

Marine Mammal Monitoring on Navy Ranges (M3R) Program at
AUtec: 2015 AFTT Progress Report.

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2015 AUTEC Field Effort

In 2015 field efforts were carried out at the U.S. Navy's Atlantic Undersea Test and Evaluation Center (AUTEC) during two time periods prior to the spring and fall Submarine Commander Courses (SCC). The tests were conducted under the auspice of the Living Marine Resources Program (LMR) and the Office of Naval Research (ONR). The first took place April 23rd – May 11th, and the second October 24th – November 6th. There was an additional test conducted from August 10th – 23rd when range activity was low and weather conditions are generally better, thus maximizing the opportunities for locating and tagging beaked whales to gather baseline data (Table 1).

Vocalizing cetaceans were detected using the M3R system [1]. A RHIB with expert observers (D. Claridge, C. Dunn, Bahamas Marine Mammal Research Organisation) and tagger (J. Durban, NOAA or L. Hickmott, Open Ocean Consulting Ltd.) were directed to vocalizing animals. A total of 39 days were spent in the field, during which 20 days had low sea-states which allowed the team to conduct visual searches for marine mammals on the AUTEC Weapons Range with support from M3R.

During this search effort, the on-water team covered 2070 km resulting in sightings of ten different species seen in 30 separate groups. Species sighted included: Blainville's beaked whale (*Mesoplodon densirostris*, $n = 16$), sperm whale (*Physeter macrocephalus*, $n = 1$), dwarf sperm whale (*Kogia sima*, $n = 2$), pygmy sperm whale (*K. breviceps*, $n = 1$), short-finned pilot whale (*Globicephala macrorhynchus*, $n = 1$), melon-headed whale (*Peponocephala electra*, $n = 1$), Risso's dolphin (*Grampus griseus*, $n = 1$), pan-tropical spotted dolphin (*Stenella attenuata*, $n = 1$), coastal bottlenose dolphin (*Tursiops truncatus*, $n = 4$), and West Indian manatee (*Trichechus manatus*, $n = 2$).

Table 1: 2015 Field Data Summary

| Date | Effort (km) | Effort (hr) | Species Found | Group Size | Dur. (Min) | Biopsy No. | Tag No. |
|----------|-------------|-------------|-------------------------|------------|------------|------------|---------|
| 23 April | 126.3 | 6.9 | <i>K. sima</i> | 5 | 9 | | |
| | | | <i>G.macrorhynchus</i> | 20 | 88 | | |
| | | | <i>G.griseus</i> | 5 | 20 | | |
| 23 April | 73.2 | 1.9 | - | | | | |
| 23 April | 108.6 | 9.6 | <i>M. densirostris</i> | 2 | 114 | | |
| 23 April | 33.5 | 2.2 | - | | | | |
| 23 April | 102.2 | 7.6 | <i>Mesoplodon sp.</i> | 1 | 1 | | |
| 6 May | 90.9 | 8.2 | <i>M. densirostris</i> | 1 | 9 | | |
| | | | <i>S. attenuata</i> | 40 | 16 | | |
| | | | <i>M. densirostris</i> | 4 | 119 | | 1 |
| 10 Aug | 153 | 5.4 | - | - | | | |
| 11 Aug | 185 | 5.4 | - | - | | | |
| 12 Aug | 142 | 8.6 | <i>P. macrocephalus</i> | 1 | 35 | | |
| 13 Aug | 152 | 11.6 | <i>T. truncatus</i> | 5 | 45 | | |
| | | | <i>T. truncatus</i> | 6 | 59 | | |
| 17 Aug | 17 | 4.3 | <i>T. truncatus</i> | 4 | 37 | | |
| 19 Aug | | | <i>T. manatus</i> | 1 | 75 | | |
| 21 Aug | 136 | 10.8 | <i>T. manatus</i> | 1 | 40 | | |
| | | | <i>M. densirostris</i> | 1 | 136 | | 1 |
| | | | <i>M. densirostris</i> | 2 | 128 | | 2 |
| | | | <i>M. densirostris</i> | 1 | 5 | | |
| 22 Aug | 91 | | <i>M. densirostris</i> | 3 | 371 | | 2 |
| | | | <i>G. macrorhynchus</i> | 18 | 85 | 6 | |
| 23 Aug | 152 | | <i>K. sima</i> | 5 | 2 | | |
| | | | <i>K. breviceps</i> | 2 | 2 | | |
| 29 Oct | 150 | 11.4 | <i>M. densirostris</i> | 1 | 73 | | 1 |
| | | | <i>M. densirostris</i> | 4 | 17 | | |
| 30 Oct | 118 | 9.8 | <i>M. densirostris</i> | 3 | 182 | | |
| | | | <i>M. densirostris</i> | 2 | 125 | | 2 |
| | | | <i>M. densirostris</i> | 6 | 53 | | 1 |
| 31 Oct | 83 | 1.9 | <i>M. densirostris</i> | 1 | 63 | 1 | |
| | | | <i>M. densirostris</i> | 3 | 109 | | |
| 1 Nov | 51 | 1.9 | <i>T. truncatus</i> | 12 | 17 | | |

