

## **Improved Satellite-Monitored Radio Tags for Large Whales: Dependable ARGOS Location-Only Tags and a GPS-Linked ARGOS Tag to Reveal 3-Dimensional Body-Orientation and Surface Movements**

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### **LONG-TERM GOALS**

Two different implantable satellite-monitored radio tag technologies will be developed for whales: 1) a programmable, location-only (LO) Argos tag using contemporary technology will be available in two lengths and be adaptable to testing a variety of attachments. Ultimately, it will be suitable for many scientific users to track local and seasonal movements of medium to large whales over varying time scales (months to a year); and 2) an improved recoverable GPS/TDR tag will include 3-axis accelerometer and compass sensors to document the detailed dive behaviors and foraging ecology of large whales over scales of weeks to months and will be capable of carrying additional acoustic recording devices useful in evaluating future noise response experiments.

The goal of this project is to develop reliable sensing and monitoring technologies to identify the seasonal distributions of large whales, their underwater behavior, their ecological relationships, and ultimately their behavioral responses to man-made sounds. We have made progress this year in the development of both tag-types. We have been able to use funds from other funding sources to defray field costs for these projects and save ONR funds.

### **OBJECTIVES**

#### Location only tags

After a design work with Wildlife Computers the tag was fielded on Pacific Northwest gray whales in 2009, funded by the International Whaling Commission, to determine the efficacy of such tags for use on western gray whales. A primary part of this project involved the photo follow-up of tags to examine wound healing. The results of 20 months of photo re-identification were presented at the 63<sup>rd</sup> annual meeting of the IWC Scientific Committee in Tromso, Norway in June 2011. A distinguished panel of 7 marine mammal veterinarians determined that the tags produced only expected scarring and divot formation and posed no significant hazard to whales to the extent that the panel felt comfortable even allowing western female gray whales to be tagged, including those which might be pregnant because the panel felt there was no risk to fetal development.

## Report Documentation Page

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A current GPS/TDR tag (initially funded by JIP, MMS, and ONR) will be further developed to provide an accurate depiction of underwater dive behavior and body orientation between surfacings. The data will be downloaded from recovered tags to evaluate complex foraging behaviors. The addition of an acoustic dosimeter from Cornell (C. Clark) will help interpret responses during future controlled-exposure experiments (CEE). The existing GPS/TDR tag will be field tested on whales with the Cornell acoustic dosimeter before moving forward with additional sensor integration.

## **APPROACH**

During this FY, opportunities arose to use IWC funds to tag western gray whales with the prototype LO tags and follow-up the tag wound healing on 18 LO tags applied on eastern North Pacific Gray whales tagged in Sept-Dec. 2009.

Regarding the GPS/TDR tag, the work plan objective was to start this activity during the second year, however, with the influx of the outside funds (above) this development task was put off until next year. The replacement TDR tags from the sperm whale 2008 experiment prepared by Wildlife Computers were going to be used (without a 3-axis accelerometer/compass), but incorporating an acoustic dosimeter, designed by Chris Clarke's lab at Cornell during the Navy/SOCAL BRS experiment in August/September 2010. However, due to the urgent need to tag sperm whales during the Deep Water Horizon oil spill (using older-style Telonics tags to assure data compatibility with the 2001/2005 SWSS taggings) and the impending September work with the LO tags on Western Gray Whales, the SOCAL/BRS work was postponed until 2011.

## **WORK COMPLETED**

### Location only tags

After a design work with Wildlife Computers the tag was fielded on Pacific Northwest gray whales in 2009, funded by the International Whaling Commission, to determine the efficacy of such tags for use on western gray whales. A primary part of this project involved the photo follow-up of tags to examine wound healing. The results of 20 months of photo re-identification were presented at the 63<sup>rd</sup> annual meeting of the IWC Scientific Committee in Tromso, Norway in June 2011. A distinguished panel of 7 marine mammal veterinarians determined that the tags produced only expected scarring and divot formation and posed no significant hazard to whales to the extent that the panel felt comfortable even allowing western female gray whales to be tagged, including those which might be pregnant because the panel felt there was no risk to fetal development.

Five WC LO tags were applied to sperm whales (out of 34 tags applied to 26 whales) during a July field season following-up on the Deep water Horizon oil spill.

