Integrated Measurement of Naval Sonar Operations and Precise Cetacean Locations: Integration of Fastloc GPS into a LIMPET tag.

Final Report for Task C, contract Number: N66604-14-C-2438

Reporting Period:

September 6, 2016 - December 31, 2017

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Project Summary

The objective of this project was to integrate a Fastloc® GPS into a remotely-deployed, dart-attached, medium-duration satellite tag suitable for attachment to a beaked whale. This modification will allow for opportunistic monitoring of the reaction of cetaceans, including sonar-sensitive Blainville's (*Mesoplodon densirostris*) and Cuvier's (*Ziphius cavirostris*) beaked whales, to Mid-Frequency Active (MFA) sonar operations over the medium-term (weeks to months) with a high degree of spatial precision not currently available with existing satellite tags. These data, which will include precise localizations, and the presence or absence of deep foraging dives before, during, and after sonar exposure, are critically needed inputs for the Population Consequences of Disturbance (PCoD) model that is being developed to measure the health of animal populations. The project will be executed in three phases.

Task A Objective: The objective of Task A was to integrate the Fastloc® GPS receiver into the Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) style package and conduct land-based testing. Satisfactory completion of the testing was the go/no-go criterion to exercise Task B.

Task B Objective: The objective of Task B was to conduct field tests of the GPS LIMPET tags on several species of cetaceans to assess tag performance. Successful completion of field testing was the go/no-go criterion for exercising Task C.

Task C Objective: The objective of Task C was to deploy the final variant of the GPS LIMPET tag at SCORE prior to a Naval MFA sonar exercise.

Tasks included in this reporting period

Task C (Option 2)

Please note that this work was completed in collaboration with Dr. Russel Andrews (Alaska SeaLife Center) and David Moretti (Naval Undersea Warfare Center): this report compliments reports for the project submitted by these collaborators.

Background

While LIMPET tags are currently being applied to beaked whales on Navy ranges to monitor their behavior during MFA events (e.g. Tyack et al. 2011, Schorr et al. 2014, Falcone et al. 2017), limitations inherent in spatial data derived from the Argos system have presented challenges to the data analysis. The current LIMPET satellite tags can only provide a location estimate during the infrequent times when the whale surfaces and an overpass of an Argos-system satellite occur simultaneously. In contrast, there is always a sufficient number of GPS satellites overhead to allow a location to be calculated after every dive. Traditional GPS receivers require tens of seconds to acquire both the range and ephemeral data needed to calculate a position, but most whales surface for too short of a time for that amount of data collection. The Fastloc® system, however, captures a small amount of the GPS satellite signals (snapshots) within ~ 300 ms for rapid calculation of pseudo-ranges and then those data are stored and subsequently transmitted for post-processed location calculations, now allowing GPS receivers to be incorporated into marine mammal tags (e.g Witt et al. 2010, Dujon et al. 2014).

At the completion of Task B, the final variant of the Fastloc-GPS Low Impact Minimally Percutaneous External-electronics Transmitting (hereafter GPS-LIMPET) tag was identified by the mold AM-333B-AF with a v-dipole design (Figure 1). This tag had undergone rigorous impact and ballistics testing, outlined in the report for Task B, and had been previously deployed on free ranging whales. Here, we describe results of final testing and field deployments of the GPS-LIMPET tag as part of the Task C demonstration plan.

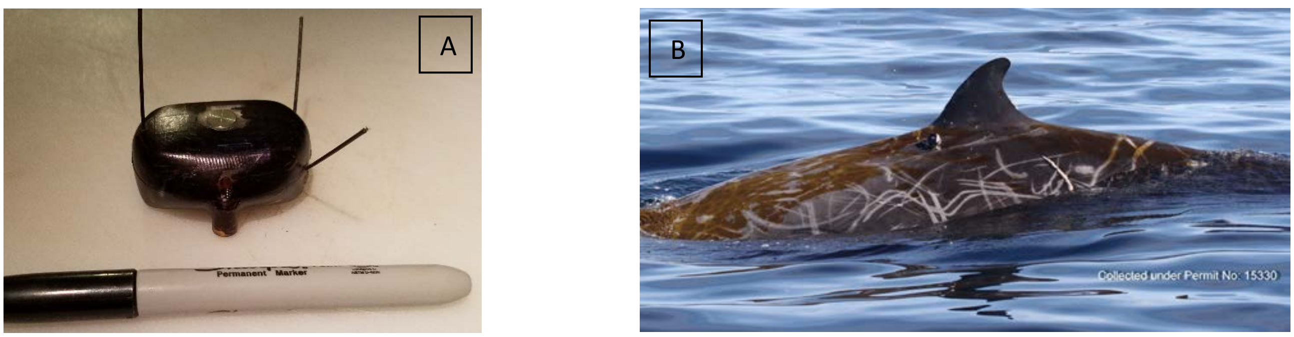

Figure 1. A) Fastloc GPS-LIMPET tag in the SPLASH10-F-333B configuration. B) GPS-LIMPET deployed on an adult male Cuvier's beaked whale (ZcTag053).

Land-based precision test with final version of the GPS-LIMPET tag

Our original plan was to conduct a focal follow of a GPS tagged whale and compare the footprint locations of the whale to our GPS-linked data collection device (Mobile Demand; https://www.ruggedtabletpc.com/) to assess precision of location estimates. Due to whale behavior and/or sea state conditions, we were unable to conduct a focal follow long enough to obtain a reasonable track for comparison. Therefore, to assess the precision of the Fastloc-GPS locations in the v-dipole configuration in a manner that would replicate the field test, we conducted a land-based experiment. The tag was activated in a bucket of saltwater and was positioned 0.5 m away from the stationary Mobile Demand.

The ‘tracking’ experiment consisted of taking the tag out of the water to simulate a surfacing and then re-submerged. This was repeated 5-7 times over approximately 2 minutes. When the tag was out of the water, a position was marked with the Mobile Demand and the latitude/longitude was recorded in an Access database. The tag was out of the water for a few seconds each surfacing, reflecting the average amount of time a beaked whale dorsal fin is at the surface when the animal surfaces to breathe. Each two-minute experiment mimicked a “surface bout”. Surface bouts were repeated several times throughout the day with a minimum of five minutes between each bout. There were 94 GPS locations recorded on the Mobile Demand and the distance between those locations were compared to each other to set a baseline location for the tag. The mean distance between locations collected by the stationary Mobile Demand was 1.1 m (SD = 3.2). This mean location was used to compare to all Fastloc-GPS snapshots from the tag.

Over the course of this experiment, the tag attempted 35 GPS snapshots in 25 ‘surfacings’. A total of 24 snapshots (69%) were successful in generating a location estimate (snapshots with ≥ 4 satellites). Fifteen of the snapshots (43% of the total) had five or more satellites and a residual of <30, generally considered to be the standard cutoff for high-quality location estimates. The mean distance of all successful snapshots from the actual tag location was 163 m (SD = 233.9). This dropped to 52 m (SD = 31) for snapshots with more than four satellites. A plot of the position estimates from the GPS-LIMPET tag compared to the Mobile Demand positions demonstrates the loss of precision when made with only four satellites (Fig. 2).

