clean ocean foundation

South-West Coast Scientific Group

Response to the Consultation on the Southern Ocean Region Proposal for Offshore Renewable Energy.

Australian Government, Department of Climate Change, Energy, the Environment and Water

South-West Coast Scientific Group

The South-West Coast Scientific Group of the Clean Ocean Foundation comprises three retired academics, a Marine Biologist, a Medical Academic and a Physicist. We have a combined 50 years' experience in Marine Sciences and 35 years in evaluation of research for policy development.

We declare an interest as surfers, whale and bird watchers, and recreational fishermen. We have a strong interest in our marine environment but recognise the urgency of halting global warming.

The Southern Ocean region is not a recognised geographical region nor is this term used locally. The Southern Ocean spans the globe and reaches from Antarctica to Australia, Southern Africa and South America. The term which better describes the region spanning South Australia and Victoria is the Bonney Coast Upwelling, an area of unique ecological importance for all marine life, and especially for Blue Whales and seabirds. The Bonney Coast Upwelling is described in detail later in the text.

Professor James Dunbar
Associate Professor Laurie Laurenson
Dr Michael Coates

Warrnambool
Victoria 3280
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Cover Photo: The endangered *Northern Royal Albatross*
Courtesy of BrettJarrett@bayofwhalesgallery.com

Executive Summary.

Offshore wind farms will make an important contribution to Australia's move to renewable energy.

Current Government policies for Blue Whales and Seabirds indicate that the Bonney Coast Upwelling from Robe to Cape Otway is far too biologically significant for the risks from the establishment of wind farms.

If the Minister declares in favour of renewable energy over the environment, some risks need to be mitigated. They are:

- Damage from turbines. Refined risk mitigation strategies for whales and birds by undertaking and using the information from specifically commissioned baseline surveys;
- Seismic testing: use of the extensive existing 2D survey data (see Figure 1 on page 13);
- Construction methods that pose a significant risk to marine life, for instance, pile driving;
- Disruption of whales' migration, feeding and calving from shipping through collisions and noise;

The Proposal needs to demonstrate the benefits from the wind farm for the South-West of Victoria.

Preamble

"We are hurtling towards disaster, eyes wide open.." UN Secretary General.

Australia is particularly prone to the consequences of global warming. The climate is now hotter by 1.1ºC. Already we see record wildfires, record breaking temperatures, rising sea levels and extreme climate events such as flooding in Queensland.

The oceans are near a tipping point. Polar ice is melting at an alarming rate, oceanic currents driven from Antarctica are weakening, the sea is 3ºC warmer and increasingly acidic.

The United Nations insists that deep, rapid and sustained emissions reductions are needed now. Based on the advice that he gets from the best scientists in the world, including Australians, UN Secretary General António Guterres has repeatedly spoken out with rare honesty about what needs to happen. "We are hurtling towards disaster, eyes wide open," he has warned[18].

The Director of the International Energy Agency has said "Development of new oil and gas fields must stop this year if the world is to stay within safe limits of global warming and meet the goal of net zero emissions by 2050."

The Australian Government aims to have 83% of the Australian national electricity grid running on renewable energy by 2030. Renewables already provide 36% of the generation. Solar and wind will be the largest sources of renewable energy and set to grow from approximately 50GW to

250GW between now and 2050[1]. Victoria's wind targets are over 2GW by 2032, 4GW by 2035 and 9GW by 2040.

Offshore wind farms can support larger turbines, have stronger winds and avoids the onshore "not in my backyard" reaction.

Apart from during the construction stage, recreational and commercial fishermen are unlikely to be disadvantaged. Wind farms can act as reefs and quasi-marine parks, increasing some stocks[20].

Wind farms emit no greenhouse gases during operation, emit no air pollutants and use virtually no water.

The Clean Ocean fully supports the move to renewable energy generated from offshore wind power.

Offshore renewable energy infrastructure area proposal: Southern Ocean region off VIC and SA.

The part of the Bonney Coast Upwelling in the proposal extends from Warrnambool, Victoria, to Port MacDonnell, SA. The Australian Government consultation document recognises the international significance of the natural environment in this region, including the Bonney Coast Upwelling that is highly important for biodiversity and ecosystem function. It is stated that the marine environment as a whole should be considered before any decision to declare is made. Significant wildlife includes birds, cetaceans, and rays [sic]. According to the consultation document, the project proposals in Commonwealth water must not be inconsistent with recovery plans for relevant matters of national environmental significance or be likely to interfere with long term conservation of threatened or endangered seabird species[12].

The Clean Ocean Foundation cannot support renewable energy projects between Robe and Cape Otway in the proposal's current form. We are particularly incredulous that such a project, intended to ostensibly lower greenhouse emissions is proposed at the same time the Minister is considering allowing exploration for fossil fuels in the same area!

The Department's own Conservation Management Plan for the Blue Whale 2015-2025.

The Endangered Blue Whale (Courtesy of BrettJarrett@bayofwhalesgallery.com)

The Blue Whale Conservation Plan lists noise and vessel disturbance as threats. Maintaining and improving existing legal and management protection, assessing, and addressing anthropogenic noise, and minimising vessel collisions are very high or high priorities for action[6].

On page 28, the Plan describes Biologically Important Areas for the blue whale but states that they are not defined in the EPBC Act. It goes on to describe the area between Robe and Cape Otway as part of the Bonney Coast Upwelling system, recognising it as a key foraging area for whales, dolphins, seals, fish and birds. To be clear, it is the area of the upwelling which is important for feeding shown below in Figure 2 in the Appendix, on page 26 of this document. As Figure 2 shows, this is a uniquely large and rich feeding area of the Australian coast.

On page 44 the first action listed is maintaining and improving existing legal and management protection which would address all threats to the Blue Whale.

The planned area of the wind farm is exactly where most Blue Whales have been sighted[8].

Between 1998 and 2022, approximately 1,700 blue whales were spotted. Other species of whale seen included Southern Right, Fin, Humpback, Pilot, Sei, Sperm, Orca, and four species of dolphin. (Peter Gill, Personal Communication 18th August 2023.)

Birds

The international importance of this area for seabirds is covered on pages 25 to 27. The region proposed for the wind farm is rich in vulnerable and endangered species, some covered by treaties[14].

This area is a feeding ground for 60 species of oceanic birds, 14 of them albatross, including the Shy Albatross, which breeds on three remote islands off Tasmania (Brett Jarrett. Personal communication, 18th August 2023).

Wind turbines are known to kill birds. It is difficult enough to determine the mortality rate on land but it is far more difficult at sea. One estimate puts it at 40 birds per turbine per year but with wide variation between species. It seems that high buildings and power lines result in greater numbers of deaths[11].

The generally-low flight altitude of the bird species is a determining factor. It can also be that wind turbines displace the birds from their natural feeding area with adverse consequences[13].

Australian Government Wildlife Conservation Plan for Seabirds.

Objective 2 lists as a very high priority identifying important habitats and the need to mitigate threats from renewable energy. EPBC Act amendments are to be completed by 2030. Another very high priority is the consideration of habitats in relation to renewable energy.

Objective 2 states that by 2023 a comprehensive sensitivity analysis should be published to mitigate threats from renewable energy[3].

The Clean Ocean Foundation asks where this analysis has been published?