### 3-axis accelerometers incorporated into GPS/TDR (Mk-10) tags

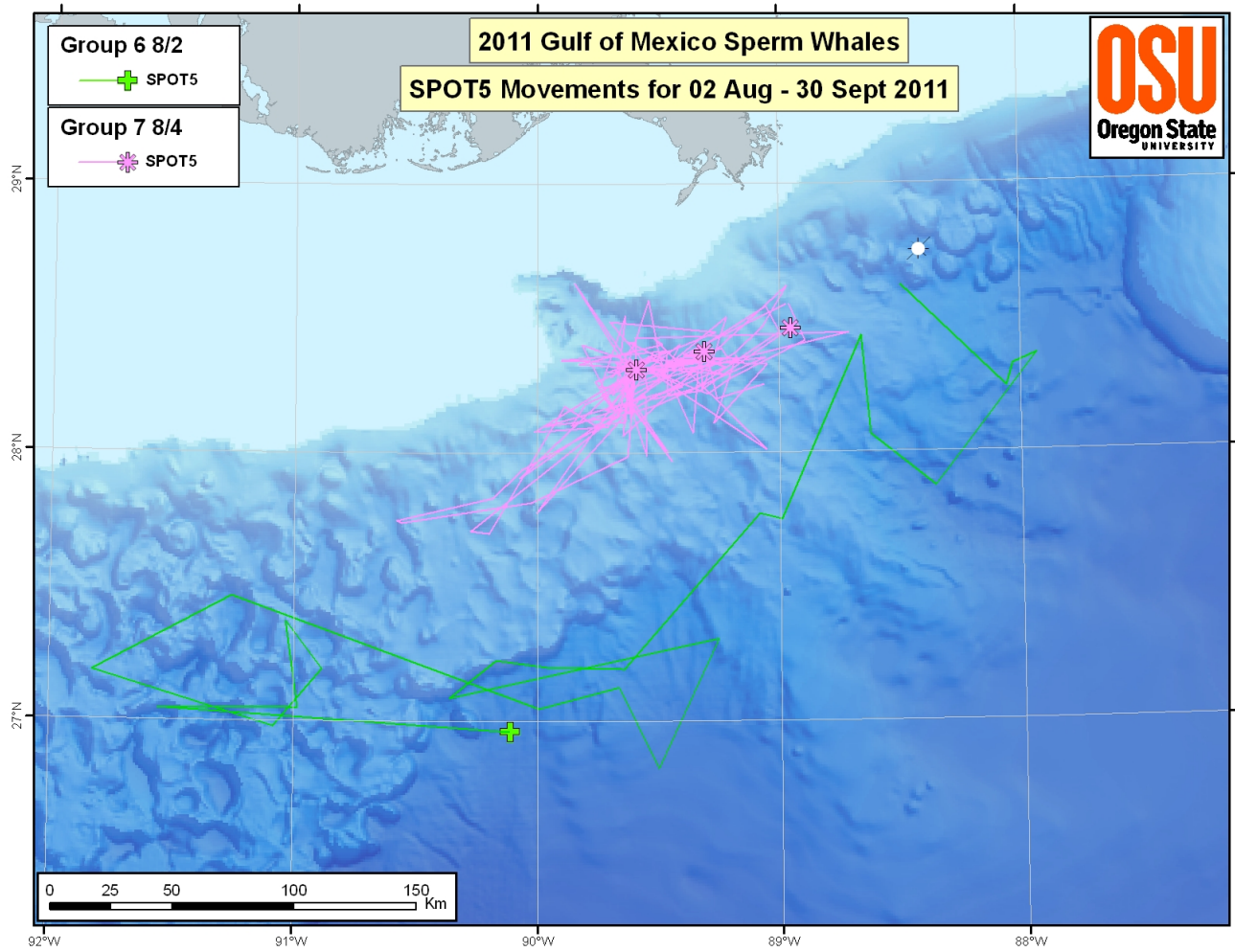
Our previous experience at developing this tag began with a 2007 deployment where the corrodible wire holding the tag into the attachment sheath sheared. In 2008, WC modified the design to a heavier wire and we provided three large studs in the attachment sheath that penetrated into three female voids in the tag float, which prevented the tag from rotating and shearing the wire. However, in 2008 the tag manufacturer did not draw a vacuum on the casting matrix and small bubbles in the casting collapsed under the pressure of sperm whale dives to "kill" the electronics. Eleven of these tags were deployed in FY12 in the GOM as part of the NRDA follow-up to the Deepwater Horizon/BP oil spill

