

Blue whale ecology in the South Taranaki Bight region of New Zealand

January-February 2016 Field Report

March 2016



Report prepared by:

Dr. Leigh Torres, PI
Assistant Professor; Oregon Sea Grant Extension agent
Department of Fisheries and Wildlife, Marine Mammal Institute
Oregon State University, Hatfield Marine Science Center
2030 SE Marine Science Drive
Newport, OR 97365, U.S.A
+1-541-867-0895; leigh.torres@oregonstate.edu
Webpage: <http://mmi.oregonstate.edu/gemm-lab>
Lab blog: <http://blogs.oregonstate.edu/gemmlab/>

Dr. Holger Klinck, Co-PI

Technology Director
Bioacoustics Research Program
Cornell Lab of Ornithology
Cornell University
159 Sapsucker Woods Road
Ithaca, NY 14850, USA
Tel: +1.607.254.6250
Email: Holger.Klinck@cornell.edu

Assistant Professor
Oregon State University and
NOAA Pacific Marine Environmental Laboratory
Hatfield Marine Science Center
2030 SE Marine Science Drive
Newport, OR 97365, USA

Collaborators:

Ian Angus¹, Todd Chandler², Kristin Hodge³, Mike Ogle¹, Callum Lilley¹, C. Scott Baker²,
Debbie Steel², Brittany Graham⁴, Philip Sutton⁴, Joanna O'Callaghan⁴, Rochelle Constantine⁵

¹ New Zealand Department of Conservation (DOC)

² Oregon State University, Marine Mammal Institute

³ Bioacoustics Research Program, Cornell Lab of Ornithology, Cornell University

⁴ National Institute of Water and Atmospheric Research, Ltd. (NIWA)

⁵ University of Auckland, School of Biological Sciences

Research program supported by:

The Aotearoa Foundation, The National Geographic Society Waitt Foundation, The New Zealand Department of Conservation, The Marine Mammal Institute at Oregon State University, The National Oceanographic and Atmospheric Administration's Cooperative Institute for Marine Resources Studies (NOAA/CIMRS), Greenpeace New Zealand, OceanCare, Kiwis Against Seabed Mining, and an anonymous donor.

Executive Summary

In 2014, a blue whale foraging ground was confirmed in the South Taranaki Bight (STB) of New Zealand, overlapping with an industrially active region with oil and gas activity, potential seabed mining, and dense vessel traffic. Between 20 January and 10 February 2016, a comprehensive survey for blue whales was conducted in the STB region to collect essential data on blue whale ecology, including details on their distribution, residency, abundance, behavior, health and population parameters. Results from this survey, as well the 2014 and the upcoming 2017 surveys, will provide robust scientific evidence for environmental managers and stakeholders to develop effective and appropriate management plans to protect this blue whale population and their habitat.

During this 2016 field season, five hydrophones were deployed across the STB region that will record blue whale vocalizations for two years, providing data on blue whale behavior and distribution patterns. Additionally, during 10 vessel days in the STB region, almost 1,500 miles were surveyed and 22 blue whale sightings of 33 individuals were made. These sightings documented foraging behavior, a pair of racing whales, five mother-calf pairs, the first aerial footage of nursing behavior in baleen whales, and a whale with apparent deformities. El Niño conditions caused very warm surface waters across the study area, which is in contrast to survey conditions during 2014. The distribution of blue whales was subsequently different as well, with most whale observations occurring in the western area of our study region, off Kahurangi Point. This variation in distribution patterns relative to environmental variability highlights the importance of studying blue whale habitat use patterns, which will enhance our ability to anticipate blue whale occurrence. Oceanographic conditions in the STB were recorded through a continuous surface temperature record, 84 CTD casts, and 44 hours of hydro-acoustic data on blue whale prey (krill) availability.

Through genetic, stable isotope, and hormone analysis of 12 tissue biopsy and 8 fecal samples collected from blue whales, we will continue to examine the population structure, foraging ecology, and health of these animals. Moreover, analysis of ~4,000 photographs captured will contribute to our on-going photo-id analysis that matches and compares the occurrence of individual blue whales to describe residency and distribution patterns. Aerial video footage of blue whales filmed with an Unmanned Aerial System (aka, drone) provided insightful behavioral data and will be used for photogrammetry analysis to document individual morphometrics (length, girth, health, and reproductive status).

Looking forward, data analysis will proceed and a brief field season in the STB will occur in June 2016 to replace batteries and hard-drives on the hydrophones. A second comprehensive blue whale research field season will occur in the STB region during January and February 2017. Currently, only partial funding is available to support this research program. Co-funding from various groups continues to be solicited through research funding proposals. Given the continued interest and growth in the exploitation of New Zealand's offshore resources, marine conservation projects, such as this research on blue whale ecology in the STB region, are essential to ensure the simultaneous protection of biodiversity and their habitats.

Background

In 2013, the existence of a blue whale foraging ground in the South Taranaki Bight (STB) of New Zealand (Fig. 1), lying between the North and South islands of the country, was hypothesized based on opportunistic sightings, whaling records, seismic survey observation data, and oceanographic data (Torres 2013). The following year, a brief research expedition confirmed this hypothesis by observing blue whales in the STB, including evidence of foraging (Torres et al. 2015). Additionally, genetic analysis of samples collected during the 2014 research determined New Zealand blue whales to be most genetically similar to Australian ‘pygmy’ blue whales, yet a new haplotype was documented and no photo-identification match was made to 174 individual Australian blue whales assessed (compared to 1 in 44 individual New Zealand whales assessed). These results suggest that New Zealand pygmy blue whales may comprise a unique population.

Many questions remain regarding this blue whale population including their spatio-temporal distribution patterns across the region, residency rates, abundance, behavior patterns, and population connectivity. Addressing these knowledge gaps is of significant conservation management concern as the STB is New Zealand’s most industrially active marine region, with seven active oil and gas platforms, significant seismic exploration for new petroleum deposits, drilling of new oil rigs, seabed pipeline, potential seabed mining for iron sands, and vessel traffic. All of these human activities have the potential to impact blue whales through habitat degradation, habitat displacement, acoustic interference, and ship strikes. In order to ensure effective management to protect this blue whale population and their habitat, we have embarked on a research program to collect the necessary data to fill these knowledge gaps and inform environmental managers and other stakeholders in New Zealand about blue whale ecology in the STB region.

Between 20 January and 10 February 2016, we conducted a research expedition in the STB region in order to address these primary objectives:

- Determine the spatial and temporal distribution of blue whales in the region and describe how habitat varies relative to whale distribution in order to improve predictability of blue whales.
- Quantify the significance of the STB foraging ground by addressing how often individuals re-occur in STB and how long individuals are resident in the STB.
- Estimate the abundance of blue whales that use the STB region and what proportion of New Zealand blue whales feed in the area.
- Describe the population connectivity and trend of this blue whale population to better understand the population’s reproductive capacity and if the population is stable, increasing, or decreasing.