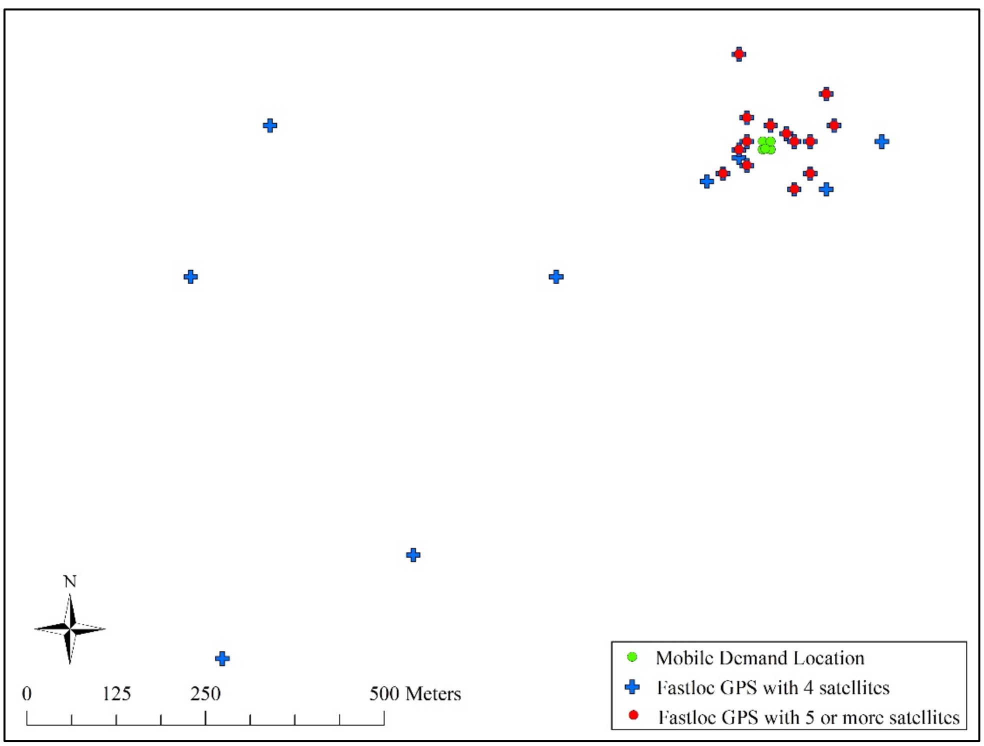

Figure 2. Scatter plot of position estimates generated during the precision test. The GPS-LIMPET tag was with 0.5m of the Mobile Demand during all portions of the test. GPS position estimates calculated with 5 or more satellites are much more precise than those generated with only 4 satellites.

Fieldwork

In total, sixteen days were spent on the water, surveying 2,258 km totaling 123.3 h of effort (Figure 3, Table 1). Five days were lost due to poor weather conditions. During this effort, we had 61 sightings of 12 different species, including 11 sightings of Cuvier's beaked whales and 14 sightings of fin whales (Figure 4, Table 1). Five GPS-LIMPET tags were deployed, including three tags on Cuvier's beaked whales and two on fin whales (*Balaenoptera physalus)* (Table 2). One tag attempt was made on a Cuvier's beaked whale with the tag missing the whale and landing in the water. The tag was recovered for later use. Due to weather challenges and the lack of suitable target species in the demonstration area, we leveraged projects in Hawaii to deploy four additional tags for assessment of GPS performance (Table 2) including three tags on short-finned pilot whales (*Globicephila macrorynchus)* and one on a false killer whale (*Pseudorca crassidens*).

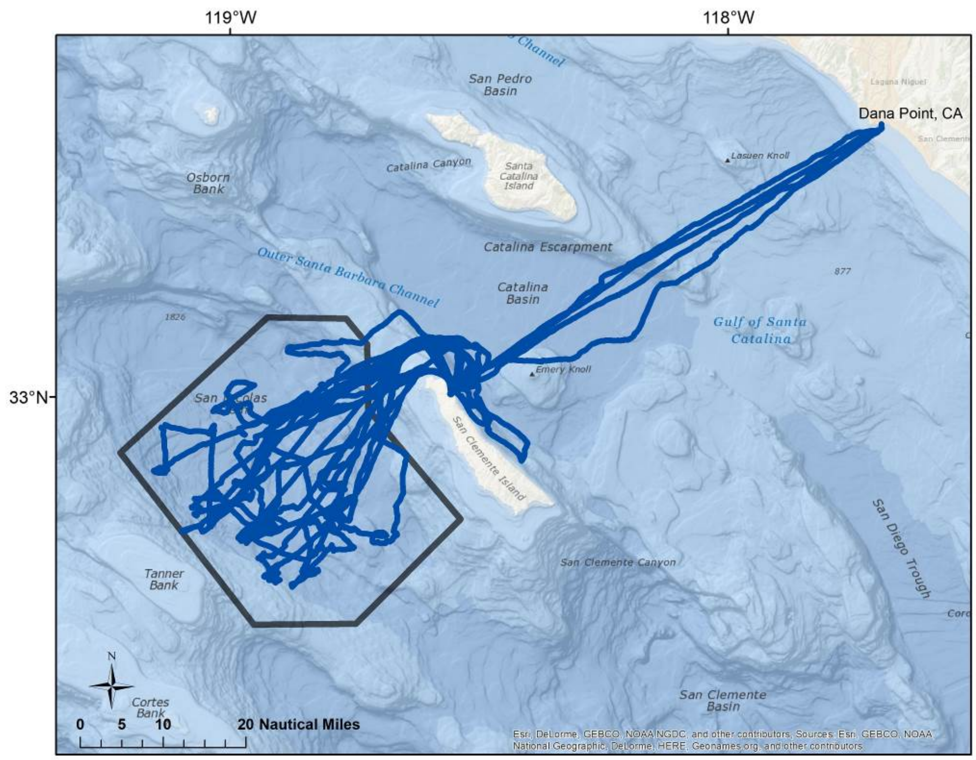

Figure 3. Vessel tracks (blue lines) showing on-water effort during the demonstration phase at SCORE. The black polygon represents the SOAR boundary.

Table 1. Effort and sighting information by day during the demonstration phase.

