ORIGIN ENERGY 2011 OTWAY BASIN SEISMIC PROGRAM

AERIAL SURVEY FINAL REPORT

MARGIE MORRICE and PETER GILL

BLUE WHALE STUDY INC.

Contents

EXECUTIVE SUMMARY

Blue Whale Study Inc. (BWS) conducted five aerial surveys in and adjacent to the Astrolabe and Bellerive seismic survey blocks during February 2011. This was in response to additional management measures applied to Origin Energy by the *EPBC Act* Referral Conditions, to mitigate any impact on blue whales from seismic survey activity. Aerial surveys covered the entire Astrolabe and Bellerive prospect areas and surrounding 10km buffer regions, and inshore to the coast, using seven parallel transects 6nm apart and mostly perpendicular to ambient depth gradients. Aerial surveys included a pre-seismic acquisition survey, three surveys during seismic acquisition in the Bellerive prospect, and a post-seismic survey after seismic acquisition was terminated on 19 February. Seismic acquisition in Astrolabe was postponed until further notice, due to a poor weather forecast and consistent blue whale sightings during the first three aerial surveys.

A total of 51 blue whale sightings were recorded for 56 individual whales, with sightings per survey gradually increasing with time, and a high percentage of whales feeding. The relative abundance of blue whales (Encounter Rate; ER = whales/1000km surveyed) was high for these surveys (ER 20.4), compared with previous work in the region published by BWS. A single blue whale was sighted in the Astrolabe prospect area, and eight in the Astrolabe buffer area, while none were sighted in the Bellerive prospect or surrounding buffer. However, one blue whale was confirmed just south of the Bellerive prospect. Most of the remaining sightings were inshore of Astrolabe, from Moonlight Head to Port Fairy during transit legs to and from Warrnambool. The relatively large numbers of blue whales and their apparent movement inshore, and the lack of occurrence of blue whales in the southern half of Astrolabe and the entire Bellerive prospect areas, was likely due to changing oceanographic conditions in this region. Although upwelling is regarded as the principal driver of marine productivity along this coast, it appears that an additional forcing factor was the ‘100 year’ floods over the summer. These resulted in unseasonably high river runoff, creating extensive nutrient inputs for phytoplankton blooms along the coast downstream of these river systems. No ‘significant krill aggregations’ were encountered, and there were no incidents reported for the aerial survey team.

1. INTRODUCTION

To satisfy requirements of the EPBC Act Referral Decision for the Origin 2011 Otway Basin 3D seismic survey, Origin Energy contracted BWS to conduct aerial surveys for blue whales and their prey before, during and after seismic surveys in the Astrolabe and Bellerive prospects. These surveys were used to supplement mitigation measures by MMOs on board the seismic vessel, *M/V Ramform Sterling* (*RS*). This requirement was due to the likely presence of blue whales in this south-eastern extremity of the 'Bonney Upwelling' blue whale feeding area during summer (Gill *et al.,* 2011), and concerns that seismic noise could displace blue whales from migration paths or preferred feeding areas. BWS has extensive prior experience in conducting blue whale aerial surveys in this region for both ecological research and mitigation/monitoring activities. For a comprehensive project description including aims, methods, and reporting and HSE frameworks see Marine Mammal Aerial Survey – Project Plan (Appendix 1, Project Plan).

2. PROJECT TIMING

Origin originally intended to conduct the 3D survey during December (early in the blue whale season) to reduce the possibility of encountering blue whales. However, delayed availability of the seismic vessel *RS* meant that the 3D survey was eventually conducted in February, a peak month of blue whale occupation of the feeding area (Gill *et al.,* 2011). BWS aerial surveys in previous seasons had often found blue whales in the Astrolabe prospect area. Bellerive had never been surveyed by BWS except in rare transits to the Tasmanian west coast, but we considered it less likely that blue whales would be encountered there than in Astrolabe, which is closer to known upwelling centres.

The seismic survey program was forecast to commence no earlier than 15 February 2011, but due to unexpectedly rapid progress in the *RS's* prior projects in Bass Strait, the seismic survey was brought forward one week, so the first complete aerial survey was carried out on 8 February 2011, just prior to commencement of the seismic survey.