All research was conducted under New Zealand Department of Conservation permits 45780-MAR and AEC287. A marine consent for the deployment of the hydrophones was issued by the New Zealand Environmental Protection Authority (<http://www.epa.govt.nz/EEZ/whats-going-on/current-activities/marine-scientific-research/Pages/default.aspx>).

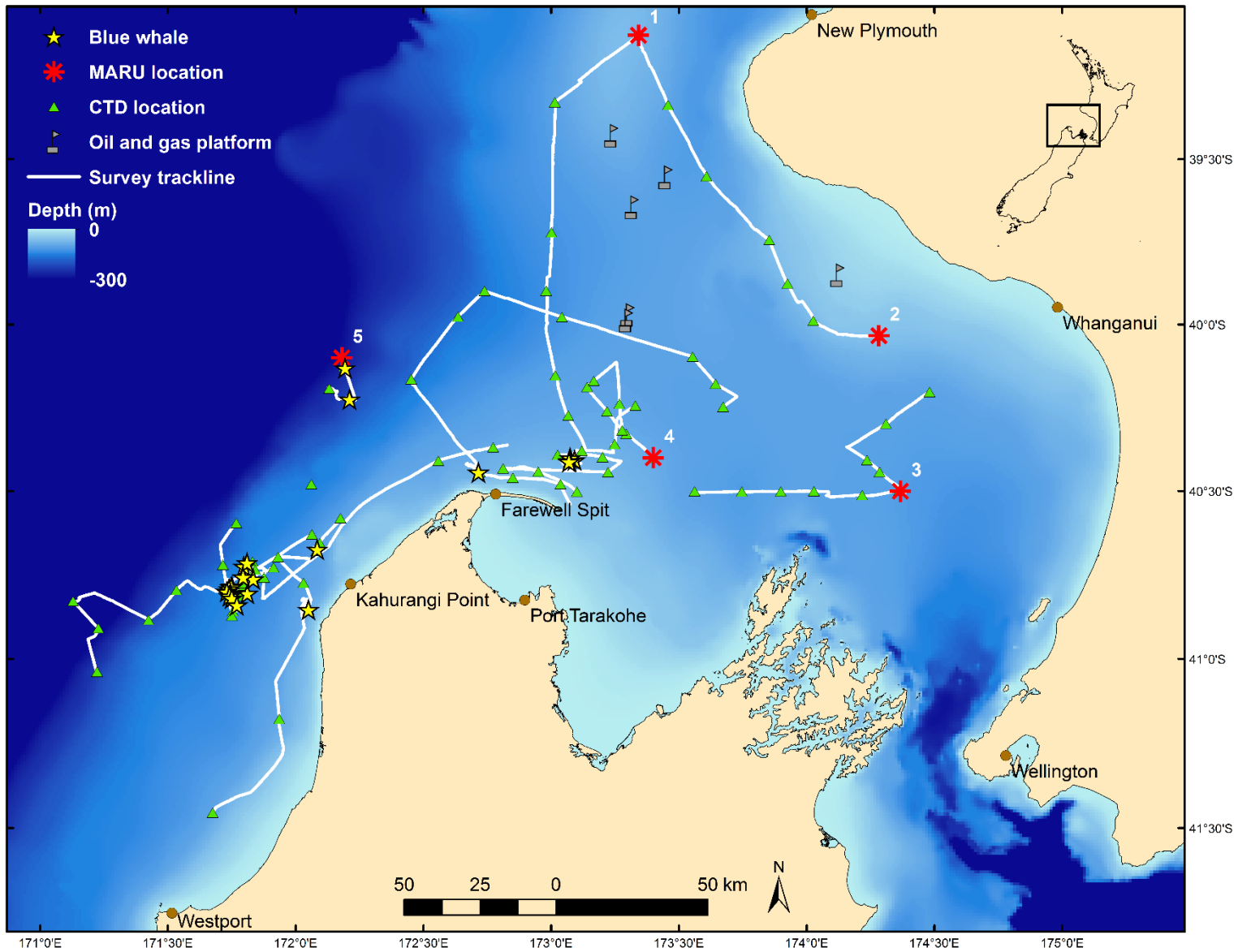


Figure 1. Overview map of blue whale survey effort in the South Taranaki Bight (STB), with inset of location within New Zealand.

Methods

A 14 m jet propelled catamaran, the *RV Ikatere*, equipped with oceanographic sampling capabilities and a flying bridge for observational work, was used as the research platform in the STB between 20 January and 10 February 2014. The research effort was based out of Port Tarakohe, near the town of Pohara, New Zealand (Fig. 1) due to its proximity to the center of the STB (~ 100 km away). Field work consisted of the deployment of a 5-unit hydrophone array across the STB region, survey effort for blue whales, oceanographic sampling, collection of hydroacoustic backscatter data on prey availability, behavioral observations of whales, and collection of photo-identification, photogrammetry, and acoustic data, and krill and whale skin and fecal samples.

Hydrophone deployments

The goal of this component of the research program is to monitor for the presence of acoustically-active low-frequency baleen whales, specifically blue whales, in the STB region of New Zealand over a two year period. Five marine autonomous recording units (MARUs) developed by the Bioacoustic Research Program at Cornell University (<http://www.birds.cornell.edu/page.aspx?pid=2713>) were deployed at pre-designated locations permitted by the New Zealand Environmental Protection Authority. The MARU is a digital audio recording system contained in a positively buoyant 17-inch glass sphere, which is deployed on the bottom of the ocean using an iron anchor (Fig. 2). A hydrophone mounted to the MARU acquires acoustic data, and these sounds are recorded and stored on internal electronic storage media. MARUs record acoustic data continuously, and will be retrieved, refurbished, and redeployed every 6 months over the course of two years.

The five MARUs were deployed off the aft deck of the *Ikatere* using the A-frame (Fig. 2). Prior to each deployment a CTD cast was performed. All deployments proceeded without incident. Aerial footage of a MARU deployment filmed by a drone can be viewed here:

<https://www.youtube.com/watch?v=KZDALWUBDaM>



Figure 2. Kristin Hodge prepares a MARU for deployment off the aft deck of RV Ikatere.

Blue whale survey effort

In order to describe the distribution patterns of blue whales in the STB region and their associated habitat use patterns, survey effort with synoptic habitat sampling was conducted on days with suitable weather conditions (Beaufort Sea State < 5). To record the oceanographic conditions throughout the water column, profiles of water column depth, temperature, and salinity were recorded using a Sea-Bird microCAT (SBE 911plus) Conductivity, Temperature and Depth (CTD) sensor that was lowered at a rate of 1 m/s until approximately 10 m off the bottom (Fig. 3). CTD casts were performed at the start and end of survey, approximately every hour while on survey, and at all blue whale sightings. Depth and surface water temperature were recorded continuously during survey effort. Weather conditions were updated at the start of survey effort, every 30 mins, and as weather changed.