Tagging Effort and Position/Tracking Data Summary

Ten Wildlife Computers LIMPET satellite transmitters were deployed on Blainville’s beaked whales in 2015, including seven SPLASH tags and three SPOT tags. SPLASH tags provide location and dive depth. SPOT tags provide location and time-at-temperature data (proxy for depth). Tags were deployed on individuals of both sexes, including one deployment on an adult female with a dependent calf and another on a female with a calf estimated to be 3 years old (still at least socially dependent). All but two individuals tagged had been photo-identified at AUTEC in previous years. Tag durations ranged from five to at 89 days and more than 2100 location estimates have been compiled and significant diving behavior data have been logged. Analysis of these data is underway under the lead of John Durban (NOAA). Details for each deployment are summarized in (Table 2).

Table 2: Summary of LIMPET tag deployments on *M. densirostris* on the AUTEC Weapons Range during 2015. (Deploy Dur. is the number of days on animal since the tag was deployed; No. Loc. Est. are the number of location estimates from satellite transmissions.)

| Date | Deploy Time | Tag No. | Tag Type | ID | Age Class | Sex | Deploy Dur (Days) | No. Loc. Est. |
|-----------|-------------|---------|----------|---------|-----------|---------|-------------------|---------------|
| 16 May 15 | 12:19 | 133062 | SPLASH | Md597 | Adult | Female | 5 | 24 |
| 21 Aug 15 | 11:31 | 133063 | SPLASH | Md569 | Adult | Male | 14 | 83 |
| 21 Aug 15 | 13:13 | 133064 | SPLASH | Md552 | Adult | Female | 12 | 139 |
| 21 Aug 15 | 13:42 | 133067 | SPLASH | unknown | Adult | Female | 10 | 101 |
| 22 Aug 15 | 11:36 | 133065 | SPLASH | Md515 | Adult | Female | 10 | 83 |
| 22 Aug 15 | 11:39 | 133066 | SPLASH | Md517 | Adult | unknown | 13 | 120 |
| 29 Oct 15 | 13:17 | 143494 | SPLASH | Md555 | Adult | Female | 12 | 143 |
| 30 Oct 15 | 12:34 | 129719 | SPOT | unknown | Sudadult | unknown | 63 | 433 |
| 30 Oct 15 | 13:49 | 129721 | SPOT | Md562 | Adult | Female | 89 | 646 |
| 30 Oct 15 | 15:33 | 129720 | SPOT | Md504 | Adult | Female | 27 | 340 |
| | | | | | | | | |

Photo-ID Summary

Sixteen groups of Blainville’s beaked whales were seen with a median group size of 2 (range 1 – 6). Groups included five mother/calf pairs. In all, there were 22 different individuals photo-identified, of which 14 were “known” whales. There were two new (“unknown”) adult females and one new sub-adult whale which we were unable to match to our existing Blainville’s beaked whale photo-identification catalogues from throughout the Bahamas, as well as five new calves (four young of the year). These eight “new” animals will be added to the AUTEC photo-identification catalogue. The sighting histories for the previously “known” whales are summarized in Table 3.