The Clean Ocean Foundation notes that habitat modification by wind farms may adversely affect whale and seabird populations.

In evaluating the evidence and taking the Department's own policies for blue whales and seabirds into account, offshore renewable energy projects undertaken off the Bonney Coast Upwelling between Robe and Cape Otway are incompatible with the Department's own environmentally protective policies.

The Clean Ocean Foundation opposes offshore renewable energy projects off the Bonney Coast Upwelling between Robe and Cape Otway.

The Port Phillip Bay Question.

Why should wind farms be located in the South-West of the State and not in Port Phillip Bay where it would be both much nearer to the users, transmission losses would be minimised, and it would be cheaper to build and maintain?

The Minister will need to work on the social licence given the background of regional and rural disadvantage across many aspects of life. Why should rural people have the disamenity at the expense of their environment?

The consultation document is metro-centric in its thinking. Ross Garnaut in *The Superpower Transformation* paints a bright future for regional centres like Portland[15].

This case for regional development has been missed from the consultation, except for a vague mention of power for the aluminium smelter and for green hydrogen. A much stronger case for the benefits to Portland and surrounding area needs to be made. If the regional case is not made, the local assumption will be of local disbenefits to generate electricity for Melbourne.

The Clean Ocean Foundation asks if the wind farm would generate enough power for the aluminium smelter and for the manufacture of green hydrogen?

The consultation document mentions increased tourism because of the wind farm. After leaving the Geelong Freeway, anyone visiting Portland from Melbourne drives continually past onshore wind farms. At Cape Bridgewater, the visitor drives underneath wind turbines. Looking at wind farms 10 kilometres out to sea does not seem like a tourist attraction but rather an eyesore.

The Clean Ocean Foundation recognises that the Minister may overrule the environmental policies of his own Department in favour of generating renewable energy. For that reason, we describe some opportunities for risk mitigation.

Mitigation of the negative impacts on the marine ecosystem require the optimum methods of construction, operation and decommissioning to be used.

For whales, mitigation largely involves minimising noise by eliminating seismic surveys and pile driving, and preventing collisions with ships. Seismic testing and pile driving are the largest hazards and can be eliminated. Four Local Government Authorities have passed motions opposing seismic testing because their constituents have withdrawn social licence for it. Seismic testing is covered in detail in the Appendix. Noise from pile driving is also a huge, unnecessary hazard.

Seismic testing can be avoided by using existing 2D data.

Two types of marine seismic blast surveys form the basis for exploration of the sea floor geological structures, 2D and 3D. The latter of the two is a more recent development and has a higher resolution of subsurface geological features[9]. As the name implies, 3D surveys provide a three dimensional view, assisting in the interpretation of data. Despite this, 2D seismic blast surveys have a long history of use and huge areas of the ocean floor in south-eastern Australia have been surveyed using this method (Figure 1 on page 13). There are existing methods of re-analysis of 2D seismic data that result in effective 3D visualisations of the ocean floor geology which render the use of 3D data moot[2,17,19]. Given that the scientific literature overwhelmingly shows that seismic blast surveys are hugely damaging to ecosystems (infra vida), it is incumbent on authorities to not use these methods wherever possible. The development of wind farm systems off the south-east coast is one such example. An over-abundance of 2D seismic blast survey data already exists across almost the entire region (see Figure 1, page 13) and it is prudent to utilise these data using pseudo-3D analyses instead of further 3D data collection processes. Our view is that there is sufficient data already available to safely proceed with the development of wind farm infrastructure without subjecting the regional ecosystem to another systematic extinction event.

Most offshore wind farms around the world were built using 2D data.

Mitigation of harm to birds

For birds, mitigation can involve painting the blades highly-visible colours, orientation at right angles to flight paths (although the turbines must face into wind) and ensuring blade-tip clearance is higher than flight paths. Different species require different strategies. Baseline surveys can pinpoint effective local mitigation strategies[10].

Pile driving can be minimised by using gravity-based foundations or floating platforms.

Clean Ocean Foundation supports the recommendations for the best environmentally friendly construction techniques identified by Sea Shepherd[16].

The Clean Ocean Foundation believes that Baseline surveys of Blue Whales and Oceanic Birds are necessary.

Baseline surveys of birds and whales should precede any declaration by the Minister. *The Blue Whale Study* does such surveys (http://bluewhalestudy.org/).

Bird studies are harder but should assess the populations and flight paths[4,5,7].

A precautionary approach should be adopted. If a wind farm site could adversely affect the population levels of whales and other cetaceans, or seabirds, the site should be rejected.

Minimising shipping movements.

Construction and maintenance of the wind farm will increase noise and the risk of ships colliding with whales. Operators should be required to show in their risk management plan how risks will be mitigated, such as using maintenance staff accommodation platforms, slow boat speeds, and marine observers.

Adopt a World's Best Marine Debris Management Plan with Community Oversight.

Clean Ocean Foundation already supports the work conducted by community group Beach Patrol 3280 that attempts to mitigate the chronic and severe existing marine debris problem along the coast in SW Victoria. We would recommend stringent protocols and support be set up to monitor and mitigate debris from all aspects of the offshore windfarms and that proper infrastructure and to manage and remove all marine debris.

Clean Ocean Foundation, through its work on the National Outfall Database for the Marine and Coastal HUB (DCEEW), understands just how critical meaningful community involvement in achieving better outcomes for the environment.

We would strongly recommend this needs to include proper funding for effective community involvement in oversight and action to address and mitigate ALL marine debris along the shipwreck coast from the initial design phase onwards (https://www.nespmarinecoastal.edu.au/).

Decommissioning

Any proposal to build a wind farm should contain the environmental impact assessment for decommissioning.

The Clean Ocean Foundation asks what decommissioning strategies are planned?

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Appendix

The case against noise-induced damage from seismic testing

Herein we provide scientific evidence to show that (1) noise from seismic blast surveys (and pile driving) are particularly damaging to the marine environment (species and ecosystem) and that (2) given the large amount of 2D data already available for the region, such seismic surveys are not required at all.

We also define a "blast" as any noise louder than 120dB.

Figure 1 below presents a map of the area within the Bonney Coast Upwelling in which the proposed wind farm will be located. The locations of all the 2D and 3D seismic surveys that have been undertaken across the region have been added to this map.

