Humpback Whale Satellite Tagging in the South-Western Indian Ocean

WORKSHOP, NOVEMBER 19-21 2014

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1. Background

In the Southern Hemisphere, humpback whales (Megaptera novaeangliae) undertake extensive annual migrations between summer feeding areas in the Antarctic and sub-Antarctic waters, and winter breeding areas in subtropical and tropical coastal waters. The breeding population of Southwest Indian Ocean (SWIO) has been identified as Breeding Stock C by the International Whaling Commission (IWC, 1998) and currently four sub-stocks are recognized: C1 along the east coast of Africa from South Africa to Somalia (split into C1 (South) and C1 (North) in the region of northern Mozambique), C2 in the Mozambique Channel from the Comoros Islands to Aldabra (Seychelles), C3 around Madagascar and C4 off the Mascarene Islands. Significant advances in understanding population structure and movement in the SWIO have been made, but considerable questions remain for the region. Population genetics and photographic mark-recapture studies indicate significant genetic differentiation and a limited interchange between C1 and C3, whereas no genetic differentiation and a higher rate of interchange between C2 and C3 (Rosenbaum et al. 2009, Cerchio et al. 2008, Erst et al. 2011). Photographic recaptures also suggest relatively substantial interchange across years between C3 and C4 (Dulau-Drouot et al. 2011), while the relationship between C1 and C2 is not fully clear. In the Northwest Indian Ocean, an isolated and non-migratory population occurs in the Arabian Sea (Rosenbaum et al., 2009; Pomilla & Amaral et al., 2014).

Satellite tagging of individual whales offers an effective way to complement population-level studies (genetic, photographic) that are occurring throughout the SWIO. Telemetry data have been very informative for enhancing our understanding of complex population structure and connectivity in this and other regions (See Carvalho et al. 2014; Rosenbaum et al, 2014). In the SWIO, several tagging projects have been implemented in the region recently (2011-2014) to better understand movement of individuals during the annual breeding season.

2. Objectives of the Worskshop and Participants

Globice, in partnership with WCS, organized this regional workshop on humpback whale satellite tagging in the Western Indian Ocean under the MIROMEN (Migration Routes of *Megaptera novaeangliae*) research project. MIROMEN is supported by the European Commission (BEST Program) and targets the assessment of the migration routes and movements of humpback whales from Reunion throughout the SWIO. The workshop had a general goal of sharing satellite telemetry results and increasing collaborations for a regional scale analysis of humpback whale movement patterns across the entire SWIO region.

More specifically, the workshop's main objectives were to:

1. Assemble researchers working on satellite tracking of humpback whales in the South Western Indian Ocean (SWIO);
2. Define management or conservation issues/questions that might be addressed with the existing telemetry data;
3. Define common scientific publications for regional scale analyses and discuss the sharing of data;
4. Define a regional strategy for humpback whale studies in the SWOI.

The workshop was held at Kelonia (Saint Leu, Reunion) from 19 November to 21 November 2014 and was addressed to organizations carrying out tagging programs in the SWIO or planning to implement such research programs in the near future. In addition to researchers actively conducting telemetry programs, other participants with varied expertise were invited to provide relevant information on other research initiatives and funding opportunities. The attendees' names and contact details are provided in Table 1.

Table 1. Contact details of the Workshop Participants (alphabetical).

SURNAME	FIRST NAME	EMAIL ADDRESS	AFFILIATION
Cerchio	Salvatore	scerchio@wcs.org	Wildlife Conservation Society (WCS), USA
De Toma Ca-dinouche	Adele	adele.detoma@coi-ioc.org	Commission de l'Océan Indien (COI)
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Glenard	Zoé	globice@globice.org	Globice, Reunion
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Mouysset	Laurent	globice@globice.org	Globice, Reunion
Rosenbaum	Howard	hrosenbaum@wcs.org	WCS, USA via skype
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Trudelle	Laurene	laurene.trudelle@gmail.com	Centre de Neuro-science Paris Sud (CNPS), Université Paris Sud, France
Tyack	Olivier	otyack@gmail.com	Mauritius Marine Conservation Society (MMCS)
Vely	Michel	megapteraone@hotmail.com	Megaptera, France
Willson	Andy	andywillson@gmail.com	Five Oceans Environmental Services, Oman
Zerbini	Alexandre	alex.zerbini@noaa.gov	National Oceanic and Atmospheric Admin-istration USA via skype

The following partners and observers also attended one or more workshop sessions:

Marc Perrier Corticciato, Brigade Nature de l'Océan Indien (BNOI)

Jacques Fayan, BNOI

Suaad Al Harthi, Environmental Society of Oman

Matthieu Le Corre, University of La Réunion

Virginie Plot, University of La Réunion

Jérôme Bourjea, Ifremer

Rémi Dodemont, Opération cétacés

Patrick Pinet, BeBraX

Vanessa Estrade, Globice

Guillaume Cottarel, Globice

The workshop agenda is presented in Appendix 1.

3. Presentation of research programs on satellite tagging in the South West Indian Ocean

The initial day of the workshop was dedicated to the presentation of the different programs on satellite tagging conducted in the SWIO in order to present a global overview of the available data on a regional scale and to discuss these outcomes. Overviews of all current and planned satellite tagging projects on all the four sub-stocks in the western Indian Ocean (C1 to C4, as defined by the International Whale Commission, IWC, 2011) were presented. In addition, relevant documents relating to satellite tagging of humpback whales (published papers, IWC papers, conference posters arising from these projects) were made available to workshop participants. A summary of each presentation is provided below.

3.1. Presentation summaries

3.1.1. Megaptera's humpback whale tracking project, Comoros - Sabrina Fossette (Megaptera, Greenland Institute of Natural Ressources)

In October 2011, 2012 and 2013, seventeen satellite transmitters were deployed on wintering humpback whales from the south-western Indian Ocean breeding stock at the Comoros islands. Thirteen individuals were successfully tracked for 19.2±12.6 days (range=2–49 days) and travelled between 133 km and 5804 km in total. Whales either remained at their wintering site for several weeks or dispersed along the west coast or east coast of Madagascar where at least three main stop-over sites were identified. Two whales also dispersed from the sub-breeding stock C2 to the sub-breeding stock C3. In addition, two individuals travelled along straight paths to distant, potential, foraging areas. One whale reached the French sub-Antarctic islands while the other travelled to one of the supposed Antarctic foraging areas for humpback whales of this breeding stock. These results raised several questions: what is the main function of the stop-over sites (i.e. resting, foraging, mating)? What drives the different migratory strategies, i.e. different migratory paths? Is the foraging site identified on the Crozet plateau an important foraging site for humpback whales of the other sub-stocks?

Reference paper: Fossette S., Heide-Jørgensen M.P., Villum Jensen M., Kiszka J., , Bérubé M., Bertrand N., Vély M. 2014. Humpback whale (*Megaptera novaeangliae*) post breeding dispersal and southward migration in the western Indian Ocean. *Journal of Experimental Marine Biology and Ecology* 450: 6–14