3. AERIAL SURVEY SUMMARY

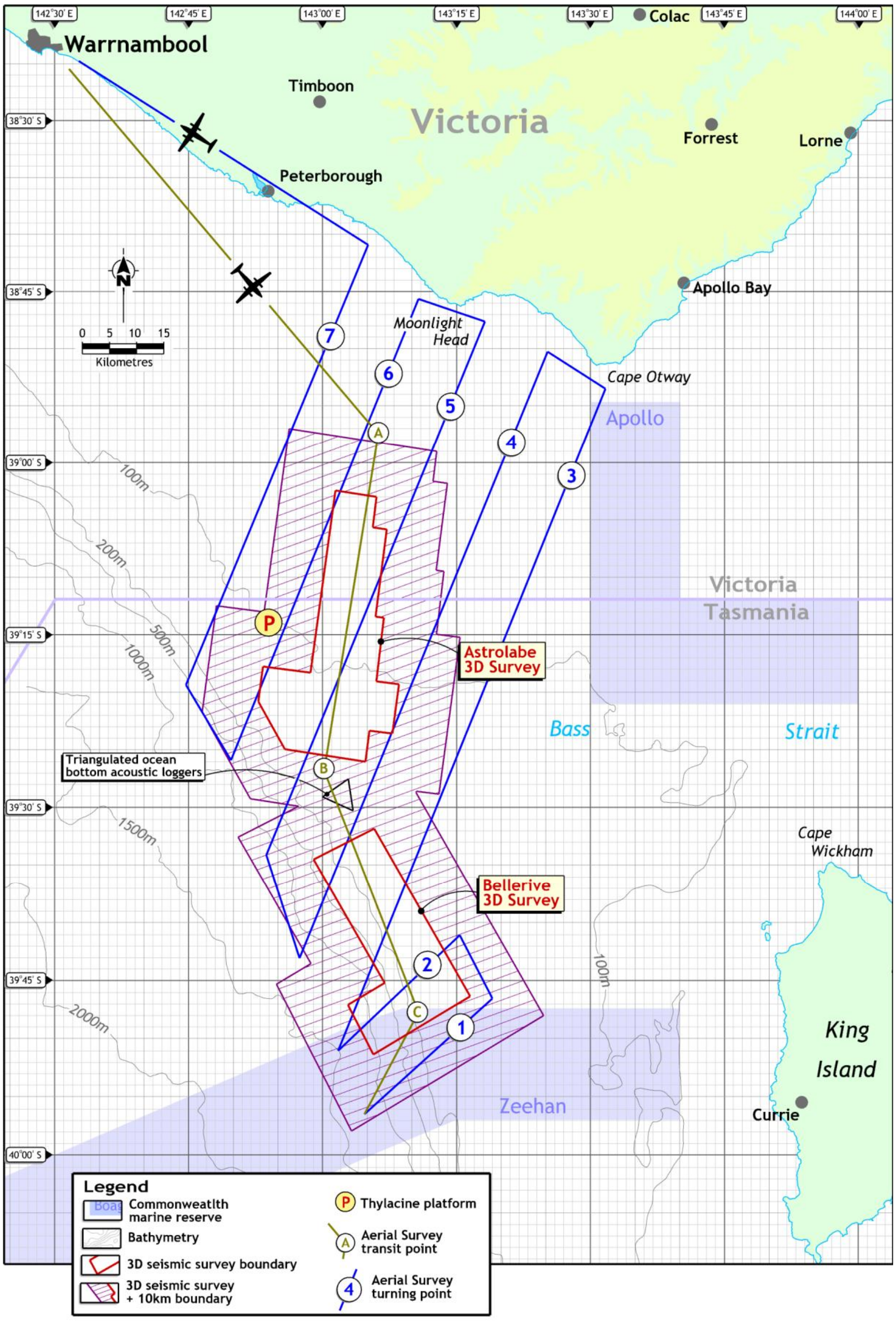
Summary details of individual surveys are given in Table 1. The survey methodology can be found in the Project Plan (Appendix 1), and Daily Reports for individual surveys (Appendices 2-6). Geelong Aviation and Flight Training was the preferred aircraft provider, having been used by BWS for aerial surveys since 1999. Aircraft were high wing twin engine Cessna 337 (two surveys) and Partenavia P68B (three surveys). Both are suitable for over-water work.

Table 1. Summary of aerial surveys during Otway program.

