The Norwood Resource
Balanced Science

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Committee Secretary
Senate Standing Committees on Environment and Communications
PO Box 6100
Parliament House
Canberra ACT 2600

Dear Committee Members,

Impact of seismic testing on fisheries and the marine environment
Submission from The Norwood Resource Incorporated

A. Introduction

The Norwood Resource Incorporated (TNR) commends the establishment of this Inquiry as it provides a welcome opportunity to make a **public submission based on the facts, science and research** even though we are of the view that the premise for this particular Inquiry is based on misinformation.

In fact, when one considers the facts, science and research in a balanced way, one must ask "What impact?" Many researchers and regulators around the world, following a detailed and balanced review of all the information have come to the same conclusion as the US Bureau of Ocean Energy Management (BOEM) who advised "*To date, there has been no documented scientific evidence of noise from air guns in geological and geophysical (G&G) seismic activities adversely affecting marine animal populations or coastal communities*"

We well recall the words of the Australian Federal Energy Minister, Gary Gray when he stated at the APPEA 2013 Conference, its "***about spreading fear and confusion to achieve a dramatic media-driven objective.***" However ***"The noise is made by a relatively small number of people.***" He added "***We need to put evidence and science into the current debate – and balance the misinformation that is being peddled in the public arena, and we need to be robust about it***"

TNR was formed by a group of retired or semi retired former long term industry professional with a deep knowledge of the oil and gas industry who have:

- a strong sense of integrity and a deep respect for society and the environment;
- been dismayed by the non-factual assertions and opinions that bombard the media about the oil and gas exploration and production industry;
- the knowledge and experience to challenge the misinformation peddled in the media; and
- the passion to present balanced information to the public so that those who wish to base their opinions on the facts and science can do so.

TNR has now been operating for over 6 years initially as an informal group and in August 2013 became incorporated and registered with the ACNC.

The focus of our activities to get the facts and truth about the impact of oil & gas exploration and production operations into the public space involves publishing numerous articles and papers about both offshore and onshore oil & gas exploration and production, as well as papers refuting and rebutting many of the assertions by many eNGOs and even some researchers. (http://thenorwoodresource.org.au/)

The articles, which TNR publishes, are generally of three types:

- Factual scientific articles. (eg. "How loud is the sound of a breaching whale?") https://thenorwoodresource.org.au/article/how-intense-is-the-sound-of-a-breaching-whale/
- Articles that challenge "popular" but misinformed, claims from 'green' groups (eNGOs) https://thenorwoodresource.org.au/article/is-the-greens-bight-campaign-designed-to-misinform/
- Articles that dissect and challenge "peer-reviewed" scientific publications https://thenorwoodresource.org.au/article/is-science-manipulated-by-environmental-groups-and-some-researchers/

B. Structure and Summary of TNR's submission

We note that the terms of reference for this Inquiry are as follows:

"The impact of seismic testing on fisheries and the marine environment, with particular reference to:

a. *the body of science and research into the use of seismic testing;*
b. *the regulation of seismic testing in both Commonwealth and state waters;*
c. *the approach taken to seismic testing internationally; and*
d. *any other related matters."*

Firstly, TNR notes that the term "testing" is not used by the international petroleum industry nor regulators of the industry. The process of using sound pulses to map the subsurface is termed "seismic surveying", "seismic acquisition", "seismic recording" or "seismic operations". This process is not dissimilar to echo-sounders, which are in widespread use in the oceans and, although emitting sound at different frequencies, the sound levels emitted by echo-sounders and those emitted by seismic arrays are not all that different. The term "testing" has been coined by those who wish to spread fear and confusion in society and will not be used again in this submission except where used in the terms of reference.

TNR's focus in this submission will be on item a) of the Terms of Reference as the body of facts, science and research is the most important component of understanding why, in BOEM's words ***"there has been no documented scientific evidence of noise from air guns in geological and geophysical (G&G) seismic activities adversely affecting marine animal populations or coastal communities".*** When the science is understood in a balanced way, and we mean all the science and not "cherry-picked or pseudo-science", it becomes clear as to why very minimal impacts have been documented in over 50 years of seismic surveying.

Our submission to item a) of the Inquiry's Terms of Reference has been subdivided as follows:

1. The science of sound in water;
    - i) Some key points about the properties of sound and how it is generated
    - ii) How sound is measured and reported
    - iii) How rapidly do sounds attenuate?
    - iv) What sound levels are actually experienced in the near-field (ie close to the source)?
2. Other sounds in the ocean and how they compare with seismic sounds;

3. A brief review of the wealth of unpublished data collected during seismic surveys often as part of approvals under the EPBC Act or other regulatory process (marine mammal observations, sound level monitoring, aerial surveys, etc); and
4. A brief review and critique of the published research (bearing in mind that research, which fails to find impacts is unlikely to be published)

C. Detailed submission relating to each item listed in the terms of reference

a. the body of science and research into the use of seismic "testing"

Marine seismic surveys for petroleum exploration have been used since the 1950s and as such, a significant body of experience, scientific monitoring and research now exists to facilitate an assessment of the impact of seismic surveys on marine life.

It should be noted that up to the late 1960s/early 1970s, depending in what part of the world the surveys were conducted, explosives were used as the seismic source. Ironically, even 50 years later, many people believe that explosives are still used and hence the descriptors of "blasting" or even "atomic explosions" which, as will be seen below, are totally misleading in terms of the relative sound levels.

In providing TNR's feedback to this item, it is useful to subdivide the knowledge acquired during over 50 years of conducting seismic surveys into 4 main sections as follows:

1. The science of sound in water. (sound levels, how they are generated, conversion of pressure values to dB values, how sounds attenuate, near field/far field sound levels, differences between air and water, etc);
2. Other sounds in the ocean and how they compare with seismic sounds;
3. A brief review of the wealth of unpublished data collected during seismic surveys often as part of approvals under the EPBC Act or other regulatory process (marine mammal observations, sound level monitoring, aerial surveys, etc); and
4. A brief review and critique of the published research (bearing in mind that research which fails to find impacts is unlikely to be published).

1) The science of sound in water.

The best website for the average reader to gain a better understanding of the science of sound in water is run by DOSITS (Discovery of Sound in the Sea) - https://dosits.org/.

i) Some key points about the properties of sound and how it is created:

- Sound is created by vibrations in a medium (eg. water or air)
- Vibrations in water are created by a variety of means such as earthquakes, wave action, calving/colliding icebergs, marine life vocalisations, explosive detonations, the release of compressed air (typical of seismic surveys) or vibratory acoustic projectors (on which the development of marine vibrators are based).
- Sound waves travel through a medium in the form of alternating regions of high pressure and low pressure.
- As sound travels through a medium, individual particles of the medium do not travel with the wave but only vibrate back and forth on a spot.
- A sound wave's **amplitude (or intensity)** relates to changes in pressure.

- A sound wave's **frequency** relates to the number of times the wave changes from high pressure to low pressure in a given period of time (ie 1 second).
- The degree of damage to auditory systems (or even whole organisms in the case of significant pressure variations) is dependent on the rate of pressure change. Thus, higher intensity, higher frequency sound waves are more impactful that lower intensity, lower frequency sound waves.
- The degree of pressure change is dependent on the **initial velocity and initial pressure** of the sound generator. The following table summarises the differences between high explosive TNT and a seismic source, which, in this case is taken as a single 100-300 cu in airgun operated at 2000psi at a depth of 5-10m:

	High Explosive TNT	**Seismic airgun**
Initial speed/velocity (m/s)	6900	42
Initial pressure (pascal)	21GPa	13.8MPa
Initial pressure (psi)	>3,000,000	2,000

Table 1. This comparison demonstrates that initial velocity and initial pressure of high explosives are between 154 and 1530 times higher than for an airgun respectively.

- The attached video (Attachment 1) shows a clip taken from a seismic workboat while the seismic source is operating. The video camera initially films the pulses from above sea level and then the camera is placed underwater to film the pulses from relatively short range. It is immediately obvious that such an exercise could not have been executed safely if the crew had been filming high explosive TNT detonations (or even atomic explosions) at such a short distance.

In conclusion, based on the science of sound in water, the claims made by environmental groups that seismic pulses are like explosive blasting or atomic explosions are clearly deliberately false and without foundation.

ii) How sound is measured and reported

Although the key properties of sound that may potentially have an impact on marine organisms are **absolute values** such as pressure (amplitude/intensity) and frequency, and it is these values that are measured by hydrophones, the values are converted to **relative values called decibels (dB)** for reporting purposes.

Unfortunately, relative values are related to specific conditions and, as a result of this decibel values in water have a different relative value from decibels in air. Scientists have agreed to use 1 microPascal (μPa) as the reference pressure for underwater sound. In air, however, scientists have agreed to use a higher reference pressure of 20 microPascals. **Thus, sound intensity given in dB in water is not the same as sound intensity given in dB in air.**

In addition to the different reference pressures used in water compared to air, there are also differences in densities and sound speeds for the two mediums**. For the same pressure higher density and higher sound speed (as in water) both give lower intensity.**

The result is that sound waves with the same intensities in water and air when measured in absolute values (of watts per square meter) have relative intensities that differ by 61.5 dB. This amount must be subtracted from sound levels in water referenced to 1 microPascal (μPa) to obtain the sound levels of sound waves in air referenced to 20 microPascals (μPa) that have the same absolute intensity in watts per square meter. **The difference in reference pressures causes 26 dB** of the 61.5 dB difference. The **differences in densities and sound speeds account for the other 35.5 dB**.