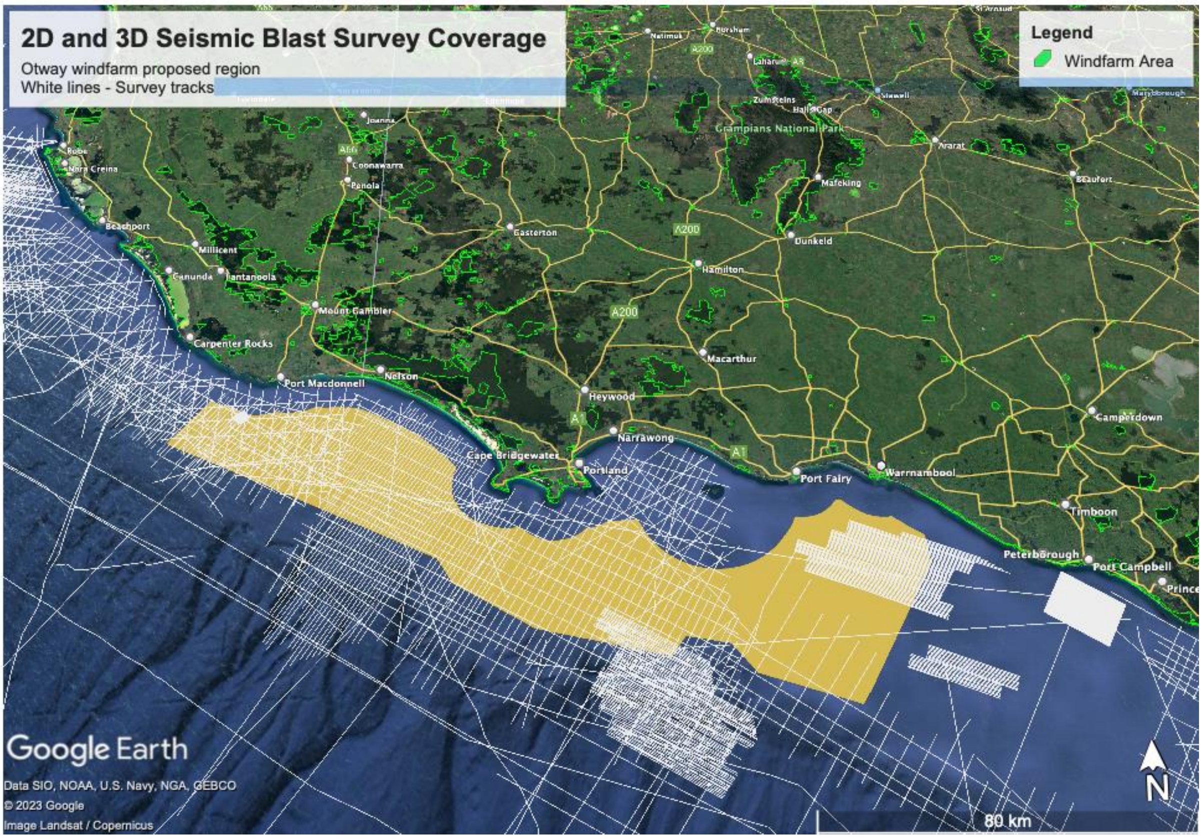

Figure 1: Proposed region for the Bonney Coast Upwelling Wind Farm with the locations of all 2D and 3D seismic surveys across the region superimposed.

The impact of Seismic Blast Surveys on Zooplankton

Marine plankton are classified as phytoplankton or zooplankton. Zooplankton consume phytoplankton which form the basis of marine food webs. The abundance of phytoplankton can be measured by satellite imagery of Chlorophyl-A.

Phytoplankton are eaten by zooplankton which are eaten by small marine creatures which are eaten by larger ones. This is the cycle of marine life. The operation area for the proposed wind farms is where baleen whales (e.g. Pygmy Blue and Southern Right Whales) eat plankton.

Zooplankton form the basis of marine food chains and in particular Antarctic Krill (*Euphausia superba*) are considered keystone species.[8] Keystone species "are only those species having a large, disproportionate effect, with respect to their biomass or abundance, on their community"[31] This means that any significant impact on keystone species has a cascading and widespread impact on the ecological community they support. While most zooplankton in the Bonney Coast Upwelling do not fall into this strict definition, they do fall into the definition of key species because they drive ecosystem processes, energy flows, or both. Fundamentally these zooplankton form the basis and functioning of the wider Bonney Coast Upwelling ecosystem and disturbance of these process will have knock-on effects. In the literature, there is no dispute about the overall importance of zooplankton to the marine ecosystem functioning or over the importance of krill in particular to whales as a food source.

The proposed area for the wind farms is 5,135 km^2 in depths ranging from 35m to 200m, with unknown acquisition periods. We know that the noise associated with seismic blasts kills or seriously debilitates many zooplankton species[23,44], including killing krill larvae at least up to 1.2 km from the source of the sound. Seismic blast survey proponents dispute these data and we show why this viewpoint is biased and incorrect (Vide infra). Assuming that the mortality of krill larvae is accurate, and the survey lines are less than 1.6 km apart (Figure 1), such surveys have the potential to kill krill larvae across the entire survey area and through the full water column. Critics of McCauley et al.[23], Richardson et al.[34] suggest that zooplankton will recover within 4 days but this assumption and misunderstands the life cycle of krill. Krill have a breeding season that lasts ~5 months. Once the eggs are fertilised they sink to depths between 100 and 2000 m. The eggs hatch and the larvae move steadily to the surface over a few months growing through four developmental stages. The adults spawn multiple times across the breeding season and reach sexual maturity at 2 years[18]. Given the length of time krill larvae spend in the areas vulnerable to seismic blasts (depths to 1.2 km), the scale of the potential mortality of larvae is immense (1,027 km^3). If even a fraction of the potential mortality of krill larvae is realised, it would have an immense impact on the populations of this keystone species. Krill only reproduce in the warmer months. Since entire year-classes of larvae would potentially be killed in the Bonney Coast Upwelling, the notion that they will recover in 4 days[34] is unfounded. Their life cycle does not allow it.

There is an absence of knowledge regarding the impact of seismic blasts on marine zooplankton. The limited knowledge that we do have is for surface surveys. We know nothing of sub-surface water impacts. The EPBC Act specifically states that lack of scientific knowledge is not a sufficient reason to allow a damaging activity to occur. The mortality of krill larvae caused by seismic blasting has been shown in shallow surface waters, but the results imply a catastrophic level of mortality to those larvae in deeper waters. These observations, in their entirety, provide evidence that seismic surveys should not be permitted (in any form) in the proposed region as they destroy the food source for the Pygmy Blue Whales, seabirds, and other species. We already have evidence that the whales themselves have been losing condition over the last 20 years (Peter Gill, Personal Communication, 18th August 2023).

Richardson et al.[34] critiqued the work of McCauley et al.[23] suggesting that while the impact of the mortality on zooplankton may occur, that the recovery rates would render the problem negligible. A critical review of the report shows that the work cannot be used in a scientifically valid way to reduce the importance of McCauley et al.[23] Among the limitations of Richardson et al.'s report are:

1. The modelling is being used to argue against direct observations. This is not how modelling is used scientifically. Models cannot negate the observed real evidence; rather observed evidence is used to inform and modify modelling such that it better reflects reality.
2. The model is not a peer reviewed report and has not been published in the scientific literature. This means that it is the opinion of its three authors. Further, the report was funded by the industry's lobbying organisation, the Australian Petroleum Production and Exploration Association (APPEA), which greatly damages the report's independence and credibility.
3. The modelling was based on small zooplankton with several-day reproductive time scales from the North West Shelf, a high current region. Krill was not included. Zooplankton abundance, species composition and diversity in tropical areas are substantially different compared with those in temperate environments,[9] and the high current regimes of the North West Shelf do not apply to temperate Australian waters. Extrapolating what may or may not occur from a tropical to temperature environment tells us little about the Bonney Coast Upwelling.
4. The authors use the CSIRO's Ocean Forecast Australia Model (OFAM) to represent the upper ocean circulation around Northern Australia in which they seed particles (representing reproducing populations of zooplankton) uniformly across a hypothetical survey site. The model assumes (in substantial error) that zooplankton populations are uniformly distributed across the ocean. They are not. This has been clearly shown[9,21].
5. The authors attempt to model the growth of populations of all zooplankton (all species combined) using a simple logistic model to estimate the population growth across time. Apart from the substantial confounding across species (i.e. the life cycle of krill species is completely different from the average copepod), the model assumes a carrying capacity which they estimate in summer from other CSIRO sources. Carrying capacity of an environment for any species or group of species is not static; it varies both across time and space. Since the carrying capacity of the system is critical to the size of the population and how much it can grow, this single estimate that drives the model is inadequate. This becomes a one-time estimate of population size potential based on an assumed uniform seeding level. These are compounding errors rendering the results largely meaningless.
6. The model uses a simplistic approach in calculating zooplankton mortality and population growth. They correctly state that natural mortality is very hard to estimate in the wild and then go on to use natural mortality estimates based on laboratory studies. To state the obvious, these are mortality rates in the laboratory, not the wild, and are meaningless in this context. Natural mortality in the wild varies by size, across space and across time (predation, availability of resources, etc.). A simplistic one-off value tells us