## RESULTS

### Location only tags

A 13-year old male western gray whale was tagged on 4 Oct 2010 off Sakhalin Island, Russia. Despite an incomplete deployment (tag exposed 4-5 cm), the whale named Flex was tracked for 128 days. It spent 69 days off Sakhalin Island prior to migrating. The migratory route was a real surprise for most scientists, who expected western gray whales to have a winter destination along the Asian coast, perhaps in the South China Sea. The tagged whale, however, crossed the Bering Sea and the Gulf of Alaska, intersecting the US along the straits of Juan de Fuca and traveling south 20-25 km off shore with its last location off the Central Oregon coast. Its southward migration coincided with the timing of the last portion of the last eastern gray whale migration south. Although Flex was not tracked further than the 9<sup>th</sup> of Feb, Weller et al. determined that he had previously been to the eastern north pacific from a photo taken 8 April 2008. During an expedition to tag additional gray whales in August 2011, Flex was re-sighted in good body condition confirming an annual round trip.

It was an ONR objective that the location only tags developed in this project are done in collaboration with a manufacturer who would make them available to other researchers. We worked with Wildlife Computers who made these tags available to other users immediately. Some of those users have experienced technical difficulties associated with tag failures upon deployment. These users have all attempted to apply tags at greater distances than our group. We typically deploy tags within 2-3 meters and use deployment pressures for baleen whales of ~5 bar (~75 psi). The other groups attempting to deploy tags from greater distances have used pressures up to 10 bars and photo documentation has shown instances of tag damage upon application. The tags we designed with WC were casted in a thin-wall stainless steel tube and will likely require additional tube strength to endure the larger acceleration and deceleration pressures associated with longer deployment distances. Four of the five LO tags applied to sperm whales transmitted data and three were still transmitting by October 2011 (shown in Figure).



*Figure 1. The WC Spot-5 LO Argos tag locations for July through September.*

3-axis accelerometers incorporated into GPS/TDR (Mk-10) tags

Eleven Mk-10 tags were deployed on sperm whales during July 2011 (Table 1). The details of these results will be reported in the FY-12 report, but it is fair to say that the Mk-10 tags lasted an average of 25 days and a software error failed to release the tags at their pre-programmed release times.

**Table 1. A comparison of the GPS and Argos locations for the 11 Mk-10 tags applied to sperm whales in the Gulf of Mexico as a follow-up to the DWH oil spill. Data are also compared to the ST-15 Telonics tags applied to 8 of the eleven whales tagged with Mk-10s.**

Comparison of distances computed from Argos and GPS locations for sperm whales tagged with both ST-15 and MK-10 or only MK-10 transmitters

PTT	TagType	Argos Dist(km) <sup>1</sup>	GPS Dist(km)	Pair % Argos Dist <sup>2</sup>	% GPS/Argos Dist <sup>3</sup>	Argos Days	GPS Days	#Argos Locs <sup>4</sup>	#GPS Locs
840	MK-10	520	113		22%	12.7	12.5	36	13
5826	ST-15	30		6%		14.0		2	
4177	MK-10	1249	762		61%	34.7	34.5	140	99
832	ST-15	0		N/A		0.0		0	
833	MK-10	1486	1408		95%	25.3	25.3	108	134
845	ST-15	518		35%		26.0		13	
5838	MK-10	564	465		82%	9.6	9.2	57	47
5803	ST-15	141		25%		9.5		6	
4173	MK-10	2728	1797		66%	49.4	41.2	174	161
823	ST-15	1752		64%		49.3		65	
5701	MK-10	1343	1159		86%	24.4	24.4	93	126
5655	ST-15	534		40%		25.7		23	
5685	MK-10	1700	1487		87%	28.2	28.0	109	124
5921	ST-15	1012		60%		28.5		18	
5644	MK-10	1679	1428		85%	29.8	29.7	113	142
5910	ST-15	790		47%		29.7		28	
838	MK-10	1089	1080		99%	20.5	20.6	82	96
5640	MK-10	623	379		61%	17.9	17.7	55	28
5654	MK-10	1893	1633		86%	34.2	34.2	106	124