A 60-dB difference in relative intensity represents a million-fold difference in power. Thus, yet again, the environmental groups' lack of understanding of the science (and apparent refusal to seek out the facts) leads to the outlandish claims often seen in the media – which are often incorrect by a factor of 1 million!

iii) How rapidly do sounds attenuate?

Pressure (the value on which sound is based) in any medium attenuates at an exponential rate and is generally inversely proportional to the square of the distance from the source (similar to light).
Unfortunately, given sound levels are reported in a **relative scale, which is logarithmic**, sound attenuation curves showing the decay of sound away from a source misrepresent the changes in pressure. That is, they tend to attenuate 'slower' than pressure attenuates in a medium. Furthermore, when distance is also converted to a logarithmic scale, in order to plot a significant range of distances on a graph, the apparent attenuation of the sound is also significantly misrepresented.

The following graphs in figure 1 show how the same sound attenuation curves in water can be plotted. The logarithmic nature of the values plotted on the vertical & horizontal axes clearly demonstrate how the attenuation (or decay) of the sound can be misrepresented in the minds of non-scientists:

- Fig 1a shows how sound attenuation curves are normally plotted in research papers, environmental plans, etc. **The vertical scale, in decibels, is a logarithmic scale, as is the horizontal scale.** This implies that sound decays in a linear fashion away from the source. NB. To visualise the distorting nature of logarithmic scales, note how the sound decay values on all 3 graphs are terminated at 50km. Thus, the small gap representing the distance (50km) between the end of the decay curve and the right hand end of the graph (100km) in Fig 1a, represents the same distance as the whole 50km of decay curve values shown to the left of the small gap and also shown in Figs 1b and 1c;
- Fig 1b retains the **logarithmic decibels** on the vertical scale but plots **distance on the horizontal scale in absolute (or linear) values.** This shows that sound decays more rapidly nearer the source but, bear in mind that the vertical scale is still logarithmic and therefore does not represent the absolute values of pressure;
- Finally, in Fig 1c, when the logarithmic decibel values are converted back to absolute (or linear) pressure values and plotted against distance on the **horizontal scale in absolute (or linear) values** an accurate understanding as to how rapidly sound pressure attenuates in water is obvious.

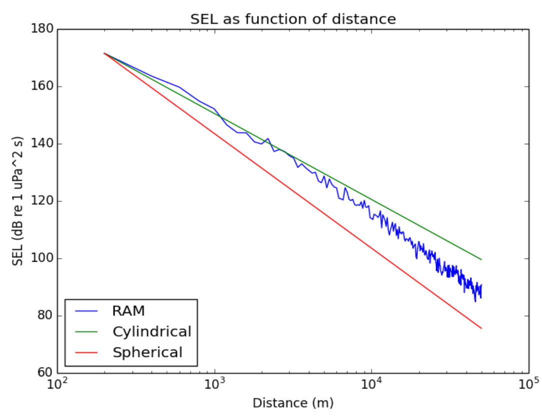


Fig 1a

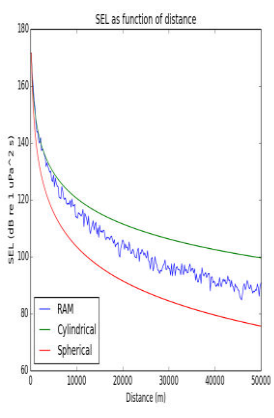


Fig 1b

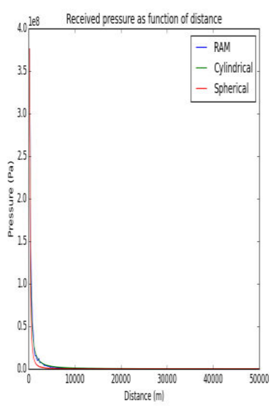


Fig 1c

To find a simple analogy, which demonstrates how quickly pressure drops in a medium, one needs to look no further than **domestic high-pressure water cleaners**, which operate at 2000 psi, the same pressure as seismic sources. These cleaners can be bought at local hardware stores. They are not dangerous weapons and no licence is required to purchase one. However, just like an electric drill, such equipment can be dangerous if used incorrectly.

The effective part of the jet of water is within 20-30cm of the nozzle. It is the pressure at this distance that does the cleaning and could, if the jet came in contact with the body, actually penetrate the skin or cause serious cuts. However, given the **inverse square law**, which means that when the distance from the source doubles, the pressure halves, the pressure very quickly drops off such that the jet would dissipate by about 2-3metres (although the sound could still be heard).

This is effectively what happens in the vicinity of a seismic source. It has always been accepted that if a marine organism is exposed to a seismic source within about 5-10 metres (depending on the organism) then some physiological damage can be expected. However, at greater distances, the impact is unlikely to be physiological but can be behavioural, depending on how that organism perceives the sound.

iv) What sound levels are actually experienced in the near-field (ie close to the source – within about 30m)?

As a result of the rapid attenuation of sound pressure away from the source, as demonstrated above, it is evident that any physiological damage will only occur in the near vicinity of the source. Thus, before considering other sounds that marine organisms are exposed to, the misunderstandings and misinformation regarding oft-quoted source levels must be addressed.

A typical seismic array does not consist of one canister of compressed air (often called an "airgun") that is released at intervals but an array of airguns of different volumes.

As outlined in Caldwell and Dragoset's paper entitled "A brief overview of seismic air gun arrays" published in 2000, "*the sound pressure (amplitude) generated by an air gun array is:*

1. *linearly proportional to the number of guns in the array (i.e., all else being equal, a 30-gun array will generate twice the amplitude of a 15-gun array);*
2. *linearly proportional to the firing pressure of the array (a 4000-psi array will have twice the amplitude of a 2000 psi array); and*
3. *proportional to the cube root of the volume of the array (an 8000-in^3 array will generate about twice the amplitude of a 1000-in^3 array if they contain the same number of guns)*."

In addition to the above source array variables mentioned by Caldwell and Dragoset, the aerial dimensions of the source array also have a significant impact on the resultant source level generated by the array. For example, an air-gun "array" in which all the elements (air-guns) are arranged in a cluster (with relatively short separation between each element) would generate a higher source level than if they are arranged in an array.

Thus, based on the above criteria, the number of air-guns (elements), the firing pressure and the aerial dimensions of a seismic array have significantly more influence on source levels than the volume of the array, which has relatively minimal influence. Despite this, the larger volumes do provide the low frequency components that are so important to achieving optimum imaging of the deeper horizons in the sub-surface geology. The deeper horizons of a geological basin often contain the target horizons and, even when they do not, they are especially important in understanding the geological history of the area.

As in the case of the amplitude levels and frequency of sounds experienced in the neighborhood of a noisy party or rock concert, unless a person is at the event, the high frequency components or even the voices are rarely heard but the "thump, thump" of the low frequency components are. This is because low frequency sounds travel further through most media than high frequency sounds.

In a similar way to a set of organ pipes or the mechanics of a pipe instrument like a trumpet or clarinet, the smaller air-gun volumes produce primarily high frequency sounds and the larger volumes produce primarily low frequency sounds. **It should be noted that the source levels of different volume air-guns (elements) are very similar and in the range of 220 to 230 decibels**. It is mainly the frequency components and hence character of the source signals that are different.

It is useful at this juncture to consider how the above 3 parameters affect source levels in a practical sense. As noted above, the sound pressure (amplitude) is linearly proportional to the number of elements in the array. **However, this only holds true if all the elements occupy the same location.** This, of course, is impossible as the elements are spread over an area, which is typically of the order of 15m by 16m (or more) as shown in the following diagram:

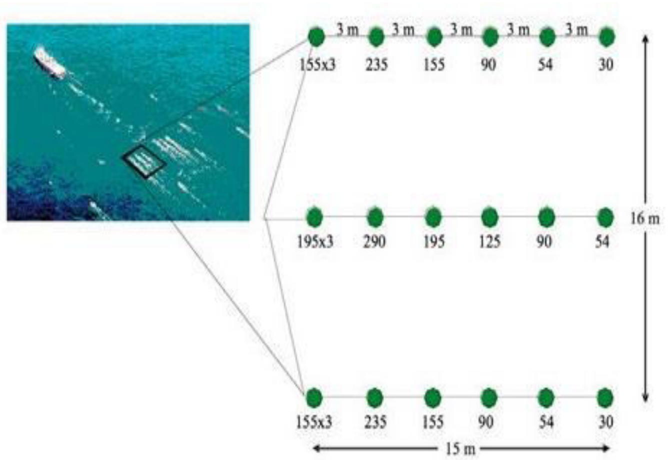
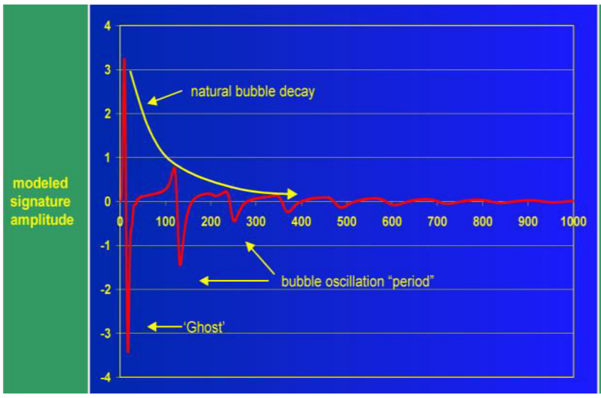