very little about the recovery rate of an impacted population. This is a compounding error of the approach.

This study amounts to an exercise in modelling, but the approach is simplistic and does not contribute to assessing the impact of seismic blasts on the population of zooplankton in the Bonney Coast Upwelling, nor for that matter in the NW Shelf environment. The zooplankton species are different, the baseline assumptions used in the model do not apply to the Bonney Coast Upwelling and thus are fundamentally flawed, and there are compounding oversimplifications in the calculation methodology. The model used is essentially a steady state model. These approaches were widely used in fisheries for decades and have ultimately been discarded because they simply do not represent real-world ecological interactions or processes.

Significantly, in the final section under Model Caveats, Richardson et al.[34] acknowledge many of the above limitations in their approach and the limited usefulness of their results. They are important limitations but they only appear at the end of the document and not in the executive summary. Furthermore the initial report produced by Richardson et al.[34], on which the APPEA publication is based, explored what would happen if they "turned the current down" to something realistic for southern Australia. This model run resulted in the recovery rate for small three-day life cycle zooplankton exposed to a 3D seismic survey increasing from three days to three *weeks*. This sobering result was not presented in the APPEA paper. Furthermore, these APPEA paper results have been widely misrepresented by APPEA and the gas industry to justify seismic blast surveys.[37] This is willful misrepresentation of the available data. Finally, this report has not been published in the scientific literature. Would it survive scientific peer review by a high ranking journal as McCauley et al.[23] has? One can now add the results of an independent study of how small copepods respond to exposure from small air gun signals[44], where the results support the findings of McCauley et al.[23].

A second publication, the work of Fields et al.[14], has been used to counter the research of McCauley et al.[23]. This paper examines the mortality of copepods (specifically *Calanus finmarchicus*) to seismic blasts, but has absolutely no bearing on the issues with respect to the zooplankton in the Bonney Coast Upwelling. The McCauley at al.[23] study stated, quote, "The 'copepods dead' category was dominated by the smaller copepod species (*Acartia tranteri, Oithona spp.*)". These copepods had an average size of 0.5 mm, while the Fields et al.[14] copepods *Calanus finmarchicus*, were about 2.5 mm in length or five times bigger than those in the McCauley et al. study, which actually reinforces their observation that smaller copepods were more susceptible to damage. Vereide et al.,[44] using similar size copepods as that of McCauley at al.,[23] obtained similarly higher mortality resulting from air gun signal exposure. In addition the Fields et al.[14] copepods are not a species of zooplankton present in this environment, but more significantly, McCauley et al.[23] clearly states that there is a substantial issue with krill mortality. Krill was not part of the Fields et al.[14] study.

The conclusion reached here is that seismic blast surveys have a critical impact on the krill of the Bonney Coast Upwelling resulting in total mortality of all the larval stages. Krill are keystone species in this environment and total mortality of the young of this group of zooplankton is potentially catastrophic. It should not be permitted, the science demonstrates this. Contrary arguments presented by proponents of seismic blast surveys in the region (for gas and oil reserves) have misrepresented the science and caused substantial damage to the Bonney Coast Upwelling ecosystem.

Fishes and Eels

Continental shelf waters support the majority of species diversity and abundance with respect to fishes because the shallow waters tend to be more productive (light penetration to the sea floor) and more complex habitats. The Bonney Coast Upwelling is entirely across the continental shelf (Figure 2 below).

The impact of seismic surveys on fishes has not been widely addressed. Much of the work has been conducted using modelling approaches where estimates of impacts have been established based on the physical structure of various organs, the use of caged experimental studies and laboratory research. The state of the science was reviewed by Carroll et al.[10] who provided a detailed summary. Subsequent to this paper there has only been one additional study of particular note.

Table 1 on page 20, taken directly from Carrol et al.[10], examined 28 studies on adult/juvenile fishes, fish eggs, fish larvae and elasmobranchs (sharks). The red, yellow and blue highlighted parts of the table indicate possible or measured responses to seismic sounds, representing 24 of the 28 studies (86%). The green represents studies that found no impact of seismic surveys (17 of the 24 studies - 71%). The percentages do not sum to 100 because some of the studies found both positive and negative responses.

While these data are in themselves concerning when it comes to assessing the impact of seismic surveys based on a precautionary principle, there are two fundamentally significant further issues shown here. Firstly, Carroll et al.[10] failed to find, and thus refer to, any research identifying community level impacts on fishes or sharks. It is not listed on the table and none of the papers referred to address these concerns. Community impacts refer to how the fish assemblages may change with time (periods > 1 year) as a result of components of the assemblages suffering significant damage (i.e. changes in abundance of some species and/or groups of species that potentially lead to cascading ecosystem impacts). Secondly, the grey areas in the table refer to aspects of seismic survey impacts that have not been researched. **Thirty-seven of the 40 (93%)** possible categories of study that we should have some data (excluding categories unlisted) have no usable information to allow us to assess the potential impact of seismic testing on the most diverse group of vertebrates in the world. Marine fishes constitute ~14,800 of the ~33,000 species of fish with another ~900 elasmobranchs (almost entirely marine). It is estimated that there are approximately 45,000 vertebrates.

Previous proponents of the seismic surveys intended in the Bonney Coast Upwelling region use the results of Meekan et. al.[24] to suggest that seismic surveys do not impact fishes. It is worth pointing out that this paper certainly attempts to address community level impacts of seismic surveys on the North-West Shelf of Australia. These authors found no impact of the process on the community structure of benthic (bottom dwelling) fishes using techniques of baited underwater videos and tagged fishes, although the study made no attempt to look for small scale physiological impacts on any fish. Points to note from this paper; reviews have described it as intriguing and worthy of further research. Nevertheless, the study used what are termed BRUVS to collect abundance data of fishes. These are baited underwater camera systems used to attract fish and are intrinsically biased (there are reviews demonstrating this in the scientific literature:

unknown fishing selectivity).[47] This means that the results are not definitive and require further work. Further, the study examined impacts over 8 months and in waters less than 80m in depth. Eight months does not constitute a sufficient time scale to fully assess community level impacts as it does not represent seasonal variability, interannual variability, or recruitment cycle (recruitment defined as the size at which fishes become susceptible to the fishing gear used) for many of these species. This tropical study cannot form the basis for the determination of ecosystem impacts on the temperate south coast of Australia and has no validity in justifying seismic surveys in these environments.