Date	Effort (h)	Distance (km)	# Sightings	# Species	# Biopsies	# Tags deployed
11/4/2016	3.8	102	0	0	0	0
11/7/2016	11.3	176	4	3	0	0
11/8/2016	9.1	172	4	3	0	0
11/9/2016	7.9	167	4	3	0	0
11/11/2016	11.3	193	7	3	0	1
11/12/2016	8.9	164	2	2	0	0
11/14/2016	2.3	95	0	0	0	0
1/5/2017	4.0	96	1	1	0	0
1/6/2017	9.1	141	3	3	0	0
1/7/2017	10.4	181	5	3	0	0
1/8/2017	11.6	174	9	4	1	1
1/9/2017	3.6	54	2	2	0	0
1/10/2017	9.8	177	7	4	4	1
1/12/2017	2.9	98	1	1	0	0
4/2/2017	7.3	115	7	4	1	1
7/25/2017	10.0	151	5	3	0	1

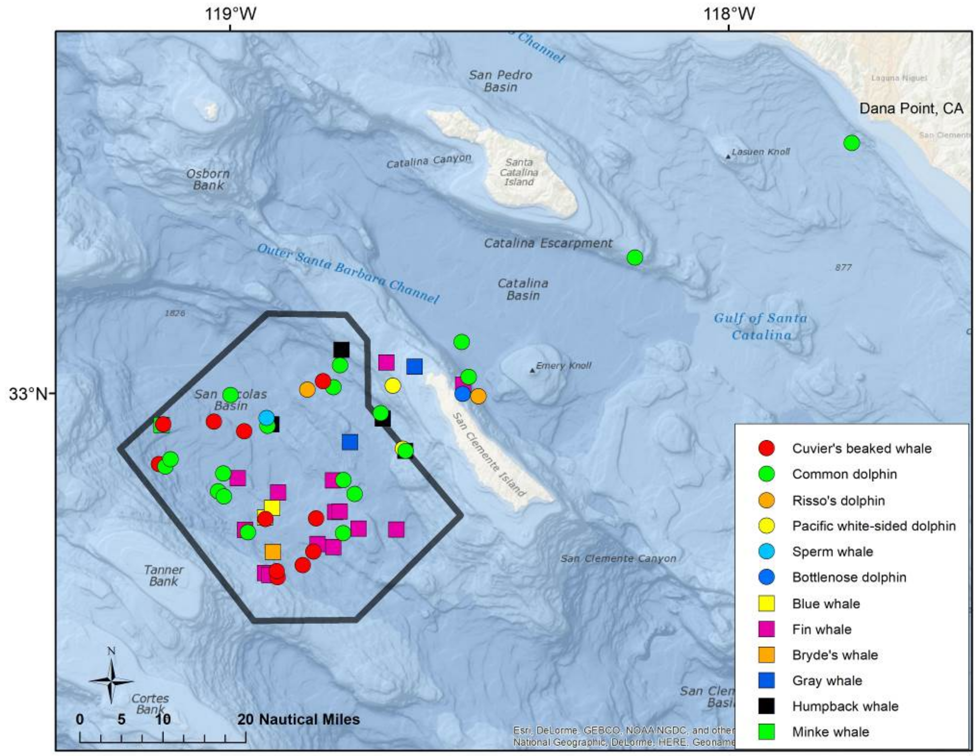

Figure 4. Map showing sighting locations by species. The black polygon represents the SOAR boundary.

GPS-LIMPET tag performance

Overall, GPS tag performance was good across a variety of taxa (See Appendix I for tag programming details). The percentage of successful versus failed snapshot attempts ranged from 37-83% (Table 3), depending on the species. The lowest rate of successful fixes was recorded by a fin whale, which is not surprising given the location of tag deployment (dorsal fin) and the surfacing behavior of this species (refer to the *fin whales* section below for additional details). Receiving a successful snapshot via Argos was the largest limiting factor; this can be attributed to satellite availability, which is limited except at high latitudes. For snapshots that were received, we compared the number of snapshots with four satellites versus five or more, in terms of the better accuracy of location estimates (Table 4) (e.g. Witt et al. 2010, Dujon et al. 2014 and the *land-based testing* section). The tag with the lowest percentage of successful GPS attempts, BpTag078 (Table 3), still had 66.7% of received locations with five or more satellites. The number of these optimal received locations went as high as 87.5% for ZcTag059, indicating that good snapshots were prevalent despite the challenges associated with data collection using these types of tags on free-ranging species.

Table 3. GPS performance results from tags deployed during Task C. Tags with a * include GPS messages from the tags received by land-based Argos receiving stations (Motes, Wildlife Computers Inc., Redmond, WA).

TagID	Duration of data (Days)	# successful GPS attempts	# Successful attempts / # successful + failed attempts (%)	# GPS loc's received including Mote data	% GPS loc's received including Mote data	# GPS loc's received without Mote data	% GPS loc's received without Mote data
BpTag077*	15.1	1050	53.0%	48	4.6%	44	4.2%
BpTag078	67.3	2286	36.7%	N/A	N/A	356	15.6%
GmTag169	22.0	853	82.3%	N/A	N/A	526	61.7%
GmTag170	14.9	545	71.4%	N/A	N/A	258	47.3%
GmTag171*	23.0	841	67.2%	488	58.0%	485	57.7%
PcTag055	8.7	276	42.7%	N/A	N/A	166	60.1%
ZcTag052*	2.4	176	82.6%	72	40.9%	38	21.6%
ZcTag053*	11.7	479	81.3%	221	46.1%	89	18.6%
ZcTag059	10.3	354	78.0%	N/A	N/A	72	20.3%

Table 4. Assessment of the number of locations with more than four satellites, which lead to increased accuracy over location estimates with only four satellites. Tags with Mote data included are indicated by a *.

TagID	Total # of GPS loc's received	Mean # Satellites per location	# GPS Locs with >4 satellites	% GPS Locs with >4 satellites
BpTag077*	48	5.3	32	66.7%
BpTag078	356	5	219	61.5%
GmTag169	526	5.3	372	70.7%
GmTag170	258	5	160	62.0%
GmTag171*	488	5	313	64.1%
PcTag055	166	5.3	109	65.7%
ZcTag052*	72	6.2	53	73.6%
ZcTag053*	221	5.4	165	74.7%
ZcTag059	72	6.8	63	87.5%

We assessed the daily update rate for each tag (mean number of locations received per day) for both GPS location estimates and Argos location estimates. In five of nine cases, the mean GPS update rate ranged from 43-106% greater per day than the Argos location update rate (Table 5). The two fin whales and two beaked whale had GPS update rates lower than those generated by Argos, although in the case of ZcTag053, with the addition of land-based Argos receiving stations, or Mote data (Wildlife Computers, Redmond, WA), GPS locations outweighed Argos locations by 136%. For these two species, update rate via GPS could be influenced by tag position on the body, surfacing behavior, sea state, or a combination of all three. If the tag is unable to collect a successful snapshot (four or more satellites), the tag will continue to try and collect a snapshot at the expense of a normal Argos transmission. Additionally, if the tag is transmitting an Argos message with GPS data included and the message is corrupted (e.g., the full 32-bit transmission is truncated), Argos may still be able to receive the signal well enough to ID the tag and use the uplink to generate a traditional location estimate.

Table 5. Location update rate of Fastloc-GPS versus Argos location estimates.

TagID	Mean # GPS snapshots received / day without Mote data	Mean # GPS snapshots received / day including Mote data	Mean # Argos location estimates / day
BpTag077	2.9	3.2	7.6
BpTag078	5.3	NA	11.6
GmTag169	23.9	NA	11.6
GmTag170	17.7	NA	10.1
GmTag171	21.1	21.2	14.7
PcTag055	19.1	NA	10.9
ZcTag052	15.8	30.0	9.5
ZcTag053	7.6	18.9	8.0
ZcTag059	7.0	NA	9.1

Specific details on individual tagged whales

Cuvier's beaked whales

Three GPS-LIMPET tags were deployed on Cuvier's beaked whales on the SOAR training range in the Southern California Bight (SCB). Deployments occurred at estimated ranges of 10, 14, and 16 m.