Fig 2 to the left shows a seismic vessel towing two air-gun arrays (plus the streamers, the front ends of which, are showing behind the air-gun arrays). One array, consisting of 3 strings of 24 air-guns is sketched in plan view. It measures 16m (crossline) by 15m (inline). The numbers annotated are in in^3 and the total volume of the array is 3397 in^3.
© WesternGeco. *Source: Landro & Amundsen: http://www.geoexpro.com/articles/2010/01/marine-seismic-sources-part-i*

The key issue in understanding the source levels of seismic arrays is to understand the manner in which the source signatures (ie amplitude and frequency) of the individual elements in the array coalesce (or are summed) to produce the overall source array signature. The diagrams and descriptions on the following page, summarise this process:



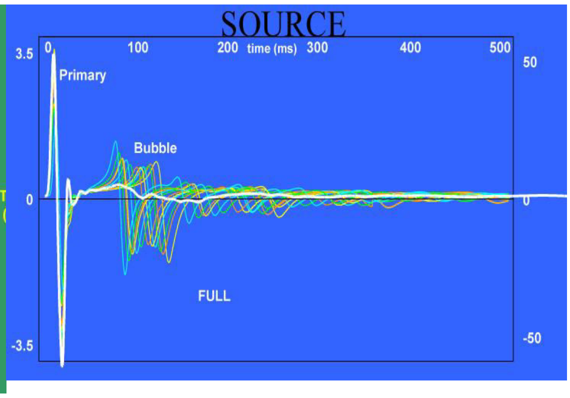


Fig 3a above is a plot of pressure or amplitude (vertical axis) versus time (horizontal axis) of a single air-gun, referred to as an air-gun's pressure signature. It shows the first, or primary, positive pressure pulse due to the initial expansion of the bubble that is created by release of compressed air. The following negative pulse, referred to as the "ghost", is due to the reflection of the initial pulse at the sea surface. The subsequent lower amplitude pulses in red are known as the "bubble train".
Given that the pressure or amplitude of an individual air-gun is proportional to the cube root of the volume, there is not much difference between the primary pressure or amplitude levels of different volume air-guns. However, there are significant differences in the frequency content and hence the periodicity of the "bubble-trains".
Source of Figs 2 and 3: IAGC August 2002 publication: Airgun Arrays and Marine Mammals.

Fig 3b above shows how a series of signatures (ie. primary pressure pulses and bubble trains - shown in different colours) from different volume elements in an array, are summed (or coalesce) to produce the overall source signature (in white) for that array. Note that, due to the different "bubble train" oscillations produced by the different volume elements in the array, the "bubble train" in the signature of the full source array is significantly minimised. This is the main intent of a seismic array – to minimize the "bubble train" so that it or its reflections do not mask or interfere with the reflections of the primary pulse. In addition, as all the primary pulses of the individual elements are summed as if they are at the same point, the amplitude (pressure) of composite signature is boosted compared to the individual signatures. **However, note that in the field, the individual signatures are not summed at the same point.**

The seismic industry reports the source level of its arrays as being 1m from a theoretical source point but, as can be seen from the array diagram in Figure 2, there is no position in the water that is 1m from all the individual elements. **Unfortunately, this gives an inflated value for the source level of an array and often leads to misunderstandings regarding its source level relative to potential impacts on marine life.**

Actual source levels of arrays are of the order of 20dB lower than the theoretical source levels due to the fact that the individual signatures within an array are attenuated due to the distance between the elements before they coalesce. **It should also be noted that a significant amount of the attenuation occurs in the near field (ie within about 30m of the source) because, in general, as the distance from the source doubles, the source level halves.**

In conclusion, the oft-quoted **seismic source levels of 250-260dB** claimed by environmental groups are **never experienced in the vicinity of seismic arrays** with values in the range of **228-242dB being more typical.** Due to the logarithmic scale of decibels, these oft-quoted values mean that the pressure levels experienced in the vicinity of seismic arrays are 8-16 times less than the theoretical models based on all the array elements occupying the same position in space (which, of course, is impossible).

Thus, yet again these groups exaggerate the source levels in their objective to spread fear and confusion regarding the perceived impacts of seismic surveys.

2) Other sounds in the ocean and how they compare with seismic sounds

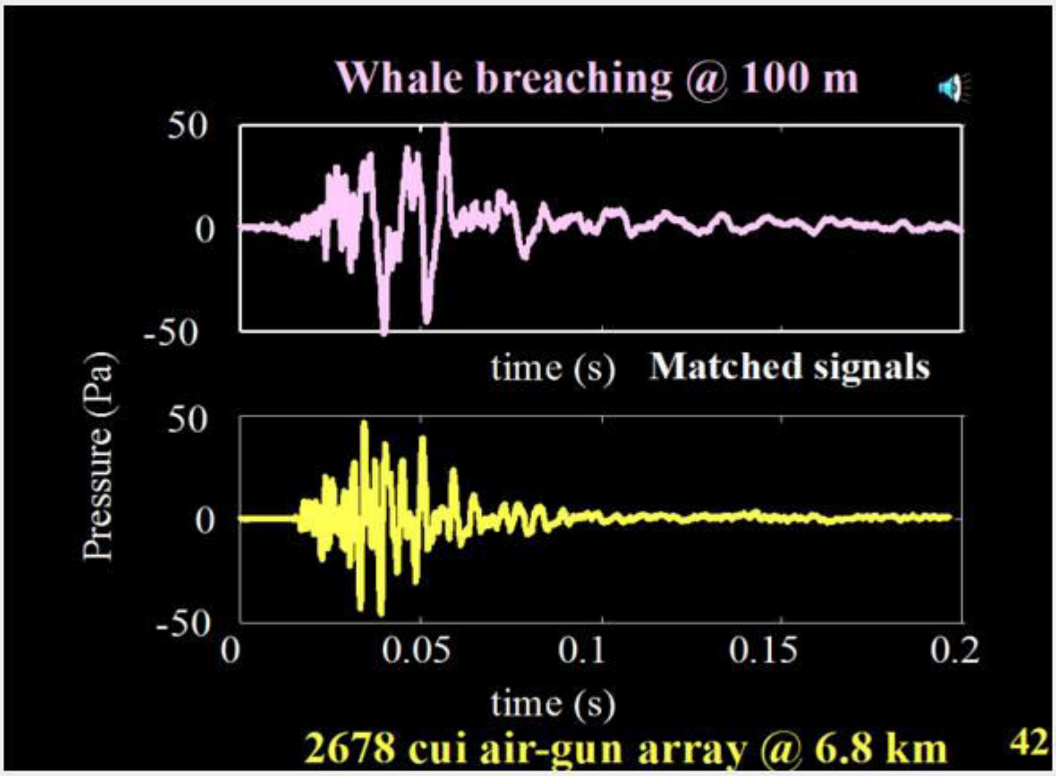
The ocean is not actually a quiet place! This is why animals in the ocean have developed an exceptionally wide range of different sounds that have evolved to enable them to be heard by others of their kind in a noisy environment. The wide array of frequencies, intensities and duration of calls are all designed to take advantage of various communication "niches" in the ocean (in a similar way to different broadcasting frequencies in air). It should be noted that not all marine animals hear the same frequencies equally well. In a similar way to the differences between humans and bats or dogs some marine animals hear well at higher frequencies and relatively poorly at lower frequencies. Others, such as the large whales, hear better at lower frequencies.
In terms of **sound levels**, the following is a brief tabulation of a variety of man-made, natural and biological sounds in the ocean:

Sound Type	**Sound level (decibels)**
Single seismic element (airgun)	220-230 dependent on volume
Seismic array (actual, not theoretical)	228-242
10lbs of TNT	279
Undersea earthquake	272
Volcanic Eruption	255
Lightning Strike	260
Calving/Colliding icebergs	220/250
Sperm Whale	236
Bottlenose dolphin	225
Killer Whale	224
Blue Whale	190
Snapping Shrimp (Individual)	189
Breaching Whale	200
Navy Sonar	235
Echosounders	Up to 230
Fish finding sonar	Similar to echo sounders (see above)
Large ship	200
Pile driving (eg for offshore wind-farms)	Up to 220

Table 2: Typical sound levels in the ocean.

As can be seen from the above tabulation, the sound levels from seismic surveys are similar to many other sounds in the ocean including natural, biological and other man-made sounds. Thus it is false to claim seismic sounds have an adverse impact on the marine environment. Some key points:

i) Sperm whales can vocalise at up to 236dB, which are credited as the most powerful sounds in the animal kingdom (https://www.youtube.com/watch?v=tw7E7owEBm8).
ii) The sound of a Humpback whale breaching is similar to what a marine animal would hear just 128m from the source (https://thenorwoodresource.org.au/article/how-intense-is-the-sound-of-a-breaching-whale/). As shown in the linked article, this distance is calculated from actual recordings of a whale breaching at 100m compared to the recording of a seismic pulse at 6.8km.



Comparison of sound energy levels of humpback breaching and seismic source

Fig 4. Recordings of humpback whale breaching compared to seismic pulse.

While the difference in distances is significant, the inverse square law dictates that the whale sound at 1m (which is what the whale would hear) is the same level as the seismic sound at 128m. Perhaps this explains why humpback whales often approach seismic arrays, as shown in this photograph of a whale in the vicinity of an operating seismic source offshore West Africa.

Fig 5 Humpback Whale near operating seismic source

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iii) The sound levels and spectra of calving/colliding icebergs in the Antarctic are very similar to seismic sounds (https://thenorwoodresource.org.au/article/the-antarctic-waters-are-certainly-not-quiet-and-yet-many-whale-species-feed-there-throughout-the-summer-months/). Unfortunately, the links in the above linked article need updating so the following figure (Fig6) shows some key displays from those links.