Date	Interval since previous flight	Aircraft	Distance nm Duration h:m	Observers	Blue whale sightings			Total blue whale sightings	Total blue whales	Weather summary (BSS = Beaufort Sea State)
					Astrolabe & buffer	Bellerive & buffer	Outside			
08 Feb 2011	-	VH-JOE C-337	488 3:39	M. Morrice P. Gill	2	0	1	3	3	Overcast; haze; wind S-SSE, BSS* 4-5
10 Feb 2011	2 days	VH-JOE C-337	494 3:49	M. Morrice P. Gill	2	0	2	4	4	Overcast; haze; wind light E, BSS 1-2; low cloud in places
14 Feb 2011	4 days	VH-PNV Partenavia	766 5:49	M. Morrice P. Gill	5	0	5	10	11	Low overcast; haze; wind SE, BSS 2-3
BELLERIVE SEISMIC SURVEY COMPLETED 19 FEBUARY 2011 – DECISION TAKEN TO DISCONTINUE SEISMIC DUE TO WHALES & WEATHER										
24 Feb 2011	10 days	VH-LJR Partenavia	436 3:17	M. Morrice P. Gill R. Meagher	0	0	13	13	15	Early fog; low cloud, rain in places; wind light, variable
25 Feb 2011	1 day	VH-LJR Partenavia	560 4:20	M. Morrice P. Gill	0	0	21	21	23	Some low cloud but little haze; wind SE BSS 3-4
TOTAL			2744 20:54		9	0	42	51	56	

A survey grid was laid out to cover the Astrolabe and Bellerive prospect areas and surrounding buffers, and extending in to the coast (Figure 1). This grid was modified from past BWS survey tracks, which generally run perpendicular to prevailing bathymetry to minimise survey bias (as whales often aggregate along bathymetric features) and conformed to the requirements of the Referral Decision (i.e. separation of transects no greater than 6nm).

Figure 1. Aerial survey trackline for the Otway 3D seismic survey.



Five aerial surveys were carried out from 8 – 25 February 2011. Most surveys covered the Standard Survey Pattern (Points A, B, C, Transects 1-7). The pre-start survey on 8 February was intended to check for the occurrence of blue whales and prey in both prospect areas. As blue whales were sighted within the Astrolabe 10km buffer zone, another survey was flown on 10 February to investigate whether blue whales remained in this prospect. As a precautionary measure, this aerial survey also covered the Bellerive prospect area. Blue whales continued to be sighted within the Astrolabe prospect area on 10 and 14 February, but not in the Bellerive prospect area, allowing the seismic survey of this prospect to continue more or less uninterrupted until completion on 19 February. Due to the consistent occurrence of blue whales in Astrolabe, and a poor weather forecast, Origin decided to discontinue any further seismic acquisition of the area. A post- seismic acquisition aerial survey was conducted on 24 February but was incomplete due to delays caused by poor weather conditions (only Transects 4, 6 were covered). A complete survey (Standard Survey Pattern) of both prospect areas was conducted on 25 February.

Weather conditions for surveying were generally good throughout the survey, i.e. less than BSS 4, and only affected survey progress on one occasion when the flight had to be aborted (24 February, Table 1). Haze, overcast conditions and some low cloud were common in the prospect areas for most surveys, but this didn't significantly affect observer visibility within the survey area, i.e. 3nm from the trackline.

4. BLUE WHALE SIGHTINGS

There were 51 blue whale sightings over the course of five aerial surveys, totaling 56 individual whales (Table 1; Figure 2). Of these, two sightings on 14 February were possible resights of whales sighted earlier that day. Most sightings were of single adult whales, with pairs of whales sighted three times, and one sighting of three whales. A calf was also sighted on the return transit leg to Warrnambool on 24 February.