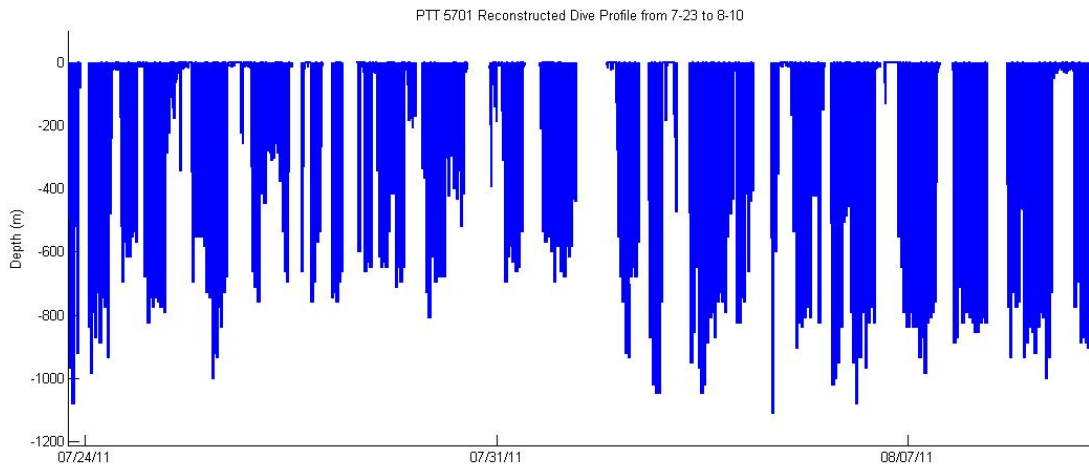
<sup>1</sup>The location used for the ST-15 in the pair was the location closest to the final Argos location for the MK-10

<sup>2</sup>Pair % Argos Dist is (Argos distance ST-15 / Argos distance MK-10)\*100

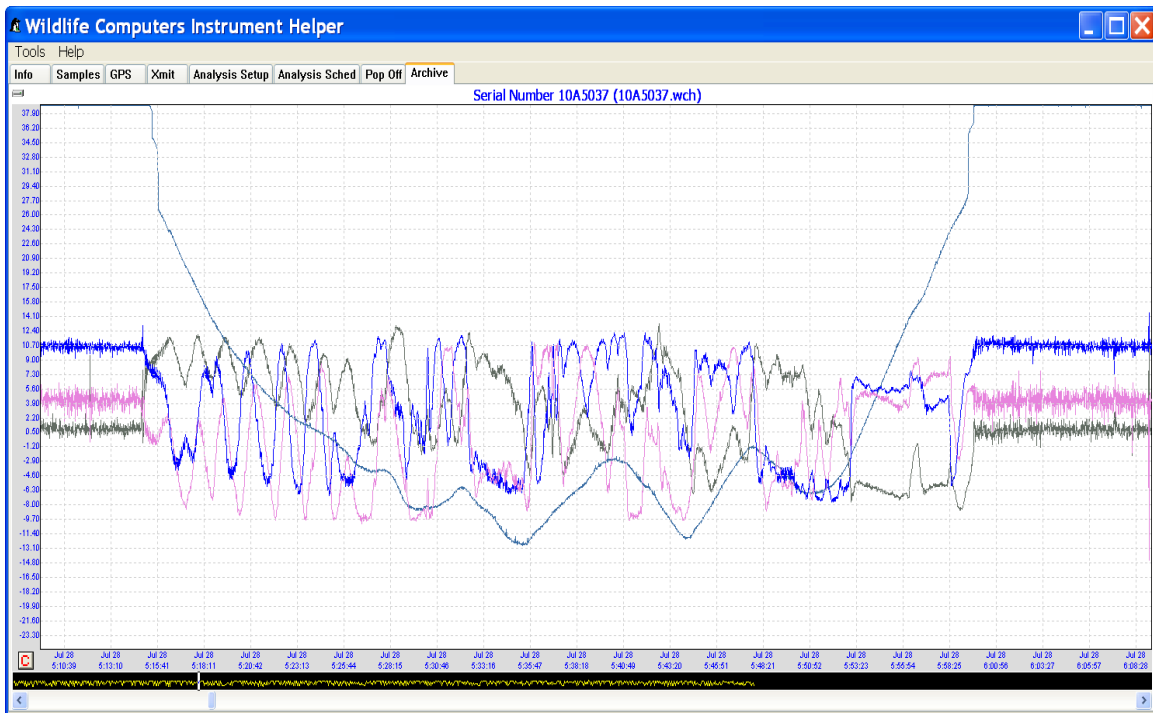
<sup>3</sup>% GPS/Argos Dist is (GPS distance MK-10 / Argos distance MK-10)\*100