These data will be used to update the demographics analysis for AUTEC. These results will in-turn inform the Population Consequences of Disturbance (PCoD) model under development for *Md* at AUTEC.

Table 3. Sighting histories for Blainville's beaked whales

| ID | Sex | Age Class | No. Years Sighted | Dates Sighted | Comments |
|-------|-----|-----------|-------------------|---------------|---|
| Md501 | F | Adult | 6 | 27-Apr-05 | Moderate amount of cookie cutter scars |
| | | | | 6-May-06 | |
| | | | | 2-Sep-07 | |
| | | | | 23-Aug-08 | Fin leans to left |
| | | | | 5-Aug-13 | Probable mother of Md566 |
| | | | | 25-Apr-15 | |
| | | | | 30-Oct-15 | |
| Md504 | F | Sub-Adult | 5 | 24-Sep-05 | Immature animal |
| | | | | 6-May-06 | |
| | | | | 23-Aug-07 | Tagged with Dtag (Md07_235a) |
| | | | | 5-Aug-13 | Biopsy collected (sample 130805_Md01); mature now |
| | | | | 25-Apr-15 | |
| | | | | 30-Oct-15 | LIMPET(SPOT 129720): w/ dependent calf |
| Md517 | M | Adult | 4 | 6-May-06 | |
| | | | | 23-Aug-07 | Dtag (Md07-235b) |
| | | | | 2-Sep-07 | |
| | | | | 23-Aug-08 | |
| | | | | 22-Aug-15 | LIMPET(SPALSH MK10 tag 133066) |
| | | | | 30-Oct-15 | |
| | | | | 31-Oct-15 | |
| Md529 | F | Adult | 4 | 23-Aug-07 | |
| | | | | 2-Sep-07 | |
| | | | | 5-Sep-07 | |
| | | | | 16-Sep-08 | |
| | | | | 2-Nov-13 | LIMPET(SPALSH MK10 tag 129715) |
| | | | | 22-Aug-15 | |
| | | | | 30-Oct-15 | |
| Md553 | F | Adult | 4 | 19-May-08 | |
| | | | | 15-Sep-08 | Mother of Md557 |
| | | | | 5-Aug-13 | |
| | | | | 6-May-15 | Satellite tagged with depth tag |
| Md555 | F | adult | 2 | 22-May-08 | Biopsy collected |
| | | | | 29-Oct-15 | LIMPET (SPLASH MK10 tag 143494) |
| Md562 | F | Adult | 2 | 15-Sep-08 | |

| | | | | | |
|-------|---|-------|---|-----------|---|
| | | | | 30-Oct-15 | LIMPET (SPLASH MK10 tag 129721) |
| Md568 | F | Adult | 4 | 7-May-09 | |
| | | | | 8-May-09 | |
| | | | | 6-May-12 | |
| | | | | 7-May-13 | Biopsy collected |
| | | | | 7-May-15 | |
| Md569 | M | Adult | 5 | 28-Sep-08 | |
| | | | | 9-May-09 | |
| | | | | 17-Jun-11 | |
| | | | | 2-Nov-13 | |
| | | | | 21-Aug-15 | LIMPET (SPLASH MK10 tag 133063) |
| | | | | 31-Oct-15 | Biopsy (sample 151031_Md01) |
| Md591 | F | Adult | 2 | 6-May-12 | |
| | | | | 30-Jun-12 | Recent attack by shark or other predator |
| | | | | 1-Jul-12 | Biopsy collected |
| | | | | 6-May-15 | w/ 6-8 month old calf |
| Md597 | F | Adult | 2 | 1-Jul-12 | Satellite tagged but tag bounced out |
| | | | | 6-May-15 | Satellite tagged w/ depth tag, transmitted 4 days |
| Md601 | F | Adult | 2 | 26-Jul-12 | |
| | | | | 29-Oct-12 | w/ dependent calf estimated to be <3 months old |
| | | | | 30-Oct-12 | |