Based on Carroll et al.[10,] and an understanding of the diversity of marine fishes and sharks, seismic surveys are proceeding in an **information vacuum**. Attempts to use data gathered from the North West Shelf (a tropical ecosystem) and apply them to the Bonney Coast Upwelling region (a temperate ecosystem) are scientifically flawed. The Precautionary Principle should be applied to the environmental impact.

The proponents of seismic surveys have argued that these process have been widely conducted in southeast Australia over many years and that there has been no scientific evidence suggesting that any negative effects have occurred. Based on the work of Carroll et al.[10], the most obvious reason for no evidence that negative impacts have been found is because no studies have been conducted that specifically look for them.

Moreover, there is evidence from commercial fisheries which confirms negative impacts that seismic surveys have on fishes.[13,25,40]

	Adult/juvenile fish	Fish eggs/larvae	Elasmobranchs
PHYSICAL			
Swim bladder damage	1,2		
Otolith/inner ear damage	3; 4		
Temporal Threshold Shift	5; 1a,3a		
Permanent Threshold Shift	5		
Organ/tissue damage	1,2,6		
Mortality	1,2,6-11	12-14; 13,15	
BEHAVIOURAL			
Startle/alarm response	1,8a; 6,7,8a,9,16,17		
Sound avoidance/migration*	9,18-20; 7,12,16-18,21-23,24a; 18		
Other changes in swimming	20		
Predator avoidance			
Foraging			
Reproduction			
Intraspecific communication			
PHYSIOLOGICAL			
Metabolic rates			
Stress bio-indicators	16; 6a; 10a		
Metamorphosis/settlement			
CATCH EFFECTS			
Catch rates /abundance	7,19,25,26; 21-23; 12,18,23,27,28		28

1= Popper et al. 2005⁺, 2 = Popper et al. 2016⁺, 3 = Song et al. 2008⁺, 4 = McCauley et al. 2003, 5 = Hastings and Miksis-Olds 2012, 6 = Santulli et al. 1999, 7 = Hassel et al. 2004, 8 = Boeger et al. 2006, 9 = Wardle et al. 2001, 10 = Radford et al. 2016⁺, 11 = McCauley and Kent 2012, 12 = Dalen and Knutsen 1987, 13 = Booman et al. 1996, 14 = Payne et al. 2009, 15 = Kostyuchenko 1973, 16 = McCauley et al. 2000, 17 = Pearson et al. 1992, 18 = Løkkeborg et al. 2012, 19 = Pickett et al. 1994, 20 = Peña et al. 2013, 21 = Skalskiet al. 1992, 22 = Slotte et al. 2004, 23 = Engås et al. 1996, 24 = Chapman and Hawkins 1969, 25 = Miller and Cripps 2013, 26 = Thomson et al. 2014; 27 = Løkkeborg and Soldal 1993, 28 = Przeslawski et al. in prep.

1a: Statistically significant hearing loss immediately upon exposure of freshwater adult Northern Pike to 5 pulses at 400 Hz and exposure of Lake Chub to 5 and 20 pulses at 200, 400 and 1600 Hz. Recovery within 18 hrs. A shift was observed only in adults and not in juvenile Pike.
3a: Adult freshwater Northern Pike and Lake Chub exhibited temporary hearing loss, but no damage to the sensory epithelia studied in any of the otolithic end organs, demonstrating that hearing loss in fishes is not necessarily accompanied by morphological effects on the sensory hair cells.
8a: Repeated exposure to air guns resulted in increasingly less obvious startle responses in effected fish, indicating possible habitation to the disturbance.
10a: Fish exposed to playbacks of pile-driving or seismic noise for 12 weeks no longer responded with an elevated ventilation rate to the same noise type, and showed no differences in stress, growth or mortality compared to those reared with exposure to ambient-noise playback.
24a: Free ranging Whiting school responded to airgun sound by shifting downward, temporary habituation was observed after one hour of continual sound exposure.
* Includes changes in vertical/horizontal distribution.
⁺Freshwater/brackish species.

KEY

- Red: Response at realistic exposure levels
- Yellow: Response at unrealistic/unknown exposure levels
- Green: No response at either realistic or unrealistic exposure levels
- Blue: Possible response (conflicting results)
- Dark grey: No data, has not been tested
- Light grey: Not applicable

Table from Carroll et al. (2017)[10].

Damaging impact of seismic blasting on short fin eels.

Short fin eels have an immense cultural value for the indigenous peoples of South-West Victoria, forming the basis of a UNESCO World Heritage site at Budj Bim. Their cultural connection to the land and the eels stretches back 40 to 60 thousand years which Australia has global responsibilities to protect.

Eels have a unique life cycle with adults migrating to the ocean in spring and migrating from South-Western Victoria all the way to the Coral Sea to their spawning grounds. Those that survive this long and arduous journey reproduce in the deeper waters and then die – they only reproduce once in their lifetime. This means that reproducing animals do not get a second chance and anything that reduces the number of eels reaching their spawning grounds has a negative impact on the numbers of offspring. The spawned eggs hatch into larvae and these then use the currents to drift back down the Australian east coast and migrate back to the rivers from where their parents came.

It is well known that seismic blasts kill fish. We also know that these surveys change the behaviour of fish: they can disorientate them and they can make them more vulnerable to predators, and other adverse impacts. Specific information about seismic blasts relating to short fin eels is absent but the effects on other kinds of eel are damaging.[1,32,36,38] We have no reason to believe that short fin eels are any different.

Eels are vulnerable throughout their life cycle. Adult eels have a single opportunity to successfully reproduce. They are already under significant pressure from climate change, impacts on the land that pollute their rivers, and water extraction. Larval eels return on ocean currents to South-West Victoria as part of the zooplankton. These currents pass through the Bonney Coast Upwelling.

Studies have shown that seismic blast surveys kill about 64% of zooplankton out to at least 1.2 km[23] from the sound source and so larval eels are almost certainly killed by these activities. Adding an additional pressure to these already vulnerable animals is irresponsible and a breach of our duty to protect World Heritage sites and cultural traditions that may be 60,000 years old and ignores consultation with Indigenous groups who venerate the importance of eels to their society.

We accept that there are multiple impacts that are harming the number of eels returning to South-West Victoria. However, we have control over whether or not there are seismic blast surveys in the Bonney Coast Upwelling. As we have every reason to believe that these seismic blasts are damaging the eels stocks through disruptions to their migration patterns, we have a social and legal responsibility to protect these vulnerable animals from known damaging activities like seismic blast surveys.

Cetaceans and Pinnipeds

In this section we focus on groups of animals (other than fishes) that are prevalent in the Bonney Coast Upwelling system. These feed on a variety of invertebrates and small fishes and are considered the most vulnerable of the species in the region, for example Pygmy Blue Whales.[27]

As detailed elsewhere, seismic surveys are in fact explosions and have a well-documented history alluding to their impact on marine mammals. As far back as Aubrey et al.[7], who reported on the use of "seal bombs" with sound exposure levels of 190dB re 1 μPa^2-s at 1 m to deter seals from impacting commercial fish catches. 190dB is two orders of magnitude less than the ~230dB associated with seismic blasts (the distance that these sounds travel is well documented: see McCauley et al.[23]).