3.1.2. Humpback Whale Satellite Tagging in the West Indian Ocean - Salvatore Cerchio (WCS, Cetamada,CNPS)

Humpback whales wintering in the Southwest Indian Ocean are thought to exhibit population substructure based on genetic and recapture data, with the primary subdivision occurring between Madagascar and east Africa. In order to investigate movement through the region during the breeding season months, and gain insights on population connectivity, breeding behavior and habitat utilization, humpback whales were satellite tagged on both east and west coasts of Madagascar during peak breeding season in 2012 and 2013, respectively. In 2012, twelve whales were tagged off northeast Madagascar: seven adult males, three mothers, and two adult females. In 2013, eleven whales were satellite tagged off southwest Madagascar: 3 adult males, 2 mothers, 5 adult females, and 1 adult of unknown sex. Mean tag duration was 21.9 days (3-58 days) in 2012, and 26.6 days (2-57 days) in 2013. Females generally had longer duration deployments, with means of 29.7 and 30.5 days, compared to 16.3 and 21.6 days for males, in 2012 and 2013 respectively. No individuals remained near the tagging sites and several whales displayed extensive long-range movements in short periods of time. Considering movements around Madagascar, whales tagged in the NE tended to spend time on a 500km stretch of the central east coast, whereas whales tagged in the SW tended to spend time on the south and southeast coasts, with little overlap between the animals from the different regions within the tag duration timeframe. Considering whales that departed Madagascar waters, three females and one male tagged in the NE travelled north on similar northwesterly trajectories: a mother and adult female travelled over 1,100 and 2,300km in 13 and 23 days, respectively, ending beyond Aldabra, and a mother travelled over 2,100km to north Kenya in 25 days, whereas a male travelled over 2,800km to Somalia, crossing the equator (to 2^{0}59.9'N), in 32 days. Southerly movements included an adult female tagged in the NE that travelled 900km to Walters Shoals, returned to Madagascar briefly, and then moved south again, covering over 5,600 km in 58 days; and an adult female tagged in the SW that travelled to the Crozet Islands in 57 days, representing the only apparent migration to feeding habitat. Despite these long range movements in relatively short periods, no whale

travelled to the western coast of Madagascar, Mozambique, or the Mascarene Islands, where breeding aggregations are well documented. These results suggest that there may be more interchange between Madagascar and central-east Africa than previously thought, and whales off east and west Madagascar may not use the same habitat within breeding seasons. We applied a switching State-Space Model to estimate behavioral modes of "transiting" (consistent/directional movement, b-mode approaching 1.0) vs. "localized" (variable/non-directional movement, b-mode approaching 2.0). Overall, females were more likely to display transiting behavior compared to males (b-mode females=1.24, b-mode males=1.55); however, a GLMM analysis of b-mode including a Sex x Region variable indicated that this relationship was significant only for whales tagged on the east coast in 2012. Females in both regions displayed comparable degrees of transiting behavior, whereas males displayed significantly more localized movement on the east coast (p = 0.005), and only slightly more localized movement on the west coast (non-significant, p = 0.284, possibly due to small sample size of 3 males). This suggests male mating strategy may involve a higher degree of localized searching, whereas females travel more extensively during breeding season, at least from the east coast of Madagascar.

Reference paper: Cerchio, S., Trudelle, L., Zerbini, A., Geyer, Y., Mayer, F.X., Charrassin, J.B., Jung, J.L., Adam, O. and Rosenbaum, H. 2013. Satellite tagging of humpback whales off Madagascar reveals long range movements of individuals in the Southwest Indian Ocean during the breeding season. Paper SC/65a/SH22 presented to the IWC Scientific Committee, Jeju Island, South Korea, June 2013.

Peer-reviewed publication status: paper in prep.

3.1.3. MIROMEN, humpback whale tagging project in Reunion - Violaine Dulau (Globice, WCS, BNOI)

La Reunion Island has become an important humpback whale breeding habitat within the southwest Indian Ocean in recent years (Dulau et al., 2012). Regional photo-identification comparisons indicate some exchanges between Madagascar and Reunion on different years (Dulau et al., 2012), but the level of connectivity within the breeding season is still unknown. Photo-identification studies demonstrate that although some whales remain around the island for several weeks, most individuals coming to Reunion are transient and are thought to reach other destinations during the season (Dulau et al., 2012). The movement pattern of humpback whales from Reunion was assessed by deploying 15 satellites tags in August 2013, during the peak of the breeding season. Photo-identification data and biopsies were collected simultaneously. Tags were fully implantable and embedded SPOT5 satellite transmitters were deployed using a modified pneumatic air gun (Air Rocket Transmitter System). The tags were duty cycled to transmit 18h daily (9hr on, 3hr off) for 3 months after deployment after which tags duty cycle switched to transmit every other day. Prior to data analysis, several filters (Z quality, speed, continent) where applied to removed unreliable positions. A state-space model (SSM) was fitted to the filtered tracks to improve the accuracy of the locations, to standardize the number of locations available per day and to infer animal behavioral state from movement pattern. The model was set to provide 8 best estimated locations per day and three categories of behavior movement were identified: localized, transit behavior and uncertain. Fifteen adult whales were successfully tagged, including 8 males and 7 females (6 with a calf). Among the 15 deployed tags, 3 stopped transmitting within 1 or 2 days, while the 12 others lasted for 12 to 71 days. Overall, the mean tracking duration was 25.5 days (sd=18.6). When considering only the 12 tags that lasted for more than 3 days, the mean tag duration was 31.5 days (sd=15.7). Nine whales left Reunion within 1 to 16 days after tag deployment and, among them, 7 reached Madagascar. Whales headed to the northeast coast of Madagascar and then spread along the eastern coast. One passed the northern tip of Madagascar but stop transmitting shortly thereafter. One whale moved northeast from Reunion, along the Mascareigne Plateau, up to latitude -12.5^0 and turned back south to St Brandon shoals, where it stayed for 4 days before the tag stopped. One male stayed for 15 days around *La Perouse* seamount, located 90NM off Reunion before he stopped transmitting. Two other males stopped over for 1 to 13 days around this underwater seamount and one male passed by without stopping. The output of the SSM model showed that localized movement behavior was mostly restricted to shallow waters, or was associated with steep bottom, which indicates proximity to underwater relief such as island slope and seamounts. Transiting movement behavior occurred in deep oceanic waters and over flat bottom, reflecting trans-oceanic movements between islands, but was also largely observed in shallow waters mainly reflecting transit along Madagascar shelf and over the Mascareignes Plateau. Localized behavior showed a patchy distribution and individuals remained in localized behavior, which can be associated to breeding activity, from few hours to 20 days. This study revealed:

- High level of connectivity from Reunion to Madagascar during a breeding season;

- Trans-oceanic movement of mothers with very young calf;
- New breeding habitat: seamount of La Perouse and Mascareignes Plateau (St Brandon Shoal); and
- New insights on the movement behavior of individuals. Males tend to spend more time in localized patches than females and visit several breeding habitat during over the season.

Reference Paper: Paper in prep.

3.1.4. The Arabian Sea Humpback Whale : From first records to tracking - Andrew Willson (Five Oceans Environmental Services, University of Exeter, Environment Society of Oman)

Assessment of humpback whales in the Northern Indian Ocean dates back to a sightings and strandings review by Reeves (1991), whereby a range was inferred within the Arabian Sea with year round seasonality. Subsequent publication of biological data (Mikhalev 1997) from Soviet whaling in the region from 1964-66 found animals caught off Oman and Pakistan/India to have a breeding cycle synchronous with northern hemisphere populations. Questions of population identity and ecology of these whales initiated with small vessel surveys undertaking genetics studies and mark recapture techniques. These studies between 2000-2006 have confirmed isolation of Arabian Sea humpbacks for approximately 70,000 years (Pomilla/Ameral et al. 2014) and a population associated with Oman of 82 animals (95%CI=60-111), (Minton et al. 2008).

Better understanding of spatial and seasonal ecology of the whales was identified as a priority in 2010 with emergence a number of threats planned for known hotspots, including; fishing, port construction, oil and gas exploration, coastal infrastructure expansion and development of fast ferry routes. Furthermore, small vessel surveys were restricted to survey in localized areas for limited periods of time and constrained by piracy, seasonal bad weather during summer monsoon (Willson et al. 2013). These conditions necessitated implementation of alternative approaches to data collections. Passive acoustic monitoring was deemed most suitable for defining seasonality in known hotspots, and satellite tagging appropriate for understanding broader spatial ecology and identification of pathways and new hotspots.