***Md* Cumulative Effect of Sonar Modeling**

The cumulative effect of sonar exposure is being examined through visual methods and through the application of an energetics model informed by visual, tag, passive acoustic, and biological data.

Analysis of BMMRO photo-ID data suggests a lower proportion of calves and sub-adults at AUTEC as compared to animals off the coast of Abaco approximately 150 km to the north [2, 3]. This suggests a lower calf survival rate and/or a greater inter-calf interval.

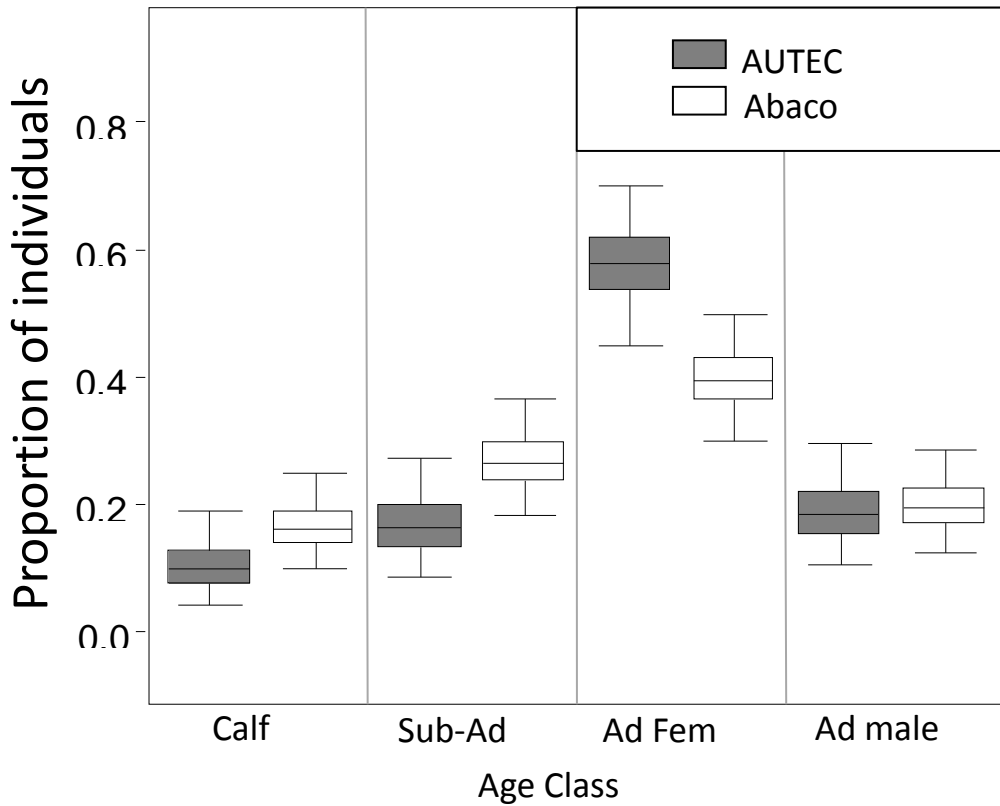


Figure 1: Proportion of age classes at AUTEC and Abaco (Claridge 2103)

Understanding the structuring and movement of animals within the Bahamas is critically necessary if exposed animals at AUTEC are to be compared to those in other geographic areas within the Bahamas. Analysis of AUTEC satellite tag data suggests animals exhibit high site fidelity. BMMRO examination ten years of sighting data show but one AUTEC animal sighted outside AUTEC. Genetic analysis confirmed a high degree of relatedness.