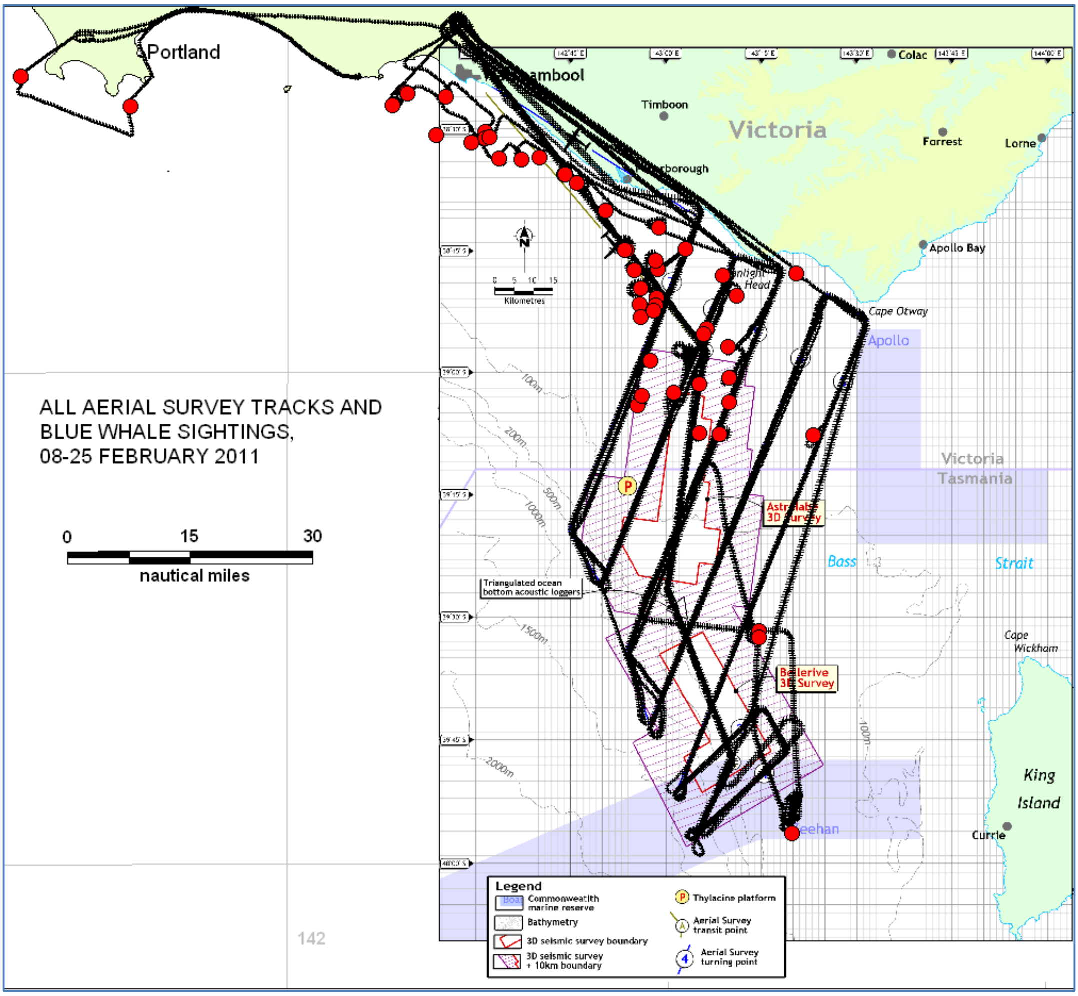
4.1. Distribution of whales in relation to seismic prospect areas

A single blue whale was sighted in the Astrolabe prospect area, and eight in the Astrolabe 10km buffer area, while none were sighted in the Bellerive prospect or surrounding 10km buffer. Most of the remaining sightings were between Point A and the coast, from Moonlight Head to Port Fairy. During an attempt to reach Warrnambool over water during poor flying conditions on 24 February, two sightings occurred off Portland.

During the first two surveys (8 February and 10 February) no blue whales were sighted south of the northern third of Astrolabe. A notable exception was on 14 February when the aircraft was recalled to investigate several whale sightings by shipboard MMOs just to the south of the

Bellerive buffer. One of these the aerial survey team was able to confirm as a feeding blue whale. This sighting challenged the prior perception that all whales were feeding well to the north. The final survey on 25 February was undertaken in the best visibility of all surveys, and no whales were sighted in Astrolabe or Bellerive (although two were within just over 1nm of Bellerive's eastern buffer). Given that we had consistently found them in Astrolabe during the first three surveys, this suggests that oceanographic and prey conditions had changed between 14 and 24 February. A possible explanation is given in Section 5.2 relating to oceanographic conditions.

Figure 2. Survey tracks and blue whale distribution, all surveys.