As of November 2014 the collaborating team (Environment Society of Oman, Five Oceans Environmental Services, NOAA and Instituto Aqualie, University of Exeter and Wildlife Conservation Society) are in the middle of a two year telemetry study. During February 2014, 5 whales were tagged over a three week period, with only 3 tags transmitting over the total of 7 weeks with average transmission duration of 46 days (maximum= 55 and minimum 41 days). Data was processed using 'R' for filtering with a conservative approach to generate positions for best daily location; 0 and Z locations removed, duplicate and land based locations filtered and the Argos 'SDAfilter' (Freitas et al, 2008) was applied using default parameters and a maximum swim speed of 7.2m/s. Best daily locations were transferred within ARC GIS (10.1) into track lines and habitat utilization grid cell density plots.

Results from the first year have confirmed previous studies showing localizing behavior between two primary sites. All whales were males and remained within the Halaniyats Bay around the primary tagging site for between 10 days and 30 days after tracking. There after all whales moved north eastwards with Localisation points at the Halaniyat Islands and east of the Halaniyats Islands on the continental shelf. The routes to the northeast included one along the edge of the continental slope and two through shallower coastal waters. Tracking of two of the whales terminated in the Gulf of Masirah. Tracks and density plots from this study confirmed whales were engaged in localized behavior in the heavy fishing grounds of the Gulf of Masirah and adjacent to oil and gas production facilities and new multi-purpose container port in Duqm. Tracks indicating transitory behavior were convergent with high density shipping routes and coastal gillnet fisheries (Willson et al. 2014)

The preliminary results have already been presented to the IWC Scientific Committee, and used in Oman to help inform government and industry stakeholders to make them aware of the importance of mitigation actions. Next steps are to complete another field season of tagging and generate combined ecological niche models with effort corrected sightings records. Using this work risk assessment will continue to be the focus of research effort with outputs to support regional assessment of threats and in the long-term generation of a conservation management plan.

Reference paper: Willson A., Collins T., Baldwin R., Cerchio S., Geyer Y., Godley B., Gray, H., Al-Harthi5 S., Minton G., Al Zehlawi5 N., Witt M. , Rosenbaum H.C., , Zerbini A. 2014. Preliminary results and first insights from satellite

tracking studies of male Arabian Sea humpback whales. Paper SC/65b/SH19 presented to the IWC Scientific Committee.

Peer-reviewed publication status: paper in prep.

3.1.5. A proposal for satellite tagging of humpback whales off the East coast of South Africa - Ken Findlay (University of Pretoria)

Although no satellite tagging of humpback whales has been carried out on the east coast of South Africa, the Mammal Research Institute Whale Unit of the University of Pretoria (Findlay) is proposing the deployment of 10-12 tags on northward migrating whales off the coast of KwaZulu – Natal, South Africa in July 2015. This proposed tagging will be done at Richards Bay, some 80 nautical miles south of Cape Vidal where shore-based monitoring of migrating humpback whales has been carried out intermittently since 1988. This shore-based monitoring has resulted in increased estimates of this migratory stream of between nine and 11.4 % per annum (Findlay et al. 2011a). Both photographic identification and reports of lost harpoons during the historic whaling era link this migratory stream with the population that breeds in the austral winter in coastal waters of Mozambique (Findlay et al., 1994; Findlay et al., 2011b), but little further information is available on the dispersal of this migration stream across the Western Indian Ocean. Although a single photographic return links St Lucia (between Richards Bay and Cape Vidal) with Antongil Bay in Madagascar, genetic, photographic and catch data suggest some regional segregation between the animals utilising the Mozambique breeding grounds and those in other areas of the Western Indian Ocean.

The proposed tagging will be undertaken with two major objectives in mind. The first objective is aimed to understand the dispersal of animals from this northward migration stream, while a second aim is to provide some independent verification of the migration characteristics (migration speed and distance offshore) which are vital to the ground-truthing of the assumptions used for input in the modelling analyses of the shore-based population trends and in analysing the efficacy of new automated video tracking systems to be used for monitoring of this migratory stream in the future (Findlay and Hough, 2004).

3.2. Group Discussions on the main outputs of existing research programs

The participants identified the following key points from the project presentations:

- **Definition of within season exchange between substocks:** The existing tagging data represented a substantial amount of data on the movement of humpback whales between breeding sites and revealed exchanges between different sub-stocks of the SWIO during the same breeding season, notably from:
  - Reunion (C4) to the eastern coast of Madagascar (C3)
  - Mayotte (C2) to Madagascar (C3)
  - Madagascar (C3) to the Northeast coast of Africa (C1North)

- **Movements and behavior relative to sex of tagged whale:** Females (including those with calves) showed extensive movement, generally more than males, which was relatively unexpected. Different hypotheses were discussed in an attempt to explain why females with a calf were undertaking such wide-range movement with various participants proposing several non-mutually exclusive alternatives: females with young calves could be avoiding reproductive males to protect their calves; mothers might be introducing their off-spring to the location of the important breeding sites; these extensive movements could serve to develop musculature and stamina for the calf before the long migration back to Antarctica.

- **Influence of timing of tagging on results and findings:** Most tagging projects aimed to assess movement of individual's within the breeding area, and therefore tags were generally deployed in the middle of the breeding season. This point raised the issue of defining the peak of breeding activity between sites, which seems to vary throughout the SWIO, and how this can influence the planning of future studies. This provided the opportunity to draw an overall picture of the timing of migration and breeding activity within the SWIO with participants providing opinions based on their region of work. For sub-stock C2 the peak seems to occur relatively late in the season: in mid-September in Mayotte/ Comoros and in mid-October in Aldabra (Seychelles). In the northwest of Madagascar (Nosy Be), presence of whales peaks in mid-August to late

September, with mother with calf being sighted up to November, while in the northeast and southwest Madagascar the peak occurs distinctively earlier in late July/August. In Reunion (substock C4), the peak of the breeding activity occurs in mid-August, with most whales being sighted in July-September. The participants recognized the need to define more precisely, the timing of migration and peaks of breeding activity, using consistent methods and effort on different sites. This could be done using passive acoustics, and it was noted that the existing tagging data provide useful information to select high-use areas to deploy acoustic recorders. It was also noted that the existence of stationary arrays in the Indian Ocean dedicated to monitoring tectonic activity could provide useful acoustic data.

- **Utilization of seamounts and plateaus distant from land masses:** The presented results show the use of underwater seamounts by humpback whales in several cases. Different hypotheses were suggested: according to the timing and the latitude of these mounts, they could be used for breeding as well as feeding; the low latitude seamounts, such as off Reunion, likely serve as breeding habitat, while whales might use the seamounts and oceanic islands located South of Madagascar for feeding during their southern migration. Seamounts could also be used as stop-over sites by whales to rest or to feed on migration, or they could be serve as navigation markers. It will be difficult to determine the role of the seamounts with the present dataset but other types of data might help answer this question in the future.

- **First data from tagging on southbound migratory routes and destinations:** Three tagged whales initiated their migration back to the feeding ground. Two whales (one from Mayotte, C2, and one from southwest Madagascar, C3) traveling SSE from Madagascar were tracked down to the plateau of the French sub-Antarctic Crozet Islands (western group, ca. 46°S 50°E), and one (from Mayotte, C2) traveling SSW passed the Prince Edward Islands and was tracked to 57°S 27°E. The fact that whales might head to oceanic seamounts to feed before reaching the Antarctic feeding ground was discussed. These data are the first recorded tracks of southern migration in the SWIO. However, the participants recognized that these data are insufficient to assess the exchanges between breeding and feeding areas, and that only one study (Megaptera in C2) tagged in late season specifically attempting to get migratory information. The participants agreed that this topic should be addressed when the technology has improved to allow for increased tag duration. Archival tags that record depth would also be useful to use in that case, to be able to identify areas where feeding occurs, from diving profile.

4. Argos data analysis

During the first afternoon, talks focused on the impacts of tagging, the statistical analysis of Argos data, and conservation applications of information gathered through telemetry. This provided the opportunity to discuss the different methods and types of analysis that could be developed on a regional scale. The presentations are summarized below.