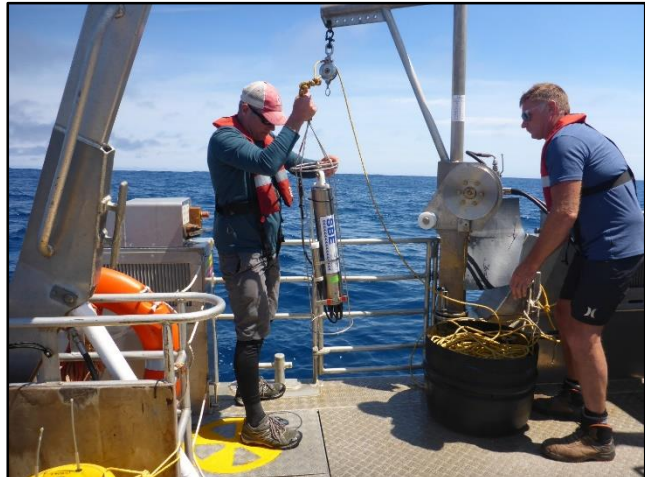


Figure 3. NIWA first mate, Andrew James, and Todd Chandler deploy the CTD.

Survey effort was conducted with one observer posted on the port and starboard sides of the flying bridge (~5 m above sea level; Fig. 4). Additional observers surveyed the entire area. Effort and sightings data were recorded to a ruggedized laptop secured on the flying bridge. Survey effort was conducted at either 8 knots with simultaneous hydro-acoustic data (maximum speed allowable), or at 25 knots in order to cover the large STB area more quickly but without complimentary hydro-acoustic data. Hydro-acoustic backscatter data quantifies prey availability and density through the water column (Fig. 5) and were recorded while on survey at 8 knots

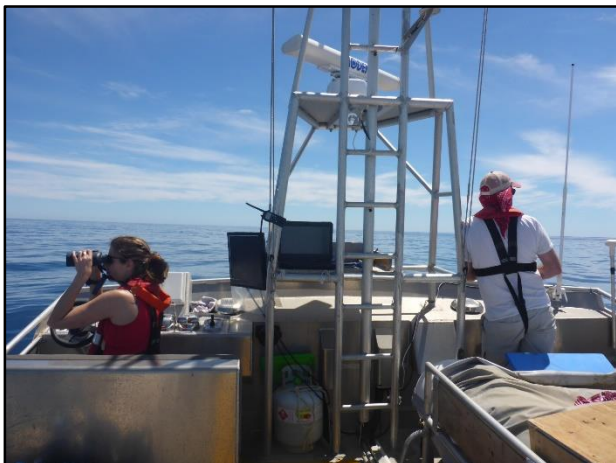


Figure 4. Port and starboard side observers scan the ocean for blue whales from the flying bridge of the RV Ikatere.

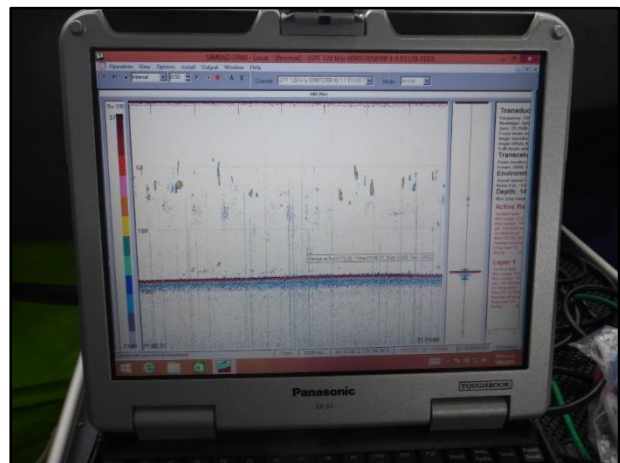


Figure 5. An echo-sounder image of dense krill patches at 50-80 m depth captured through hydro-acoustics in the STB.

using a Simrad EK60 echosounder (Simrad ES120-7DD splitbeam transducer, 120kHz transceiver, 250 W, 1.024 ms pulse length, 0.5 s ping rate) deployed 1.26 m below the research vessel.

At all blue whale sightings, survey effort was stopped, the transducer raised from the water (to increase vessel maneuverability), date, time, and location recorded, and the animal(s) were approached for behavioral observation and further data collection. Immediately after each blue whale sighting, hydro-acoustic data were collected to assess prey availability in the region.

Photo-identification work captured images of the left and right sides of each blue whale whenever possible. These photographs are used to match individuals based on unique markings between sightings, years, and regions, and will be used to generate an abundance estimate through capture-recapture statistical methods. Two Canon DSLR cameras with 100-400 mm lenses were used for photography (Fig. 6).



Figure 6. Leigh Torres and Kristin Hodge conduct photo-id effort of a blue whale surfacing to the port side of the RV Ikatere.

After a reasonable amount of effort spent on photography, biopsy effort was initiated, with simultaneous photography effort to identify sampled whales (Fig. 7). Skin biopsy samples were collected using a lightweight biopsy dart fired from a Paxarms biopsy projector (Krützen et al. 2002; New Zealand Department of Conservation permits 45780-MAR; AEC287). Samples of sufficient size were divided for genetic and stable isotope analyses (Fig. 8). All genetic samples were stored in 90% ethanol and refrigerated, and all stable isotope samples were frozen at -20°C . Genetic analysis will inform the population diversity of these New Zealand blue whales and their connectivity to neighboring blue whale populations (Australian, Antarctic, South Pacific). Genetic data between sampling years will also be used to generate an abundance estimate through capture-recapture statistical methods. Stable isotope analysis will reveal the trophic feeding level and area used by sampled blue whales, and will be compared to sample results from 2014.



Figure 7. A photo-id image of the left side of a blue whale as a tissue biopsy is collected (sample can be seen in dart head).



Figure 8. Senior Marine Ranger for DOC, Callum Lilley, displays a recently collect tissue biopsy sample from a blue whale.

A fine-mesh (500 μ m) dip net attached to a long pole was used to collect fecal samples from surface waters opportunistically when material was observed (Fig. 9). Sample material was placed in a sterilized plastic jar, then frozen. Fecal samples will be analyzed for genetic composition of the whale (sex, microsatellites) and hormone levels (reproductive and stress).



Figure 9. Fecal matter from a blue whale defecation event remains at the surface temporarily (left), and the dip-net is pull through the fecal matter to collect a sample (right).

To collect photogrammetry data of blue whales to derive metrics of body condition (length, width, health, pregnancy) an Unmanned Aerial System (UAS; a.k.a. drone) was launched from the aft deck of the *Ikatere* when weather conditions and whale behavior were favorable. A DJI Phantom 3 UAS with a live feed to an Ipad mini 3 was employed. Gloves and clear face protective gear were worn during launch and retrieval of the UAS to conduct overflights of whales and collect morphometric and behavioral data (Fig. 10).