ZcTag052, the first GPS-LIMPET tag deployed on a beaked whale, transmitted for only 2.4 days. Sonar was being actively used just south of SOAR at the time of deployment (Fig. 5), and while the tagged whale did move a bit north in the first day, it returned back into the area of tagging within a short time. GPS positions were obtained between 67% to 216% more often than Argos locations when augmenting Argos-received data with Mote received data (Table 5). Though ZcTag052 had double the mean number of GPS locations received by Argos than subsequent beaked whale tags, this was likely due to the short duration of the deployment resulting in few competing data messages needing to be sent via Argos (see section below on tag trade-offs).

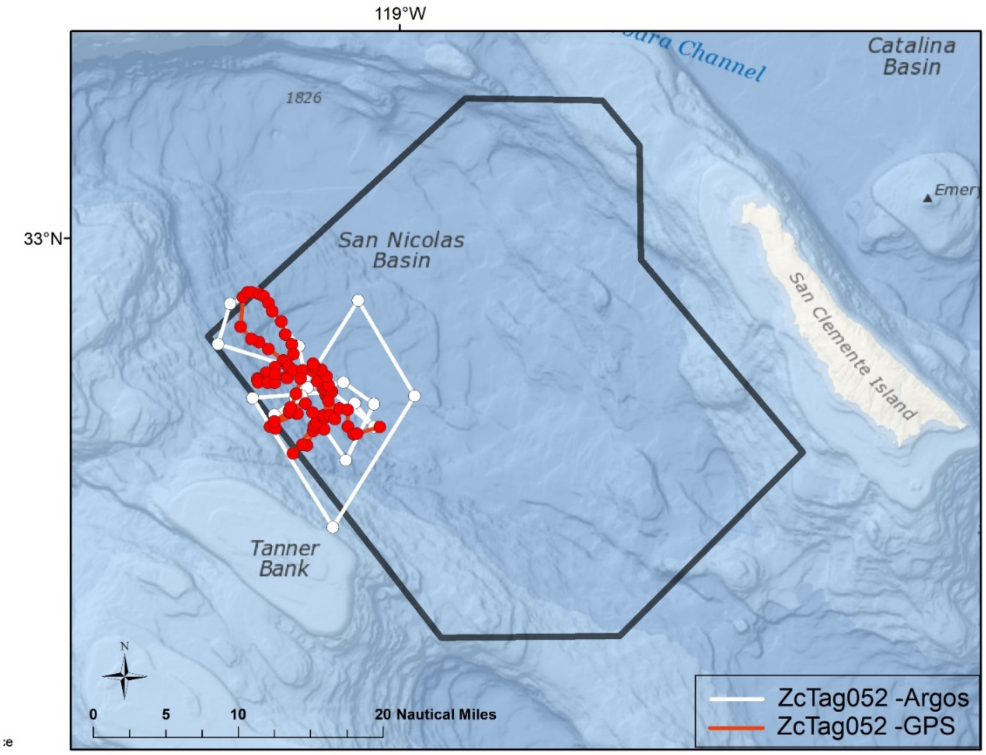

Figure 5. Comparison of filtered Argos tracks and position estimates (white) and GPS track and position estimates (red) generated with more than four satellites over the 2.4 days ZcTag052 transmitted. The black polygon represents the SOAR boundary.

ZcTag053 was deployed in early January 2017 (Fig. 6), prior to the onset of Navy helicopter sonar training. This tag transmitted for 11.7 days, and overlapped with three days of undersea warfare exercises. A total of 221 GPS location estimates were collected, with 74.7% generated with more than four satellites (Table 4).

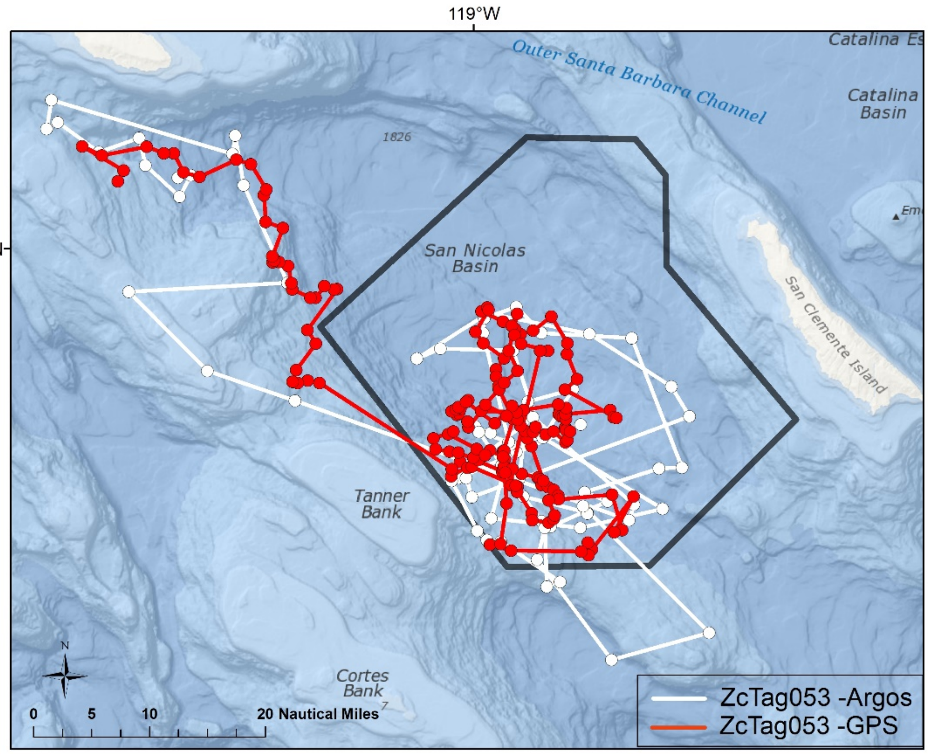

Figure 6. Comparison of filtered Argos track and position estimates (white) and GPS track and position estimates (red) generated with more than four satellites over the 11.3 days ZcTag053 transmitted. The black polygon represents the SOAR boundary.

The installation of Motes (Wildlife Computers Inc., Redmond, WA) on San Clemente and San Nicolas Islands has dramatically increased our ability to collect data transmitted by nearby tags (Jeanniard-du-Dot et al. 2017). In the case of ZcTag053, a total of 89 independent GPS location estimates were received via Argos with each message being received on mean 1.4 times (SD = 0.8). The Mote collected 221 independent GPS location estimates, with each location received a mean of 3.4 times (SD = 4.5) (Fig. 7).