4.1. Oral presentations

4.1.1. Assessing the Effects and Performance of Implantable Satellite Tags on Humpback Whales - Alexandre Zerbini (NOAA, Cascadia, Instituto Aqualie, Center for Coastal Studies, Australian Antarctic Division Marine Mammal Center, IWC, Wildlife Computers), via Skype

Satellite-monitored radio tags have yielded important information for the conservation and management of large whales. However, long-term tag attachments are typically invasive and systematic studies of their impacts have been limited. In addition, the exact causes of tag failure are poorly understood, and could include transmitter or attachment failure, post-impact damage, or removal/rejection by the animals. Tags used on baleen and sperm whales have varied in design, but often consist of an anchoring system and electronics package that are partially/fully embedded in the whale's body. We undertook follow-up monitoring to assess implantable satellite tag retention and tag impact on a well-studied population of humpback whales (*Megaptera novaeangliae*) in the Gulf of Maine. Standard techniques were used to deploy tags equipped with articulated (2011, n=19) or rigid (2012,

n=16) anchoring systems in 35 individuals with strong prior residency characteristics and known demographic traits. Tagged whales were then re-encountered and photographed over time to assess the state of the tag, wounds at the tag site and the overall condition of the whale. Images were also requested from commercial whale watching naturalists operating regularly in the area. During the tagging year, individuals were re-sighted on an average of 10 days (min=1, max=26), spanning 44 days on average post-deployment (min=1, max=136). Immediate behavioral responses to the tagging were highly variable, but no disturbance was noted when tagged whales were re-encountered on subsequent days. Visual assessments of the tag site ranged from focal lesions to broad swellings. Significant swellings persisted over extended periods (at least 391 days in one case) and appeared to be related to tag breakage and/or the location on the body. All of the whales tagged in 2011 were re-sighted in 2012, and coverage of those individuals now spans more than 600 days in some cases. Females tagged in 2011 (n=9) were observed with a calf in 2012 as frequently as 18 other females that were also present during tagging, but were not tagged. Articulated tags transmitted for 23.8 days (d) on average, with a maximum of 97d in one case. Rigid tags transmitted for 29.5d on average, with three tags lasting for more than 80d. Repeated resightings of tagged whales after deployment revealed important design flaws that could explain the relatively short and variable tag durations. Articulated anchors failed at the articulation point resulting in premature detachment of the electronics package and, in some cases (n=7), in part of the anchor likely being left in the body of the whale. Another design limitation was found at the interface between the anchoring system and the electronics resulting in bending and/or breakage of the tag (n=5). Because this interface is similar to those used in various tagging projects over the past 10 years it is possible that tag failures occurred regularly but were not documented because follow-up of tagged animals was of insufficient temporal resolution to observed tag damage. This is the first study to describe the short- and medium-term behavioral and physiological effects of satellite tagging on humpback whales; long-term effects will be evaluated as the project continues. Tag design changes arising from this study have already resulted in increased tag duration (average=56d, maximum=>192d) and highlight the importance of follow-up studies to further develop satellite tagging technology. Understanding and minimizing tag performance as well as tag impacts will increase the scientific and conservation value of this technology.

Reference paper: Robbins, J.; Zerbini, A.N., Gales, N.; Gulland, F.M.D., Double, M., Clapham, P.J., Andrews-Goff, V., Kennedy, A.S., Landry, S., Mattila, D. and Tackaberry, J. 2013. Satellite tag effectiveness and impacts on large whales: preliminary results of a case study with Gulf of Maine humpback whales. Paper SC/65a/SH05 presented to the IWC Scientific Committee, Jeju Island, South Korea, June 2013. 10pp

4.1.2. Applying State-Space Model to tracking data - Alexandre Zerbini (NOAA, Cascadia, Instituto Aqualie), via Skype

Telemetry studies have rapidly become a significant source of data to understand movements and habitat use of marine vertebrates. As such, they have important applications in conservation and management. One of the most widely used types of telemetry data are those derived from Argos satellite tags, which typically provide information on time, latitude and longitude (PTT-only tags) and also dive behavior and other environmental (temperature, light level) data (archival tags). Satellite telemetry of humpback whales (*Megaptera novaeangliae*) has typically been conducted using implantable PTT-only satellite tags (although improvements in tagging technology now allows for archival tags to be packaged into an implantable tag). Modeling telemetry data can be useful to describe animal movement, address Argos location errors, estimate behavioral states and standardize animal tracks. In this presentation, I discuss some of my personal experience with state-space models (particularly the models developed by Jonsen *et al.* (2005, 2007) and Johnson *et al.* (2008)), including the use of packages for the R open-source software. Examples of data analysis with different objectives were provided. In general, state-space models fit Argos data and represented movement of humpback whales, particularly in medium to large scales. One of the main advantages of using these models is increase comparability among whale tracks as they allow for predicted locations to be computed at the same, at regular time intervals for all individuals. In addition, the Jonsen model allows for estimation of behavioural states, which can assist in assessing habitat use when other behavioural information (e.g. dive data) is not available.

4.1.3. Habitat modelling from tagging data - Laurène Trudelle (CNPS, WCS, Cetamada, NOAA)

Argos satellite tags were attached to 23 individuals during the 2012 and 2013 breeding seasons at two distinct regions of Madagascar: in the Sainte Marie channel (Northeast) and off Anakao (Southwest). We aim to understand

how physiographic and oceanographic parameters influence the distribution pattern of humpback whales on the breeding grounds according to sex and breeding status using Argos satellite tags. We combined State Space Model and regression techniques to study the relationships between habitat use and environmental parameters according to sex and breeding status. For this, the individual locations were correlated to physiographic (bathymetry, slope, distance from shore) and oceanographic (sea surface temperature, surface current) variables by extracting the relevant data relative to the whale tracks. The data set was divided in two different track types: "pelagic" tracks and "coastal" tracks. The observed whale tracks indicated that the Central East, South and Southeast coasts were important areas in terms of time spent by the whales. They stayed essentially on the continental plateau (shallow waters) and that movement patterns differed between males and females. The geostrophic current and the chlorophyll concentration influence the behavior of humpback whales during their pelagic movements. Humpback whales could feed opportunistically in the Walters Shoals seamounts (South of Madagascar) during breeding ground; a known foraging area for tropical birds (Le Corre et al. 2012).

Publication status: Paper in prep.

4.1.4. Using tracking data to assess population overlap with human activities - Howard Rosenbaum (for WCS), via Skype

Knowledge of movement patterns and migratory routes can be instrumental in supporting a wide range of management decisions. Our aim was to better understand the potential overlap of humpback whale (*Megaptera novaeangliae*) breeding and migratory habitat with anthropogenic activities off the coast of West Africa. We used Argos satellite-monitored radio tags to collect data on 13 animals off Gabon, a primary humpback whale breeding area. We quantified habitat use by determining the number of tag transmissions and used a state-space model to determine the behavioural state of individuals using speed and turning angle. We developed a spatial metric of relative potential impact (RPI) using models of cumulative human activities, oil platforms, toxicants, and shipping. We detected strong heterogeneity in movement behaviour over time consistent with genetic evidence for multiple populations. Potential overlap of whale habitat and human activities was found to be extensive and greatest in exclusive economic zones close to shore, particularly for the hydrocarbon industry. In addition, whales potentially overlap with different activities during each stage of their migration. Breeding areas were also found to be extensive, with whales migrating north of Gabon late in the breeding season. Coupled with existing population-level data, these results may inform the definition of whale populations and actions to mitigate potential threats as part of local, regional and international management and could be applied to tracking date for humpback whales in the southwestern Indian Ocean.

Reference paper: Rosenbaum HC. Maxwell S.M., Kershaw F., Mate B. 2014. Long-Range Movement of Humpback Whales and Their Overlap with Anthropogenic Activity in the South Atlantic Ocean. *Conservation Biology,28(2): 604-615.*

4.2. Group discussion on method and data analysis

After these presentations dedicated to methods and data analyses, several points were discussed.