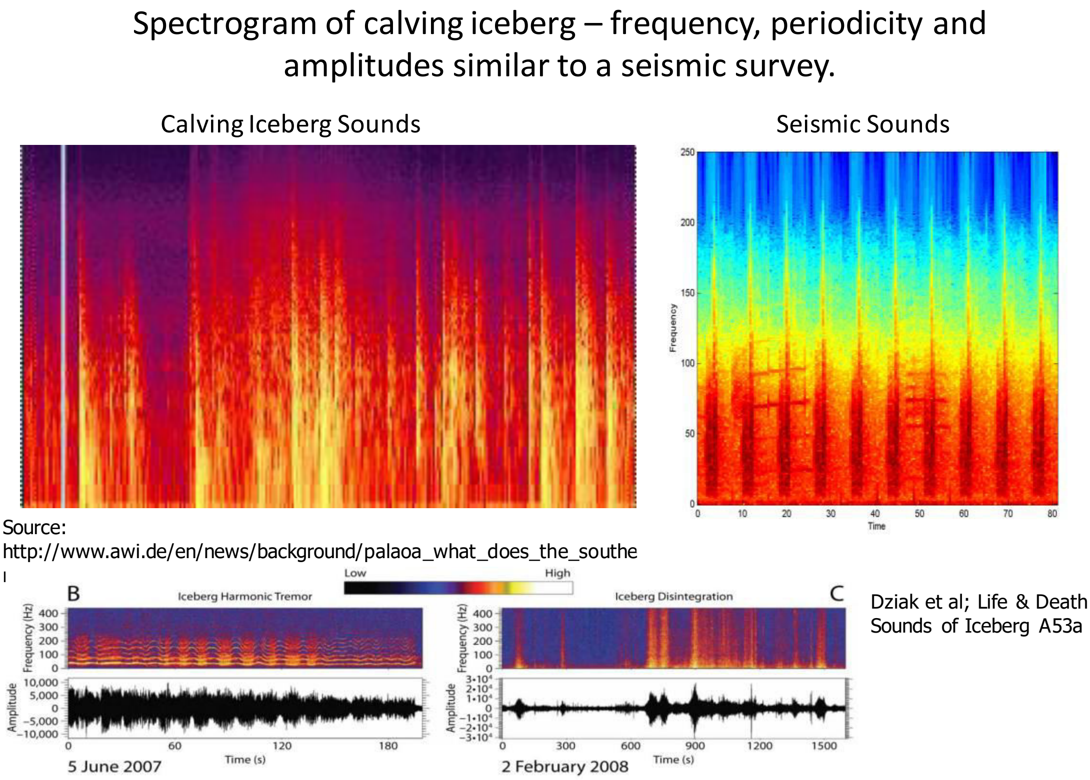

Fig 6: Top panels are sound spectra showing similarity between calving iceberg sounds and seismic sounds. Bottom panel show the sounds made by Iceberg A53a as moved northwards into warmer waters.

During the summer months, these ice-sounds will be at their most intense (and for 24hrs/day, every day, unlike seismic surveys), yet marine life (including zooplankton) flourishes in the area with migratory whales specifically visiting during the summer months to join in the feeding frenzy.

iv) Finally, it is noted that every ship on the ocean has an echo-sounder and many fishing vessels have fish finding sonar (which is based on echo-sounder technology). These emit high frequency signals at levels up to 230dB but there appears to be no concern from environmental groups, the regulators or the fishing industry regarding the potential impact of these sounds. These sounds are generated at similar levels to seismic sounds but, given their higher frequencies which result in more rapid changes in pressure (time between compression and rarefaction in a sound wave is shorter) could be more damaging to marine animals' auditory systems.

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3. A brief review of the wealth of unpublished data collected during seismic surveys often as part of approvals under the EPBC Act or other regulatory process (marine mammal observations, sound level monitoring, aerial surveys, etc)

Unfortunately, this extensive body of facts and information is largely ignored when it comes to reviews of the perceived impact of seismic surveys on marine life. However, it is this basic observational information that should first be considered to plan and conduct further monitoring and/or research to investigate potential knowledge gaps.

Ironically, it is highly likely that more funds have been spent on monitoring (auditing) actual seismic surveys than have been spent researching the potential impacts of seismic surveys on marine life.

Examples of important monitoring/auditing studies conducted in Australia include the studies conducted by Woodside as part of their Maxima 3D seismic survey in the vicinity of Scott Reef, Western Australia. Also, Santos' monitoring programs conducted mainly offshore Tasmania, Victoria and South Australia during 2002-2007. Unfortunately, these studies are rarely fully published in scientific journals and therefore constitute "grey material" in our understanding and assessment of the effects of seismic surveys on marine life. Nevertheless, such studies are a very important part of our knowledge base and should at least be used to formulate and plan research studies or even to check the validity of some of the "one-off" results that have often arisen from research studies, which have never been duplicated.

Some important observations can be made as a result of a balanced understanding of seismic surveys carried out in Australian waters, especially when monitoring/auditing is carried out or when seismic activity is compared with other studies such as whale populations. Observations include:

i) Cetaceans (and even fish) continue to occupy an area (or even 'voluntarily' enter an area) in which seismic surveys are being carried out. This has been clearly demonstrated by:
   - Numerous Marine Mammal Observer (MMO) reports. Unlike the fishing industry, which does not have independent observers assigned to <u>all</u> vessels, <u>every</u> seismic vessel operating in Australian waters must have MMOs on board. In fact, because MMOs also report on all fauna observed in the vicinity of a seismic survey, they now tend to be called Marine Fauna Observers (MFOs). Even though Australia does not have a regular program of collating and analysing MMO reports (like, example, the UK – Stone 2003) the reports show that whales stay in the area while seismic vessels are operating and are quite often sighted within the 2km operational shutdown zone (otherwise, if they moved away, given reasonable sighting distances are about 5km there would be no sightings during seismic survey operations);
   - Passive acoustic monitoring using seabed loggers deployed before, during and after seismic surveys clearly show that whales (and fish) remain in the vicinity while seismic traverses are being acquired. The following figure (Fig 7) shows a 5-day playback of the data recorded by a seabed logger for a survey conducted offshore Western Victoria.

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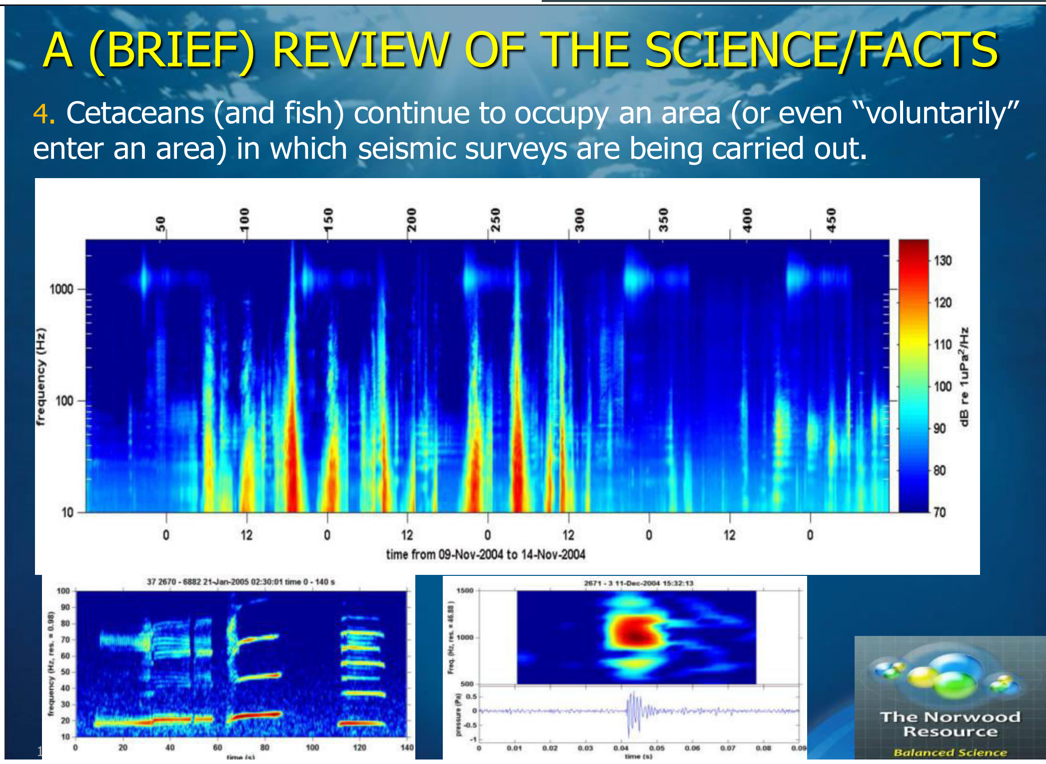

Fig7: Top plot: Seabed logger playback from noon on 9 November to noon on 14 November (5 days in 12hr increments marked on the horizontal axis). Lower plots show a blue whale call (plot duration 140 seconds) and a fish "pop" (plot duration 0.09 second).