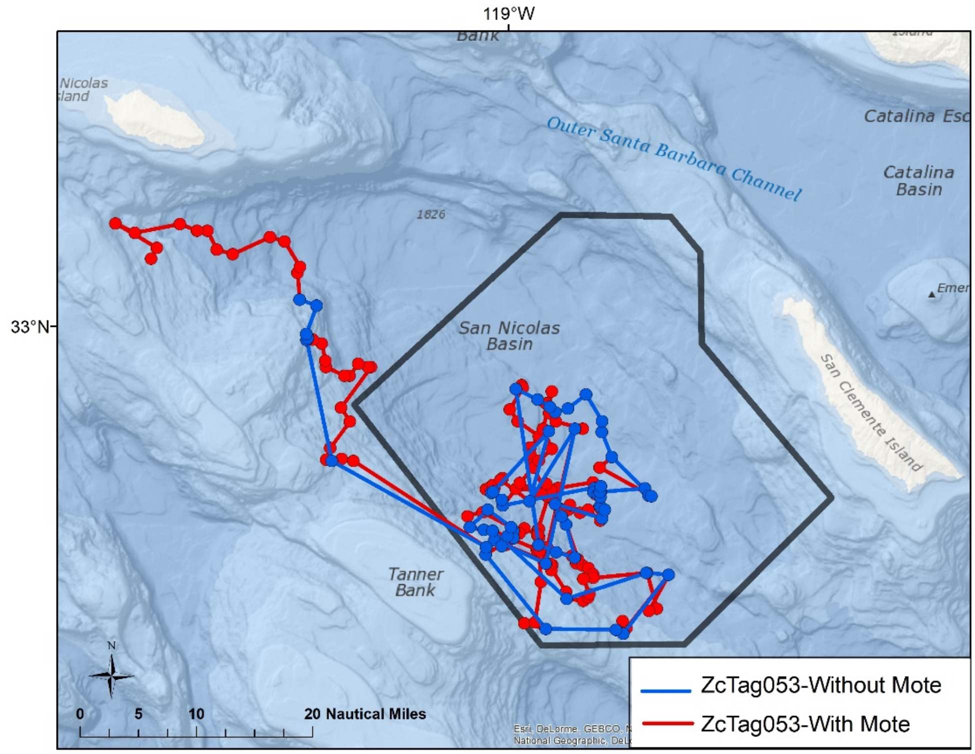

Figure 7. Comparison of GPS location estimates received by Argos satellites (blue) and Argos satellite data combined with land-based Motes (red, the same track as shown in Fig. 6) placed on San Clemente Island and San Nicolas Island, showing the additional points that were received via the land-based stations. The black polygon represents the SOAR boundary.

ZcTag059 was tagged on the SOAR range immediately prior to a sonar training operation. This tag transmitted for 10.3 days, with the animal spending most of its time just south and west of the range boundary (Fig. 8). No Mote data was available for this animal at the time of the report, but for this particular whale, the Argos update rate was higher than the Fastloc-GPS update rate (Table 5). Placement of the tag, while not on the dorsal fin, was just forward of the fin and in an area that should have allowed for clear reception for successful snapshots; the reason for a lower number of GPS location estimates is unclear. One possibility is that poor weather conditions truncated the transmission of GPS data, but allowed enough of a signal for Argos to generate a position estimate based on Doppler shift.

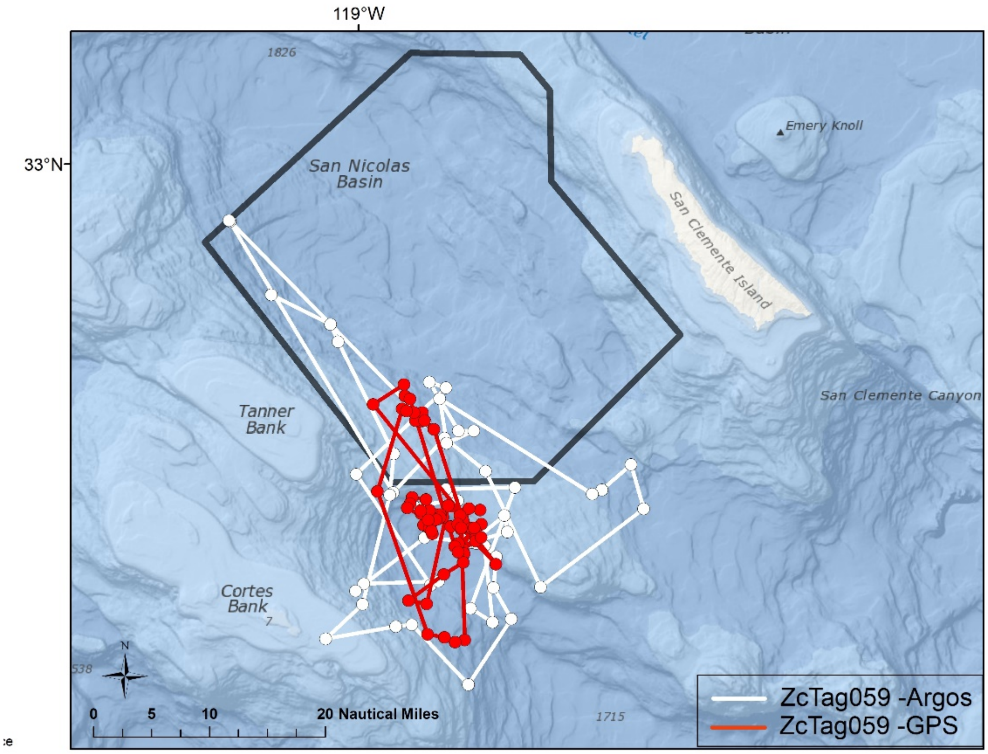

Figure 8. Comparison of filtered Argos tracks and position estimates (white) and GPS track and position estimates (red) generated with more than four satellites over the 10.3 days ZcTag059 transmitted. The black polygon represents the SOAR boundary.

Estimation of rate of horizontal movement on Cuvier's beaked whales; Argos vs. Fastloc-GPS

One of the primary goals for better location estimates for beaked whales generated by GPS is improved assessment of the rate of horizontal movement. By comparing the overall rate of movement (km/hr) by individuals using both GPS location estimates (with five or more satellites) and Douglas filtered Argos locations, we can assess how well 'course-scale' Argos data represents the fine-scale movements that may be occurring by tagged beaked whales. Table 6 outlines the horizontal rate of movement between successive location estimate as compared between filtered Argos locations (Schorr et al. 2014) and GPS. For all three whales, rates of movements derived by Argos location estimates were 59-62% higher than those rates calculated by Fastloc-GPS position estimates. These increased rates generated by Argos location estimates are likely due to the following contributing factors: 1) the number of available GPS locations was higher than those for Argos locations, 2) Given a high degree of site fidelity and limited range of daily movement, even small errors in Argos location estimates may introduce a greater estimated rate of movement versus GPS.

Table 6. Mean rate of horizontal displacement between successive GPS position estimates obtained with five or more satellites (top), and filtered Argos position estimates (bottom) for tagged beaked whales.

