# Documentation of a blue whale foraging ground in the South Taranaki Bight, New Zealand

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## ABSTRACT

In 2013, a hypothesis was put forward that blue whales (*Balaenoptera musculus*) use the South Taranaki Bight (STB) in New Zealand as a foraging ground for krill, specifically the euphausiid *Nyctiphanes australis*. This hypothesis was based on a desktop analysis of previously collected data and published papers. Between 21 January and 4 February 2014 an experienced field team was assembled to field test the hypothesis, with four main objectives: collect photo-identification data; obtain tissue biopsy samples; record environmental and prey data; document foraging behaviour. Over five days of survey work, 314km of survey effort were conducted in the STB. Ten sightings of blue whales were made of an estimated 50 individual blue whales, including a cow/calf pair. A minimum of 21 blue whales were identified through photo-ID analyses, with only one possible re-sight of an individual, indicating that a relatively low proportion of the blue whales present in the STB were encountered during the field work. Ten biopsy and two faecal samples were collected. Behaviour patterns consistent with blue whale foraging in other regions were frequently observed. Krill swarms were observed at five sightings and detected hydro-acoustically in dense surface patches and in a widespread, near-bottom layer. Krill were also captured near blue whales and identified as *N. australis*. Observations and data collected during this field effort strongly support the hypothesis that the STB is a blue whale foraging ground. Continued data collection and analyses are needed to determine the significance and extent of this foraging ground. Improved information on the ecology and abundance of this population of blue whales is urgently needed to manage multiple anthropogenic activities in the STB effectively.

KEYWORDS: BLUE WHALES, FEEDING GROUNDS, NEW ZEALAND, PHOTO-ID, EUPHAUSIIDS, FEEDING

## INTRODUCTION

A blue whale (*Balaenoptera musculus*) foraging ground was recently hypothesized to exist within the South Taranaki Bight (STB) situated between the North and South islands of New Zealand (Torres 2013). This study and hypothesis are based on previously collected data, published papers, and desktop analyses. The objective of the current research project was therefore to field test the hypothesis that blue whales forage for krill, specifically the euphausiid *Nyctiphanes australis,* in the STB. High densities of *N.australis* in this area have been previously linked with a cold-water upwelling in the STB (Bradford & Chapman 1988; Torres 2013). Improved information on the ecology and population status of blue whales within the STB is urgently needed to manage multiple anthropogenic activities in the STB effectively.

The four main objectives of this research project on blue whales in the STB were to (1) collect photo-identification data and assess connectivity of individual blue whales to other populations, (2) obtain tissue biopsy samples for genetic analysis to identify the blue whale subspecies present in the STB (Antarctic (*B.m. intermedia*) or pygmy (*B.m. brevicauda*)), (3) record environmental and prey data to describe the habitat use patterns of blue whales in the STB, and (4) document blue whale foraging behaviour.

## METHODS

A 14m jet propelled catamaran, the *Ikatere,* was used as the research platform for this project in the STB between 21 January and 4 February 2014. The *Ikatere* has oceanographic sampling capabilities, a flying bridge for observational work with a secondary helm, and can travel at high speed over extensive distances in search of whales (Fig. 1).

Recent analysis of satellite imagery in the STB, identified an area north of Farewell Spit as having increased productivity during January, and was therefore targeted for survey work to increase the encounter rate with blue whales (Fig. 2). Field work was based out of Tarakohe, which is the port of closest proximity to the research area.

Figure 1. The RV *Ikatere,* used for blue whale survey work in the South Taranaki Bight between 21 January and 4 February 2014