This logger was placed roughly in the middle of a survey, which consisted mainly of a series of lines perpendicular to the coastline traversing from shallow to deep water, with a few tie-lines parallel to the coastline.
In the above figure, the vertical axis of the top plot is frequency (in a logarithmic scale from 10Hz to approx. 3000Hz), while the horizontal axis is time (in a linear scale consisting of 120 hrs marked in 12hr increments) and the colour coding represents sound levels in 1Hz frequency bands (ie not the overall amplitude of the sound but the spectral amplitude of the sound).

The 3 key sound sources seen on this plot are:

- seismic traverses (the vertical "peaks" such as the one centred on the first 12 hour marker) which represent the arrivals from a seismic traverse being acquired to/from the coast at a distance from the logger. The peak of the event represents the closest point from the seismic source to the vessel. The following "peak", about 7 hours later indicates that traverse was actually closer to the logger. It is interesting to note that the "peaks" are asymmetrical. This is because sound attenuates more rapidly towards the inshore direction than the offshore direction.
- Blue whale calls, represented by many of the horizontal light blue lines between 10 and 100Hz that are seen right across the plot. The detailed recording of a single blue whale is seen on the bottom left plot.
- The fish "chorus" seen as a series of regular light blue "blobs" at about 1000Hz starting at about 8pm each day (ie dusk) with most of the intensity occurring just after dusk and then tapering off during the night.

Given acquisition of the first seismic line commenced at about 6am on 10 November and the plot starts at noon on 9 November, it can be seen there was no diminution in blue whale calls or the fish chorus once the survey commenced.

A further playback shown below as Fig 8, taken out of the same data set, shows the very recognisable call of a blue whale in amongst the individual seismic pulses which occur every 10 seconds. The blue whale call is clearly not masked and the blue whale clearly remains in the area of the seismic survey.

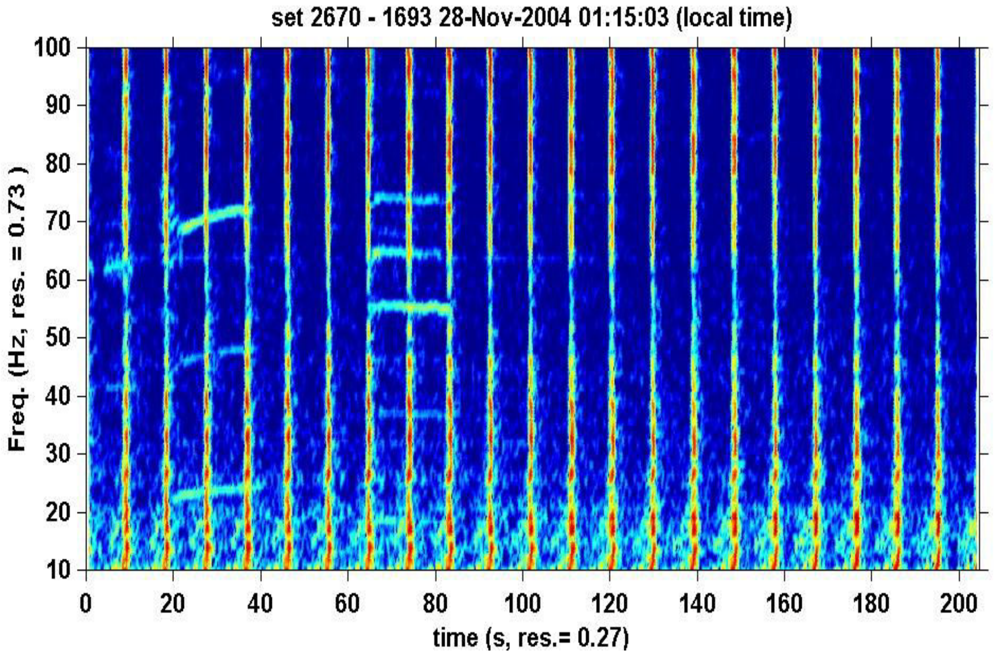

Fig 8: Blue whale calling during seismic survey.

- Aerial monitoring of blue whale movements, conducted during a seismic survey to the west of Kangaroo Island during 2003, clearly showed that blue whales do not move away from the area during seismic operations. Details of the findings can be found in the following link (https://thenorwoodresource.org.au/article/how-do-whales-and-dolphins-react-to-seismic-surveys/)

  The following Fig 9 shows the movements of a group of blue whales relative to the position of an operating seismic vessel. The traverse of the seismic vessel and the path of the blue whales are colour coded to denote the same time periods. This example shows that the pod of whales did not respond to the approaching vessel. Other instances were observed, none of which showed movement away from the approaching vessel even down to within the “power-down” zone, which was 3km in 2003, which triggered a shut-down of the source.

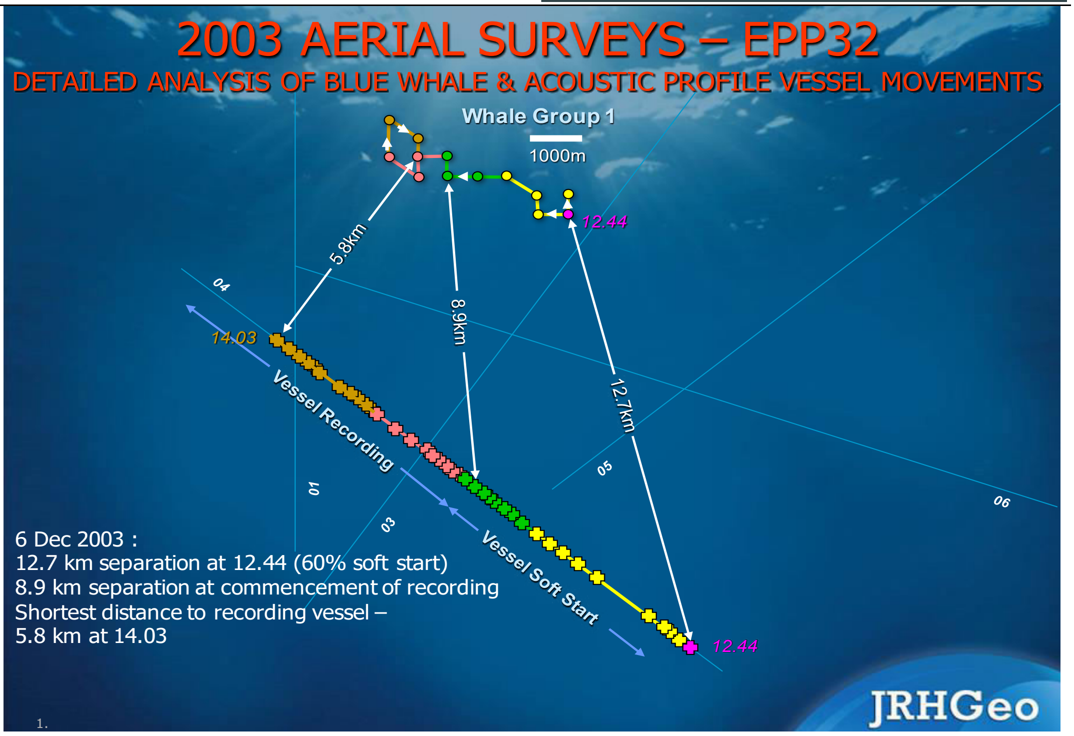

Fig 9: Movement of blue whales relative to approaching seismic vessel.

ii) Areas where the increase in whale populations have obviously not been impacted by petroleum activity as they have increased at very close to the maximum growth for the species (eg the Humpback Whale population of NW Australia; Southern Right Whale population in the Bight).

Despite the waters of the Great Australian Bight being described as "pristine" by many of the environmental groups who wish to stop exploration in the area, a significant amount of seismic exploration has already been conducted there since the 1960s. This is discussed in the following linked article: https://thenorwoodresource.org.au/article/is-the-engo-campaign-against-bps-bight-drilling-program-deceptive/. Note, in particular, Figure 2 in the linked article showing the 122,000 km seismic coverage and 12 wells pre-2011 in the Bight as well as the narrative indicating the significant seismic activity since then.

For environmental groups to claim on the one hand that seismic activity adversely impacts marine organisms but on the other hand claim that the area where all this activity has been carried out is "pristine" is surely testament to the lack of impact of seismic surveys.

In addition to this, population counts of Southern Right Whales (SRW) at the Head of the Bight, have shown that the SRW population which visits that area is growing at 7% per annum, which is close to maximum for the species.
Meanwhile item 3 of the link https://thenorwoodresource.org.au/article/the-right-to-protest-or-lobby-should-not-be-abused/ demonstrates how the humpback whale population on the NW Shelf of Australia has recovered at the same time that the NW Shelf was developed into an extremely important petroleum province for Australia. The last map of the series (2012) is shown below:

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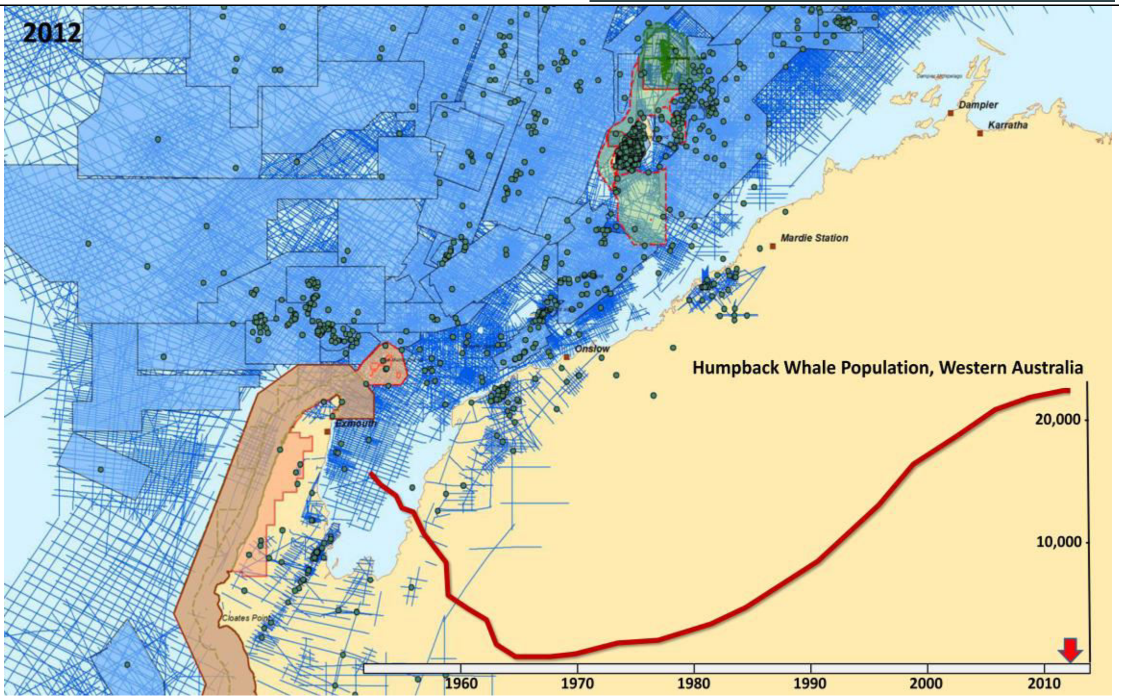

Fig 10. The last of a series of 60 maps showing humpback whale population growth and petroleum exploration activity (seismic coverage and wells) since 1953 on the NW Shelf of Australia.

It clearly demonstrates that petroleum activity, including extensive seismic activity, has had no impact on the humpback whale population growth which is close to maximum at between 10 and 11%, especially given the population growth has been similar on the East Coast of Australia. Very limited seismic exploration and no petroleum development has occurred North of Eden on the East Coast of Australia. On the contrary, it was the impact of whaling in the 50s/60s that decimated the population to approximately 600 in the mid-60s. Note that although the hunting of humpbacks became prohibited in the 60s, it was not until 1978 that the last whaling station in Australia (Albany) was shut down. This was a long time after the seismic industry had stopped using explosives as the seismic source.

In summary, the above is but a very small proportion of the available information that is not published in peer-reviewed journals but which must be considered in conjunction with the findings of peer-reviewed and published research projects.

4) A brief review and critique of the published research (bearing in mind that research, which fails to find impacts is unlikely to be published)

One of the most comprehensive and detailed published studies of published research was by Carroll et al, 2016 "*A critical review of the potential impacts of marine seismic surveys on fish and invertebrates*" (doi.org/10.1016/j.marpolbul.2016.11.038).

A key finding of this review was that, in the authors' words, it had*"...identified scientific evidence for high-intensity and low-frequency sound-induced physical trauma and other negative effects on some fish and invertebrates; however, the sound exposure scenarios in some cases are not realistic to those encountered by marine organisms during routine seismic operations. Indeed, there has been no evidence of reduced catch rate or abundance for fish with catch observed to increase, decrease or remain the same.*"

Experience around the globe and also here in Australia shows that fisheries and seismic activities can and do co-exist. In addition, when one has a detailed understanding of the topic, including the physical aspects of how the sound is generated, how quickly it attenuates (even in water!) and how it compares to other natural sounds in the marine environment (as outlined earlier in this submission), one is not surprised that this is the case.

One basic question that should be considered, especially given this inquiry is focussed on the perceived impact of seismic activities on fisheries, is how the health of fisheries in areas not exposed to seismic activities compares with those areas exposed to seismic activities. Only the fishing industry and fishing regulators can provide the rigorous analyses that will answer this key question but, as far as we understand, no such comparisons have been published.

In fact, one very important area of research that would assist in understanding the perceived impacts of seismic surveys on fisheries would be to compare the catch per unit effort (CPUE) in various fisheries with the occurrence of seismic surveys in order to measure actual impacts on fisheries. For example, Parry, G. D., 2006 "*The effect of seismic surveys on catch rates of rock lobsters in Western Victoria, Australia*". Although relatively few in number (mainly due to the difficulty of obtaining accurate and reliable CPUE information) a number of studies have been carried out in various parts of the world to compare the variations in catch per unit effort (CPUE) with the occurrence of seismic surveys. None of these studies have demonstrated seismic surveys have a consistent impact on fisheries as mentioned by Carroll et al, 2016.

Most studies in the published domain have been designed to show that various life stages of fish may be physically affected by exposure to seismic surveys (rarely, if at all, have the studies been designed to demonstrate no impact). The literature abounds with such studies but, unfortunately, few, if any, results are duplicated and in all cases the fish subjects were very close to the seismic source or subjected to exposures that are virtually impossible to occur in the vicinity of a typical commercial seismic survey.

After over 50 years of worldwide seismic surveys and more than 30 years of extensive peer-reviewed scientific research, there remains no evidence that sound from properly mitigated seismic surveys has had any impact on marine populations. However, there have been a number of peer-reviewed published research studies, which unfortunately have been based on either flawed scientific methodology or on exposing marine organisms to sound levels that are very clearly not typical of seismic surveys. These are cited often and hence confound the whole issue of what the science, research and monitoring/auditing of seismic surveys reveal.

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Examples of unrealistic experimental methodology and sound exposure scenario include:

- McCauley et al, 2003 "*High Intensity anthropogenic sound damages fish ears*";
- Engas et al, 1996 "*Effects of seismic shooting on local abundance and catch rates of cod*";
- Aguilar de Soto et al, 2013 "*Anthropogenic noise causes body malformations and delays development in marine larvae*"; and even more recent studies such as
- Fitzgibbon et al, 2017 "*The impact of air gun exposure on the haemolymph physiology and nutritional condition of spiny lobster, Jasus edwardsii*"; and
- McCauley et al, 2017 "*Widely used marine seismic survey airgun operations negatively impact zooplankton*".

The following section provides further information to support the statements made above relative to some of the key research on which many parties to the current debate base their understanding of the impacts of seismic surveys on marine life.

i) An oft-cited study, even to this day, is **Engas et al, 1996. "*Effects of seismic shooting on local abundance and catch rates of cod*"** which suffered from methodological and statistical problems. Trawling the same transect for 17 days in a row would surely result in a reduction in catch. The fishing industry surely knows this, as would the seismic industry. In addition, when the daily catch data for the 17 days of the study were finally released just under a decade ago, it was demonstrated that combining the data into "before", "during" and "after" samples obscured the fact that **the catch had reduced before the start of the seismic survey**. This study effectively involved trawling through an area in which a seismic survey was being conducted for 7 days before, 5 days during and 5 days after seismic activities. Even though daily samples were recorded, they were combined into just 3 samples to compare the before, during and after results. Concerns about this study included:
   - Fishing the same small area for 17 days continuously would surely lead to lower catches;
   - It took about 19 years before the basic data for the study was released (one wonders why?);
   - When the daily catch data was analysed, it demonstrated a **downturn in catch before commencement** of the seismic survey. See the second item in the following link (https://thenorwoodresource.org.au/article/is-science-manipulated-by-environmental-groups-and-some-researchers/):

ii) **McCauley et al, 2003. "*High Intensity anthropogenic sound damages fish ears.*"** This study was originally conceived as a behavioural study in which a seismic source approached caged pink snapper from a distance and the behaviour of the snapper was videoed. The source went right over the cage which as in 19m of water, thus exposing the fish to extremely close pulses (less than 10m) that would not occur in a typical commercial survey. Concerns about this study included:
   - The experimental methodology was not set up to measure the distance at which physiological damage would occur to fish ears;
   - It is generally accepted that damage can occur at 5-10m but, due to the manner in which sound attenuates in water (eg. sound pressure levels at 20m are 4 times lower than at 5m or half that at 10m), the study did not identify the distance at which the onset of damage occurred; and
   - Thus, this study simply confirmed what was already known, especially given typical surveys do not operate in water depths of less than 20m

iii) **Aguilar de Soto et al, 2013. "*Anthropogenic noise causes body malformations and delays development in marine larvae.*"** This study exposed scallop larvae in a small tank to sound levels that are totally unrepresentative of the levels they would be exposed to in the open ocean. There are many issues with this work including:

- Pulses were at 3 sec intervals, not the normal 10sec intervals in most seismic surveys;
- Given the pulses had been recorded from pulses arriving from an actual seismic survey at "tens of kilometres", which were amplified, the signal length of 1.5 secs meant that the exposure time (or duty cycle) was 50% of total time compared to the exposure time (duty cycle) in typical seismic surveys being 0.5%;
- Small tank (2m diameter by 1.3m deep);
- Stationary source, not a moving source, thus maintaining maximum sound exposure for long periods;
- Minimum exposure time was 24 hours at continuous maximum exposure levels, whereas that from a passing seismic survey would be for less than half an hour and maximum exposure levels would only be for a few minutes;
- The authors state that the intended exposure sound pressure level was 160 dB rms re 1 μPa but that the overall exposure level due to near field effects was closer to 195–200 dB rms re 1 μPa. Thus, not only is the exposure level in this study significantly higher than scallop larvae would be exposed to during seismic surveys, it would be for significantly longer; and
- Finally, it took 66 hours of continuous exposure to lead to malformations and it is noted that no malformations resulted in the scallop larvae exposed to 24hrs of continuous intense sound.