	Tag ID	*N*	Mean rate (km/hr)	SD of rate (km/hr)	Max rate (km/hr)
GPS	ZcTag052	52	1.92	1.02	5.83
	ZcTag053	164	1.86	1.02	6.39
	ZcTag059	61	1.59	0.84	3.74
Argos	ZcTag052	21	3.23	2.21	7.73
	ZcTag053	70	2.98	2.41	9.99
	ZcTag059	48	2.69	2.10	9.36

Fin whales

Two fin whales were tagged as part of the demonstration phase of this project.

BpTag077 was deployed in January of 2017 immediately prior to a MFA sonar training exercise. The tag was deployed in the middle of the dorsal fin on an adult sized whale. Both Argos and GPS performed poorly in terms of location estimates received (Fig. 9 and Table 3 and 4), particularly when compared to BpTag078. However, when looking at the number of reported GPS snapshots taken (1050 in 15.1 days or a mean of 70 locations per day, Table 3) indicates the tag was collecting data, but not transmitting that data via satellite (only 48 received in 15.1 days or a mean of 2.9 locations per day received, Table 3). A review of the programming of this tag revealed that GPS snapshots were to be taken every 8 minutes, with failed snapshots to be re-tried immediately. This high collection rate of GPS snapshots was done to facilitate at-sea tracking of the animal for verification of GPS locations via a focal-follow of the whale, but ultimately may have proved self-defeating. The average dive time of a fin whale is ~ 8 minutes, and if the dorsal fin was only clearing the surface once per surface series (typically on the terminal dive), it is possible that a majority of the times the tag was clearing the surface, it was attempting a GPS snapshot. Unless the whale brought the dorsal fin clear of the water multiple times per surfacing, the tag would be unable to transmit as it was collecting a GPS snapshot. Programming for subsequent fin whale tags was adjusted based on this supposition, and the improved throughput of GPS data can be seen by comparing performance against BpTag078 (Table 3 and 4, and text below).

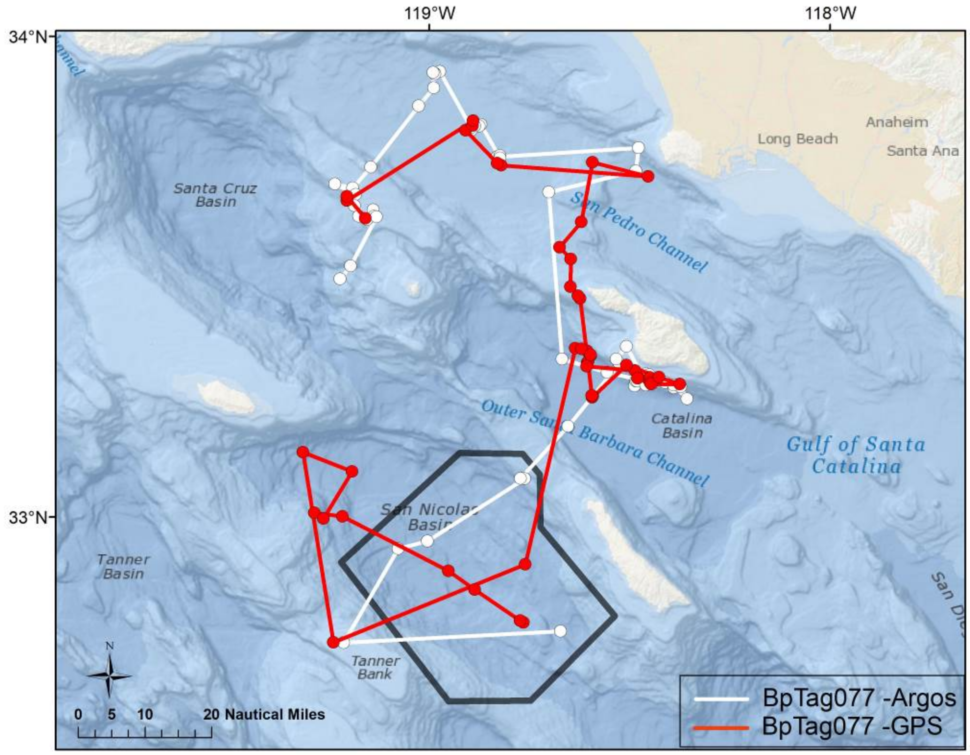

Figure 9. Comparison of filtered Argos tracks and position estimates (white) and GPS track and position estimates (red) generated with more than four satellites over the 15.1 days BpTag077 transmitted. The black polygon represents the SOAR boundary.

BpTag078, estimated to be a juvenile, was tagged mid-fin on April 2, 2017. While the overall number of successful snapshots was lower than BpTag077 (Table 3), the mean number of GPS position estimates received per day was higher (Table 5, Fig. 10). This increase was likely due to the change in tag programming, with a GPS snapshot attempted every 30 minutes versus 8 minutes for BpTag077. Of the snapshots received, 61.5% had more than four satellites, on par with the performance of pilot whales (Table 4).

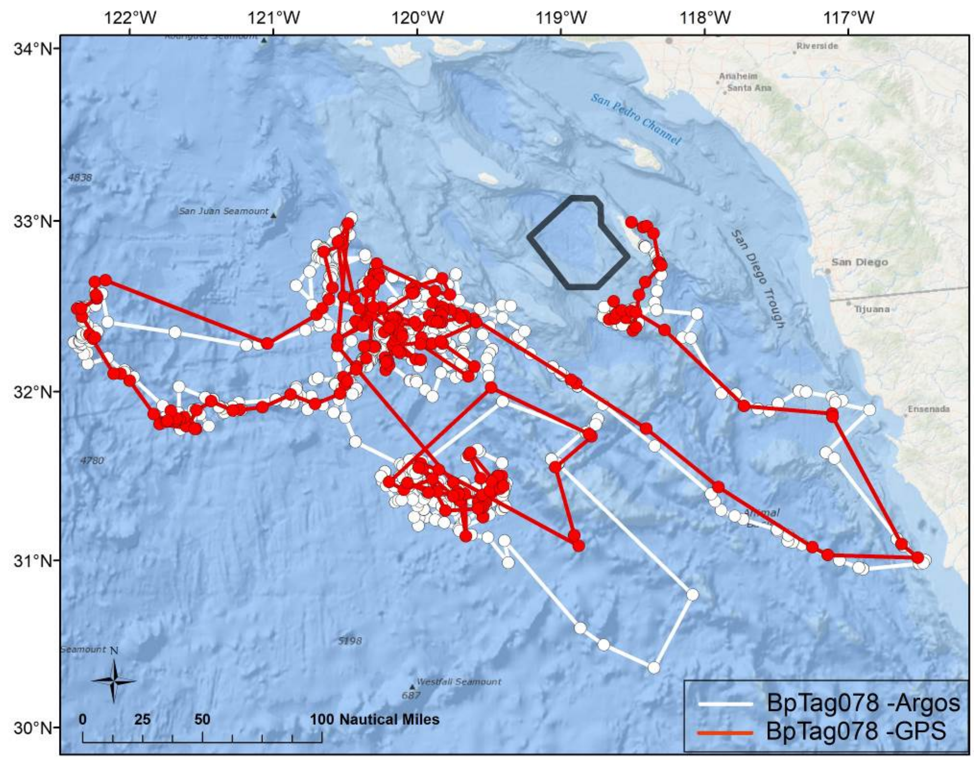

Figure 10. Comparison of filtered Argos tracks and position estimates (white) and GPS track and position estimates (red) generated with more than four satellites over the 67.3 days BpTag078 transmitted. The black polygon represents the SOAR boundary.