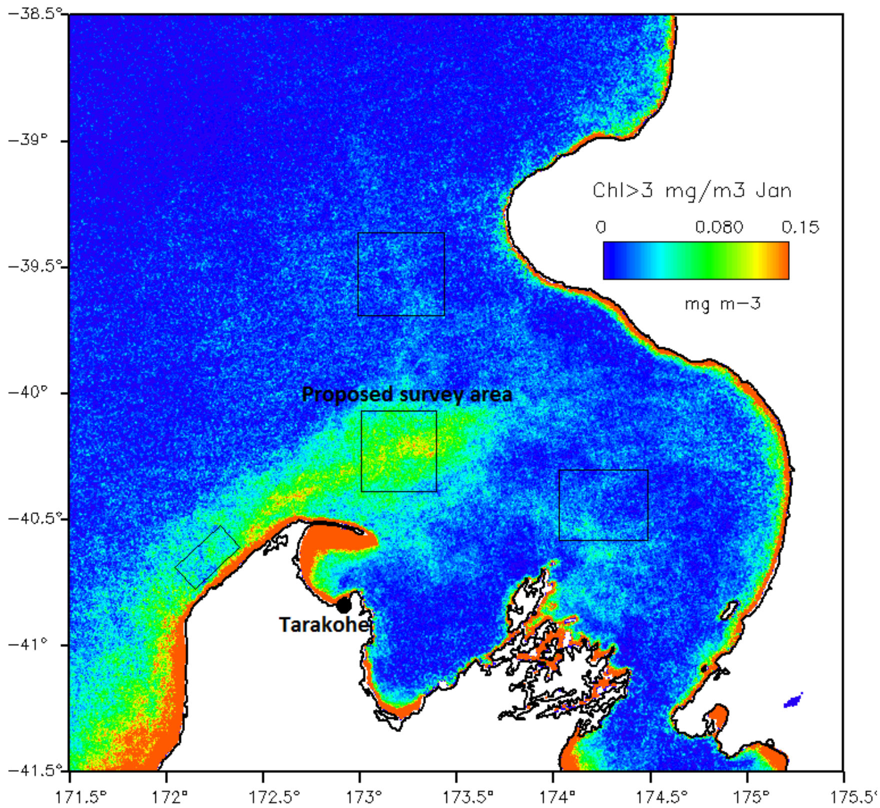


Figure 2. January composite of the proportion of time a "bloom" occurs (chl-a > 3 mg/m$^3$) in the South Taranaki Bight. The middle box was the proposed survey area. Port Tarakohe in Golden Bay is denoted by the black dot.

Twice daily high resolution remotely sensed satellite data on sea surface temperature (SST) and chlorophyll *a* were assessed to locate areas of upwelled water and high productivity, and hence likely areas to encounter blue whales (e.g. Fig. 3). Additionally, marine mammal observers aboard seismic survey vessels working in the area, researchers on other platforms in the STB, and airline pilots shared blue whale sighting information with our field team to increase the likelihood of encountering whales during our survey work.