  The first item in the following linked article: (https://thenorwoodresource.org.au/article/is-science-manipulated-by-environmental-groups-and-some-researchers/) provides more detail than the above summary. The interested reader is referred to the comment/discussion section in which the lead author (Aguilar de Soto) commenced correspondence to defend the research but decided she was too busy.

iv) **Fitzgibbon et al, 2017. "*The impact of air gun exposure on the haemolymph physiology and nutritional condition of spiny lobster, Jasus edwardsii*"** This is a more recent study, which unfortunately still suffers from poor methodology as well as sound exposure levels which are unrepresentative of those involved in typical commercial seismic surveys. Concerns with the Fitzgibbon et al paper include:

- Water depths of 5-10m (see narrative to Fig 1); Source depth of 4.5-5.1m. These are not typical water depths or source to receiver distances for seismic surveys. In fact, if the impact was caused as a result of being 5-10m from the source, this is not a new finding but one that has generally been accepted for decades;
- Significant doubt regarding sound exposure levels at less than 40m source/receiver distance. Note the sound attenuation curves in Fig 1 in the paper (Fig11 in this submission) are relatively flat at distances below 40m, which demonstrate that the sensors have been over-driven and hence the sound exposure levels the authors quote as leading to physiological impact are lower than actually source levels.

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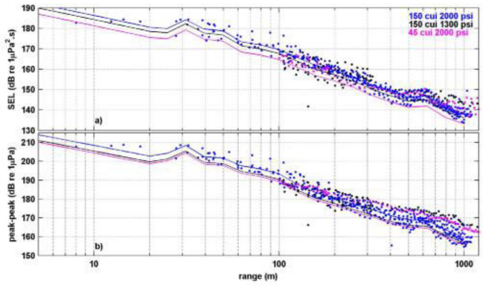

Figure 1. Quantification of sound exposure by range between the air gun vessel and the lobster pots in the 45 in³, 150 in³ low pressure and 150 in³ high pressure air gun exposure experiments. Sound level is expressed in received sound exposure level (**a**) and received peak-peak level (**b**) in the three trials with range expressed logarithmically.

Fig 11: Sound attenuation curves as reported in the Fitzgibbon et al 2017 paper.

Note that, although the interpretation of the sound level curves continue to have a slope after the peculiar reversal between 20 and 30 metres, the actual plotted values (in blue dots) remain roughly horizontal below 40m.
How this figure could have been accepted for publication after a rigorous peer-review process obviously calls into doubt the effectiveness of the peer-review procedure adopted for this paper;

v) **McCauley et al, 2017. "*Widely used marine seismic survey airgun operations negatively impact zooplankton"*** This piece of research clearly contradicts well known facts such as barnacle larvae (zooplankton!) settling and growing on seismic trailing equipment during operations (ie these zooplankton have been exposed to seismic sounds before settling and thrive on the trailing equipment during operations).

Growth of zooplankton on trailing equipment represents one of the biggest problems encountered during seismic operations especially in warmer waters such as the NW Shelf. See following figure, which demonstrates the problems encountered when trailing equipment is retrieved:

Fig 12. Barnacle growth on streamer depth controller.

In addition, considerable concern has been expressed about the experimental methodology as follows:

- Small sample sizes;
- The higher proportion of dead plankton remained constant out to 1200m from the sail-line. This defies any sound exposure impact theory, in which one would expect a decrease in mortality away from the source, given the exposure level at 1200m would be significantly lower than the sound exposure level at, say 100m;
- Large day-to-day variability in both baseline and experimental data; and
- The large number of speculative conclusions that appear inconsistent with the data collected over a two-day period.

However, even if the results of the McCauley et al 2017 study were to be replicated, which is unlikely, an investigation by CSIRO, published as Richardson et al. 2017, demonstrated that, in a typical seismic survey which resulted in the mortality rates reported by McCauley et al, the fast growth rates of zooplankton and the current-driven mixing of plankton from outside the survey area would allow the zooplankton populations to recover in a few days.

It is interesting to note that the Australian Institute of Marine Science (AIMS) is planning to re-investigate the impact of a (commercial) seismic array on zooplankton in a significantly more rigorous fashion.

Unfortunately, despite extensive research and experience over 30 years, research projects continue to be published which present "outlier" results that contradict all previous results. The methodology leading to these new results is invariably questioned and this leads to the conclusion that rigorous research should be conducted before the results can be accepted. For example, this is currently happening on the NW Shelf with the NWSS (North West Shoals to Shore) program conducted by AIMS (Australian Institute of Marine Science). Unfortunately, in the meantime, the incomplete and "outlier", but published, results being investigated by AIMS are considered final by those who wish to prevent seismic surveys.

b) the regulation of seismic "testing" in both Commonwealth and state waters

The only comment TNR wishes to make in this section is that we are confident that the regulation of seismic surveys in Australian waters represents one of the most rigorous and precautionary systems in the world. However, we would suggest that this regulatory regime is actually no more successful in protecting the marine environment than less rigorous regulatory regimes and the reason for this is as outlined in previous section in that the risks to the environment are not as significant as claimed if one takes to time to understand the facts, science and research available after 50 years of seismic surveys using compressed air.

c) the approach taken to seismic "testing" internationally;

It was not until the 1990s that societal concerns, triggered by marine mammal strandings attributed to navy sonar, arose about the potential impact of seismic surveys on marine life. This resulted in the introduction of regulatory enforceable mitigation measures in various jurisdictions around the world. The UK's JNCC were the first jurisdiction, in 1998, to issue statutory marine mammal mitigation measures for use during seismic surveys with a set of guidelines, which had been in voluntary use since 1995. Australia followed in 2001 with guidelines, which had been developed in 1999 and applied voluntarily from that time. Other jurisdictions such as Brazil, Canada, California, Gulf of Mexico, New Zealand and Sakhalin had also developed mandatory guidelines by the mid-2000s. The notable omission from this list is Norway, which due to the fact that whaling still continued in Norway, presumably considered the development of mitigation measures to avoid potential impact to marine mammals was unnecessary.

One is left to ponder how populations of marine mammals thrive in Norwegian waters compared to UK waters. Based on the thriving tourism industry, especially cruises along the Norwegian coastline (actually through petroleum exploration/development areas) which is very dependent on the health of the environment and sights to be seen (including marine mammals), one is left to conclude that marine mammal populations in Norway are not impacted by seismic surveys.

Despite not issuing guidelines covering marine mammals, the Norwegian Government has been very supportive of the petroleum and fishing industries co-existing and, in 2014, Norway's Fisheries and Petroleum Departments did publish a guide entitled "*Implementation of seismic surveys on the Norwegian Continental Shelf*". This focussed on the coexistence of the petroleum and fishing industries, two of Norway's most important industries, and did not address marine mammals. One very important section of this guide states:
"*Coexistence means that both industries adapt to each other, and experience shows that fisheries and petroleum activities can coexist. Coexistence has not been without problems but with assistance from Government the industries have arrived at mostly amicable solutions.*"

Most of the published research into the potential impacts of seismic surveys on marine life by the late 1990s had been conducted on fish, eggs and larvae. This research supported the generally agreed notion that physiological impacts would only occur within 5-10m and that, due to behavioural responses, there would only be temporary displacement of fish from the survey area. Thus, fisheries were not considered in the guidelines and most consultations with fisheries revolved around the issue of temporary loss of catch.

However, the impacts on marine mammals were less well covered in the published literature and therefore less well understood even though the voluntary monitoring and anecdotal evidence that resulted from seismic operations indicated that potential impacts on marine mammals were minimal (eg humpback whales and dolphins coming into close proximity of the source and dolphins riding vessel bow waves while the seismic source was active). Even though there was no evidence to suggest that marine mammals had ever been adversely impacted by seismic survey sounds, the guidelines tended to be precautionary. Indeed, given the guidelines in the different jurisdictions were developed on the basis of the same body of science and research, the differences in mitigation measures tend to demonstrate the degree of precaution applied on the basis of information that is far from definitive.

Even though the steps/stages of mitigation are similar throughout all the guidelines, the specifications for each step/stage could be very different. Examples include:

- Pre-shoot observations ranging from 30 minutes to 90 minutes. A seismic vessel typically travels at 8-9km/hr thus, in the worse case scenario, one is looking out for animals about 12km from where the source is activated for the soft start;
- Soft starts (ie ramping up the source from lowest to operational level) ranging from 20 minutes to 45 minutes;
- Shut down distance (if marine mammal sighted within the shut down zone) ranging from 500m to 3000m (Australia's 3000m was subsequently reduced to 2000m in a 2008 update). It is noted that, even if an animal moves into the exclusion zone while the source is active (ie is not avoiding the source), only the UK guidelines allow seismic operations to continue;
- In addition to the above very prescriptive mitigation measures, the species of concern are quite different throughout the jurisdictions. For example, the Australian guidelines do not include dolphins whereas most of the others do (quite pragmatic as it would be very frustrating to have to shut-down operations every time dolphins come to ride the vessel's bow wave, especially as they can vocalise at 225dB which is very similar to seismic source levels).

Since about 2007 it has been possible to harmonise the guidelines in the different jurisdictions on the basis of the best available science and a rigorous review of that science. This came in the form of Southall et al, 2007 "*Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendation*" published in Aquatic Mammals Vol 33, Number 4.

Unfortunately, despite a subsequent update, the various guidelines around the globe are still quite different although there is a potential move by IOPER (International Offshore Petroleum Regulators) to try to agree on a consistent set of global guidelines.