Potential impacts of noise include interruption of essential behaviours[49], masking signals of interest (e.g., the sounds of predators, conspecifics or prey)[19], displacement from crucial habitat[11], direct physical injury including temporary or permanent hearing loss[16,22], and in extreme cases, death[15].

NOPSEMA (The National Offshore Petroleum Safety and Environmental Management Authority, also responsible for offshore renewables) is well aware of the issues associated with seismic surveys[2,3]. A common thread with the environmental plans approved by NOPSEMA is the acceptance of the use of literature and hydro-acoustic modelling to form the basis of determining the degree of impact of seismic survey activity on this group of animals (and others). We find no reference to requirements that the organisations proposing seismic surveys do anything further to determine the potential damage. The two examples provided stipulate a 10-km buffer (around the seismic source) for the protection of whales (Southern Right, Pygmy Blue) and primarily by association pinnipeds and birds.

NOPSEMA's responses states "NOPSEMA required the titleholder put in place effective whale detection and control measures to demonstrate that blue whales would not be injured or displaced from foraging in BIAs. In response, the titleholder included a 10-km observation zone that applied to the foraging BIA and a 10-km buffer; 10-day interval aerial surveys; the use of passive acoustic monitoring; and trained marine fauna observers / PAM operators to implement a shutdown of the seismic array should a blue whale be detected entering the shutdown zone of an active seismic source" (https://docs.nopsema.gov.au/A702829) with respect to blue whales.

We presume that the 10-km range comes from a 3-km visual search distance from the survey vessel (onboard observers) and 10 km from 10 day interval aerial searches for whales. Both of these requirements are inadequate based on simple calculations of blue whale cruising speeds and dive durations. With respect to the 3-km visual searching for whales, the dive duration of such whales is variable, typically of the order from a few up to fifteen minutes, depending on what the whales are doing. Owen et al.[29], and Davenport et al.[12] used a single Pygmy Blue Whale tagged with a high resolution tag attached for seven days to give an average dive time of 7.6 minutes and maximum of 17.5 minutes. Thus in a single dive, these whales can move ~1.3 km in 7.6 minutes or 2.9 km at their maximum dive time (while cruising) and substantially farther at higher speeds. This suggests a whale can easily move from visible range to beyond without being detected. The point here is that from simple observations of the behaviour of blue whales[29], the requirements of seismic survey shutdown specified by NOPSEMA to prevent harm to whales in the Bonny Upwelling cannot be achieved at all either by onboard observers or aerial surveys. This argument is equally applicable to southern right whales (dive time < 33 min)[6]; maximum speed ~ 17km/hr[4]; and Australian fur seals (dive time 6 min, cruise speed 9 km/hr[5]).

With the information provided in the previous paragraph, we note that the Federal EPBC Act states with respect to Pygmy Blue Whales that "The risk of physical impacts is minimised by implementation of the practical measures outlined in the EPBC Act Policy Statement 2.1 – interaction between offshore seismic exploration and whales. While the seismic guidelines advise that seismic surveys should be undertaken outside of biologically important areas at biologically important times". It further states that "it is not known at what distance from a seismic source, behavioural impacts may occur or the extent of any behavioural impact".

Based on the requirements of the EPBC Act, it is incumbent upon the proponents of the seismic surveys to have an understanding of the range impacts of their surveys on the whales. The 10-km range has no basis in the scientific literature and is easily debunked by simple whale cruising speed and diving behaviour calculations. It appears to be based on the modelling criteria of sound propagation in waters from sound propagation models and has no replicated and published scientific literature to support it.

Further, "Under the EPBC Act, environment assessments are undertaken to support environmental and heritage protection and biodiversity conservation. A person must not take an action that has, will have or is likely to have a significant impact on any of the matters of environmental significance without approval from the Commonwealth Minister for the Environment. An action is a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things". The actions and activities of NOPSEMA and the proponents of such activities with respect to seismic surveys, at face value, are a breach of the obligations under the EPBC Act. We know from Freedom of Information obtained that NOPSEMA is aware that the current risk mitigation is inadequate[2,3].

We observe that Action Area A.2 of the Blue Whale Conservation Management Plan states "Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area". This requirement is in place regardless of activity type (migration, foraging, breeding), behaviour (nursing, singing, resting, etc.), time of year, and time frame of use. There is some evidence that blue whales feed year round[26]. Blue whales must be able to use Biologically Important Areas without injury.

In addition to the above, we can demonstrate from the scientific literature that the impact of seismic surveys, regardless of the modelled sound levels, propagation or received sounds by whales, has impacts well beyond the specified 10 km range.

In 2019, Kavanagh et al.[20] published a paper in Nature (across large spatial scales and multiple species) showing negative impacts on both baleen and toothed whales. They modelled data from whales observation (> 8,000 hours) covering an area of more than 880,000 km^2 finding a significant negative impact of seismic activity across species and habitats. Their results found an 88% (82–92%) decrease in sightings of baleen whales, and a 53% (41–63%) decrease in sightings of toothed whales as a result of seismic surveys (compared with control surveys). Weilgart[45] presented a conference paper to the "CBD Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity" that lists a wide variety of impacts of seismic noise on marine mammals. Among many salient issues raised (with associated reference to the scientific literature) are the observations of Richardson et al.[35] who state that there were changes to dive durations and breathing patterns in bowhead whales up to 54–73 km from seismic surveys at received levels that could be **as low as 125 dB re 1μPa**.

These examples demonstrate significant issues with impacts of seismic survey noises on cetaceans. Again, we are presented with the counter argument that seismic surveys have been in operation in the Bonney Coast Upwelling regions for decades and there does not appear to be an effect. We respond with the same statement as above that few resources have been provided to actually assess the impact, hence no observations have been made. The level of impact on cetaceans and other species in the area is assessed based on hydro-acoustic modelling methods rather than on the direct measurement of the impact of the animals in question. Modelling does not inform the debate, only replicated experimental studies with the animals in question.

We have focussed on the whales here, but this does not lessen the significance of other species present in the ecosystem. The whales represent the species with the widest and quickest movement capability. What about the species with less mobility (e.g. benthic fauna)? We would expect these to be protected with a more stringent strategy (EPBC Act) established to consider the whales.

The balance of scientific evidence tells us that seismic blast surveys are damaging to pinnipeds and cetaceans, further where there is insufficient information, the precautionary principle and the EPBC Act tell us that these processes should not be permitted in the Bonney Coast Upwelling despite the long history of their approval.

Birds: Seabirds and Migratory Shore Birds.

Antarctic Prion in the blow of a Blue Whale off the Bonney Coast (Courtesy of BrettJarrett@bayofwhalesgallery.com)

Seabirds highlight the interdependence in the ecosystem, starting with krill. Some seabirds such as shearwaters and petrels, prey directly on krill. Others, such as gannets, terns and albatross, as well as tuna, prey on bait fish that may have fed on krill.