- **Impacts of tagging on individuals and ethical considerations:** The participants discussed the impact of implantable tags on whales and recognized the importance of following-up studies in assessing their effects on animal health. It was emphasized that it would be valuable to publish existing data on whale reaction to tagging (using photographs of tag implantation at different times after deployment), even if they are few and opportunistic, because information on tagging impact on breeding sites is lacking. Some raised the concern of broken tags that might be migrating into the tissue and potentially into the body cavity, but it was mentioned that mortality is unlikely to occur. Follow-up studies conducted in the Gulf of Maine have shown no evidence that tagging present a threat to reproductive success and survival of humpback whales; however, it is currently recognized that it is difficult to detect changes at a population level due to small sample sizes. Through these studies, the group was made aware that tags can cause physical damages (tissue protrusion, skin discoloration, divot due to loss of blubber, and localized swelling which can persist after the tag is rejected or if some portion of the tag remained in the body of the animal), which vary accord-

ing to the location of the tag. More substantial physical reactions seem to occur when the tag is implanted too low on the body of the animal. Comment was made that researchers need to consider that this is a highly invasive methodology, and must be cognizant that individuals are injured to some degree in the process. Although it is agreed that mortality is unlikely and that population level effects are also unlikely, minimal data to test these assumptions exist and there may still be fitness effects for individuals that have gone undetected. Others concurred on this opinion. Therefore, these concerns should be taken into consideration when designing and developing projects, so that tagging efforts are conducted in a responsible fashion with clear conservation benefits in light of the potential costs and impacts.

- **Post processing of Argos data for improving and making inference on movement of individuals.** A variety of models exist to standardize Argos data, improve accuracy of positions, and infer behavioral states of movement for inference on behavior of individual whales. The choice and performance of the model depend on the type, quality, and spatial scale of the data together with the objectives of the analysis. Therefore the participants agreed that objectives of regional analyses need to be defined and prioritized beforehand, rather than trying to agree on a method to be applied on a regional scale. The resolution of the regional analysis will be constrained by the different duty cycles used within the existing data.

- **Application of telemetry data to conservation:** The participants agreed that it would be highly valuable to overlap anthropogenic activity with tracking data, as carried out in the Atlantic by Rosenbaum et al. (2014). Key conservation issues in the SWIO were discussed, including hydrocarbon exploration and production (E&P), shipping traffic and coastal development. When considering E&P, and particularly the impact of industry-related noise, the issue of the availability of seismic data was discussed. Rosenbaum et al (2014) have indicated that using only the current distribution of offshore platforms as a proxy for oil and gas activity represents a minimum and underestimate industry activity, since it does not take into consideration exploration (i.e., seismic surveys) and thus oil and gas activity could be substantively underestimated (particularly in the SWIO). This point was reiterated in discussion. It was mentioned that there might be way to model acoustic/noise data in the SWIO following the methodology recently applied by the NOAA Cetacean and Sound Mapping project (http://cetsound.noaa.gov/); however, detailed data on occurrence of seismic surveys would need to be acquired and processing/analysis time would be non-trivial.

- **The influence of currents and need for correction.** The problem of how to correctly analyze tracking data to look at the impact of ocean currents on animal movements was raised. Looking at Argos tracks alone is not sufficient to assess if an animal is influenced by and/or able to detect currents. Current-corrected tracks (see Gaspar et al. 2006 PRSB for methodological details) can be obtained first and compared to the Argos tracks. It is also important to assess the quality and resolution of current data in the area and take that into account when drawing conclusions on the impact of currents on movements. Several papers have been published in the past few years on this topic and should be used as a reference to perform similar analyses on the regional humpback tracking dataset.

5. Session on regional data analyses and publications

During the second day of the workshop, the participants acknowledged the importance of sharing data collected by the different groups and the importance of carrying out analyses on a regional scale, using common analysis methods. The representatives of each organization expressed their willingness to share the data. It was agreed that data sharing would occur only once each organization will have published their data. A review of the existing data (number of tags, tag duration, period, etc.) provided an overview of the data available at a regional scale (see Appendix 2). The workshop participants then identified research topics relevant to humpback whale conservation that could be addressed with the existing tag data. Different research themes were identified within the overarching aims of both conducting a regional analysis and preparing collaborative scientific publications.

Several different themes were identified in a general discussion to serve as targets for regional papers. Each theme was discussed in turn, to establish whether it was feasible to conduct a regional study on the topic. For each

identified study, a lead author(s) and key contributors were identified. Although all data contributors are expected to be included as co-authors on the resultant papers (according to a Memorandum of Understanding to be developed, see below), the lead(s) is(are) expected to do the primary manuscript writing, with substantial input from the identified key contributors. The themes and identified roles are as follows:

5.1. Connectivity and population structure

The objective of this initiative would be to conduct a regional analysis with all existing data, in order to evaluate the connectivity between the different sub-stocks in the SWIO, to identify the potential migration routes, to assess the movements of individuals depending on their gender, to better understand the breeding strategies of humpback whales and to assess the consequences of these movements on abundance estimates.

Main authors: Salvatore Cerchio and Ken Findlay*

Key contributors: Violaine Dulau, Michel Vély, Howard Rosenbaum

* Discussion ensued regarding whether to wait until the C1 East coast of South Africa tagging (planned by Ken Findlay in 2015) has been completed and published which would delay commencing this paper likely until mid-2016 at the earliest. Decisions will be made as the work further develops.

5.2. Breeding habitats characterization & use:

This analysis will aim at characterising breeding habitat depending on different environmental variables (such as bathymetry, SST, etc.).

Main authors : Laurène Trudelle

Key contributors: Violaine Dulau, Salvatore Cerchio, Sabrina Fossette

5.3. Migratory movements and strategies:

This analysis will highlight the migration strategy of humpback whales, in term of energy costs and assess the oceanographic variables that could influence their trajectory.

Main authors : Sabrina Fossette

Key contributors: Laurène Trudelle

5.4. Assessment of the threats faced by humpback whales in the SWIO

This analysis will assess and characterize the threats faced by humpback whales on a regional scale, such as: anthropogenic ocean noise (e.g., seismic explorations, marine traffic) pollution, accidental captures, ghost fishing, ship collisions, coastal development, whale watching, climatic change, ocean acidification, “scientific hunt” and disease.

Main author: Howard Rosenbaum

Key contributors by topics:

Acoustic impacts and seismic surveys: Salvatore Cerchio

Tourism/ Whale-watching: Anjara Saloma

Fishing interactions and collisions: Ken Findlay

5.5. Connectivity between breeding sites and feeding grounds

Although this topic was identified as essential, it was agreed that the current data was not sufficient to assess the connectivity between breeding and feeding grounds. This research topic should be dealt with on a long-term basis and should allow the evaluation of the impact of climate change on humpbacks and food availability.

5.6. Follow up of physiological impacts of tagging on humpback whales

As only a few follow up studies exist, particularly in the breeding grounds, it was thought that the existing data should be grouped together to provide relevant information on the humpback whales' physiological/behavioural reactions to the implantation of Argos tags. It will be useful to advance technologies as well as to increase the fixation time, while minimizing its impact on animals.

Main authors: Claire Garrigue and Violaine Dulau

Key contributors: Alexandre Zerbini

5.7. Overlap with Marine Protected Areas

This conservation study aims at assessing the use of existing marine protected areas and their relevance for humpback whales.

Main author: Violaine Dulau

Key Contributors: Salvatore Cerchio, Howard Rosenbaum

6. Future strategies for research on humpback whales in the Western Indian Ocean

The third day of the workshop was dedicated to discussion for elaborating a regional strategy for humpback whale studies in the SWIO. Although the primary goal of the workshop was focused on development of collaborations involving satellite telemetry data on humpback whales, the organizers and participants recognized the opportunity to discuss broader regional collaboration and partnership. It was a highly unusual event to have such a critical mass of the research groups active in SWIO cetacean research together at a single workshop, and it was valuable to take advantage of the meeting to develop plans for a broader consortium and further reaching partnerships. Initial presentations were provided to inform the workshop participants of regional initiatives conducted in other parts of the world, and current or near-future funding opportunities that could be applicable to the effort.

