET tags
- The Australian Marine Mammal Centre, Australian Antarctic Division – tagging, physical impacts of tagging (Nick Gales, Mike Double, Sarah Laverick, Virginia Andrews-Goff)
- Peter Best, University of Pretoria Mammal Research Institute – tagging of southern right whales, physical impacts of tagging
- Simon Childerhouse, Blue Planet Marine – tagging of southern right whales
- Frances Gulland, The Marine Mammal Centre and US Marine Mammal Commissioner – physical impacts of tagging
- Bruce Mate, Oregon State University Marine Mammal Institute – tagging of southern right whales, physical impacts of tagging
- Michael Noad, University of Queensland – DTAGs and Z tags
- Alex Zerbini, NOAA – tagging, physical impacts of tagging

10. PREPARATION AND DISTRIBUTION OF THE REPORT

A draft report was considered by the workshop and amended prior to conclusion of the workshop. An opportunity to amend the report further was provided to the workshop participants via email.

The report from this workshop will be distributed to funding bodies, advisory committees and scientific committees that can support and direct southern right whale research and also to the research groups that may implement this research within government and non government organisations throughout Australia.

This report will be published on the website of the Australian Marine Mammals Centre within the DSEWPaC: www.marinemammals.gov.au

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APPENDIX 1 – LIST OF PARTICIPANTS

First name	Last name	Organisation
Virginia	Andrews-Goff	Australian Marine Mammal Centre (AAD), Tasmania
John	Bannister	Western Australian Museum, Western Australia
Simon	Childerhouse	Blue Planet Marine, Tasmania
Mike	Double	Australian Marine Mammal Centre (AAD), Tasmania
Rosemary	Gales	Department of Primary Industries, Parks, Water and Environment, Tasmania
Saras	Kumar	Department of Environment, Water and Natural Resources, South Australia
Andrew	Lowther	South Australian Research and Development Institute, South Australia
Kelly	Waples	Department of Environment and Conservation, Western Australia
Mandy	Watson	Department of Sustainability and Environment, Victoria

Apologies: Rachael Alderman, Peter Best, Stephen Burnell, Claire Charlton, Robert Harcourt, Rebecca Pirzl

APPENDIX 2 – MEETING DOCUMENTS

Meeting documents provided by Simon Childerhouse

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