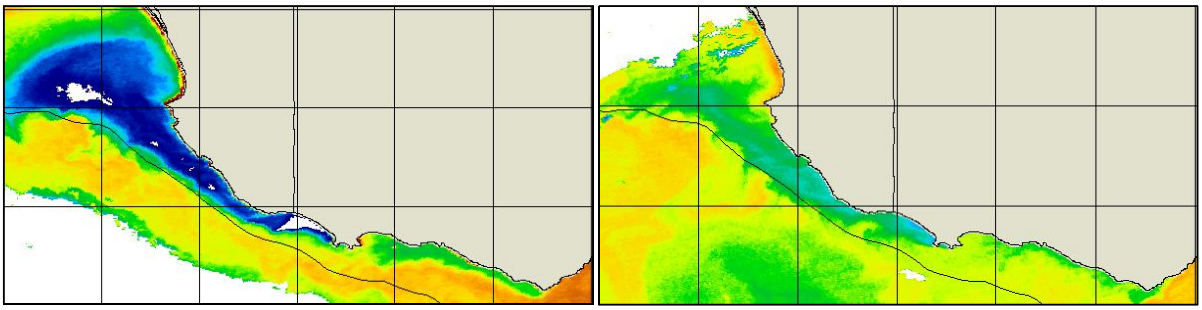


The lack of blue whale sightings in the southern half of Astrolabe and the whole Bellerive prospect or its 10km buffer has three possible explanations or a combination of these. Firstly, there may have been little food available at the time of survey in those areas. However, it was difficult to determine surface prey availability from the air due to difficult observer sighting conditions for krill as explained in Section 6, and it is likely that surface or near-surface krill aggregations were missed frequently. As this oceanographic region is inherently complex, there may have been natural forcing elements limiting conditions for krill in the area studied (see Section 4.2). Secondly, some whales may have been undetected by the aerial observation team if the aircraft passed over them while they were diving. Depending on the distribution of prey, whales may dive for consistently longer periods of time when krill is at depth than at the surface. We estimate that under certain feeding conditions, as many as three out of four whales may be missed during aerial surveys. Thirdly, the whales may have been avoiding this region because of seismic noise in Bellerive. Although this may have been a contributing factor, no whales were sighted in either prospect during the pre-seismic aerial survey (8 February 2011), but conditions were far from optimal for whale sighting that day, and it is possible that some whales were missed in the overcast and sometimes windy conditions.

4.2. Distribution of whales in relation to oceanographic features

The Bonney Upwelling has been unusually weak this season, possibly due to the exceptionally strong prevailing La Niña. Figure 3 shows a satellite sea surface temperature (SST) image for the strongest day of upwelling in 2010 (3 March), compared to the SST image of 25 February 2011, showing one of the stronger upwelling events for the current season. This figure clearly shows that upwelling was much more intense at a comparable period during 2010 than during 2011.

Figure 3. SST images Bonney Upwelling for 3 March 2010 (left) and 25 February 2011 (right). Blue=cold; orange=warm; white=cloud. Satellite images courtesy CSIRO.