<sup>4</sup>Argos locations passing editing criteria

Up to 80% of the dive basic information (duration, maximum depth and dive shape) was relayed for each tag via Argos, from which long-term dive profiles can be reconstructed (Figure 2). A single recovered tag provides a wealth of information, which shows the value of these tags and will be useful in discerning whether sperm whales in the GOM have diurnal dive habits or whether their dives change in relation to the bathymetric habitat. The 3-axis accelerometers appear to have worked well and their records seem to be intact (Figure 3). We are hoping that these will allow us to discern sperm whale lunges that can be used as a proxy for attempts to forage on squids. The pressure sensor record, however, has some flaws. The tag has been sent back to Wildlife computers for further evaluation.



**Figure 2. Reconstructed Dive profiles from Mk-10 GPS/TDR tag #5701 for a two-week period. A large percentage of the summarized data from the Mk-10 tags were recovered via Argos.**



**Figure 3. A 45 minute sperm whale dive from a 40-day record recorded during the summer of 2011, showing the 3-axis accelerometry data. The tag was recovered in September 2011 and its analysis will be part of our FY-12 work plan. We hope to discern lunges from the accelerometry data that can be used as a proxy for foraging attempts on squids.**

## **IMPACT/APPLICATIONS**

The new LO tags from WC cost about \$2000, about half of “extinct” Telonics LO (ST-15) tags, and require little time for assembly of attachments and penetrating tip (an additional \$150). The new tags are user-programmable for duty cycles and functions, which include “haul-out” histograms (dry time) useful in determining surface-oriented diurnal behaviors throughout the day. The resulting data are helpful in developing correction factors (probability of sighting) to estimate populations from aerial and ship-board surveys.

The smaller tags may be more useful on smaller species than on the larger whales which have been tagged to date, but do not last as long with gray whales as the 3-cell tags.

## **TRANSITIONS**

The accelerated development of the LO tag with the added funds from IWC (the two oil and gas sponsors) allowed the proof of concept not only for the lower cost casting technique, but also verified the easily changed attachments and penetrant tips for future experimentation. Both IWC and IUCN science reviews approved the use of the 3-cell (longer version) tags in September 2010 on Western gray whales and one of these was so successful that we were approved to tag more WGWs, including females. Wildlife Computers is already offering these LO tags as a mainstream product, thus fulfilling one of the ONR goals of working with a company who will mass produce the product and make it widely available to other researchers.

“Replacement” GPS/TDR tags were used in the DWH sperm whale project in 2011 and we hope to take these tags to the next evolutionary stage in 2012. Additional interest in the products of this ONR project have been expressed by the JIP, trustees of the Deep Water Horizon oil spill, and Australian colleagues planning a 2012 BRS project with humpback whales, using industry seismic sources. Brandon Southall has said that funds will not likely be available for usig these tag types during the 2012 BRS.

## **RELATED PROJECTS**

The analyses of the EGW data is again being proposed to the BOEMRE and wave energy industries in the Pacific NW. Re-tagging WGWs migrating to the eastern North Pacific during 2012 will be funded by IWC. Tagging more PCFG whales will be a goal of this ONR project. We will try to tag some of the same whales that were tagged in 2009 so we can further follow-up on their would healing and also see if the whales do the same thing (timing speed, and destination) year after year.

## **WORK PLAN**

Because four tags on sperm whales penetrated too deep and compromised the function of the saltwater switch, we are going to make a small modification to the application process to reduce the chances of this happening again during future deployments. This modification will be used on gray whales during 2012. After evaluation by Wildlife Computers, replacement GPS/TDR tags with 3-axis accelerometers will probably be applied to sperm whales again in 2012.

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