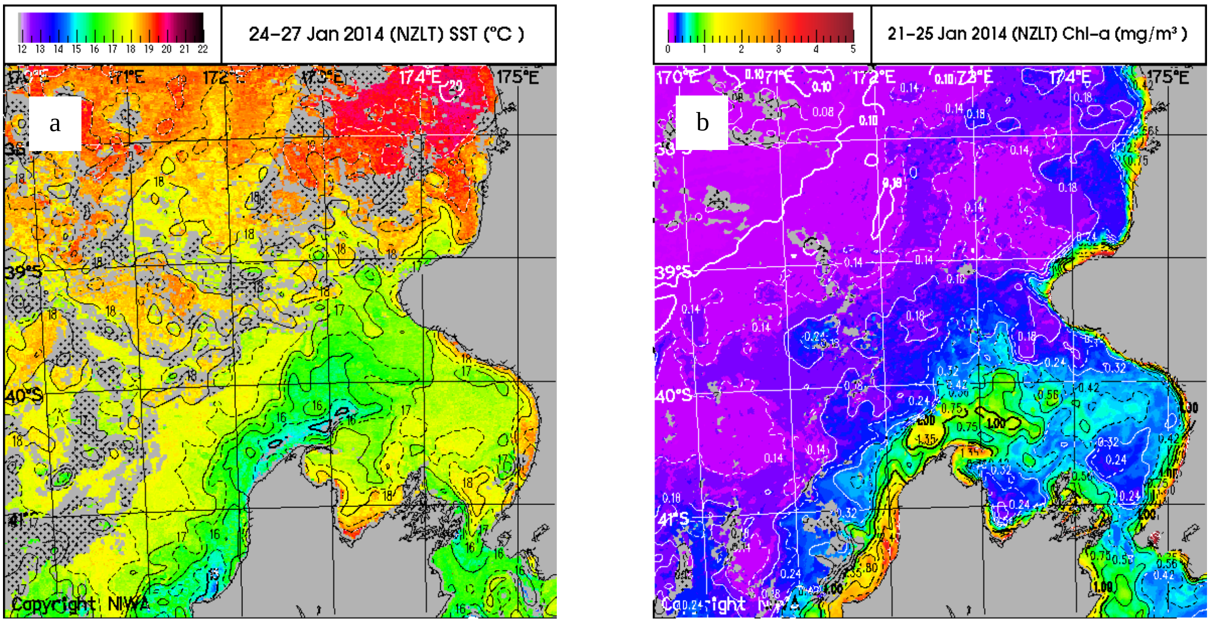


Figure 3. Composite satellite images of the South Taranaki Bight used to increase encounter rates with blue whales during survey work: (a) Sea surface temperature; (b) Surface chlorophyll-a concentration.

On days with suitable weather conditions (Beaufort Sea State (BSS) < 4) survey effort was conducted aboard the *Ikatere*. The vessel departed Tarakohe and transited to a designated survey area based on recently reported blue whale sightings, satellite imagery of chlorophyll *a* and SST, weather conditions, time availability, and previous survey effort.

Survey effort was conducted at 8 knots, with one observer posted on the port side of the vessel, and another observer on the starboard side. Any additional observers on-effort surveyed the entire area. Once at the survey area, a CTD cast collecting data on temperature, salinity, fluorometry and depth was conducted, the surface water temperature logger initiated, and the transducer was lowered into the water to record hydroacoustic data. Environmental data related to visual observation conditions were recorded at the start of survey effort, when conditions changed, and at least once every hour. These data included date, time, observers on-effort, sea temperature, water depth, wind direction, wind speed, BSS, swell height, swell direction, cloud cover, glare intensity, glare width, rain, haze, visibility distance, and comments.

All observations of cetaceans were recorded and the following data were collected: date; time; location; species; distance to sighting (based on binocular reticles calibrated to height of eye above sea level); vessel heading; bearing from bow to sighting; sighting cue; observation method; water depth; sea surface temperature; number of individuals observed; number of adults; number of calves; behaviour and comments. At all sightings of blue whales, survey effort was stopped, the transducer raised from the water (to enable increased manoeuvrability around whales), and the animal(s) were approached for further data collection.

First, photo-ID operations were initiated to capture images of the left and right sides of each blue whale whenever possible. After a reasonable amount of time and effort spent on photography, biopsy effort would be initiated, with simultaneous photography effort to identify sampled whales. Tissue biopsy samples were collected using a small, lightweight biopsy dart fired from a modified veterinary capture rifle (NZ Department of Conservation permit Rnw/HO/2009/03). All samples were stored in 70% ethanol at -20ºC. Samples of sufficient size were divided in two for DNA and stable isotope analyses. All samples were delivered to the New Zealand Cetacean Tissue Archive at the University of Auckland after field work was completed. After each blue whale sighting, a CTD was performed to collect data on water column properties, and hydroacoustic data was collected in the region of the whales to assess prey availability.

Faecal and krill samples were collected from surface waters opportunistically when material was observed. Faecal samples from whales will be genetically analysed to determine dietary components to species level (e.g. Jarman *et al.* 2002) and genetic identity of the whale. Krill samples are used to identify the prey species and for genetic analysis relative to faecal samples to describe diet. A fine-mesh (500µm) dip net attached to a long pole was used to collect faecal and krill samples. Sample material was placed in a sterilized plastic jar filled with ethanol (faecal matter) or formalin (krill). Additionally, approximately 15 krill were placed in an eppendorf vial with ethanol for genetic analysis.

## RESULTS

Weather conditions allowed five days of survey effort during the research period (21 Jan – 4 Feb 2014). In total, 19 hrs and 55 mins of survey effort were conducted, covering 314km (Figure 4). Ten sightings of blue whales were made (Table 1; one off-effort sighting) with an estimated 50 blue whales observed at these encounters, including one cow/calf pair. The age of the calf was estimated to be approximately 6 months. Foraging behaviour was observed at three sightings of blue whales and krill swarms were observed at three sightings. Additionally, 14 blue whale sightings in the STB were reported to the field team before, during and after the field work (Fig. 5; between 15 Jan and 16 Feb) by a seismic survey team, researchers for the Cawthron Institute, local fishermen and airline pilots.