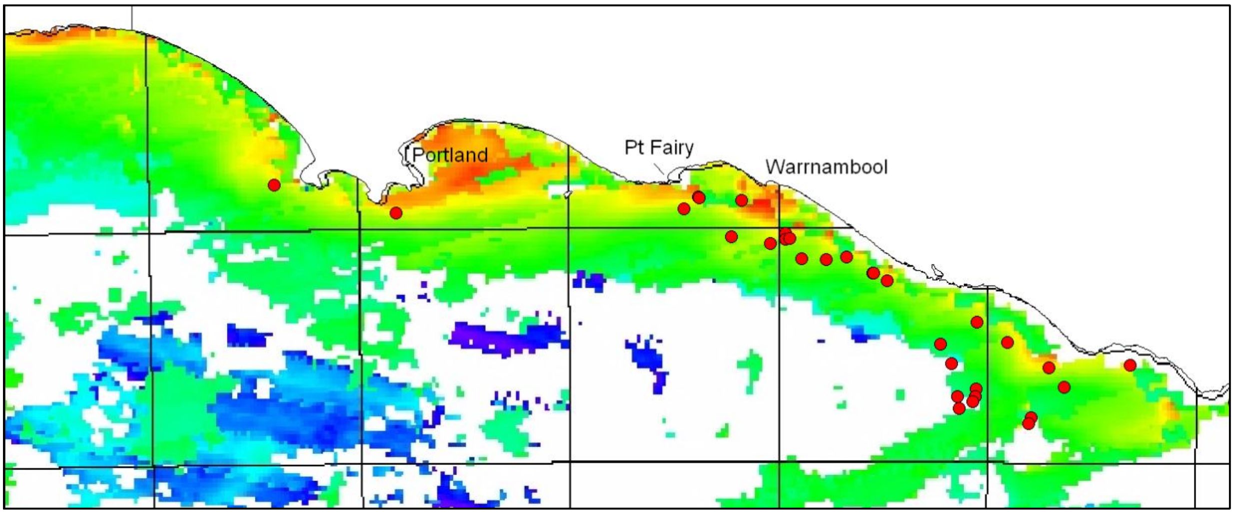


It is reasonable to assume that during a significantly weaker upwelling season, fewer nutrients would be brought into the system to sustain krill populations and blue whales. We know from photo-ID and satellite tracking data that some blue whales from the Bonney Upwelling interchange with other feeding areas such as the Perth Canyon and Sub-tropical Convergence (STC). However, even in weak upwelling seasons feeding blue whales are found in the Bonney Upwelling, though it may be more difficult to forage successfully at such times. But feeding conditions could be even worse in alternate feeding areas during such seasons. Despite the weakness of upwelling this year, overall blue whale numbers in the area surveyed were reasonably high, as described in Section 4.3, below.

During our transits along the coast between Warrnambool and the prospect area, it was apparent that the riverine runoff from the '100-year' floods having a marked effect on the inshore marine environment. Normally the rivers along this coast have their strongest runoff during winter, when no blue whales are present, and blue whales are rarely found close inshore. This phenomenally high summer runoff was clearly visible inshore during our flights (Figure 4), and from the clear indication of greener water inshore, phytoplankton blooms were prevalent in these areas.

Figure 4. Inshore plume of river runoff (paler water inshore), 25 February 2011. Warrnambool in background.

Figure 5. Aqua MODIS image showing sea surface chlorophyll-*a* (18-25 Feb) and blue whale sightings, 24-25 Feb 2011. Satellite image courtesy CSIRO. Blue = least productive; red = most productive; white = cloud.



Remarkably, many blue whales appeared to be aggregating along and offshore of the boundary between the fresh runoff/phytoplankton plume and adjacent seawater. Figure 5 overlays blue whale sightings of 24-25 February on surface chlorophyll-*a* concentrations (averaged for 18-25 February to minimise cloud effects) from a MODIS Aqua satellite image (NASA data processed by CSIRO). Although this satellite image is unfortunately compromised by green pixelation in areas of interest close inshore (possibly due to poor satellite coverage), Figure 5 shows several significant features:

- A band of enhanced primary production close inshore between Cape Otway and Portland, strongest off Warrnambool and in Portland Bay east of Portland.
- The outer edge of this band (yellow to orange) is visible, and without the interference of the green pixels, would likely be seen to extend inwards to the coast, becoming stronger as it approached the coast;
- Weak productivity west of Portland, where productivity is usually stronger at this time of year than to the east of Portland;
- Most blue whales were distributed along the seaward edge of the band of inshore production, or on filaments extending offshore from it (south of Warrnambool). This coincided with other reports of blue whales close inshore between Peterborough and Portland. However, some blue whales south of Peterborough/Port Campbell were further offshore, perhaps in areas more likely influenced by upwelling.

These observations are highly significant in two respects:

- This unusually heavy inshore riverine runoff appears to have provided an alternate source of primary productivity in the region at a time when blue whales are present; this is unprecedented in our experience and demonstrates that under certain climatic conditions, the Bonney Upwelling may not be the only forcing agent in marine primary productivity.
- The apparent increase in blue whale numbers in this inshore band of productivity during 24-25 February may explain the possible departure of blue whales from the Astrolabe prospect area between 14 and 24 February.

Under ideal circumstances we would have flown a comprehensive standard BWS aerial survey on Saturday 26 February, extending out to the shelf break from Cape Otway up to Portland and beyond. This would have enabled us to assess the relative importance of this inshore area and areas further offshore, and to compare whale relative abundance in the Otway region with that of the remainder of the 'Bonney Upwelling' feeding ground.

We also intended to conduct a small boat survey as soon as possible after 25 February, to closely observe and photo-identify blue whales off Warrnambool/Port Fairy, and to conduct water quality and plankton sampling in areas where whales were found. The weather deteriorated on 27 February, however, and the opportunity was lost.