There is only one published scientific study of the effect of seismic surveys on birds which was carried out on the African Penguins.[330]

More detailed sources of vulnerable and endangered birds in the Bonney Coast Upwelling is Cornell University's database called eBird[41] which is a compilation of citizen scientist birdwatchers' records. For recent data on seasonal presence and relative abundance of seabirds around the Bonney Coast Upwelling, the following link is relevant: Port Fairy Pelagic, Lady Julia Percy Island, VIC, AU - eBird Hotspot

Most are categorised as threatened or endangered. The plankton-rich Bonney Coast Upwelling is an important feeding area as maps in the Seabird Atlas show, as do images of chlorophyll A (Figure 2, below)[33].

On page 27 of the Wildlife Conservation Plan for Seabirds 2022, it states "Proposals for energy generation by offshore wind should be adequately assessed, and as appropriate, conditions imposed to ensure there are no adverse effects on seabirds or their habitats."[48]

Some measure of the importance of the Bonney Coast Upwelling for local birds like the Sooty Shearwaters breeding on Griffith Island, Port Fairy, and the distant ones can be inferred from the presence of the Campbell Island Albatross. It only breeds on Campbell Island group, New Zealand's furthest south sub-Antarctic Island at 52.54°S, 169.14°E.

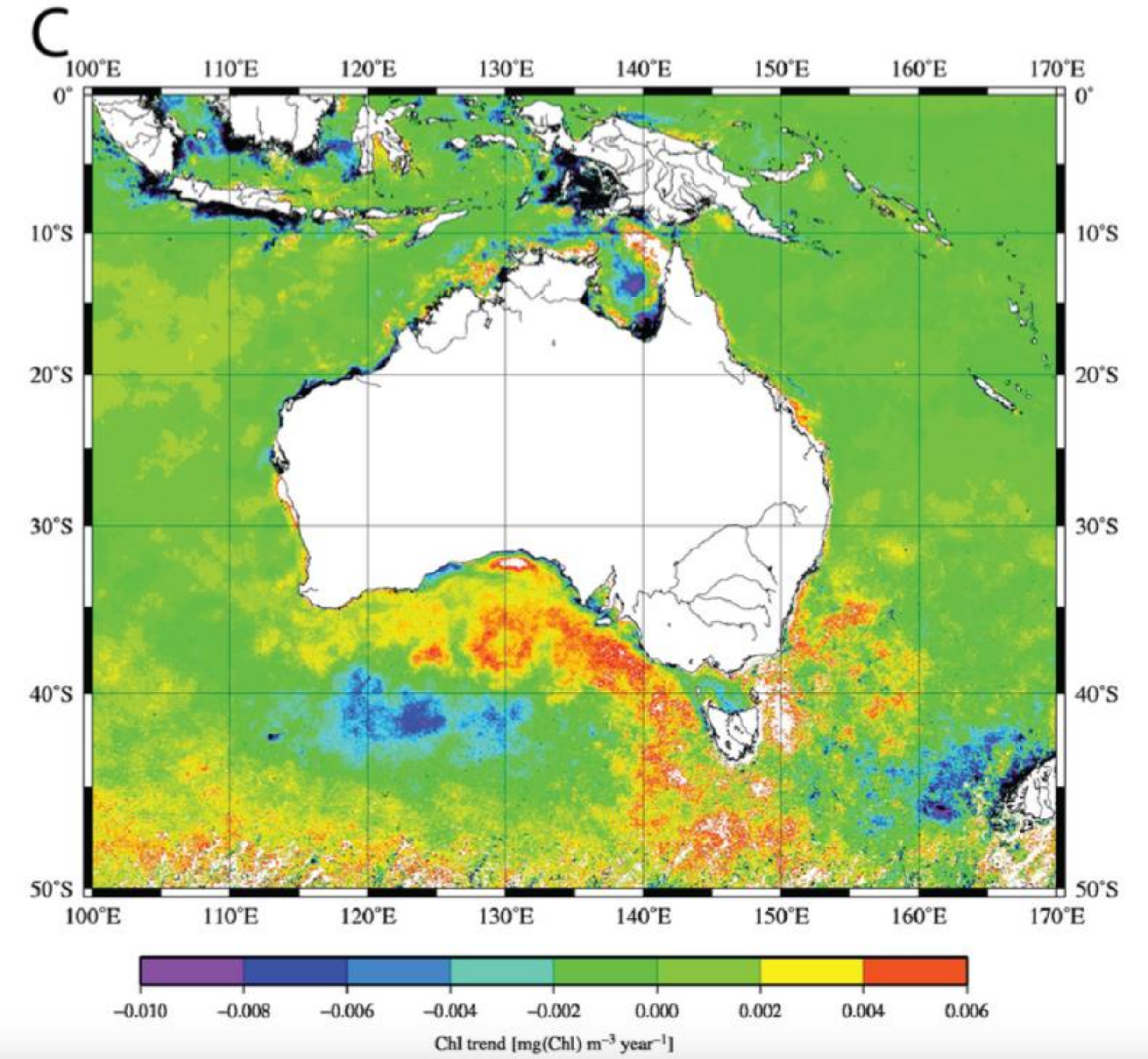

Figure 2. Trends Chlorophyll A in the Australasian region between 2003 and 2019 (Thompson et al. 2020)[42]

Little Penguins

The Little Penguin is a tourist attraction around the Bonney Coast Upwelling. To the best of our knowledge, no research has been done on the effects of seismic blasting on the Little Penguin, or as significantly, on its prey species. There have been observational reports of the strong impact of blasting on Southern Rockhopper Penguins which were found floating unconscious near blast sites off Marion Island and Saldhana Bay, South Africa.[30]

There is only one published scientific study which was carried out on the African Penguins.[30] Within 100km of their colony, penguins showed avoidance of their preferred feeding areas during seismic activities, leading to increased effort for their overall foraging. Longer term repercussions on hearing could not be excluded.

A report in the New Zealand Herald, 17th January 2018 stated:[28]

“I don't see why it wouldn't hold for our little penguin, especially if the blasting overlaps with foraging habitat like in the South African study”, University of Auckland marine scientist Associate Professor Craig Radford said.

“These little guys spend a considerable amount of time at sea foraging and if they are as sensitive to sound as the South African species then there is the potential to disrupt their foraging behaviour.”

Dr John Cockrem, a professor of comparative endocrinology, said “Seismic surveys conducted within 100km of Korora foraging areas could have adverse effects on breeding success and survival of the penguins.”

Middle Island penguins have not been studied by tagging so their feeding range is unknown. Little Penguins are hard to spot because they are under the water much of the time. The peak month for sightings in January. About 10% of sightings are beyond the Continental Shelf. Little Penguins have been seen in or near the Bonney Coast Upwelling between February and April at almost 40°S. As the Little Penguins in Warrnambool are at latitude 38.3°S, this is a distance of around 200 km.

Penguins are among the most threatened bird families, largely due to the negative effects of competition with fisheries, climate change and oil pollution[30]. The Precautionary Principle should be applied. No blasting should occur within 100km of the range of Little Penguins. The Bonney Coast Upwelling is within that range.

Finally, Australia has international treaty obligations to protect albatross and other sea birds.

Bonney Coast Upwelling

The Bonney Coast Upwelling describes a wider ecosystem the entirely overlaps the proposed wind farm area (Figures 1 and 2). Often the upwelling is characterised by the extent of the cold water rising to the surface of the ocean but is better understood by looking at the productivity that it produces and where it spreads with satellite images of chlorophyll (nutrients feed the phytoplankton which feed the zooplankton). The bright red colours represent regions of high chlorophyll A, thus areas of high phytoplankton density and consequently areas of high zooplankton density (including krill).