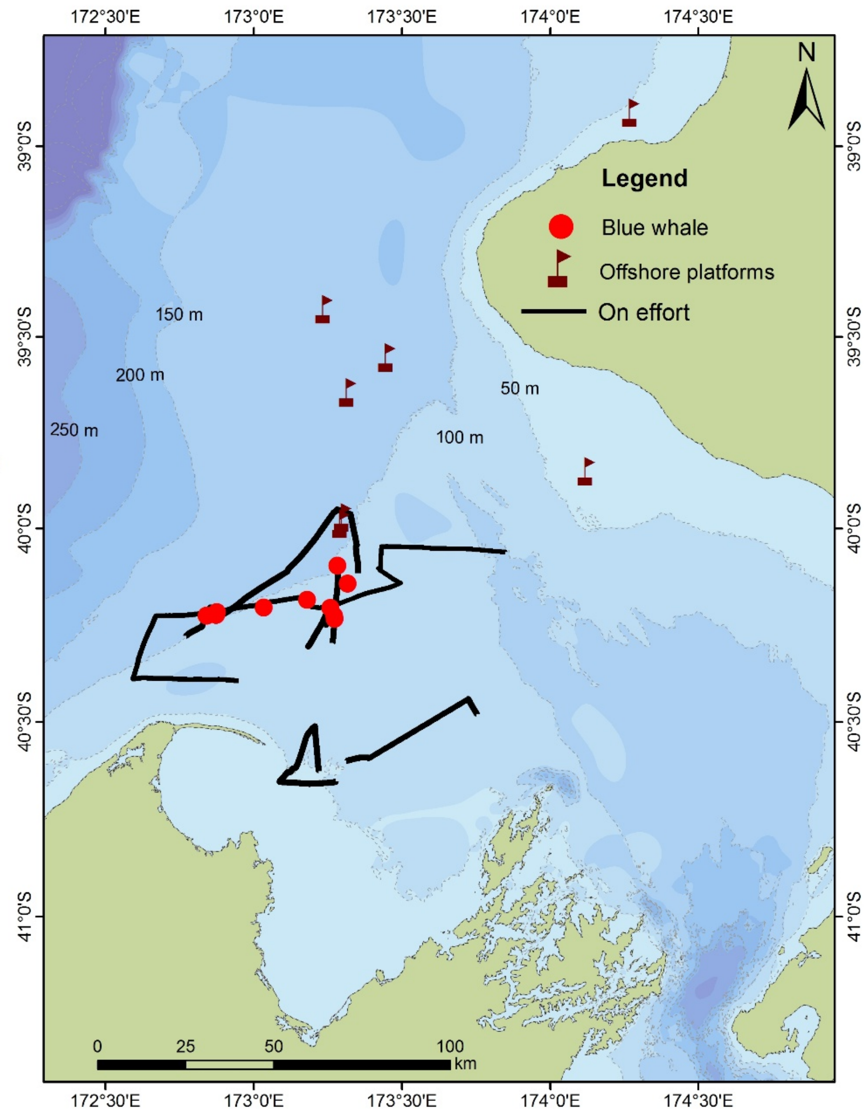


Figure 4. Survey effort and blue whale sightings in the South Taranaki Bight between 21 January and 4 February.

Table 1: Sighting details and data collected at blue whale sightings made in the South Taranaki Bight between 21 January and 4 February 2014.