6.1. Oral presentations

6.1.1. Overview of the South Pacific Whale Research Consortium (SPWRC) including its creation, operating system, different types of members, main objectives, geographical boundaries, rules *for* data sharing, research projects - Claire Garrigue (Opération Cétacés)

The South Pacific Whale Research Consortium (SPWRC) was formed by independent scientists in 1999 to investigate the status of humpback and other large whales and dolphins through the South Pacific region. The primary purpose of the consortium is to coordinate and facilitate non-lethal research on large whales in the South Pacific region and to promote a better understanding of the biology and behavior of all cetaceans. The principal field sites currently studied by the consortium and its members include French Polynesia, the Cook Islands, the Kingdom of Tonga, New Caledonia, Fiji, Vanuatu, Niue, American Samoa, Samoa, New Zealand, Norfolk Island, and eastern Australia, as well as the Antarctic feeding grounds like the Ross Sea and the continental shelf of Adelie Land. The consortium is organized as a trust and there is currently 43 members. Some of which have been involved in field studies initiated as early as 1991 collecting individual identification photographs, genetic samples, sighting records and song recordings. The consortium now meets annually to compare and review data. The results of the consortium's work appear in scientific papers and are presented during international conferences. It is also used by international or regional agencies for conservation purposes.

6.1.2. The FED FEDER Biodiversity project - Matthieu Le Corre (Ecomar, University of Reunion).

This regional project aims at enhancing regional collaboration in the SWIO and deals with the study and management of terrestrial and marine biodiversity in the SWIO. One of this program's key actions lies in the study of marine megafauna (whales, turtles, birds and sharks). The aim of this action is to combine tracking data deployed in

the SWIO on seabirds, turtles and humpback whales in order identify hotspots of biodiversity. He invited the participants to join this regional dynamics.

6.1.3. Funding Opportunities - Adèle Cadinouche (Indian Ocean Commission)

Adèle Cadinouche presented two major programs with funding opportunities, briefly described here and detailed in Appendix 3:

1. Sustainable Management of Coastal Zones of the Indian Ocean Project (2014_2017) funded by FFEM, the European Union and AFD. Within the project:

This project presents specific opportunities for: " a support to the development of a regional database for the mutualization, sharing and harmonization of regional marine mammals data"; support a regional technical workshop to develop the exchange of experiences; and funding travel in the region in order to promote the sharing of experience/expertise (in the field of ICZM).

2. Coastal Marine and Island-specific biodiversity management in ESA-IO countries Project (or Biodiversity Project) – 2014-2018- funded by the European Union, and COI.

Ths project aims to achieve 4 main results, which might concern humpback whales:

Result 1: Improved and harmonized policies, and legal and institutional frameworks for the sustainable use of biodiversity are developed across the region.

Result 2: Education, communication and information tools for the management of the use of bio-diversity are developed, enhanced and applied in support of decision-makers at regional, national and community levels.

Result 3: Improved systems for networking and exchange of data, statistics and other biodiversity-related information are established.

Result 4: Bio-diversity Thematic Centers are enhanced as mechanisms for exchanging information, experiences and best practices, in the sustainable use of biodiversity.

6.1.4. Other actions relevant to humpback whales- François-Xavier Mayer (Cétamada)

Three actions were presented:

1. The Humpback Whales World Congress / HWWC

Cetamada will be hosting an International Conference dedicated to Humpback Whales, from the 29th June to the 3rd July, in Ile Ste Marie, Madagascar. The conference will bring together practitioners, researchers, and educators from around the world, offering a unique space for the international community to engage in up-to-date knowledge and expertise.

Key Scientific Themes to be addressed include:

- Theoretical Research: Anatomy, Biology, Ecology, Ethology, Engineer Sciences, Economics, Management, History, Whaling.
- Applied Research Methods: Visual observations, acoustic, genetics, tags and drones, data collection and storage protocols, tools and software analysis support (identification of flukes, automatic classification of sound units), drop-off window.
- Regional Collaboration Programs: Humpback whales are highly mobile in their breeding areas. The workshop sessions aim to encourage and promote the exchange of cutting-edge knowledge, best practices, and achievements in the current period within and amongst the regional consortia.
- Management, Conservation and Implementation of Sustainable Development Policy: Preventative measures, conservation regulation, creation processes and management of ecologically robust marine protected areas, control measures to curb the adverse impacts of human activities, the role of participatory science and approaches.
- Economic and Social Involvement: Humpback whales are coastal species, generating direct and indirect economic activities. The sessions aim to explore viable means at safeguarding economic and social initiatives, with emphasis on potential benefits and limitations.

2. Sainte-Marie Whale Festival

The conference will be followed by *'Le Festival des Baleines'*, an innovative grand spectacle celebrating Sainte-Marie's popular and traditional culture and the passing-through of the Whales during this distinctive migration path. This will include several exhibition spaces to showcase local artisanal handicrafts and art, photography, educational workshops for children, and music concerts. Preparations are on their way.

3. The Creation of a University Consortium on Marine Mammals in the Indian Ocean

Professor Olivier Adam in partnership with CETAMADA, have begun working on the creation of a University Consortium in the Indian Ocean. As part of its agreement with the University of Antananarivo, CETAMADA supports any initiative by the Animal Biology department on research appropriate to marine mammals in Madagascar and the Indian Ocean.

6.1.5. A humpback whale fluke matching program - Anjara Saloma (Cétamada)

Photo identification remains a key technique to study humpback whales population. The proposed automated matching system can contribute to improve comparisons of photographs to be effective and accessible. Collaboration established with INRIA (National Institute for Research in Computer Science and Control, www.inria.net, a French research institute in mathematics and computer science) allowed to test a possible online matching system for humpback whales fluke catalogue. The main project developed by INRIA is “PlantNet” which is a participative project aiming to inventory wild plant species. This system was created to develop participative data collection. Photos taken can be submitted as new query on the software and sent to the automated search. The system considers shape, texture and the form from the photos and compare to all available database.

The same system could be adapted to humpback whales flukes catalogue. Visible natural markings, colors and scars are considered by the software. The system use the Content-based image retrieval (CBIR) or query by image content (QBIC) which is the application of computer vision techniques to the image retrieval problem, that is, the problem of searching for digital images in large databases. Content-based image retrieval is opposed to traditional concept-based approaches. "Content-based" means that the search analyses the contents of the image rather than the metadata such as keywords, tags, or descriptions associated with the image. The term "content" might refer to colors, shapes, textures, or any other information that can be derived from the image itself.

CBIR is probably the system that could be developed to improve the humpback whales matching system because searches that rely purely on metadata are dependent on annotation quality and completeness. Having humans manually annotate images by entering keywords or metadata in a large database can be time consuming and may not capture the keywords desired to describe the image. Currently, 653 photos (3 years of data collection) have been tested and yielded 24 within year matches and 10 between year matches.

6.2. Group discussion on data sharing and creation of a Regional Consortium

The morning presentations lead to group discussions, which are summarized below:

- **Funding opportunities:** The information provided on COI/FFEM/EU projects was received with great interest. The participants expressed their wish to be kept informed on the coming call of proposals as they could represent funding opportunities to support specific actions on humpback whales at a regional level. The COI representative reminded that some actions could be funded directly but emphasised the necessity to prioritize actions and reach consensus to be able to bring forward regional needs.

- **Automate humpback flukes comparison software:** The demo of the humpback whale fluke matching program was seen as a promising tool for regional catalogue comparison. The participants encouraged Cetamada to test it with existing dataset, working in partnership with other research groups that had established long-term catalogues and expertise in capture-recapture statistics. It was emphasized that before any matching platform, automated or otherwise, could be implemented on a collaborative regional scale, that it must be developed and tested considering the specific assumptions and utilities of capture-recapture methodology.