4.3. Relative abundance of whales

Encounter rate (ER = whales/1000km surveyed) was used as a measure of relative abundance (i.e. for comparison between surveys, seasons etc) rather than of absolute abundance (i.e. an estimated 'actual' number of whales in the area, based on extrapolations of survey data). At our current low level of knowledge of blue whale surfacing and diving behaviour in different upwelling and prey conditions (essential to predict the proportion of whales likely to be seen as the aircraft passes) estimates of absolute abundance are very unreliable.

For our five surveys combined (including transit overland) ER was 20.4, a high value compared to a mean of 10.0 for the entire blue whale feeding area recorded between 2002-07 (Gill *et al*., 2011). This is also well above any ER recorded previously for the region between Portland and Cape Otway (mean ER 4.8; range 1.7-8.2; Gill *et al*., 2011). A large contribution of this high ER was due to the numbers of whales sighted in inshore waters between Moonlight Head and Port Fairy on 24 and 25 February (ER for 24 Feb = 34.4; ER for 25 Feb = 41.0).

However, during survey transects 1-7 only, and not in transit, ER dropped to 8.9, comparable to the overall mean ER for the entire feeding area during six previous seasons (Gill *et al*., 2011). On transect within the boundaries of Astrolabe and buffer only, ER was 12.8; while obviously within Bellerive and buffer, ER was zero.

4.4. Behaviour of whales sighted

Blue whales showed evidence of feeding in 20 (39%) of the 51 sightings. This included direct observations of feeding, and of whales surfacing with distended throat pouches and partially open mouths (Figure 6). This is a high proportion of feeding animals compared to 6 seasons of past aerial survey data (23%; Gill *et al.*, 2011), indicating that the areas where whales were concentrated were of considerable value to the whales as foraging grounds. Even though blue whales were actually sighted feeding at or just below the surface on many occasions, the krill on which the whales were feeding was only visible on one occasion (see below for explanation).

In all other sightings, whales were typically moving slowly, which is characteristic of foraging whales moving between feeding patches or resting between feeding bouts.

Blue whales were observed from land raising their heads vertically above water and surface feeding close offshore of Thunder Point, Warrnambool, on 22 February. This unusual behaviour was also observed from the aircraft on 25 February, when we were able to confirm that the whales were raising their heads vertically out of the water prior to rolling onto their side to distend their throat pleats and feed. This behaviour has not been observed previously by BWS researchers in this region, but has been observed in other parts of the world including recently off New Zealand (I. Visser, pers. comm.). We speculate this may be a feeding strategy tailored to the shallow water in which the whales were found, and/or a population-specific behaviour indicating that 'New Zealand' blue whales were present in the region at the time.

No extended behavioural observations of blue whales were conducted for these surveys, particularly as there were no sightings close to the active seismic vessel. Prolonged observation involving repeated circling would have been applied to the feeding blue whales sighted to the south of Bellerive on 14 February by the *RS* and BWS aerial survey team, except that fuel resources were low on the aircraft and the seismic vessel was in a line turn at the time.

Figure 6. A blue whale surfacing after a feed.

5. 'SIGNIFICANT AGGREGATIONS OF KRILL'

The Referral Decision strongly emphasised the importance of 'significant' krill aggregations ('a high density of visible krill swarms as defined by a senior Blue Whale Study observer'), with finds of significant aggregations to trigger additional aerial surveys. In the past BWS aerial surveys have used a relative scale for surface krill swarms according to krill size: 'small' (approx 1-50m), 'medium' (approx 50-200m), and 'large' (>200m). If more quantitative measures of krill distribution and availability to blue whales are required then a vessel-based hydroacoustic survey would be conducted.

In the BWS Project Plan (Appendix 1) definitions of significant aggregations for the current surveys were additionally defined as:

- Restricted areas containing a few very large krill swarms

- Relatively restricted, though larger areas containing scattered medium-to-large swarms
- Moderate numbers of small-medium or larger swarms more widely spread
- Densely spaced small swarms covering an extensive area.

In the event, there were few (<20) recorded sightings of krill swarms, with most of these isolated single small swarms. By the above definition there were no sightings of 'significant krill aggregations'.

This almost certainly resulted from the overcast conditions that prevailed throughout most of the aerial surveys. Extensive cloud makes it very difficult to see into the water; whereas on bright sunny days krill is often easily visible if it is within 5-10m of the surface. This was emphasised by the fact that in 19 of 20 sightings when whales were observed feeding at or near the surface, no krill was visible. The exception was at 13:01 on 14 February, when the aircraft was recalled to investigate whales sighted by shipboard MMOs, and a blue whale was sighted feeding on a single medium surface swarm.