| Sighting Number | Date | Time | Depth (m) | Temp (C) | Total number observed | Number of calves observed | Behaviour | On/off survey | Photos collected | Biopsy sample collected | Faecal sample collected | Associated fauna | Krill observed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 25-Jan-14 | 14:14 | 100 | 15.8 | 5 | 0 | Unknown | On | Y | Y (1 sample) | Y | N | N |
| 2 | 28-Jan-14 | 08:17 | 109 | 15.3 | 3 | 0 | Unknown | On | Y | N | N | N | N |
| 3 | 28-Jan-14 | 09:39 | 109 | 15.2 | 2 | 1 | Unknown | On | Y | N | N | N | N |
| 4 | 28-Jan-14 | 10:38 | 107 | 15.1 | 3 | 0 | Unknown | Off | Y | Y (1 sample) | N | N | N |
| 5 | 28-Jan-14 | 17:29 | 93 | 16.4 | 12 | 0 | Unknown | On | Y | Y (4 samples) | N | N | N |
| 6 | 29-Jan-14 | 09:03 | 87 | 15.8 | 1 | 0 | Feeding | On | Y | N | N | N | Y |
| 7 | 29-Jan-14 | 10:28 | 85 | 16.2 | 5 | 0 | Feeding | On | Y | Y (1 sample) | Y | N | Y |
| 8 | 29-Jan-14 | 12:18 | 88 | 15.8 | 16 | 0 | Unknown | On | Y | Y (2 samples) | N | Sei or Bryde's whale | Y |
| 12 | 3-Feb-14 | 14:18 | 91 | 17.1 | 2 | 0 | Feeding | On | Y | N | N | Gannet feeding | N |
| 13 | 3-Feb-14 | 16:14 | 96 | 18 | 1 | 0 | Unknown | On | Y | Y (1 sample) | N | N | N |

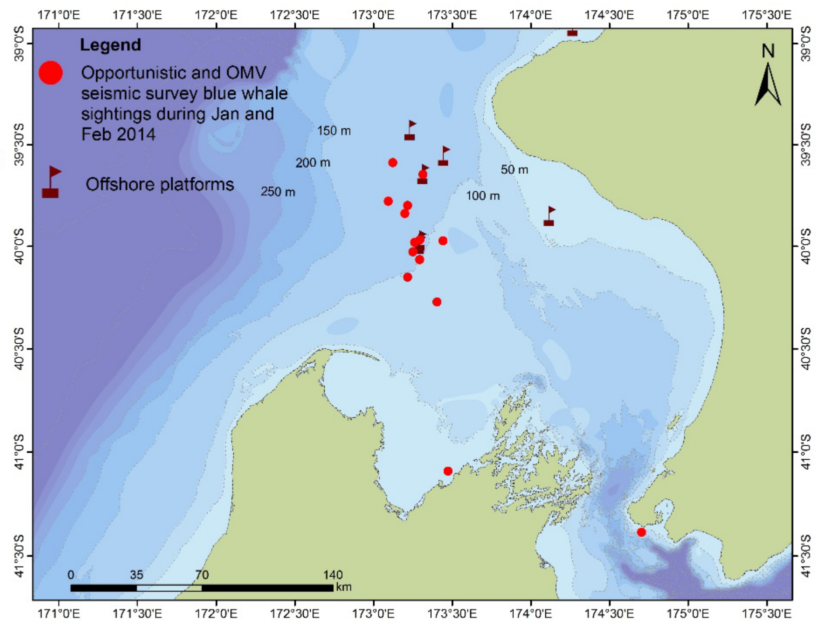


Figure 5. Additional sightings of blue whales in the South Taranaki Bight between 15 Jan and 16 Feb. Additional sightings were reported by the OMV Ltd. seismic survey team, researchers for the Cawthron Institute, local fishermen and airline pilots

A minimum of 21 blue whales were photo-identified in the STB between 25 January 2014 and 3 February 2014. This represents 42% of the estimated 50 separate blue whale individuals observed during this period (which is not to suggest that 50 individual blue whales were sighted). There was a possible re-sight within 25 January. However, the image quality from the second sighting on that date was not good enough to confirm a match. Otherwise, no re-sights were evident. This low re-sight rate suggests that a relatively low proportion of the blue whales present in the STB during our field work were encountered. At this stage no matching has been conducted with catalogues from other regions.

Ten skin and blubber biopsy samples were collected from ten different blue whales. Genetic analysis of these samples to determine the sub-species present in the STB is in progress. Two faecal samples were collected from two different blue whales and will be genetically analysed to identify prey, and possibly the individual blue whale identity. One krill sample was collected and the species was confirmed as *N. australis* (Janet Bradford-Grieve, NIWA, pers. comm.)

A total of 21 hrs and 3 mins of hydroacoustic backscatter data were recorded. These data have not been analysed yet, but qualitative assessment of the data while in the field showed high variation in prey distribution, including dense patches of krill at the surface, a less dense but consistent near-bottom layer of krill, and areas with no to little krill detected (e.g. Fig. 6). Twenty-five CTD casts were performed during the survey that recorded temperature, salinity, depth and fluorometry throughout the water column. These CTD casts were performed at the start and end of survey effort, at all blue whale sightings, and at various locations along survey lines. These data have not been analysed yet.