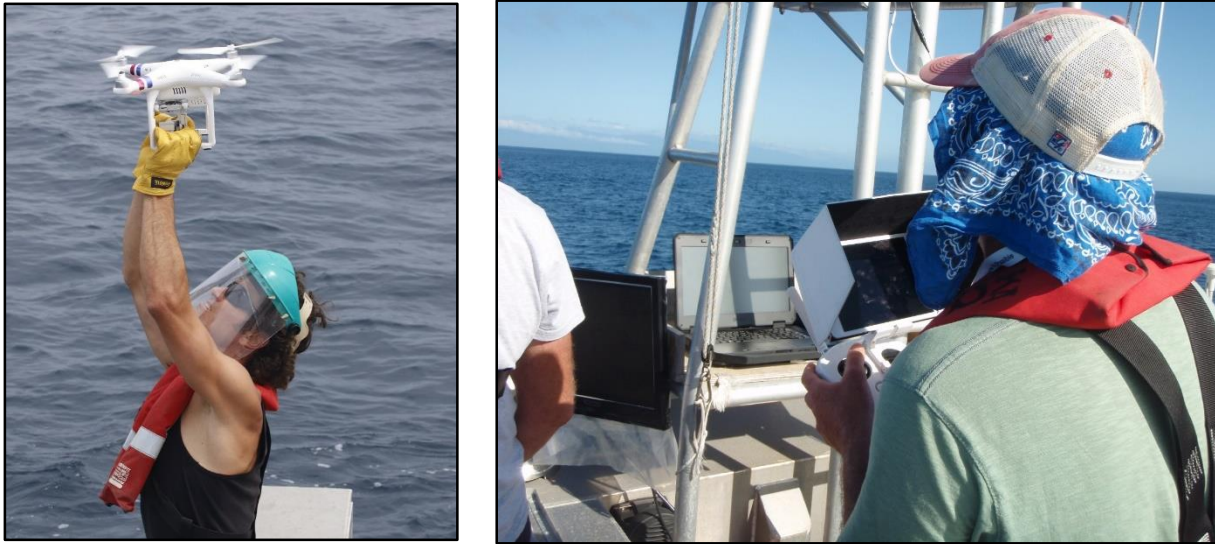


Figure 10. NIWA first mate, Sam Harrison, wears gloves and face shield during UAS deployment (left). Todd Chandler flies the UAS over whales using the controller and Ipad mini from the flying bridge of the RV Ikatere (right).

Sub-populations of blue whales have different vocalization characteristics, including pygmy blue whales across the Southern Hemisphere. In an effort to link genetic data acquired from tissue biopsy samples with blue whale acoustic calls, we deployed a hydrophone drifter in the water at sightings with appropriate conditions. This drifter included a small SoundTrap hydrophone built by OceanInstruments NZ, which was attached to a line with a weight and sea anchor on the bottom end, and a float and flag pole on the top (Fig. 11). The drifter set-up was deployed at the beginning of a sighting and the GPS location was marked. After sighting work was completed the drifter was recovered and the acoustic data downloaded.



Figure 11. Todd Chandler and Kristin Hodge display the drifter set-up on deck of the RV Ikateri (left), and the drifter floats at sea during deployment (right).

Slocum Glider

A synergistic collaboration was initiated during the field project with Dr. Joanna O’Callaghan, a physical oceanographer at NIWA. Dr. O’Callaghan is using a Slocum Glider (<https://www.whoi.edu/main/slocum-glider>) to run a transect line four times a year through the STB to collect data on oceanographic conditions throughout the water column (temperature, salinity, fluorescence, dissolved oxygen). Given the spatial overlap in study regions and the aligned research objectives to better understand the oceanographic processes in the STB, a collaboration was pursued. The Bioacoustic Research Program provided a hydrophone unit for attachment to the glider that will record all cetacean vocalizations during deployments. The glider was re-ballasted with the hydrophone unit attached and then deployed in the STB on 4 February 2016. The glider ran a west-east transect line and was recovered on 1 March 2016.

Results

A daily summary of activities and data collected during the Jan-Feb 2016 blue whale field season in the STB is itemized in Table 1. Effort and data highlights include:

- Five MARU hydrophones successfully deployed, and currently collecting acoustic data.
- Ten survey days conducted, with 1,490 miles surveyed for blue whales.
- 22 blue whale sightings were recorded, with an estimated 33 individuals observed.
- Almost 4,000 photographs were collected, as well as 12 tissue biopsy and 8 fecal samples from blue whales.
- Photogrammetry images of 4 blue whales collected using UAS.
- Ten hours of drifter acoustic data during blue whale sightings collected.
- Habitat and prey availability data were collected via surface temperature and depth data during 2,028 miles of transit across the STB, and 84 CTD casts, and 44 hours of hydro-acoustic data.
- A Slocum glider equipped with a hydrophone traversed the STB study region for 25 days.
- 9 sightings of common dolphins were also recorded, of an estimated 172 individuals.
- 4 sightings of pilot whales were also recorded, of an estimated 66 individuals.
- Two possible Sei whales (species unconfirmed) were observed on 2 February 2016.
- A possible sperm whale was observed on 2 February 2016 in 436 m of water.

Table 1. Summary of activities during Jan-Feb 2016 blue whale survey field season in the South Taranaki Bight, New Zealand.

<i>Date</i>	<i>Activity</i>	<i>Vessel miles</i>	<i>Survey miles</i>	<i># Blue whale sightings</i>	<i># Blue whale individuals</i>	<i># of CTDs</i>	<i># of photos</i>	<i># of biosy samples</i>	<i># of fecal samples</i>	<i># of drone flights over whales</i>	<i>Hrs of hydroacoustic data</i>	<i># of drifter deployments</i>
20-Jan	Mobilization	4	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
21-Jan	Weather day	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
22-Jan	Transit to Port Taranaki (weather poor)	127	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
23-Jan	Survey; deploy hydrophones	161	39.55	2	3	3	646	3	0	0	0 (error)	0
24-Jan	Survey; deploy hydrophones	108	70.37	0	0	7	0	0	0	0	5:06	0
25-Jan	Survey; deploy hydrophones	138	133.58	0	0	11	0	0	0	0	6:21	0
26-Jan	Survey; deploy hydrophones	240	316.27	4	6	15	552	2	1	0	2:56	0
27-Jan	Weather day	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
28-Jan	Weather day	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
29-Jan	Survey	139	132.57	0	0	10	0	0	0	0	7:03	0
30-Jan	Weather day	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
31-Jan	Weather day	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-Feb	Survey	169	160.55	2	3	8	478	0	0	0	3:27	2 (2:10)
2-Feb	Survey	201	147.4	4	6	9	805	5	5	2	5:10	1 (2:18)
3-Feb	Survey	192	223.64	1	1	10	78	0	1	0	3:43	1 (0:32)
4-Feb	Glider deployment (weather poor)	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
5-Feb	Survey	210	98.1	9	14	5	1434	2	1	3	3:19	3 (5:20)
6-Feb	Weather day	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
7-Feb	Weather day	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
8-Feb	Survey	201	167.55	0	0	6	0	0	0	0	7:02	0
9-Feb	Transit to Wellington	138	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
10-Feb	De-mobilization	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TOTALS	2028	1490	22	33	84	3993	12	8	5	44:07:00	7 (10:20)