6. OTHER WILDLIFE SIGHTINGS

The only other cetaceans sighted for the whole survey program were 5 sightings of unidentified dolphins, likely common or bottlenose dolphins, on 10 and 25 February. Other wildlife were seabirds and a sunfish, with Australasian gannets and albatross spp. being the most numerous on the shelf, although they were in lower numbers than expected for this time of year.

7. HSEMS

The Health Safety Environment Management System (HSEMS) for this project was developed in close consultation with Origin (Appendix 1, Project Plan). The BWS also made every effort to comply with Origin Energy's HSE Policy. All personnel involved in the project sat the Origin Induction, including three BWS standby observers. A number of hazards were identified in relation to conducting aerial surveys, and consequently a number of safety procedures and equipment were implemented for this program to minimise these risks. In particular, various items of navigational, safety and communications equipment were acquired to improve our survey effectiveness and to conform with Origin HSE requirements (Figure 7). These included: a new GPS to replace our ageing units, for accurate recording of track and sightings; an Iridium satellite phone for reliable communications with the *RS*; a *Spidertracks* unit for real time aircraft tracking; comfortable headsets to reduce fatigue and discomfort during surveys; flame-resistant flight suits (Figure 8); and marine survival jackets. In addition, a lightweight life raft was ordered from the USA but failed to arrive before the surveys were completed. All equipment is available should further aerial surveys be required during future seasons.

Figure 7. Comfortable headsets and quality navigational equipment were considered essential items for the survey.

Also, communications between the aircraft/vessel MMO's and with Origin representatives was considered of prime importance to ensure safety and to enable mitigation procedures to be implemented in appropriate time and with the right resources. Consequently a Communications Protocol incorporating an Emergency Response Plan was developed for this project (Appendix 1, Project Plan).

In addition to management procedures, the BWS worked closely with Origin representatives to develop a cooperative relationship. This was considered necessary to enable the survey to comply with government regulations and therefore minimise any impacts of the seismic survey to blue whales, and to allow quick responses to changing work conditions throughout the surveys. As part of this cooperation, a culture of honesty was established so that BWS observers didn't feel inhibited to express any concerns relating to any health, safety or environmental aspect of the project.

Table 2 summarises the HSE statistics accrued for this survey. In total only 6 hazards were identified that required attention once surveys began, relating to communication equipment and protocols, and observer comfort and safety. All of these were acted on prior to the following survey, except that disappointingly the liferaft was did not arrive before surveys were completed. We felt that our record of safe acts and environmental good practice was under-estimated as all activities were related to these practices, and protocols to manage these were followed as closely as possible. For the entire project there were no incidents relating to staff, subcontractors or the environment. Therefore, our incidence rate including our injury rate (based on 156.27 worked hours) for this project was also 0.

Figure 8. The BWS Observer Team, Pete Gill and Margie Morrice, and Origin's Bob Meagher, showing the Partenavia aircraft and observer PPE.

8. REFERENCES

Gill, P.C., M.G. Morrice, B. Page, R. Pirzl, A.H. Levings and M. Coyne. 2011. Blue whale habitat selection and within-season distribution in a regional upwelling system off southern Australia. *Marine Ecology Progress Series* 421: 243-263.

Table 2. Daily and cumulative total for BWS HSE statistics

Classification	**8 Feb**	**10 Feb**	**14 Feb**	**24 Feb**	**25 Feb**	**Cumulative Total for Project**
Total work hours	37.53	26.27	31.8	35.92	24.75	156.27
Number of staff	4	3	3	4	3	17
Number of Toolbox/HSE meetings	2	1	1	1	2	7
Observations (Hazards & Unsafe Acts)	4	1	0	1	0	6
Observations (Safe Acts & Envir. Good Practice)	0	0	1	0	0	1 *
Near Misses	0	0	0	0	0	0
First Aid Cases	0	0	0	0	0	0
Medical Treatment Cases	0	0	0	0	0	0
Restricted Work Cases	0	0	0	0	0	0
Lost Time Cases	0	0	0	0	0	0
Environmental Incidents	0	0	0	0	0	0
Other Incidents	0	0	0	0	0	0

*not well defined for survey so is under-estimated