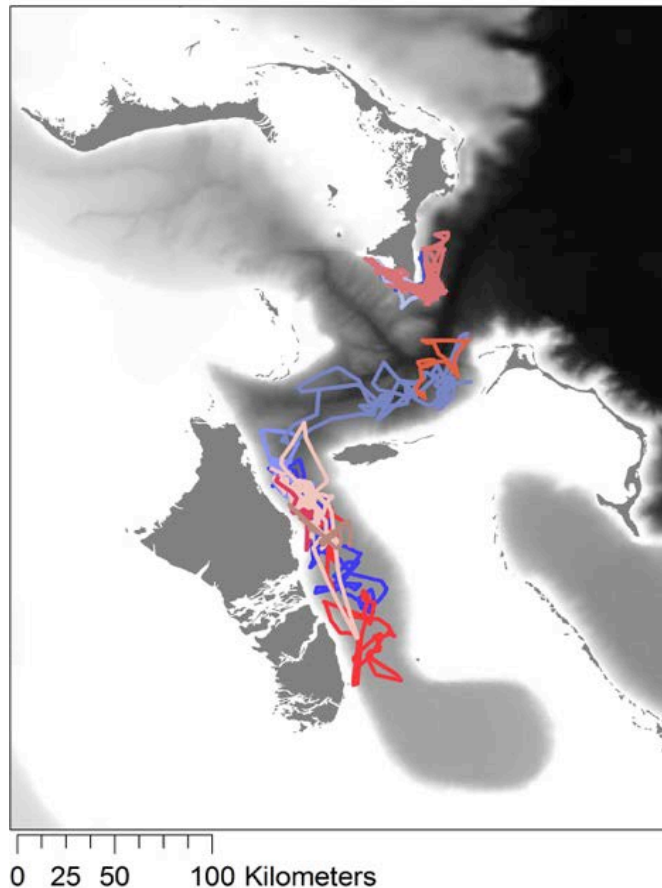


Figure 2: Md satellite tag locations for tags deployed in the northern Bahamas from 2009-2014. n = 11 tagged whales, red shades = females, blue shades = males

New et al. adapted published energetics equations to the development of a beaked whale population model. The model was restricted to a period equal to the time-to-weaning [4]. Figure 3. Energy values for a lactating female from birth to weaning. Green dashed line indicates success, red plots the female's energy stores, purple gives the energy provided by the mother through daily intake while blue gives energy provided by the calf through foraging.

The model is being expanded to allow extended model runs. In addition, correlation existed across critical parameters making the extended model highly sensitive to parameter changes. Therefore, the model is being reconfigured to eliminate such dependencies.

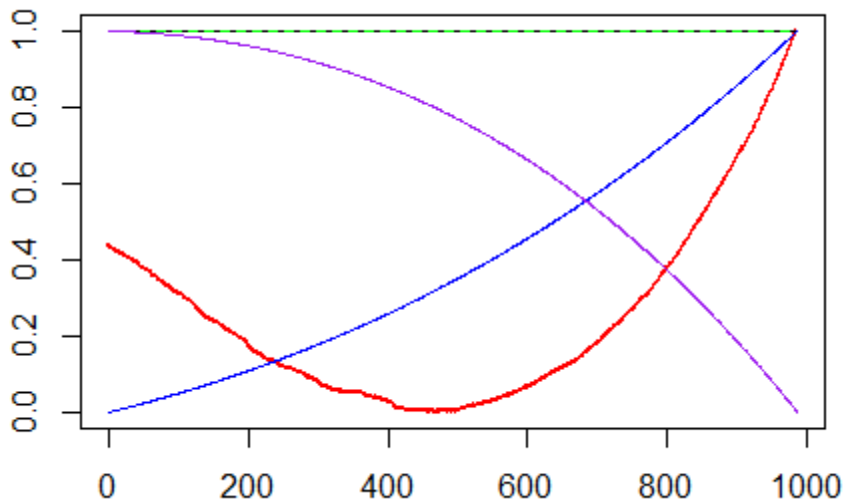


Figure 3. Energy values for a lactating female from birth to weaning. Green dashed line indicates success, red plots the female's energy stores, purple gives the energy provided by the mother through daily intake while blue gives energy provided by the calf through foraging.