Short-finned pilot whales

The GPS tags performed well on pilot whales, as demonstrated in previous tasks. Three pilot whales were tagged in Hawaii as part of ongoing work in that region (Baird 2016) (Fig. 11). One pilot whale had the highest percentage of successful snapshots received via Argos. The other two tagged whales posted numbers above all other species/individuals with the exception of the tagged false killer whale (Table 3). Along with the false killer whale, pilot whales had the greatest increase in update rate via GPS versus Argos than all other tagged whales (excluding ZcTag052, which only transmitted for 2.4 days leading to a high number of received GPS location estimates due to tag programming).

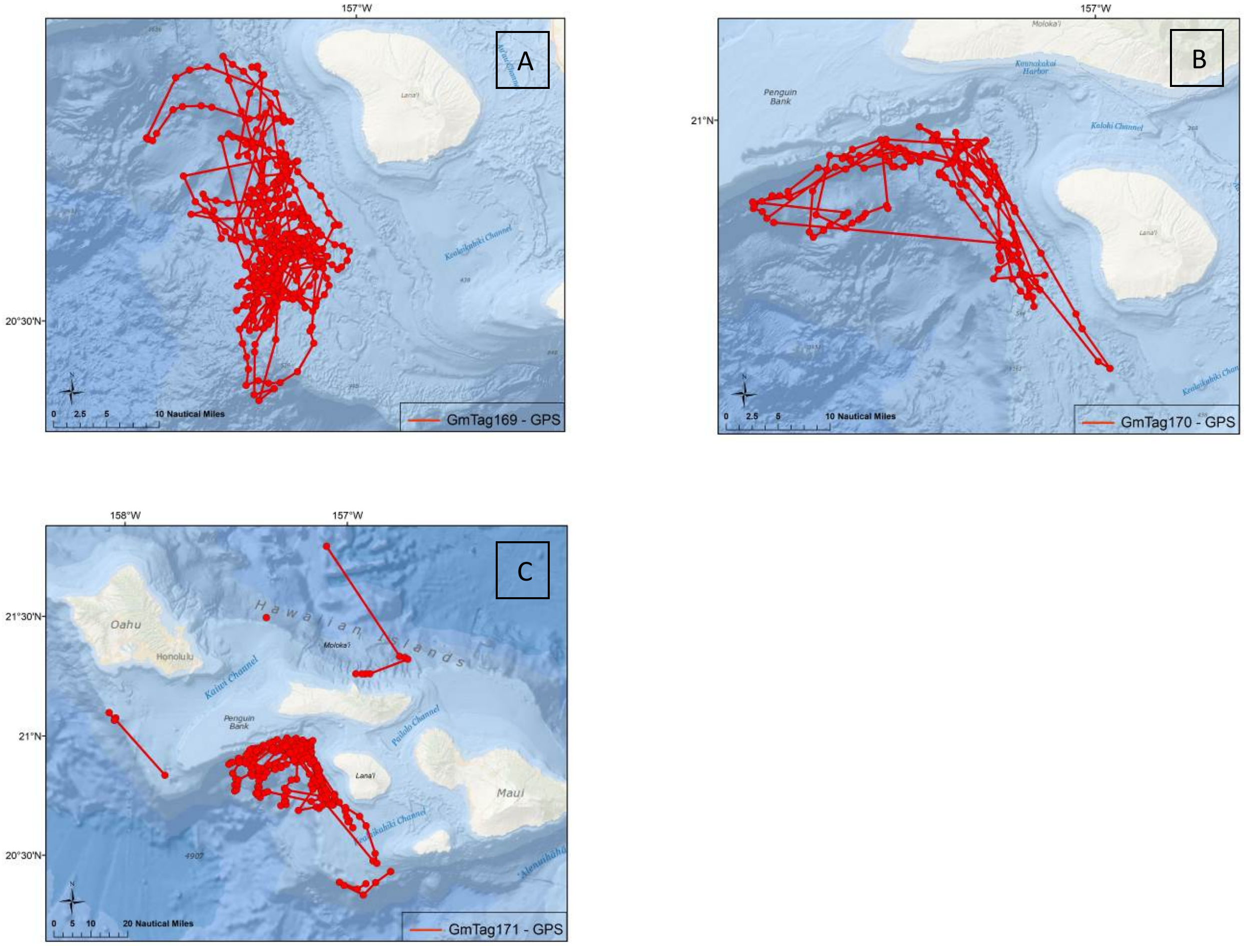

Figure 11. A) GPS track and position estimates generated with more than four satellites for GmTag169 which transmitted for 28.5 days. B) GPS track and position estimates generated with more than four satellites for GmTag170 which transmitted for 14.9 days. C) GPS track and position estimates generated with more than four satellites for GmTag171 which transmitted for 44.9 days. Note the gaps in the track for GmTag171 (C) are due to the fact the tag was duty-cycled after 20 days to conserve battery life, resulting in GPS position estimates on 23 of the 45 days the tag was transmitting.

False killer whale

Despite having the second lowest percentage of successfully collected GPS snapshots, the tagged false killer whale had the second highest percentage of GPS locations received by Argos (Table 3, Fig. 12).

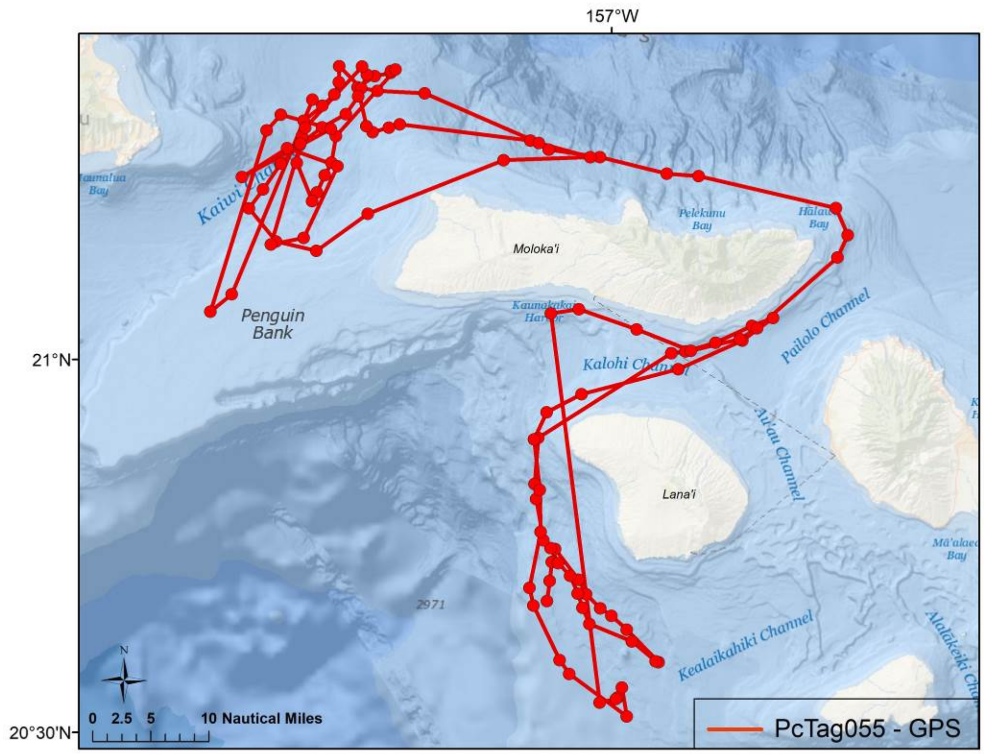

Figure 12. GPS track and position estimates generated with more than four satellites for PcTag055 which transmitted for 8.7 days.