Blue whale sighting highlights

On 23 January 2016, a pair of racing blue whales was observed. Blue whales are thought to race as a competitive behavior to attract mates. We observed these two whales racing for approximately 30 minutes at 15-18 knots, then the pair slowed with occasional speed bursts. The two animals stayed very close together and one animal was smaller than the other (Fig. 12). We collected left and right side photos, and biopsy samples of both individuals, so we will be able to determine relatedness between the individuals through genetic analysis.

Video footage of this racing behavior can be seen here:

<https://www.youtube.com/watch?v=BCv3nk89E8I>

<https://www.youtube.com/watch?v=rS471q56uIA>

A biopsy sampling event of these blue whales can be viewed here:

<https://www.youtube.com/watch?v=Yoydo1VWt3Y>



Figure 12. Two blue whales race each other at ~15 knots in the South Taranaki Bight.

On 5 February 2016, five different pairs of mothers and calves were observed within 9 km of each other. Four other sightings of 4 adults were also recorded within this area on this day. This density of mother and calf pairs is remarkable, but it is difficult to understand its significance. However, these sightings do indicate that this population is reproducing, and appears to be an important area for mothers to raise their calves during the critical ~7 month lactation period before weaning.

On 5 February 2016, the UAS was flown over a calm mother and calf pair and recorded 10 minutes of apparent nursing behavior. It is believed that this is the first aerial footage of this behavior in a baleen whale. The calf can be seen alternating between surfacing to breath and going under the mother and stationing at the approximate location of the mammary slits (Fig. 13). The pair were not moving/travelling in the water so it is unlikely that this position was facilitating transit, such as how the echelon position is used. Video recorded by the UAS can be viewed here:

<https://www.youtube.com/watch?v=9hpfVmP0hJ4>



Figure 13. Still images captured from the UAS video of the mom-calf pair nursing in the South Taranaki Bight region. The pair surface to breath (left image) and then the calf stations under the mother (right image). The calf's pectoral fins and flukes are visible under the mother.

One blue whale with a deformity was observed on 26 January and again on 3 February 2016. The whale has a large depression (concave area) behind the blow hole, and on the animal's right side under this depression is a large bump (Fig. 14). The cause of these deformities is currently unknown but could be due to malnutrition, an injury such as caused by a ship strike, or an illness such as a tumor. The rest of the whale's body appeared to be in good condition, implying that malnutrition is unlikely to be the cause. A tissue biopsy sample of this individual was collected (not at the tumor site) and could be analyzed for anomalous proteins and carcinomas.

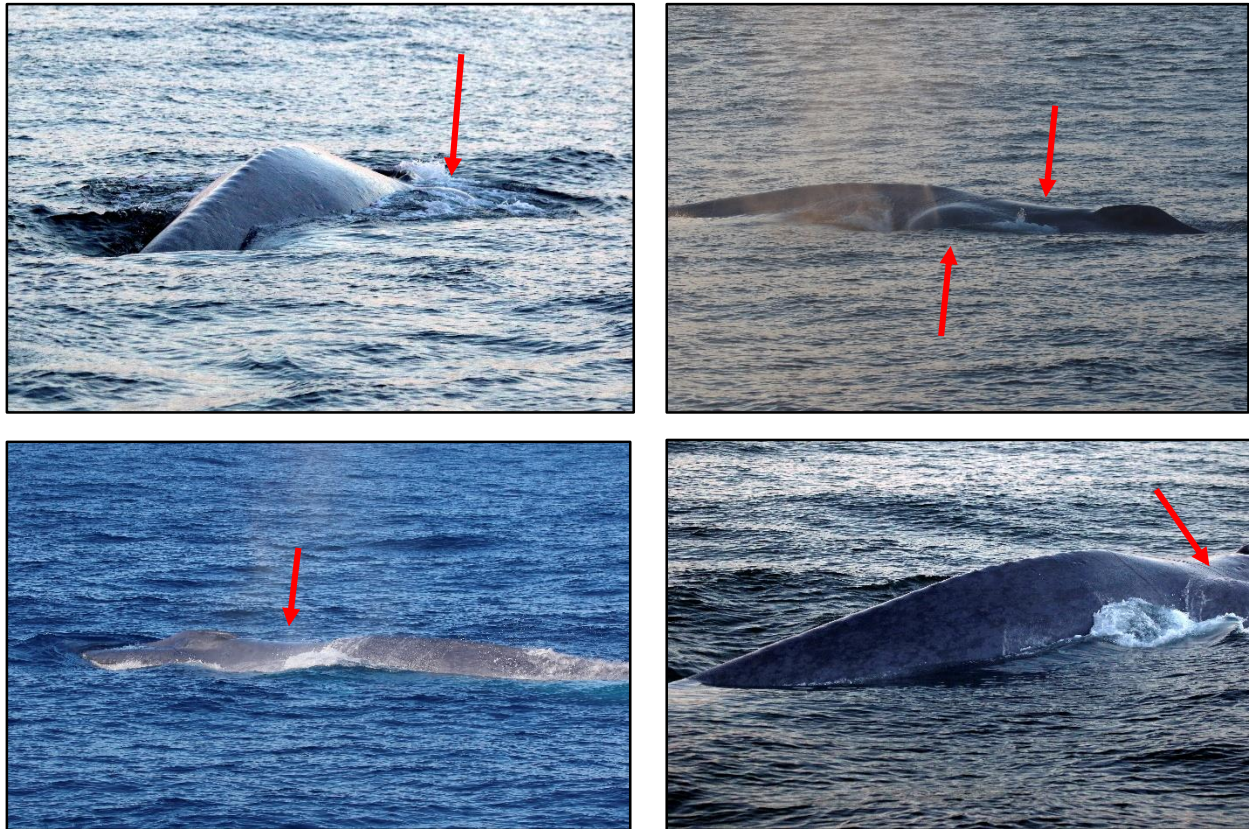


Figure 14. Selected images of a blue whale observed in the South Taranaki Bight with deformities: large depression behind blowhole and large lump on right side below depression. Red arrows point to deformities.