Model parameters are being derived through BMMRO's observational study consisting of individual-based data used to build life histories and estimate population demographics [3]. These include age at sexual maturity, time-to-weaning, abundance and population structure. As stated above, tag, visual, and genetic studies suggest high *Md* site fidelity at AUTEC. Therefore, Abaco is considered a reasonable comparative site with an "undisturbed" population with similar bathymetry. To obtain a baseline model output, parameters are being selected to provide an output that matches that measured at Abaco, specifically, the ratio of dependent calves to adult females.

To estimate disturbance, a year of sonar data was obtained from AUTEC (Figure 4). The data provide precise knowledge as to the start-time, type, and duration of every sonar operation. Changes to the number of detected deep foraging dives are used as a proxy for foraging disruption and calorie loss.

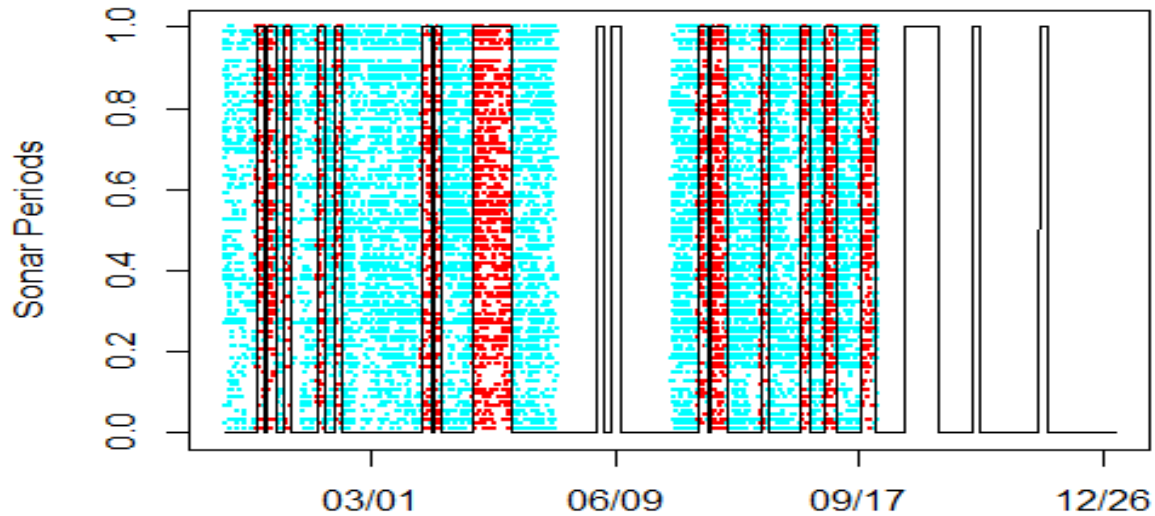


Figure 4. Blue represents time with data archives and no sonar, Red represents time with data and sonar. Black bars represent times with sonar plus 3 days post exercise.

The *Md* dive rate at AUTEC has been measured. Therefore, every dive represents a proportionate loss in the daily caloric intake. To measure dive's lost, the number of foraging dives immediately before an operation are measured using passive acoustics and compared to the number measured during the operation. *Md* abundance is calculated and the number of lost dives apportioned among individuals [5]. This is repeated for every range operation where passive acoustic data are available. Dive loss per operation type was calculated and used to estimate loss for those with no acoustic data available. The total dive loss over an entire year was estimated. This is entered into the model and extended across years with the assumption that the op-tempo is similar in out-years. Model runs are to be completed in 2016.