## DISCUSSION

During five days of suitable survey work in the STB between 21 Jan and 4 Feb 2014, 50 blue whales were observed and foraging behaviour documented. Their euphausiid prey was possibly detected hydro-acoustically, and samples captured near foraging whales were identified as *N. australis*, a known blue whale prey item in the Southern Hemisphere (Gill 2002; Torres 2013). Blue whale behaviour patterns observed were not consistent with migratory transit through the area. Instead, behaviour of blue whales in the STB appeared identical to that of blue whales observed in the Bonney Upwelling off southern Australia (PG, pers. obs.), another foraging ground where *N. australis* is prey. Whales were usually moving slowly in apparently random patterns, a typical behaviour pattern when searching for scattered swarms of krill, which often occur at depths where feeding will not be visible. Although *N. australis* often forms surface swarms, few were sighted during these surveys, consistent with the hydroacoustic evidence of aggregation at depth, which is also common for this species (O'Brien 1988). Fluke-up dives by blue whales were observed, consistent with steep decent to foraging depths.

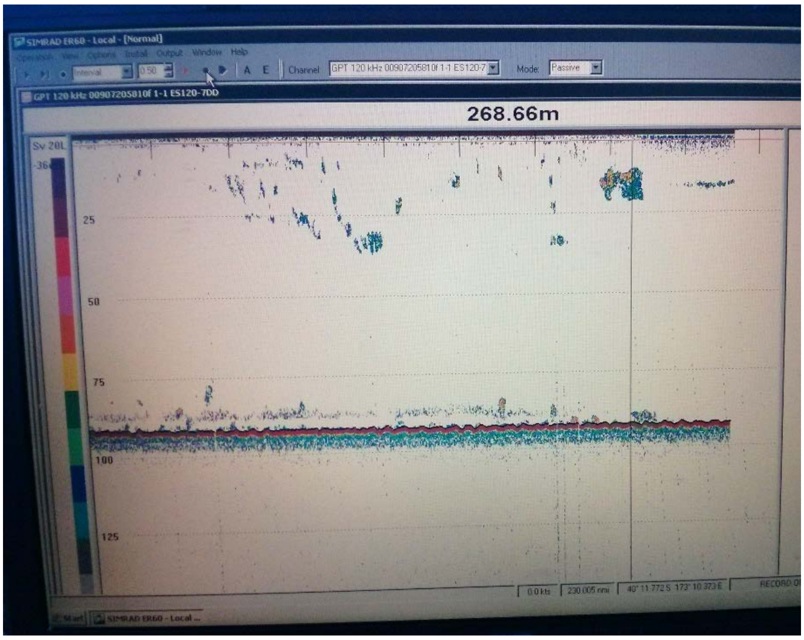


Figure 6. Computer screen image capture of hydroacoustic backscatter data showing patches of prey (presumably krill) in the upper 30m of the water column and a more dispersed but consistent layer just above the bottom. The depth of the water column at this location is approximately 90m.

On one occasion a whale appeared to carry out a surface feeding lunge, which one of us (DG) had observed on numerous occasions during a previous seismic survey in this area, during Feb and Mar 2013. Finally, two whales were observed defecating, evidence of feeding within the preceding 15-18 hours (Víkingsson 1997). While it is possible that these two whales had fed elsewhere and defecated after they had moved into the STB, a simpler explanation is that they had likely fed in the STB.

These data strongly support the hypothesis that the STB is a blue whale foraging ground.

It is important to note that the STB is a large area (approximately 55,835km$^2$) and only 314km of trackline were surveyed during this field project. Furthermore, only 5 days of survey effort during summer months were conducted. For these reasons, results presented here must be considered a snap-shot of blue whale distribution and ecological patterns in the STB. More extensive survey and research effort is needed to more fully understand blue whale ecology in the STB.