The productivity (as measured by chlorophyll) that is entirely the result of the upwelling completely intersects with the wind farm. There is little support for the argument that the proposed wind farm avoids the areas of high phytoplankton density and thus krill populations. Thus the mortality that krill will be subjected to by seismic blasts is potentially a very damaging impact to the only food source of blue whales. It is worth noting that krill are obligate schooling animals – they will always form large schools. This makes it difficult to determine whether the total abundance of krill has declined until it is too late; a well-known problem in many schooling fish fisheries.

Seismic Blast Surveys

Seismic vessels follow a series of predetermined parallel sail lines at around 4½ knots in a "racetrack" pattern, where the vessel changes direction at the end of each line. During data acquisition, the discharge interval is given as 18¾ metres for dual-source airguns or 12½ metres for triple-source airguns, corresponding to a 235dB discharge every 5 to 8 seconds. The data acquisition occurs continuously for 24-hours a day, seven days per week, for the duration of the survey, except for the time in which the survey vessel is changing direction in its "racetrack" pattern. Once a survey pattern commences, there is no respite from the noise until the total pattern is completed.

Previous surveys modelled by JASCO[46] with single lines of no more than 20-hours duration had a 24-hour accumulated sound exposures along a survey line (SEL_{24h}) of over 180dB out to around 30km either side of the 100- to 200-km track so that an area of 3,000 to 6,000 km^2 was subjected to noise louder than 180dB over an entire day.

The real question, however, is what actual exposure level of noise is harmful, given that noise damage is cumulative and permanent – the hearing damage does not heal. The JASCO[46] report uses noise levels for temporary (TTS) and permanent threshold shift (PTS), i.e. temporary and permanent hearing loss, from a variety of sources. However, there are extremely limited real data on the more-damaging impulsive noise hearing loss onset for marine mammals across a range of exposure frequency conditions. These limited data are for captive seals or dolphins and are based on avoidance behaviour or brain electrical activity. Almost nothing is known about the effect of intense impulses of noise on crustaceans, fish and invertebrates and there are no data at all for the baleen whales, such as the iconic Pygmy Blue Whale or Southern Right Whale, that are the more well known and important species around the Bonney Coast Upwelling.

The estimation of hearing parameters relies upon extensive assumptions, extrapolation, and mathematical modelling of hearing using anatomical parameters, characteristics of sound production, and assumptions based on other species. Consequently, the TTS values taken from

Southall et al.[39] that are used as "safe" levels are purely estimated from these mathematical fitting functions using non-impulsive noise and single (in most cases) individuals. The situation is worse for the far more concerning permanent hearing loss where there are no data at all! That the levels used for permanent hearing loss are arbitrarily set to be 20dB higher than those for temporary loss is ludicrous.

When various species are grouped together, based on biological similarities, the group audiograms use median values of individuals of different species, leading to substantial individual variability. There are insufficient data to analyse the variance. Taking just the mean value, as has been done, does not make sense. Each dose of noise contributes incrementally and permanently to hearing loss. Confidence levels are required to be stated. By way of analogy, using the median would be equivalent to a toxicologist advising that a new drug would be acceptable if only 50% of people were killed by it (the LD50 level). The precautionary principle requires taking the lowest confidence interval as the safest step.

Underwater sound propagation from a complex source such as an air gun array is confounded by a large number of factors, some to do with the source and some to do with the environment between the source and receiver. Small changes in environmental features can produce large changes in sound propagation loss estimates, so altering the modelled received levels. A modelling report is just that, an exercise in predicting a system's behaviour based on multiple assumptions. The JASCO report[46] gives little information if the many assumptions used in their sound propagation modelling process are constant across the survey region. Furthermore, no estimates of potential modelling errors are presented.

Despite this lack of actual real knowledge of the hearing damage caused by intense noise pulses from air guns, the report uses the high value of 160dB as the "safe" (no effect) level, the highest levels that have been selected from older works with no measures defined and only superficial observational data. Recent work suggest that this value is much too high, and using it will increase the stress on populations, especially those endangered populations that are already under threat and for which there is no evidence about safe noise levels.[23]

While the greatest damage occurs to animals nearer the sound source, the number of damaged animals increases farther from the source. (The area of the affected zone and thus the number of affected animals increases with the square of distance.) Unfortunately, the simple "all-or-nothing" approach preferred by regulators, where it is assumed that all animals whose exposure is below the RLp50 threshold are completely unaffected and all above are affected, severely underestimates the number of animals affected by the stressor. The authors have provided an example in which this "all-or-nothing" approach underestimates the number of affected animals by a factor of 280, i.e. there are **280 times** as many animals affected than what the "all-or-nothing" calculation would suggest[43].

It is suggested that, along with the mathematical model of the noise distribution in the water, the determination of the number of affected animals uses a dose-response function coupled with the actual distribution of the animals[43]. Ignoring these factors can lead to significant errors in estimates of the area and numbers of animals affected. In addition, the selection of the exposure threshold also requires information on the proportion of the population that will be protected.

The JASCO modelling[46] does not consider that the effects of the seismic discharges are not just confined to the operational area. The underwater sound transmission channel from Bass Strait to

Antarctica allowed air-gun noise from a survey undertaken off the western edge of the continental shelf in Bass Strait to be detected as far away as the Antarctic Continental Shelf, some 3,000 kilometres away.[17] Consequently, the proposed survey could allow widespread and thousand-kilometre-range noise pollution for up to 200 days per year.

The consequences of the acoustic discharges are not just confined to hearing loss. A recent study demonstrated that these acoustic discharges are likely to prove deadly to zooplankton out to at least 1.2km from the source.[23] This was the limit of the published survey and so it is likely that mortality occurred beyond the 1.2km reported. Considering that this study used a **small 150in^3 air-gun, the much larger 3150in^3 air-gun array** to be used in the proposed survey will certainly cause mortality out to a much greater distance from each line. These are alarming findings on zooplankton that underpins the entire food chain. These intense acoustic discharges will increase the stress on populations, especially those endangered populations that are already under threat and for which there is no evidence about safe noise levels.

It is well known that excessively loud noise causes damage to the ear and that this damage is both cumulative and permanent. As the ear does not recover from cumulative damage, it is essential to minimise the total exposure to excessive noise levels. The question, then, is what is the definition of excessive?

There is a real lack of actual measured knowledge of the hearing damage caused by intense impulse noise, the most dangerous kind, from air guns. The values selected as "safe" do not consider the cumulative effect of repeated high-intensity impulses over an extended period of time. These values are somewhat arbitrarily selected from the modelling of short-duration continuous (non-impulsive) noise and extrapolated to other species for which no data exists. The recent work that is reported in well-respected scientific journals, such as that of McCauley et al.,[23] suggests that the so-called "safe" values are much too high, and that there is a real risk of permanent hearing damage occurring to those animals in the survey area. Almost all of these cannot swim fast enough to escape from the blast zone, despite the use of a "soft" start to each line.

We understand that JASCO's modelling[46] of the Scarborough Gas Field demonstrated that blue whales may suffer temporary injury as far as 60 kilometres from the sound source.

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