Direct observation of blue whale foraging behavior was documented at three blue whale sightings. UAS video footage captured one feeding event; as the whale comes to the surface the distended throat grooves of the buccal cavity are distended, indicating that the whale has taken in a large ‘gulp’ of water and prey (Fig. 15). A video clip can be viewed here:

https://www.youtube.com/watch?v=qEy6pbXE_XM



Figure 15. Still images captured from UAS video clip of a blue whale foraging event. The distended throat grooves of the buccal cavity are visible.

Distribution overview

During the 2014 field season, remotely sensed satellite images of sea surface temperature (SST) were successfully used to locate cold water patches that were frequently occupied by blue whales. This approach was not as successful during the recent 2016 field season due to warm water conditions across the New Zealand region caused by an El Niño cycle. Figure 16 compares two SST satellite images within the STB and west coast region of New Zealand that were surveyed in Jan-Feb 2014 and again recently during Jan-Feb 2016. The plot on the left describes ocean surface conditions in 2014 and illustrates how SST primarily ranged between 15 and 18 °C. By comparison, the panel on the right depicts the sea surface conditions encountered during the 2016 field season, and a stark difference is apparent: during 2016, SST ranged between 18 and 23 °C, barely overlapping with the 2014 field season conditions.

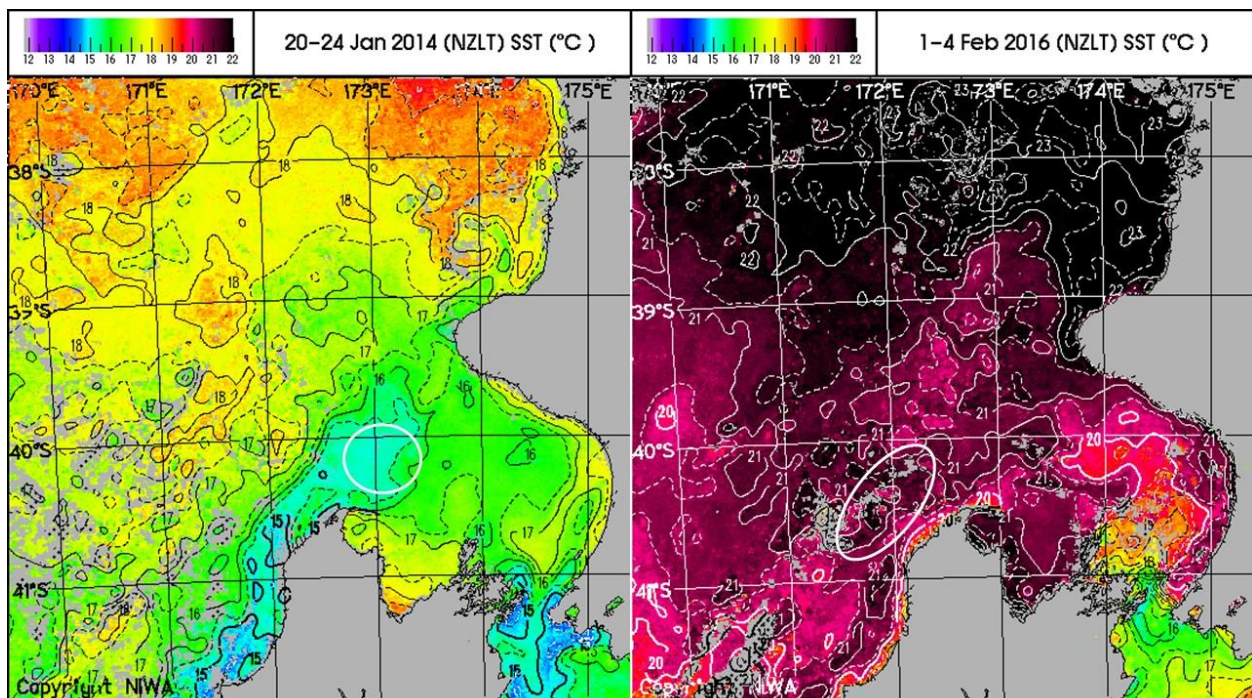


Figure 16. A comparison of satellite images of sea surface temperature (SST) in the South Taranaki Bight region of New Zealand between late January 2014 and early February 2016. The white circles on each image denote where the majority of blue whales were encountered during each field season.

The target prey of blue whales in this region, a krill species called *Nyctiphanes australis*, tend to aggregate in pockets of nutrient-rich, cool water. During the 2014 field season, most blue whales were encountered in an area where SST was about 15 °C (within the white circle in the left panel of Fig. 16). During 2016, virtually no cool water was anywhere and blue whales were mainly observed off the west coast of Kahurangi shoals in about 21 °C water (within the white circle in the right panel of Fig. 16. NB: the cooler water in the Cook Strait in the southeast region of the right panel is a different water mass than preferred by blue whales and does not contain their prey.)

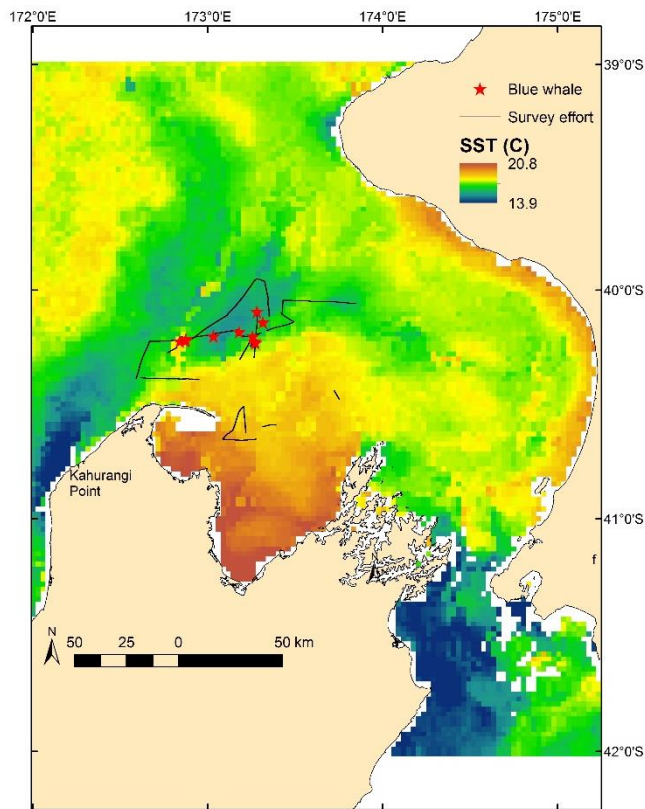


Figure 17. Survey effort and blue whale sightings in 2014 overlaid on a concurrent SST image, demonstrating the co-occurrence of whales in the cold water plume that was generated off Kahurangi Point and extended into the STB.