The oil and gas industry has been present and active in the STB since 1979. Significant growth of this industry in and around the STB is occurring, including frequent and extensive seismic surveys and drilling of test wells. Many of the blue whale sightings made during this field project were in the vicinity of the Maari Wellhead Platform (minimum distance = 11.9km; Fig. 7). Furthermore, New Zealand's first seabed mining project is located within the STB and is currently under permit consideration. The closest blue whale sighting made during this field work to the proposed mining site was 34km. Significant vessel traffic and fishing effort also occur in the STB. These current and future anthropogenic activities in the STB must be carefully considered and managed to avoid direct, indirect and cumulative impacts on blue whales. The efficacy of this management process is dependent on robust and well-directed science.

Analyses of data obtained during this field effort are underway. Photo-ID images of individuals observed in the STB will be contributed to the Southern Hemisphere Blue Whale Catalogue, a collaborative initiative involving many blue whale researchers from the Southern Hemisphere. This data sharing will enable subsequent matching with catalogues held by other New Zealand researchers, as well as those in other regions (e.g. Australia) and beyond. This approach will provide useful insights into the degree of connectivity of blue whales within New Zealand waters and with other regions. At this stage no matching has been conducted with catalogues from other regions.

Genetic analysis of the 10 blue whale biopsy samples collected in this study and previously collected tissue samples from blue whales strandings in the STB area are in progress by the University of Auckland and Oregon State University. This genetic analysis will reveal the blue whale sub-species present in the STB (Antarctic or Pygmy) and can be used as part of a genotype identity capture-recapture study to estimate population size (e.g. Hamner *et al.* 2012).

In order to describe the habitat use patterns of blue whales in the STB during the survey period, survey data will be analysed relative to the environmental data recorded via the temperature probe, CTD casts, hydroacoustic data, and satellite imagery of SST and productivity. These results will be assessed relative to locations of sightings, foraging behaviours observed, krill samples collected, and DNA faecal sample analysis to describe the links between oceanographic patterns and blue whale distribution in the STB.

Figure 7. Blue whale surfacing in front of the Maari Wellhead Platform and floating production, storage and offloading unit (FPSO).

## FUTURE RESEARCH

Although these results strongly support the hypothesis that the STB is a blue whale foraging ground, more data and analyses are needed to determine the significance and extent of this foraging ground. Primary factors to be assessed include

1. When blue whales are present in the STB (months/seasons).
2. The spatial extent of the foraging area in the STB.
3. The number (abundance) of blue whales using STB as a foraging ground.
4. The rate of persistent use of the STB as a foraging ground by individual blue whales. (Is the STB a primary feeding area used yearly/seasonally, or is it occasionally used in conjunction with other foraging areas?)
5. The population identity of these blue whales. (Pygmy or Antarctic blue whales? Are these blue whales a New Zealand stock, or part of the Australian population?)

Factors 1 and 2 listed above are linked to oceanographic and biological processes in the STB, which act to generate and aggregate prey for blue whales. Therefore, thorough habitat use analyses of blue whales in the STB are necessary to determine and accurately predict the spatial and temporal distribution of blue whales in the STB.

Data needed to assess factors 1, 2, and 3 above can be collected through systematic aerial surveys over the STB using standard line transect methodology. Aerial survey data on whale distribution and behaviour can be assessed relative to remotely sensed data of SST, productivity, wind direction and strength, and the detection of prey patches.

Factors 4 and 5 can be determined through analysis of photo-ID and tissue samples collected during boat-based work in the STB. The rate of photo-ID matches to existing blue whale catalogues will inform population identity and connectivity. Genetic analyses of tissue samples will identify the blue whale sub-species and can be used as for a genotype identity capture-recapture study to estimate population size (e.g. Hamner et al. 2012). Stable isotope analyses of tissue samples can also inform the foraging location(s) of blue whales. Data collected during this field project has initiated these analyses and results, but more data is necessary to increase sample sizes and, hence, the accuracy of results.

Results derived from this current project and future research on blue whales in the STB will link-in with a growing body of literature about blue whales in New Zealand waters (McDonald 2006; Olson *et al.* 2013; Torres 2013; Miller *et al.* 2014) to help describe, understand and protect this population. It is also suggested that a centralized New Zealand blue whale photo-ID catalogue is initiated to increase identification rates and improve the assessment of individual movement patterns. The foundation of this New Zealand blue whale catalogue can be photo-ID data collected during this field project in the STB and photo-ID data collected aboard the 2013 Antarctic Blue Whale Voyage (Double *et al.* 2013).

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