A similar review of the science pertaining to fish has been published by Popper et al, 2014 entitled "*Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*". However, a significant volume of fish research has been published since 2014, including some work by Popper et al in 2016, which tends to contradict the exposure levels mentioned in these guidelines. Given some of this research has demonstrated that there are no impacts at the exposure levels mentioned in the guidelines that generate impact, it is likely that these guidelines will need to be updated very soon.

In summary, the approach taken to regulating seismic surveys internationally is highly variable, not always based on science and research and always precautionary.

d) any other matters

One of TNR's key concerns is that the seismic industry is wrongly accused by environmental groups for causing adverse environmental impacts to the marine environment, regardless of the facts and science. This is despite, as per BOEM's analysis, there being "***....no documented scientific evidence of noise from air guns in geological and geophysical (G&G) seismic activities adversely affecting marine animal populations or coastal communities***".

What is even more disturbing is that these groups appear to ignore the harm done to the marine environment by other ocean users such as the fishing industry and the shipping industry.

Many environmental groups mislead the public by claiming that seismic surveys have a negative impact on the marine life, on the one hand, and ignoring the impacts caused by other ocean users on the other. Thus, these environmental groups lack credibility in the eyes of those who understand these matters but, unfortunately, their objective is simply to spread fear and confusion among those who are unaware of the facts and science.

i) Strandings

One area that environmental groups exploit with no consideration of the facts is the issue of cetacean strandings, although they remain very quiet when strandings occur which they cannot possibly blame on seismic surveys (because no seismic vessels were operating in the area). TNR has published two articles on strandings with the latter one found at the following link: https://thenorwoodresource.org.au/article/cetacean-strandings-a-plea-for-honesty/

The sperm whale strandings offshore Ardrossan in Dec 2014 was a classic example of environmental groups "not wanting the facts to get in the way of a good story". Even though these sperm whales stranded on the eastern coast of the Yorke Peninsula and there were two peninsulas and hundreds of kilometres of water between the stranding site and the area a seismic vessel was operating in the Bight, they still made a big issue of blaming the seismic survey.

As a result of a public outcry driven by the wild accusations of environmental groups, NOPSEMA did carry out an investigation and arrived at the conclusion that "***no evidence was found to suggest there was a likely correlation between offshore petroleum activities undertaken in the region and the strandings***".
This was a classic case of the basic science being ignored and the environmental groups using false claims in their attempts to achieve a media-driven objective that was totally misinformed.

A simple understanding of the basic science and facts should have avoided what can only be described as a misinformed media frenzy:

- the significant distance between the seismic survey operations and the strandings;
- even if the distance had been significantly shorter other factors should have been considered such as:
  - sperm whales are invariably sighted by Marine Mammal Observers (MMOs) behaving normally in the vicinity (ie within 5km) of operating seismic vessels;
  - In fact, prior to the Ardrossan strandings, 700km away (as the crow flies!) two sightings of sperm whales had been recorded by MMOs on the seismic survey in the Bight. No unusual behaviour was observed;
  - Analysis of MMO reports have demonstrated that sperm whales are relatively tolerant of seismic survey in the area;
  - This is probably not surprising given sperm whales vocalise at sound levels similar to seismic pulses at 1m (ie 235dB) and hence significantly higher than the seismic sounds a sperm whale would hear even at a few tens of metres from the source.

In addition, a significant amount of effort has been expended, especially in areas such as Tasmania and New Zealand, where stranding events are frequent (and, incidentally, offshore seismic surveys are infrequent), to see if there is a relationship between the timing of seismic surveys and stranding events. **No correlation has been found.**
A particularly relevant analysis was by Evans et al 2005 published in Biology Letters Vol 1 Issue 2 entitled "*Periodic variability in cetacean strandings: links to large-scale climate events,"* which examined cetacean stranding data from 1920 to 2002 (a total of 639 stranding events involving a variety of taxa) and found a clear 11-13 year periodicity in the number of strandings which correlated positively with climatic events which also affected oceanic conditions.

Meanwhile, even though environmental groups around the world have made a concerted effort to link seismic surveys to stranding events, it is remarkable how most have ignored the impacts of other ocean industries on the marine environment despite there being tangible evidence that impacts have occurred. These include "by-catch" and ship-strikes. However, TNR does recognise the recent work of WDCS (Whale & Dolphin Conservation Society) and WWF (World Wildlife Fund) in trying to bring the issue of ship-strikes to the fore. However, despite these efforts, the claims of environmental groups in general would lead the public to believe that the impact of seismic surveys on marine life is far greater than the impact of by-catch and ship-strikes when this is totally without foundation.

ii) "By-catch"

This is the term given to the unfortunate capture and subsequent death of cetaceans and non-target fish in fishing equipment, which is recognised as a major problem around the world. Another euphemism that could be used to describe this would be "collateral damage".
The International Whaling Commission (IWC) (https://iwc.int/bycatch) recognises this issue as a serious problem and estimates that "***at least 300,000 cetaceans are caught in this way every year. This equates to more than 800 whales, dolphins or porpoises each day, and explains why by-catch is now seen as by far the single most serious, direct threat to cetaceans.***"

In addition, it is estimated that at least 600,000 seals & sea-lions perish in fishing gear each year as well as countless seabirds

It is also highly likely that non-target fish by-catch is a far more serious problem in adversely impacting the marine environment than the impact on marine mammals. It is a well known fact that seabirds are invariably seen following fishing vessels whereas they are not observed following seismic vessels

The following image is taken from recently published article in Eco Magazine entitled "Millions of seabirds rely on discarded fish" which covers a study conducted by the University of Exeter scientists who estimate that 267,000 tonnes of fish were discarded in the North Sea in 2010 – enough to feed 3.45 million birds.

Millions of Seabirds Rely on Discarded Fish

University of Exeter   POSTED ON NOVEMBER 11, 2019   37

Fig 13. Image from Eco Magazine article "Millions of seabirds rely on discarded fish". The original article can be found at https://onlinelibrary.wiley.com/doi/full/10.1111/faf.12422

It is rather obvious that the impact of by-catch, evidence of which is seen every day by marine users, has a much greater impact on the marine environment (and, in fact, fisheries) that seismic surveys could possibly have.

The image above leads to another issue that also has a greater impact on marine life than seismic surveys, especially bearing in mind that seismic surveys travel slowly (at about 4 knots) and actually have a "built in" alerting signal, whereas fast moving ships of all types travel at 20-30 knots and are known to cause collisions and deaths in the cetacean population.

iii) Ship strikes

While the extent of this problem is sketchy and a global death toll has not been estimated as far as we are aware, it is evident that it is recognised (https://iwc.int/ship-strikes) as a global problem.

As stated on the IWC website: "***Most reports of collisions between whales and vessels involve large whales, but all species can be affected. Collisions with large vessels often go unnoticed and unreported. Animals can be injured or killed and vessels can sustain damage. Serious and even fatal injuries to passengers have occurred involving hydrofoil ferries, whalewatching vessels and recreational craft.***"
Examples have been reported from many parts of the world, including:

- North Atlantic Right Whales in the Bay of Fundy;
- Humpback whales and fast ferries in Hawaiian waters
- Bryde's whales in Hauraki Gulf, NZ.

Key issues related to the vessels include i) vessel speed; ii) size and type of vessel and iii) visibility.

Despite vessel speed being identified as one of the key factors in ship-strikes, the mix of fast ocean-going ships and increasing whale populations has meant ship-strikes are on the increase. It is noted that, even the cruising industry (enjoyed by many who care passionately about the environment) is not immune from ship-strikes. Cruise ships are very large and tend to travel at high speeds between ports of call at night when visibility is low. In some and probably fairly rare instances compared to glancing blows, whales can be stuck head on and carried on the bow of the ship well beyond the collision location, as shown in the following image on the IWC website:

Fig 14: Large dead whale on ship's bow. Courtesy of the IWC website

Thus, as summarised in this section, TNR is of the view that the media-driven claims that are adopted by environmental groups are simply not credible when one considers other threats to the marine environment when facts, science and research are taken into account in a balanced way. Furthermore, giving "**fishing kills fish (and, actually cetaceans!)**" and "**ocean cruising kills cetaceans**" we can well understand why environmental groups are reluctant to campaign against such activities.

D. Summary and Conclusions

We sincerely trust that those committee members who have taken the time to better understand the facts, science and research regarding marine seismic surveys, will realise why Gary Gray said what he did in 2013 and BOEM arrived at the conclusion that ***"there has been no documented scientific evidence of noise from air guns in geological and geophysical (G&G) seismic activities adversely affecting marine animal populations or coastal communities***".

Furthermore, we urge all committee members to view the attached video and, where possible, visit an operating seismic vessel to witness first hand how a seismic survey is conducted. We are convinced that such a visit would be an "eye-opener" for many and would assist in demonstrating how the claims of environmental groups and even some fishing organisations are simply not credible.

Finally, TNR thank you for the opportunity to place a balanced analysis of the facts, science and research in the public record and would be very pleased to provide additional information to the committee as required. Representatives of TNR also look forward to giving testimony at any Public hearings in Adelaide organised by the committee.

Yours sincerely

John Hughes
Public Officer
The Norwood Resource

Attachment: Video of active seismic source taken from workboat (above/below water)

http://www.aph.gov.au/~/media/Committees/ec_ctte/SeismicTesting/TNR%20Submission%20Att%201%20Source_Below.mp4