LIMPET tag selection: information to inform appropriate tag selection for a particular study (SPLASH10 dive reporting vs. SPLASH10-F dive reporting/Fastloc-GPS).

While the GPS tag provides far more accurate location estimates than location estimates generated by the Argos system, there are some trade-offs that must be assessed when selecting a tag for a particular study. Battery life, importance of dive data versus position update rate and accuracy, ability to get close to your target animal, Argos availability, and cost, among others must be assessed for each study. As an example: for beaked whales in the SCB, the mean time at the surface from the first to last breath for a beaked whale is 1.9 minutes with an mean of 21 minutes between shallow dives (Schorr et al. 2014). To best balance battery performance with Argos transmission performance for beaked whales, we program tags to transmit every 15 seconds, meaning the tag will only be available to transmit on average seven times per surfacing series (irrespective of Argos satellite availability). After collecting a GPS snapshot, the tag is unable to transmit for ~20 seconds while determining if the snapshot is 'successful' meaning 4 or more satellites were received during the snapshot. This process means that, at a minimum, two chances, out of seven, for an Argos transmission within a surface series will be lost for Cuvier's beaked whales in the SCB. If the snapshot is good, the tag can immediately begin to transmit data: however, the tag now has GPS location data to transmit in addition to any dive data that may be collected. Therefore, at best, a researcher needs to assume a relatively large reduction in ability to transmit dive data over the SPLASH10 tag.

In the case of Cuvier's beaked whales within the SCB where studies have demonstrated that disturbance from Navy sonar may be captured by the time between deep (foraging) dives (Falcone et al. 2017), we modified our behavior log data collection to only capture deep dives, with the time between recorded deep dives as 'surfacings'. This increased the probability of receiving a complete temporal summary of deep diving behavior, while increasing number of available messages for transmission of GPS snapshots.

Upon review of the behavior log for these three whales with tags programmed to collect only dives greater than 40 minutes, it was determined that a mean of 2.2 behavior log messages per day were needed to capture the entire day of diving behavior. Each of these messages was received via Argos an average of 2.4 times per day; therefore, a tag could in theory increase the number of received GPS location estimates by ~ 4.8 per day by excluding the collection of behavior log dive data. However, if higher-resolution diving behavior is more important than high-resolution location data, and diving behavior would generate a larger number of behavior log messages per day, researchers should consider the trade-offs of the tag types carefully.

Conclusions

Nine GPS-LIMPET tags in the v-dipole (SPLASH10-F-333B) configuration were deployed on four different species during the final demonstration phase of this project (Table 3). The LIMPET version of the GPS tags performed well on all species, although tag programming of one fin whale tag led to decreased performance. The GPS tags on beaked whales performed well, with the percentage of successful snapshots ranging from 78-83%, outperforming even pilot whales, despite the larger fins of pilot whales increasing the probability of the tag coming completely clear of the water with each surfacing on a well deployed tag (Table 3). Beaked whales had the highest combined percentage of received GPS location estimates with more than four satellites (i.e. more accurate) than any of the other species. The greatest impediment to the GPS-LIMPET tag (or any satellite-linked tag) on beaked whales is the low probability of overlap of a tagged animal at the surface with a concurrent overhead Argos satellite. This is not surprising, given the limited amount of time beaked whales spend at the surface in the area (Schorr et al. 2014), combined with the paucity of Argos satellite passes. While researchers should consider their study objectives carefully when choosing the correct tag for their study, the GPS-LIMPET tag is clearly suitable for use with these species.

Acknowledgements

Funding for this work was provided by ESTCP via contract N66604-14-C-2438 to Cascadia Research Collective (PI: Greg Schorr) via the Naval Undersea Warfare Center (NUWC), Newport, RI. Additional support for fieldwork in Southern California was provided by the US Navy Pacific Fleet via contract N66604-14-C-0145 to Cascadia Research Collective (PI: Greg Schorr and Erin Falcone) via NUWC and through the Navy's Living Marine Resources Program via contract N29340-16-C-1870 to Marine Ecology & Telemetry Research (PI: Greg Schorr). Funding for the field effort where tags were deployed in Hawaii (GmTag169-171 and PcTag055) was through a NOAA Species Recovery Fund grant to State of Hawaii and contract to Cascadia Research Collective (PI: Robin Baird). We are grateful for the support of our collaborators Russ Andrews, the M3R group at NUWC, the staff at Wildlife Computers, and Daniel Webster and Robin Baird of Cascadia Research Collective for assistance in tag deployments. We also thank Thomas Fetherston, Frank and Jane Falcone. Field work would not have been possible without support from SCORE, in particular Heidi Nevitt, Robert Tahimic, and the entire SCORE OPS crew on San Clemente Island. Tagging was conducted under NOAA OPR permits 15330, 16111, and 17086, with approval from Cascadia Research Collective's Institutional Animal Care and Use Committee.

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Appendix I. Table of relevant tag programming parameters by Tag ID. Parameters where chosen (and modified) based on consideration of animal diving behavior, battery consumption, and study questions.

	Argos Settings				GPS Settings				
TagID	Fast Rep Rate (sec)	# hrs tx / day	Duty cycled?	Max # Daily Tx	Snapshot Interval (min)	Snapshot hrs / day	Duty cycled?	Max # successful snapshots/ hr	Max # successful snapshots/ day
BpTag077	15	16	No	700	8	24	No	7	180
BpTag078	15	16	No	700	30	24	No	2	50
GmTag169	15	21	Daily for 20 days, then every 5th day	750	30	24	Daily for 20 days, then every 5th day	2	96
GmTag170	15	21	Daily for 20 days, then every 5th day	750	30	24	Daily for 20 days, then every 5th day	2	96
GmTag171	15	21	Daily for 20 days, then every 5th day	750	30	24	Daily for 20 days, then every 5th day	2	96
PcTag055	15	21	Daily for 20 days, then every 5th day	750	30	24	Daily for 20 days, then every 5th day	2	96
ZcTag052	15	21	No	500	15	24	No	4	80
ZcTag053	15	21	No	500	20	24	No	3	48
ZcTag059	15	21	No	500	20	24	No	3	48