Prey Fields

Initial prey field mapping was completed in collaboration with Oregon State University (K. Benoit-Bird) at both AUTEC and Abaco. The survey was designed to measure prey fields both on the range and to the north and south in areas where *Md* have moved when displaced during sonar operations.

In addition the Abaco site was surveyed. This should allow analysis of available prey in both a "MFAS disturbed" population at AUTEC and a comparative "undisturbed" population at Abaco.

Passive acoustic data were collected at AUTEC during the survey. These data will be used to detect *Md* foraging dives as a proxy for temporal, spatial, and foraging behavior during the survey.

Data at both sites are currently being analyzed.

Summary

Ten different species including 16 Blainville's beaked whale individuals were sighted at AUTEC in 2015. Importantly, five mother-calf pairs were sighted. These data will be used to update the *Md* population demographic analysis and to inform critical parameters including gestational time, and time to weaning that are vitally important to the on-going PCoD model development.

A total of ten ARGOS tags were deployed on beaked whales. These data are being analyzed for movement before, during, and after MFAS operations. Dive data from tags around sonar operations will inform foraging behavior and help document both movement and potential foraging disruption. In total 16 tags have been deployed on *Md* at AUTEC.

Table 2: Summary of Blainville's beaked whale tags deployed at AUTEC

| PTT | Age | Sex | Deploy date | Deploy length (days) | Avg Error Radius (m) | Sonar Tests |
|--------|-----|-----|-------------|----------------------|----------------------|----------------------|
| 93232 | A | M | 7-May-09 | 27 | 2718 | May 2009 SCC |
| 111664 | A | F | 6-May-12 | 18 | 3420 | May 2012 SCC |
| 111670 | A | F | 6-May-12 | 28 | 3616 | May 2012 SCC |
| 111676 | A | F | 30-Jun-12 | 9 | 3184 | |
| 111675 | A | M | 1-Jul-12 | 10 | 2238 | |
| 129715 | A | F | 2-Nov-13 | 28 | 7079 | November 2013 SCC |
| 133062 | A | F | 6-May-15 | 5 | 4937 | |
| 133063 | A | M | 21-Aug-15 | 14 | 4673 | |
| 133064 | A | F | 21-Aug-15 | 12 | 4184 | |
| 133067 | A | F | 21-Aug-15 | 10 | 3661 | |
| 133066 | A | M | 22-Aug-15 | 13 | 4142 | |
| 133065 | A | F | 22-Aug-15 | 10 | 8361 | |
| 143494 | A | F | 29-Oct-15 | 14 | 3201 | November 2015 SCC |
| 129719 | SA | U | 30-Oct-15 | 63 | 3426 | November 2015 SCC |
| 129721 | A | F | 30-Oct-15 | 89 | 3230 | November 2015 SCC |
| 129720 | A | F | 30-Oct-15 | 27 | 2491 | November 2015 SCC |

The data from the tags and visual studies are being used to inform the expanded *Md* PCoD model. The prototype model will be completed in 2016 will to provide insight into effect of cumulative exposure and also provide a tool to investigate various critical parameters that drive population dynamics.

Works Cited

- [1] S. M. Jarvis, R. P. Morrissey, D. J. Moretti and J. A. Shaffer, "Detection, Localization, and Monitoring of Marine Mammals in Open Ocean Environments using Fields of Spaced Bottom Mounted Hydrophones," *Marine Technology Society Journal*, vol. 48, no. 1, pp. 5-20, Feb. 2014.
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- [5] D. Moretti, T. Marques, L. Thomas, N. DiMarzio, A. Dilley, R. Morrissey, E. McCarthy, J. Ward and S. Jarvis, "A dive counting density estimation method for Blainville's beaked whale (Mesoplodon densirostris) using a bottom-mounted hydrophone field as applied to a Mid-Frequency Active (MFA) sonar operation," *J. Applied Acoustics*, vol. 71(11), pp. 1036-1042, 2010.