- **Congress and Consortium Announcement:** The presentation of the Humpback Whale World Congress and the University Consortium on marine mammals in the Indian Ocean raised varied reactions from participants of the workshop. Many participants expressed concern because researchers involved in humpback whale research in the SWIO (most of them being present at the workshop) had not been previously informed and were not invited to contribute before the initiatives were announced. Some questioned the choice of membership in the University Consortium, noting that it included primarily institutions that had no recognizable expertise in the field, to the best of knowledge of the workshop participants. This was found particularly problematic by several participants, raising questions regarding whether these initiatives were productive and in line with the objectives of the present workshop.

- **Development of Regional Initiatives:** After further discussion, the participants decided to move forward with the final objective of the workshop, and create specific initiatives and platforms to further the constructive and participatory collaboration among the workshop participants, representing the large majority of active researchers conducting work in the SWIO on humpback whales as well as other cetaceans.

In the afternoon, these constructive discussions resulted in two main achievements:

1. Common drafting of a Memorandum of Understanding for data sharing

A convention template that was once used for sharing data in the view of a regional analysis for marine turtles was taken up and reworked collectively. The decision was to draft this convention both in French and English. A Portuguese version would be appreciated for Mozambique, but we will need someone to take this charge. The main points of the Memorandum of Understanding (MOU) were agreed upon and a finalized version is to be sent to all the participants for agreement separately from this workshop report. After input and deliberation from all contributors, the MOU will be finalized during the coming year (2015).

2. Decision of the creation of a Western Indian Ocean Cetacean Consortium

All the attendees agreed, whether on behalf of their institution or in their own name, to create a consortium (a statement of collaborative research goals) aimed at bringing together researchers actively working on cetacean research activities in the SWIO under a common understanding and partnership. Therefore, the founding members of the Consortium were: Megaptera, MMCS, Cétamada, WCS, Globice and the University of Pretoria, and Andy Willson, Laurène Trudelle and Alexandre Zerbini as individuals. It was decided that this consortium will be dedicated to all cetacean species and that its geographic boundaries will be 20°E à 90°E and 12°N à 55°S (Southern limit of the Sanctuary).

The name of the Consortium was not decided, but several names were proposed:

- WIndOW : Western Indian Ocean Whale Consortium
- WIndOC: Western Indian Ocean Cetacean Consortium
- Others to be proposed

The Consortium will consist of 3 levels of membership:

- **Active SWIO Researchers**, who are involved in cetacean research in the SWIO
- **Associate Members**, active in cetacean research in other regions, through invitation or nomination
- **Observer Members** will be able to attend intermittently projects or meetings

An Executive Committee will be set up once the Consortium is officially created and members recruited. It is envisaged the Executive Committee with be voted upon by all Active Researcher members interested in being part of the Consortium. In the interim, a Steering Committee was elected to ensure the implementation of the Consortium and included the following people:

- Chair: Violaine Dulau
- Co-chair: Salvatore Cerchio

- Other members: Ken Findlay, Sabrina Fossette, Olivier Tyack, Alexandre Zerbini, Anjara Saloma, Claire Garrigue

The mandate of this steering committee will include:

1. Drafting a proposal of convention (statement of collaborative intent) that will be validated by the consortium founding members. A timeframe proposed at the workshop is now obsolete, and thus the following revised timeframe is suggested:

- March 2015, existing examples of consortium conventions will be forwarded to the Steering Committee, as template
- March/April 2015, Steering Committee will start drafting a convention.
- By end of April 2015, a first version of the convention will be submitted to the founding members.

2. Communicating and introducing the consortium to the scientific community as well as institutions involved in cetacean research or conservation.

A first meeting could be considered during the course of the year (i.e in October 2015 in Durban during the WIOMSA Meeting or during the Congress hosted by Cetamada in Sainte Marie).

The creation of a mailing list will allow exchange and prioritisation of actions to be taken in establishing the Consortium, at least on a short term basis until Consortium communication channels are established.

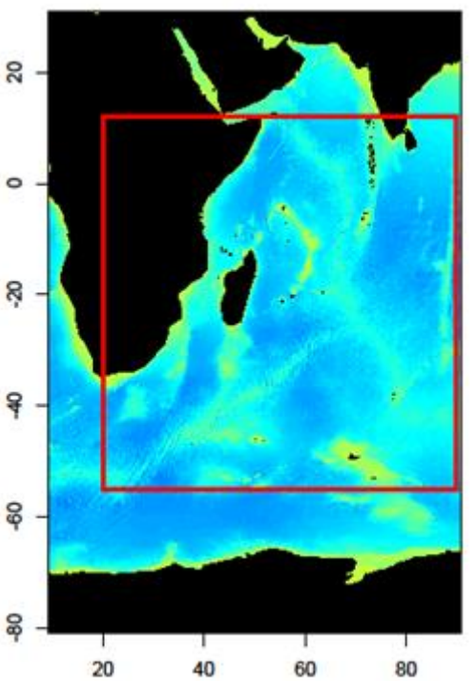

Figure 1. Geographic boundaries of the Consortium

6.3. Recommendations and Priority Actions

Participants agreed that the primary focus for actions going forward involve developing the above collaborative initiatives. In addition the following brief recommendations and priorities were raised by participants following on some of the key points discussed during the workshop:

- Being invasive, satellite tagging technique should be used to address research questions that are relevant and beneficial to species conservation.
- The importance and the necessity of coordinating actions (techniques, and time and place of tagging) in order to optimize data collection and ensure that it will contribute to a regional priorities.

- As far as possible, that photo identification studies are implemented after tag deployment in order to follow-up the impacts of the tags on the individual animals.
- The duration of attachment of the tags is currently not enough to study the southern migration routes and feeding habitats of humpback whales if tagged on the breeding grounds.
- Tracking data needs to be analyzed in conjunction with other sources of data arising from photo identification, acoustics and genetic studies. In particular, several local photo-identification databases and/or matching platforms actually do exist and are not exploited on a regional scale. Participants recognized the need to develop an online matching platform that could include an automatic matching tool, to proceed with data exchange and regional comparison. Such a regional platform could be built on the basis of existing databases and matching platforms, which first need to be reviewed and comparatively evaluated, in order to take advantage of each one's strengths and recent advancements.

7. Public session

The workshop ended with a reporting and closing ceremony event open to the public, on the evening of the last day of the workshop. During the event, participants presented the main results of the tagging projects conducted in the South Western Indian Ocean, and the main outcomes of the workshop. For this occasion, the participants shared their data to create an animation of all the whale tracks.

8. Key Achievements

In particular, this workshop achieved the following outcomes:

1) The congregation of all the researchers working on movements and migration routes of humpback whales in the SWIO and the presentation of the main results obtained through the different projects.
2) The identification of management and/or conservation issues that can be answered through satellite tracking and that could be addressed in scientific publications.
3) The initiation of data sharing: the participants demonstrated their willingness to share their data and contribute to a regional analysis. A draft of a Memorandum of Understanding (MOU) was written to catalyse data sharing.
4) The foundation of a Consortium on cetacean research and conservation in the SWIO.

Overall the participants believed the workshop to have been highly beneficial to collaborative research on SWIO humpback whales and other cetacean taxa.