However, the stratification in 2016 does not necessarily mean the ocean is unproductive; it only means that the SST satellite images were less informative to finding blue whales because they only reflect what is happening in the thin, top slice of the ocean. Despite the warm surface waters in 2016 relative to 2014, where and when blue whales were encountered high densities of krill were often synoptically detected through hydro-acoustics (Fig. 5). However, in 2014 many surface swarms of krill were observed that were not observed in 2016 season, which could be due to elevated SST in 2016. Sub-surface ocean conditions during our two survey periods in 2014 and 2016 may be more similar when compared underwater than when viewed from above. Comparative analysis of CTD data between the two sampling years will be informative. Additionally, this emphasizes the importance of the collaborative glider research that will describe sub-surface ocean conditions while simultaneously collecting cetacean acoustic data.

The variable blue whale distribution patterns between 2014 and 2016 reflects the flexibility of these marine animals to adjust to environmental conditions, and our minimal current understanding of their ecology. Examination of SST anomaly plots of January 2014 and January 2016 (Fig. 18) demonstrate that neither year was ‘normal’. These anomaly plots show how different the SST was during these periods compared to the long-term average SST across the New Zealand region. In 2014, SST conditions in our study area were $\sim 1^{\circ}\text{C}$ below average, while

The warm conditions across the survey region during the 2016 field season can likely be attributed, at least in part, to a strong El Niño occurring across the Pacific Ocean. El Niño has brought unusually settled conditions to New Zealand during the 2016 summer, which caused relatively few high wind events that normally churn up the ocean and mix the cool, nutrient rich deep water with the hot surface layer water. Therefore, the coastal, wind-driven upwelling off Kahurangi point was weak and hence minimal nutrient rich, cold water plumes extended into the STB. Under these conditions, the ocean remains highly stratified with a stable layer of hot water on top. In contrast, during 2014 this upwelling was productive with cold plumes extending into the STB where blue whales co-occurred (Fig. 17).

in 2016 SST conditions were $\sim 1^{\circ}\text{C}$ above average. This comparison demonstrates the importance of understanding the relationship between blue whales and the environment in order to better understand, and ultimately predict, blue whale habitat use and distribution patterns across the STB region. With the continuation of this research project we will build a robust understanding of blue whale ecology in the region, allowing us to anticipate blue whale occurrence and effectively manage potential anthropogenic threats.

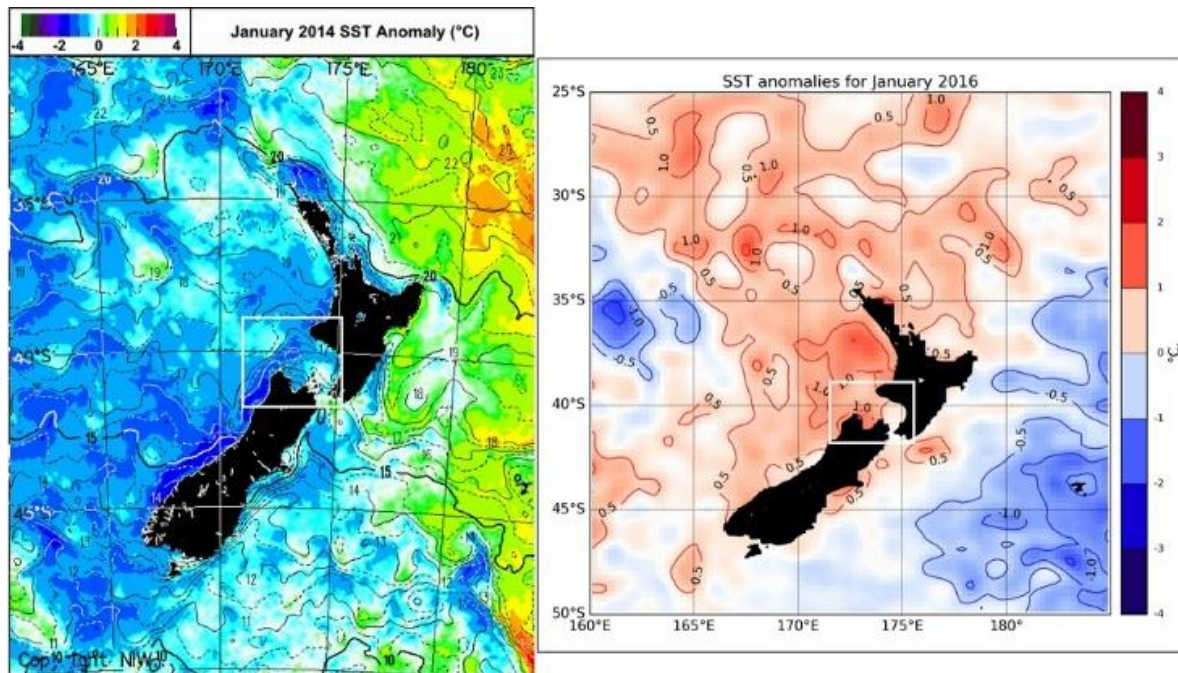


Figure 18. Comparison of sea surface temperature (SST) anomaly plots of the New Zealand region between January 2014 (left) and January 2016 (right). The white box in both plots denotes the general location of our blue whale study region. (Apologies for the different formats of these plots – the underlying data is directly comparable.)

Discussion

Overall, the 2016 blue whale field season in the STB region of New Zealand was successful. Important data on blue whale distribution and habitat were collected, 5 hydrophones were deployed, and blue whale photo-id, biopsy and fecal samples, and photogrammetry images were collected. Through these data and research experiences we are gaining a better understanding of blue whale ecology in the STB region of New Zealand.

Data collected during the 2014 and 2016 field seasons in the STB have produced solid evidence that blue whales occupy the region during summer months and use the area to feed on aggregations of krill. Moreover, a picture is starting to form now that hints at the potential year-around presence of blue whales in the STB region. This hypothesis is based on (1) reported sightings of blue whales in the region during all months of the year (Torres 2013), (2) observation of multiple mom-calf pairs, including very young calves (~2 months old), (3) discussions with multiple fishermen in the region who insist they see blue whales all year-round, and (4) observation of blue whale racing behavior indicative of breeding competition.

Acoustic data recorded by the MARUs over two years will provide critical information regarding the spatial and temporal presence, and behavior, of blue whales across the study region. Blue whales make foraging calls and the males sing during the breeding season. These male songs have region specific dialects, with the New Zealand song being distinct from the Australian and the South Pacific Islands (Balcazar et al. 2015). Therefore, the acoustic data will reveal if breeding behavior is also occurring in the STB region, the sub-population of these animals based on song dialect, and the seasonality of behavior and distribution patterns.

Through genetic analysis we will continue to explore the population make-up of these New Zealand blue whales to help distinguish if they belong to a distinct New Zealand population unit or are part of a larger Australasian population.