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APPENDIX 1- Workshop agenda

Humpback whale tagging in the Western Indian Ocean: sharing results and increasing collaborative works

Reunion island, November 19–21, 2014

WORKSHOP AGENDA

Wednesday, November 19th - SHARING PROJECTS AND METHODS

Opening session (9 am-9:30 am)

9 am • Welcome to participants
9:10 am • Presentation of the goals of the workshop
9:20 am • Roundtable

Session on tagging efforts in the Western Indian Ocean

Presentations (9:30 am-12 pm)

9:30 am • Tagging project in Comoros (Megaptera), by Sabrina Fossette
9:50 am • Tagging project in Madagascar (WCS/CNPS/Cetamada), by Salvatore Cerchio
10:10 am • Coffee break
10:30 am • Tagging project in Reunion (GLOBICE/WCS/BNOI), by Violaine Dulau
10:50 am • Tagging project in Oman (Five Oceans), by Andrew Wilson
11:10 am • Tagging project in South Africa (Univ. Pretoria), by Ken Findlay
11:30 am • Summary of existing data

Lunch

Group discussion on project results

Questions & Answers (2 pm-3 pm)

Session on modern methods for tagging and analyzing tagging data

Presentations (3 pm–5:30 pm)

3 pm • Tagging techniques, tag development and follow up studies, by Alexandre Zerbini (NOAA)
3:20 pm • Applying State-Space Model to tracking data, by Alexandre Zerbini (NOAA)
3:40 pm • Coffee Break
4 pm • Habitat modeling from tagging data, by Laurène Trudelle (University of Paris)
4:20 pm • Using tracking data to assess population overlap with human activities, by Howard Rosenbaum (WCS)
4:40 pm • Discussions

Project partners

Humpback whale tagging in the Western Indian Ocean: sharing results and increasing collaborative works. WORKSHOP AGENDA. Reunion Island, November 19–21, 2014

Thursday, November 20th - TOWARDS A REGIONAL ANALYSIS

Session on Regional data analysis and publications

Group discussion about a regional analysis and publication (9 am-12 pm)

- *o Identify differences in design, methods and analyses*
- *o Identify conservation issues that can be addressed with existing data*
- *o Identify what methods should be applied*

Lunch

Group discussion to define specific studies and papers, roles and tasks (2 pm–5:30 pm)

Friday, November 21st - HUMPBACK WHALE CONSORTIUM

Session on future strategies for the study of WIO humpback whales

Presentations (9 am-10 am)

9 am • Presentation of the South Pacific Whale Research Consortium, by Claire Garrigue (Opération Cétacés)
9:30 am • Megafauna project and FED-FEDER funding opportunities, by Matthieu Lecorre (Univ. of La Réunion)
10 am • Coffee break

Group discussion about the creation of a regional consortium (10:20 am-12 pm)

- *o Identify orientations for future tagging projects*
- *o Discuss the possibility of setting up a common regional consortium*
- *o Funding opportunities*

Lunch

Session on further collaborations

Presentation (2 pm-2:20 pm)

2 pm • Automatic matching system, by Anjara Saloma (Cetamada)

Group discussion about further collaborations (2:20 pm-5 pm)

Closing event (7 pm-9 pm)

7 pm • Public conference
8 pm • Cocktail

APPENDIX 2 - Summary of existing tracking data from humpback whales in the Western Indian Ocean for the 2011-2014 period, and plans for 2015.

Group	Region	year	Tag type	meth-od	duty cycle	N of tags implanted	N transmit-ting tags	month of deployment	Tag dura-tion (days)	Publication status
Megaptera	Mayotte-Comoros	2011	SPOT5/ mini swing	ARTS	every day from 3am to 6pm (gmt)	5	3 (1M/2F)	October	11-79	published (Fosette et al., 2014)
Megaptera	Mayotte-Comoros	2012	SPOT5	ARTS	every day from 8am to 8pm (gmt)	6	5 (2M/2F/1U)	October	18-49	published (Fosette et al., 2014)
Megaptera	Mayotte-Comoros	2013	SPOT5	ARTS		6	5 (3M/2F)	end Sept.	2-29	
		2015				minimum 5				
WCS-Cetamada-CNPS	NE Madagascar (Ste Marie)	2012	SPOT5	ARTS/ pole	6h on/ 6h off	13	12 tags (7M, 5F)	early August	3-38	IWC paper
WCS-Cetamada-CNPS	SW Madagascar (Anakao)	2013	SPOT5	ARTS	9h on/ 3h off	11	11 (7F-3M-1U)	end July	1-56	paper in prep.
Cetamada-CNPS	NE Madagascar (Ste Marie)	2014	SPOT5	ARTS	9h on/ 3h off	6	4 (3F-1M)	August	1-37	
ESO	Oman	2014	SPOT5	ARTS	4 times a day in 2 hrs blocks	5 males (3 > 1 day)	3 (M)	February	1-55	IWC paper paper in prep.
		2015				8 planned				
GLOBICE-WCS	Reunion	2013	SPOT5	ARTS	9h on/ 3h off	15 (12>2days)	15 (8M-7F)	early August	1-71	paper in prep.
Univ. Pretoria	Sth Africa	2015	SPOT5		to be determined	12 planned	plan:6M/ 6F	late July		

APPENDIX 3

Funding Opportunities - Adèle Cadinouche (Indian Ocean Commission)

Adèle Cadinouche presented two major programs with funding opportunities:

3. Sustainable Management of Coastal Zones of the Indian Ocean Project (2014_2017) funded by FFEM, the European Union and AFD. Within the project:

The activity 3 of the component 1 (regional level) stipulates " a support to the development of a regional database for the mutualization, sharing and harmonization of regional marine mammals data". Through this activity, the project can support the development/adaptation of a tool such as a photographic matching platform, as long as there is a common and regional demand for it.

The activity 2 of the component 1 proposes to support a regional technical workshop to develop the exchange of experiences. The budget is 27000Euros and for now is scheduled for year 3, so in 2016/2017. It is already scheduled that this workshop will be about marine mammals, with the objective of supporting the regional cetacean network. Once again, this budget will be allocated only on demand, which has to come from a regional body/community.

The activity 2 of component 1 is funding travels in the region in order to promote the sharing of experience/expertise (in the field of ICZM). The identification of expertise has already started in each IOC country, and will continue during the whole project. Workshop participants were invited to contact Adele if they could share expertise in ICZM practice. For example, innovative tools/mecanisms for a sustainable whale watching can be considered good ICZM practices and should be registered: a database of "good ICZM practices" would then be shared through a website.

There is no call for Proposal through FFEM project

4. Coastal Marine and Island-specific biodiversity management in ESA-IO countries Project (or Biodiversity Project) – 2014-2018- funded by the European Union, and COI.

The project aims to achieve 4 main results, which might concern humpback whales:

Result 1: Improved and harmonized policies, and legal and institutional frameworks for the sustainable use of bio-diversity are developed across the region. Action relevant to humpback whale study:

Action 1: review and harmonization of existing policies on migratory species (action 1)

Action 4: Marine Migratory Species international Symposium on humpback whales

Result 2: Education, communication and information tools for the management of the use of bio-diversity are developed, enhanced and applied in support of decision-makers at regional, national and community levels. Action relevant to humpback whale study:

Action 1: regional event on marine mammals (education, tourism)

Result 3: Improved systems for networking and exchange of data, statistics and other biodiversity-related information are established. Action relevant to humpback whale study:

Action 1: support for a regional database on marine migratory species

Action 2: Rapid assessment in marine biodiversity

Result 4: Bio-diversity Thematic Centers are enhanced as mechanisms for exchanging information, experiences and best practices, in the sustainable use of biodiversity. Action relevant to humpback whale study:

Action 1: support to marine expertise center

Result 5: Call of proposal covering the following topics, relevant to cetacean:

Marine ecosystems

Sustainable agriculture and use of Biodiversity: ecotourism

Invasive species

Tropical marine migratory species.

Two call of proposal will be launched: lot1 (min: 25,000€, Max: 60,000€) and lot 2 (min: 60,000€, max: 100,000€). The first call for Proposal has been postponed, at least until the end of February. Once it will be open, a concept note will have to be submitted within 2 months. Joint projects (2 or 3 institutions together) are most welcome, but a single leader is required.

Beneficiary countries: Comoros, Madagascar, Mauritius, Seychelles, Tanzania, Kenya