The broader extent of blue whale distribution during 2016 compared to 2014 emphasizes the need to continue to search for whales across the wider STB region, including the west coasts of the southern North and northern South islands. We are still in the discovery phase of this research effort, including obtaining a complete understanding of blue whale distribution patterns. During 2017 we will continue to survey the larger STB region for blue whales. Information gained from acoustic detections via the MARUs and glider deployments will also inform this search effort.

Media coverage

The research project received a significant amount of media coverage, both within New Zealand, and internationally. The majority of the press centered around (1) a press release by The New Zealand Department of Conservation at the start of the survey, (2) [A National Geographic Society Explorers blog post](#) about our sighting of blue whales racing, and (3) a [National Geographic Society news](#) item about our footage of the blue whale mother and calf nursing.

Additionally, we wrote 7 blog posts for the [GEMM Lab blog](#), which received approximately 2,460 views.

In total, 25 news stories were produced and, as of 18 March 2016, the YouTube link to the blue whale nursing video clip produced by National Geographic has had over 150,000 views. Appendix A includes a list web links to many of press items.

Upcoming research plans

In late June 2016 a small field team will return to New Zealand to ‘turn-around’ the five MARU hydrophones. This process will include retrieval of the five units through an acoustic release. Then the batteries and hard-drives must be replaced in each unit. Subsequently the units will be re-deployed in approximately the same locations. This work will take approximately 4-6 vessel days, depending on weather.

Another summer blue whale research field season will occur during January and February 2017 in the South Taranaki Bight region. Coordination and logistical work will continue for this field effort, including obtaining co-funding to support this research.

Data analysis until the 2017 field season will continue, including the following tasks:

- Photo-id analysis: comparison of photos captured during 2016 to images from the 2014 field season, and the photo-id catalog from New Zealand and Australia.
- Genetic analysis of the 12 biopsy samples and 8 fecal samples collected from blue whales during the 2016 field season.
- Photogrammetry analysis of the four individual blue whales filmed by the UAS.
- Hormone analysis of the 8 blue whale fecal samples collected.
- Stable isotope analysis of the 10 blue whale biopsy samples collected.
- Initial exploration of acoustic data acquired by the MARUs and drifter.
- Initial exploration of habitat data including CTD data, hydro-acoustic data, satellite imagery, and *in situ* surface temperature data.

Acknowledgements

Funding for this project was provided by The Aotearoa Foundation, The National Geographic Society Waitt Foundation, The New Zealand Department of Conservation, The Marine Mammal Institute at Oregon State University, The National Oceanographic and Atmospheric Administration’s Cooperative Institute for Marine Resources Studies (NOAA/CIMRS), Greenpeace New Zealand, OceanCare, Kiwis Against Seabed Mining, and an anonymous donor. The project was accomplished through the dedicated work and support of many individuals including Matt McGlone, Andrew James, and Sam Harrison from NIWA vessels, Richard Nelson, Brett Grant, Sarah Bury, and Kim Goetz from NIWA, Kathy Minta and Minda Stiles from Oregon State University, Laura Boren and Dave Lundquist from the New Zealand

Department of Conservation, and Christopher T. Tessaglia-Hymes and Edward James Moore III from the Bioacoustics Research Program at Cornell University.

References

- Balcazar, N. E., J. S. Tripovich, H. Klinck, S. L. Nieukirk, D. K. Mellinger, R. P. Dziak, and T. L. Rogers. 2015. Calls reveal population structure of blue whales across the southeast Indian Ocean and southwest Pacific Ocean. *Journal of Mammalogy*:gyv126.
- Krützen, M., L. M. Barré, L. M. Möller, M. R. Heithaus, C. Simms, and W. B. Sherwin. 2002. A biopsy system for small cetaceans: darting success and wound healing in *Tursiops* spp. *Marine Mammal Science* **18**:863-878.
- Torres, L. G. 2013. Evidence for an unrecognised blue whale foraging ground in New Zealand. *New Zealand Journal of Marine and Freshwater Research* **47**:235-248.
- Torres, L. G., P. C. Gill, B. Graham, D. Steel, R. M. Hamner, C. S. Baker, R. Constantine, P. Escobar-Flores, P. Sutton, S. Bury, N. Bott, and M. H. Pinkerton. 2015. Population, habitat and prey characteristics of blue whales foraging in the South Taranaki Bight, New Zealand. SC/66a/SH6, International Whaling Commission.

Appendix A: Web links to media coverage of blue whale research during January and February 2016

<http://www.stuff.co.nz/taranaki-daily-news/news/76280149/blue-whale-research-begins-off-the-taranaki-coast>

<http://www.voxy.co.nz/national/blue-whale-survey-begins-taranaki-coast/5/241950>

http://www.nzherald.co.nz/wanganui-chronicle/news/article.cfm?c_id=1503426&objectid=11580362

<http://i.stuff.co.nz/nelson-mail/76337893/Scientists-study-blue-whales-near-Farewell-Spit>

<http://www.radionz.co.nz/news/national/295787/blue-whales-race-for-female-attention>

<http://voices.nationalgeographic.com/2016/02/03/the-power-and-beauty-of-two-blue-whales-racing/>

<http://www.radionz.co.nz/national/programmes/afternoons/audio/201788541/pygmy-blue-whale-professor-leigh-torres>

<http://www.gbweekly.co.nz/the-gb-weekly-news-archives/19-february-2016/#19-february-16/page2-page3>

[Scientists search for Taranaki whales | NZNews | 3 News](#)

[Scientists study blue whales near Farewell Spit | Stuff.co.nz](#)

[Blue whale research begins off the Taranaki Coast | Stuff.co.nz](#)

[Scientists study blue whales 40km north of Farewell Spit | Stuff.co.nz](#)

[The Power and Beauty of Two Blue Whales Racing | National Geographic \(blogs\)](#)

[Blue whales race for female attention | Radio New Zealand News](#)

[Pygmy Blue Whale - Professor Leigh Torres | Jesse Mulligan, 1–4pm, 1:20 pm on 9 February 2016 | Radio New Zealand](#)

[Exclusive Video May Be First to Show Blue Whale Calf Nursing](#)

[Aerial footage of baby whale feeding in New Zealand waters believed to be a first | Stuff.co.nz](#)

[This Is Most Likely the First Ever Footage of a Nursing Blue Whale | Motherboard](#)

[Baby blue whale filmed nursing for the first time off Taranaki coast - Yahoo7](#)

[World first blue whale nursing footage - Australian Geographic](#)

['It was beautiful to see' - first known footage of whale nursing calf captured in NZ | ONE News Now | TVNZ](#)

[Rare Footage Shows Intimate Moment Between Mother Whale And Her Calf](#)

[Rare blue whale footage captured in New Zealand - National - NZ Herald News](#)

[Rare whale images a world-first | Radio New Zealand News](#)

[Incredible Rare Footage Of A Whale Nursing Her Calf Makes A Splash](#)